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T13/2132-D

**Revision 3
June 23, 2010**

Information technology - Enhanced Disk Drive - 4 (EDD-4)

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ABSTRACT

This standard describes services currently in use on IA-32 and IA-64 compatible architecture personal computer systems. These services are provided by BIOS firmware to support hard disks up to 16 exabytes (16×10^{18} bytes). This standard also provides BIOS level services for determining the relationship between BIOS device numbers and the physical mass storage devices attached to the personal computer. The services defined in this standard can be applied to mass storage devices with ATA, ATAPI, SCSI, USB, Fibre Channel, 1394, I₂O, and other interfaces. In addition, this standard defines the following:

- a) formatting required to make a CD or DVD bootable;
- b) INT 13h services used to access devices <8GB; and
- c) addressing information for Infiniband, Serial ATA, Hypertransport, and PCI Express

Draft

American National Standard

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The text which is highlighted in green may affect backward compatibility.

Revision History		
Rev	Date	Description
0	January 21, 2009	<ol style="list-style-type: none"> 1) Used ACS-2r1 as the template for this first draft. 2) Populated this template with d1572r3.doc (EDD-3) 3) Used ACSC-2 definitions for byte, word, DWord, and QWord since ACS-2 has a complete set of conventions. 4) Incorporated Erratum 5) Added editors notes where there were issues were found during conversion.
1	July 29, 2009	<ol style="list-style-type: none"> 1) Integrated e08134r1. This changes the definition of the device path. Added definitions of both SATA and PATA to definition of terms. Definitions were taken from ACS-2 verbatim. 2) Integrated e09103r1. This obsoletes Read Long, Write Long, Seek, Extended Seek, and Recalibrate. 3) Integrated e09102r3. This adds a Trusted Computing BIOS function
2	June 22, 2010	<ol style="list-style-type: none"> 1) Incorporated e09136r0 - EDD-4r1 Updates from 30-Jul telecon and 19-Aug plenary. 2) Performed a spell check 3) Normalized periods to followed by 2 spaces. 4) Incorporate e09127r3
3	June 23, 2010	<ol style="list-style-type: none"> 1) Corrected links that were not hot 2) Removed cut and paste artifacts from 2 notes in Annex A

New Capabilities added to EDD-4

Integrated Proposal List		
#	Doc	Description
1	e08134r1	Updates SATA path definition
2	e09103r1	Obsoletes Read Long, Write Long, Seek, Extended Seek, and Recalibrate
3	e09102r3	Adds a Trusted Computing INT 13h BIOS function
4	e09127r3	Adds an Annex describing peaceful coexistence of MBR and GPT

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Foreword

Foreword

(This foreword is not part of American National Standard NCITS.xxx-200x)

DOS accesses its mass storage devices using an INT13h programming interface provided by BIOS firmware to higher-level software. This interface was designed in the early 1980's, upgraded in the late 1980's and upgraded again in the early 1990's. Initially, INT 13h used a cylinder-head-sector interface that was limited to approx. 528MB of disk addressing. Later this same interface was upgraded to support approx. 8.4GB of disk addressing. Finally, extended functions were created that allowed 64-bit disk addressing. At this same time, specifications were created that allowed the CD or DVD ROM drive to boot using the same INT 13h interface that hard drives used. The Disk and CD/DVD functions have never been fully documented in a standards forum. This standard enables the following capabilities:

- a) CHS addressing with an 8.4GB limitation;
- b) Logical Block Addressing (LBA);
- c) removes the requirement of using interrupt 41h/46h to point at the Fixed Disk Parameter Table information;
- d) makes location and configuration information available to operating systems that do not use the BIOS to access mass storage devices;
- e) use data structures that apply to both IA-32 and IA-64 compatible architecture systems;
- f) use data structures that can address media capacities for the next 20 years; and
- g) boot from CD or DVD.

Requests for interpretation, suggestions for improvement and addenda, or defect reports are welcome. They should be sent to the NCITS Secretariat, Information Technology Industry Council, 1250 I Street NW, Suite 200, Washington, DC 20005-3922.

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

[Editor's Note 1: Insert INCITS Membership List Here](#)

Technical Committee T13h on ATA Interfaces, that reviewed this standard, had the following members and additional participants:

Dan Colegrove, Chair

Jim Hatfield, Vice-Chair

Mark Overby, Secretary

[Editor's Note 2: Insert T13h Membership List Here](#)

Introduction

This standard encompasses the following:

Clause 1 describes the scope.

Clause 2 provides normative references.

Clause 3 provides definitions, abbreviations, and conventions.

Clause 4 is the overview.

Clause 5 is INT 13h functions limited to 8GB if disk addressing.

Clause 6 is INT 13h functions not limited to 8GB of disk addressing.

Clause 7 is CD/DVD Booting
Clause 8 is INT 13h function definitions
Clause 9 is INT 15H Removable Media Eject Functions
Annex A describes Hybrid MBR boot

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Enhanced Disk Drive - 4 (EDD-4)

1 Scope

This standard assumes that the reader is familiar with the conventional INT 13h interface, the usage of the BIOS Device Parameter Table, and the basic operation of mass storage devices. This standard describes in detail BIOS functions and data structures that are used as an abstraction layer to allow higher-level applications to access mass storage devices in an interface and command-set independent manner. To comply with this standard, higher-level software shall call the INT functions using the data structures described herein, and system firmware shall provide the INT functions and data structures described herein.

The storage industry has increased the capacity and functionality of many types of mass storage devices. This increase in capacity and functionality has required the development of a BIOS interface. This standard documents the BIOS interface that is supplied by many BIOS vendors. This standard defines solutions to the following INT 13h BIOS-specific issues:

- a) The INT 13h interface has a limit of 528 megabytes (MB);
- b) The INT 13h interface allows more than two devices to be attached to a system but has no consistent method for storing the additional configuration parameters;
- c) The INT 13h interface does not define CHS-independent methods for addressing devices. The methods defined by the INT 13h interface are not device-geometry independent. A different method of address representation and operation is needed;
- d) Methods of data transfer continue to be added to ATA devices. Capabilities such as, DMA modes, multi-sector data transfers and PIO modes are not reported to the operating system via the INT 13h interface;
- e) Systems require more than two storage devices, and with this requirement comes the requirement to assign the order in which the devices are to be accessed. The INT 13h interface does not provide this capability;
- f) The INT 13h interface does not make location and configuration information available to operating systems that do not use the BIOS to access mass storage devices;
- g) The INT 13h interface does not provide a linkage between the BIOS device assignments on the operating system device letter assignments;
- h) The INT 13h interface does not use data structures that apply to both IA-32 and IA-64 compatible architecture systems.

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). Enhance Disk Drive - 4 (EDD-4) specifies a common set of procedures used to access or boot 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.

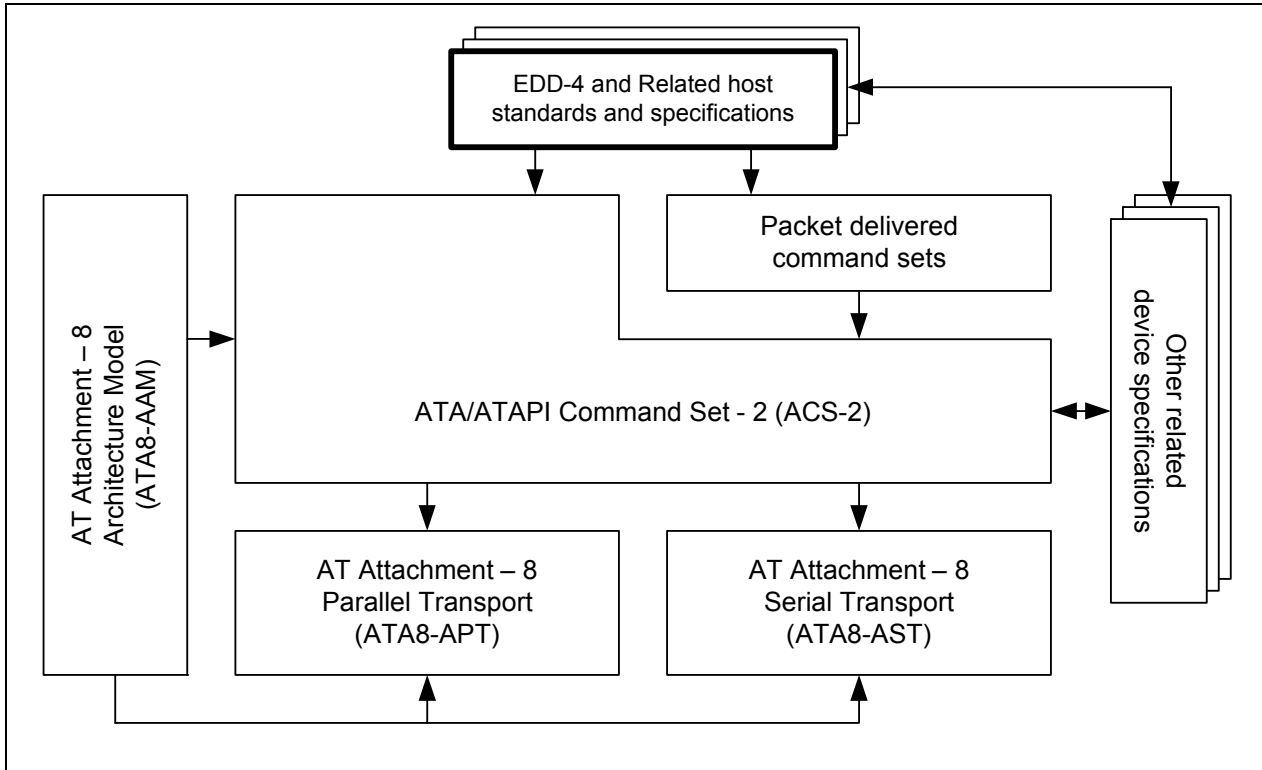


Figure 1 — ATA document relationships

2 Normative references

2.1 General

The standards list in 2.2, 2.3, and 2.4 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 in 2.2, 2.3, and 2.4.

Copies of these standards 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 as needed.

2.2 Approved references

Copies of the following documents may be obtained from ANSI, an ISO member organization:

- a) Approved ANSI standards;
- b) approved international and regional standards (ISO and IEC); and
- c) approved foreign standards (including JIS and DIN).

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or the InterNational Committee for Information Technology Standards (INCITS):

Phone +1 202-626-5738
 Web: <http://www.incits.org>
 E-mail: incits@itic.org

Table 1 lists approved ANSI standards, approved international and regional standards (ISO, IEC, CEN/CENELEC, ITUT). Additional information may be available at <http://www.t10.org> and <http://www.t13h.org>.

Table 1 — Approved ANSI References

Name	Reference
Volume and File Structure of CD-ROM For Information Interchange	ISO 9660-1988
Fibre Channel Framing and Signaling Interface - 2 (FC-FS-2)	INCITS 424-2007
(FC-LS)	INCITS 433-2006
AT Attachment 8 - ATA/ATAPI Command Set - 8 (ATA8-ACS)	INCITS 452-2009
Serial Attached SCSI - 1.1 (SAS-1.1)	INCITS 417-2006
Serial Bus Protocol - 2 (SBP-2)	INCITS 325-1998
Reduced Block Commands (RBC)	INCITS 330-2003
SCSI Primary Commands - 3 (SPC-3)	INCITS 408-2005
Multi-Media Commands - 5 (MMC-5)	INCITS 430-2007
BIOS Enhanced Disk Drive Services - 3 (EDD-3)	INCITS 407-2005
Extended Unique Identifier, 64-bit (EUI-64)	ANSI/IEEE 394:1995
IEEE Standard for a High Performance Serial Bus	IEEE 1394-2008

2.3 References under development

At the time of publication, the 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 in table 2.

Table 2 — References Under Development

Name	Project Number
ATA/ATAPI Command Set - 2 (ACS-2)	INCITS 2015D
Serial Bus Protocol - 3 (SBP-3)	INCITS 1467D
Multi-Media Commands - 6 (MMC-6)	INCITS 1836D
SCSI Primary Commands - 4 (SPC-4)	INCITS 1731D

2.4 Other references

These standards and specifications are also referenced.

BIOS Boot Specification (Compaq, Phoenix and Intel),

For the BIOS Boot Specification published by Phoenix Technologies, contact them at www.phoenix.com

EI Torito CD-ROM Boot Specification

For the EI Torito CD-ROM Boot Specification published by Phoenix Technologies, contact them at www.phoenix.com

ATAPI Removable Media BIOS Specification

For the ATAPI Removable Media BIOS Specification published by Phoenix Technologies, contact them at www.phoenix.com

Universal Serial Bus 3.0 Specification

For the Universal Serial Bus 3.0 Specification, contact the USB Implementors Forum at www.usb.org

Mass Storage Overview

For the Mass Storage Overview specification, contact the USB Implementors Forum at www.usb.org, www.usb.org/developers

Unified Extensible Firmware Interface Specification, Version 2.3 (UEFI-2.3) plus errata

For the UEFI-2.3 specification, contact the Unified EFI Forum at www.uefi.org

3 Definitions, abbreviations, and conventions

3.1 Definitions and abbreviations

- 3.1.1 ATA (AT Attachment) device:** An AT Attachment (also known as IDE) is a storage device that conforms to an ATA standard.
- 3.1.2 BDA:** The BIOS Data Area is an area of reserved memory used by the BIOS and OS to store data about the system hardware. It is located at memory segment 40h starting with 40h:00h.
- 3.1.3 BIOS:** The Basic Input/Output System (BIOS) is the firmware stored in non-volatile (NV) memory located on the computer's main board. The BIOS executes POST to test and initialize the system components and then loads the OS. The BIOS also handles the low-level Input/Output to the various peripheral devices connected to the computer.
- 3.1.4 byte:** A sequence of eight contiguous bits considered as a unit. See 3.3.10.
- 3.1.5 Carry Clear:** a condition where the Carry Flag in the ELAGS register is cleared to zero.
- 3.1.6 Carry Set:** a condition where the Carry Flag in the EFLAGS register is set to one.
- 3.1.7 CF:** The Carry Flag is a bit in the EFLAGS register in the microprocessor.
- 3.1.8 CHS:** CHS addressing is a method of addressing the contents of a storage device using logical cylinders (C), logical heads (H), and logical sectors (S). This method of addressing allows a maximum C=16,383, H=16, S=63, resulting in a maximum device capacity of 8.4 gigabytes (16,383 16 63 512 bytes per sector 8.4 gigabytes). See LBA addressing for another addressing method.
- 3.1.9 Conventional:** When a word, term, or phrase is modified by the word "conventional" it refers to the legacy style, or method of operation that is limited to addressing ATA devices that have a 528 MB capacity or less. See 3.2.10xxx for the definition of "Enhanced".
- 3.1.10 DOS:** DOS is a disk operating system that uses the system BIOS as a firmware abstraction layer to access system hardware. Examples of DOS based operating systems include MS-DOS[®], DR-DOS, PC-DOS, Free DOS, Windows[®] 3.11, and Windows[®] 95.
- 3.1.11 DWord:** A sequence of four contiguous bytes considered as a unit. See 3.3.10.
- 3.1.12 enhanced:** When a word, term, or phrase is modified by the word "enhanced" it means there is a "conventional" and an "enhanced" method of operation. The "enhanced" method is defined by this standard.
- 3.1.13 Host:** The Host is the computer system that is controlled by the BIOS.
- 3.1.14 Hybrid MBR boot code:** IA-32 compatible code located in the MBR that processes the GPT disk layout.
- 3.1.15 Hybrid VBR boot code:** IA-32 compatible code located in the VBR that processes the GPT disk layout.
- 3.1.16 IA-32 compatible:** IA-32 compatible refers to computer processor architectures that are compatible with the Intel Architecture 32-bit wide processor and data bus.
- 3.1.17 IA-64 compatible:** IA-64 compatible refers to computer processor architectures that are compatible with the Intel Architecture 64-bit wide processor and data bus.
- 3.1.18 INT 13h:** A BIOS interrupt service that provides a protocol independent method for addressing floppy, hard drive, and other storage devices.
- 3.1.19 INT 40h:** INT 40h is a BIOS interrupt service that provides a protocol independent method for addressing INT 13h devices that have a device number less than or equal to 7Fh.
- 3.1.20 GPT disk layout:** The disk layout defined by the Unified EFI specification (see UEFI-2.3).
- 3.1.21 LBA:** LBA is a method of addressing a device that involves using a Logical Block Address. For example, using 28-bit addressing, this method of addressing allows a maximum sector address of $2^{28}-1$, or 137.4 GB of data on an ATA device. See CHS for another address method.

- 3.1.22 Logical Address/Geometry:** A logical address or geometry is used to address a device by an application, such as DOS, using the INT 13h interface. INT 13h FN 8 returns the logical geometry of the device.
- 3.1.23 Master Boot Record (MBR):** The first LBA on a disk.
- 3.1.24 MBR disk layout:** The disk layout traditionally used by BIOS based systems.
- 3.1.25 NV Memory:** Non-Volatile memory is memory that retains content even when the power has been removed. The most common type of NV memory on a computer system is the CMOS RAM that is used to store system configuration information.
- 3.1.26 OS:** An Operating System is a software abstraction layer that provides services that give applications access to system hardware, in a hardware independent fashion. Examples of these services include memory management, multi-threaded task management, file system management, printer management, and screen management.
- 3.1.27 PATA (Parallel ATA) device:** A device implementing the parallel ATA transport (see ATA8-APT).
- 3.1.28 POST:** The Power-On Self-Test is the part of the BIOS that takes control immediately after power is applied to the computer. POST initializes the computer hardware so that an OS may be loaded.
- 3.1.29 QWord:** A sequence of eight contiguous bytes considered as a unit. See 3.3.10.
- 3.1.30 QWord-aligned pointer:** A pointer where the lowest order three bits are 000b.
- 3.1.31 SATA (Serial ATA) device:** A device implementing the serial ATA transport (see ATA8-AST).
- 3.1.32 seg:offset:** An addressing method where the address is calculated by the following formula: $\text{seg} * 16 + \text{offset}$. This calculation results in a 20 bit linear address space.
- 3.1.33 Standard Floppy Drive:** The Standard Floppy Drive is the generic term to define the currently used 5.25 inch floppy drives and the 3.5 inch floppy diskette drives found in many systems.
- 3.1.34 Volume Boot Record (VBR):** The first LBA in a bootable partition.
- 3.1.35 word:** A sequence of two contiguous bytes considered as a unit. See 3.3.10.

3.2 Symbols and abbreviations

Abbreviation Meaning

* multiplied by

/ divided by

< less than

> greater than

GPT GUID Partition Table (see UEFI-2.3)

MBR Master Boot Record (see 3.1.24)

OS Operating System (see 3.1.26)

UEFI Unified Extensible Firmware Interface (see UEFI-2.3)

VBR Volume Boot Record (see 3.1.34)

3.3 Conventions

3.3.1 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 3.3.6 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.

3.3.2 Precedence

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

3.3.3 Lists

3.3.3.1 Lists overview

Lists shall be introduced by a complete grammatical proposition followed by a colon and completed by the items in the list.

Each item in a list shall be 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, then the first word in the item shall not be capitalized. If the item in a list is a complete sentence, then the first word in the item shall be capitalized,

Each item in a list shall end with a semicolon, except the last item, which shall end in a period. The next to the last entry in the list shall end 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.

3.3.3.2 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:

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.

3.3.3.3 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 an 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:

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.

3.3.4 Keywords

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

3.3.4.1 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.

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

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

3.3.4.4 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.

3.3.4.5 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 return command aborted for an obsolete command, then the device shall return command completion for the command.

3.3.4.6 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.

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

3.3.4.8 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.

3.3.4.9 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.

3.3.4.10 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.

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

3.3.5 Numbering

A binary number is represented in this standard by any sequence of digits consisting of only the Western-Arab 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-Arab 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 3 shows some examples of decimal numbers using various numbering conventions.

Table 3 — 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., 666.6 means 666.666 666... or 666 2/3, and 12.142 857 means 12.142 857 142 857... or 12 1/7).

3.3.6 Bit conventions

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

3.3.7 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).

3.3.8 Register and CF Contents

The value contained in a register is expressed as "register name = value" (e.g., AH = 01h). The value contained in CF (the Carry Flag) is expressed as "CF = value" (e.g., CF = 1b).

3.3.9 Interrupt Services and Functions

The format for a function that is called via an interrupt service is:

INT XXh FN YYh where XXh is the interrupts service number and YYh is the number of the function that is performed by the service.

3.3.10 Byte, word, DWord, and QWord Relationships

Figure 2 illustrates the relationship between bytes, words, DWords, and QWords.

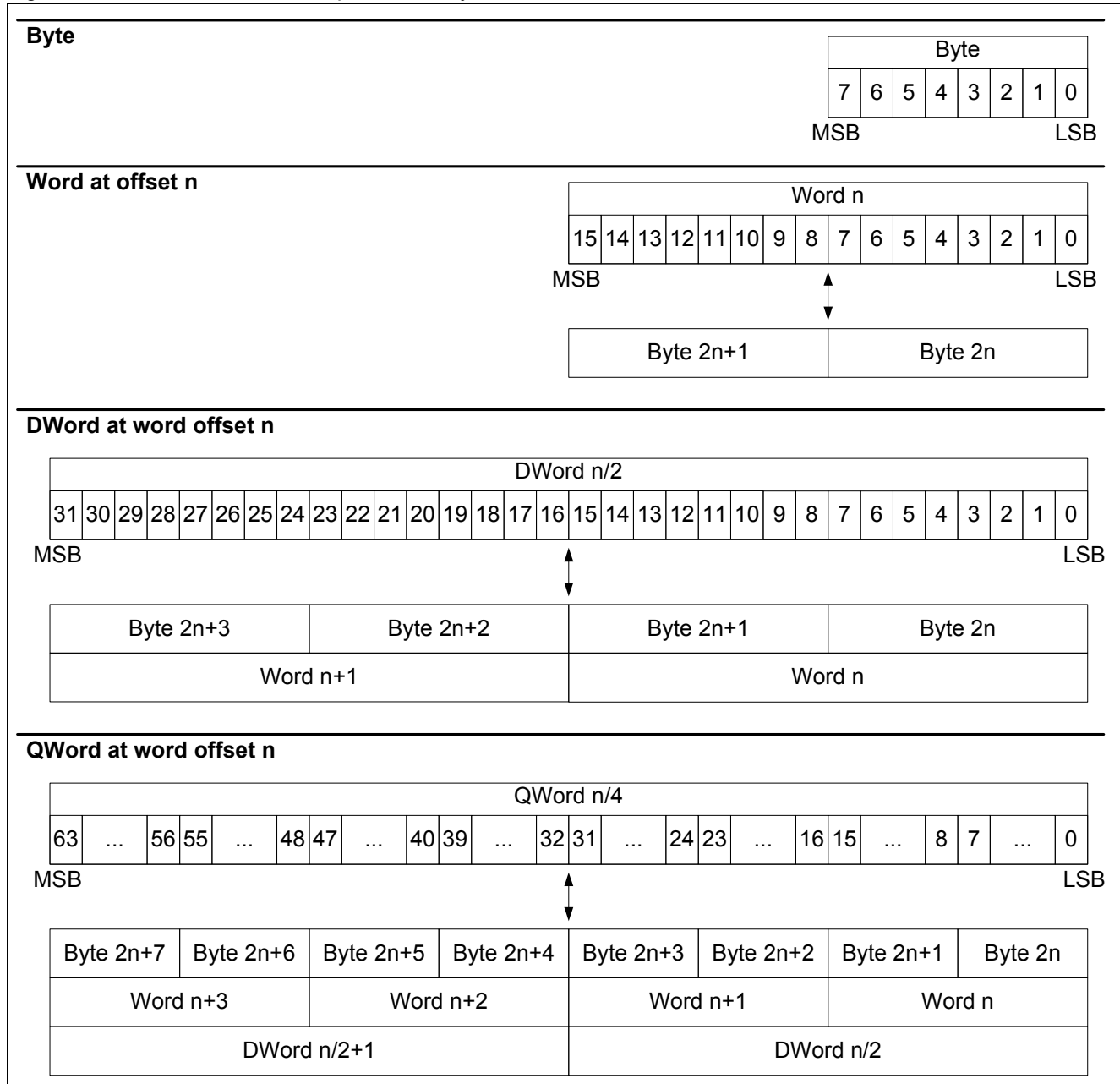


Figure 2 — Byte, word, DWord and QWord relationships

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.

3.3.11 ATA string convention

ATA strings 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 4.

Table 4 — ATA string byte swapping

Word	Byte	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

If the field contains the string "abcdefg", including one padding space character at the end, then the word and byte representations for the field are shown in table 5.

Table 5 — ATA firmware revision example

Word	Value	Byte	Value
23	6162h (i.e., "ba")	36	62h (i.e., 'b')
		37	61h (i.e., 'a')
24	6364h (i.e., "dc")	38	64h (i.e., 'd')
		39	63h (i.e., 'c')
25	6566h (i.e., "fe")	40	66h (i.e., 'f')
		41	65h (i.e., 'e')
26	6720h (i.e., "g")	42	20h (i.e., ' ', the space character)
		43	67h (i.e., 'g')

4 Overview

In the past, DOS has accessed its mass storage devices using a BIOS provided INT 13h interface. This interface was designed in the early 1980's and upgraded in the late 1980's. The maximum capacity that can be addressed by this Applications Program Interface (API) on a disk drive is 8.4 GB. The INT 13h interface, now known as the conventional INT 13h interface, uses function numbers 01h through 3Fh and is Cylinder-Head-Sector (CHS) oriented. An extended INT 13h interface has been created. The purpose of these INT 13h extensions shall be to:

- a) Replace CHS addressing with Logical Block Addressing (LBA);
- b) Remove the current requirement of using interrupt 41h/46h to point at the Fixed Disk Parameter Table information (see 8.20.4);
- c) Make location and configuration information available to operating systems that do not use the BIOS to access mass storage devices;
- d) Use data structures that apply to both IA-32 and IA-64 compatible architecture systems; and
- e) Use data structures that can address media capacities for the next 20 years.

Many BIOS, Option ROM, and OS vendors have already implemented the functions defined in this document for ATA and SCSI style devices. This standard builds on EDD-3 to enable additional mass storage technologies.

DOS and other operating systems, such as Windows[®] 98, Windows[®] NT, Windows[®] 2000, and Windows[®] XP, add the capability to consistently provide the same drive letter assignments to the user. The result of this capability is that storage devices can be added to an EDD system, and the existing drive letters do not change.

Data written on media can render the media incompatible with certain drive letters when some drive letter based operating systems are used. Technologies, such as IEEE 1394-2008, blur the difference between fixed and removable media.

One of the important aspects of this standard is to allow a BIOS to describe the physical path to a device. Figure 3 shows the basic system components that are referenced by this standard.

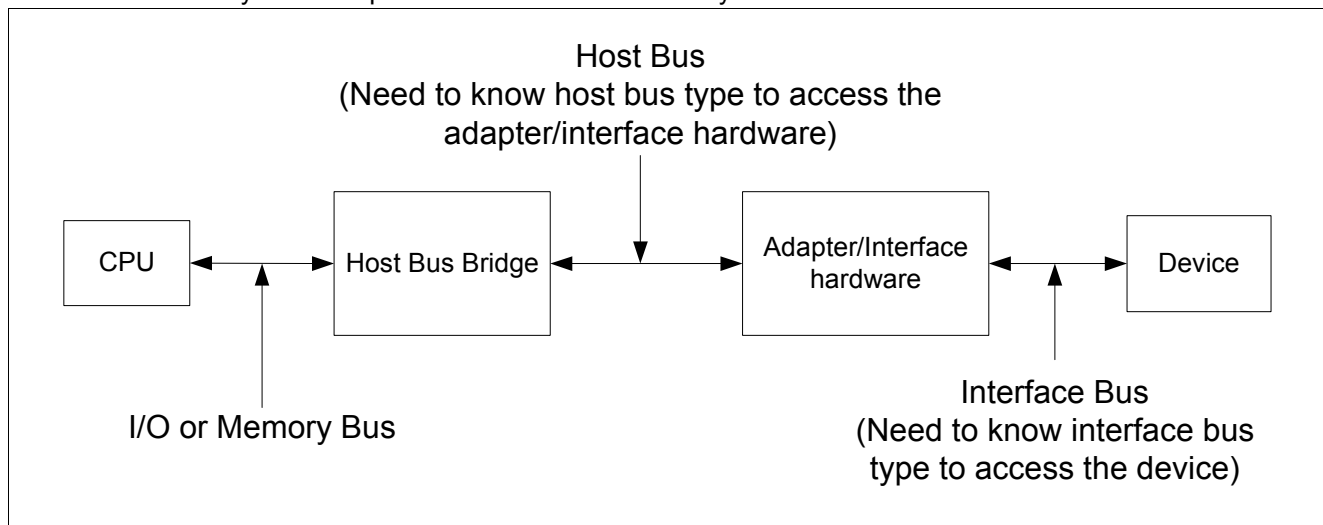


Figure 3 — System Component Diagram

5 <8GB INT 13h Functions (Conventional Functions)

The Conventional INT 13h functions can address a maximum of 8.4GB of device space. Sector sizes shall be exactly 512 bytes. The Conventional INT 13h functions pass all parameters in registers using the following template (see table 6) unless otherwise specified:

Table 6 — Conventional Register Definitions

Register	Description						
AH	INT 13h function number (Range is 00h through 3Fh)						
AL	Number of sectors to transfer						
CH	Low 8 bits of Cylinder						
CL	<table border="1"> <thead> <tr> <th>Bit</th> <th>Description</th> </tr> </thead> <tbody> <tr> <td>5:0</td> <td>Sector number. This value shall be $\geq 01h$ and $\leq 3Fh$</td> </tr> <tr> <td>7:6</td> <td>High order 2 bits of the cylinder</td> </tr> </tbody> </table>	Bit	Description	5:0	Sector number. This value shall be $\geq 01h$ and $\leq 3Fh$	7:6	High order 2 bits of the cylinder
Bit	Description						
5:0	Sector number. This value shall be $\geq 01h$ and $\leq 3Fh$						
7:6	High order 2 bits of the cylinder						
DH	Head Number						
DL	<table border="1"> <thead> <tr> <th>Bit</th> <th>Description</th> </tr> </thead> <tbody> <tr> <td>6:0</td> <td>Drive number</td> </tr> <tr> <td>7</td> <td>Set to 1 for Fixed media, clear to 0 for removable media</td> </tr> </tbody> </table>	Bit	Description	6:0	Drive number	7	Set to 1 for Fixed media, clear to 0 for removable media
Bit	Description						
6:0	Drive number						
7	Set to 1 for Fixed media, clear to 0 for removable media						
ES:BX	This register contains the buffer pointer (i.e., the beginning address of the buffer in system memory). Commands that move data from the device to memory shall use this pointer as the destination for the data. Commands that move data from memory to the device shall use this pointer as the source for the data to be transferred.						

The following conventional functions shown in table 7 are documented in this standard:

Table 7 — Conventional Function Definitions

Function ^a	Description
00h	Reset disk subsystem (see 8.2)
01h	Get status of last operation (see 8.3)
02h	Read Sectors into memory (see 8.4)
03h	Write sectors from memory (see 8.5)
04h	Verify sectors (see 8.6)
08h	Get Drive Parameters (see 8.7)
0Ah	Obsolete
0Bh	Obsolete
0Ch	Obsolete
0Eh	Read Buffer (see 8.8)
0Fh	Write Buffer (see 8.9)
11h	Obsolete
15h	Get Disk Type (see 8.10)
18h	Set Media Type (see 8.11)
19h	Park heads (see 8.12)
25h	IDENTIFY DEVICE info (see 8.13)
^a All other values are defined outside this standard	

6 >8GB INT 13h Functions

6.1 Overview

The extended INT 13h functions are numbered from 41h through 49h, 4E, and 50h. These functions are different from the conventional INT 13h interface in the following ways:

- a) register conventions have been changed to support the passing of data structures;
- b) all media addressing information shall be passed via a buffer, not registers; and
- c) flags are used to identify optional capabilities.

The caller shall specify a device number in the DL register when calling functions 41h through 48h. This is a logical number that has been assigned to the physical device by system firmware. The physical device addressing information can be retrieved via INT 13h FN 48h. The following registers in IA-32 and IA-64 compatible systems are used: AX, BX, CX, DX, DS, and SI.

Table 8 — Extended Function Definitions

Function	Description
41h	Check Extensions Present (see 8.14)
42h	Extended Read (see 8.15)
43h	Extended Write (see 8.16)
44h	Verify Sectors (see 8.17)
45h	Lock/Unlock Media (see 8.18)
46h	Eject Removable Media (see 8.19)
47h	Obsolete
48h	Get Device Parameters (see 8.20)
49h	Get Extended Media Change Status (see 8.21)
4Eh	Set Hardware Configuration (see 8.26)
50h	Send Packet Command (see 8.27)

6.2 Data Structure

The data structure for the INT 13h extensions shall be the device address packet. INT 13h converts addressing information in the device address packet to default parameters appropriate to the media. Table 9 defines the device address packet.

Table 9 — Device Address Packet

Offset	Type	Description
0	Byte	Packet size in bytes. The value in this field shall be 16 (10h) or greater. If the packet size is less than 16 the request shall be rejected with CF = 1b and AH = 01h.
1	Byte	Reserved.
2	Byte	Number of blocks to transfer. This field shall contain a maximum value of 127 (7Fh). If this field is set to FFh, then the transfer buffer address shall be found at offset 10h, the number of blocks to transfer shall be found at offset 18h, and the transfer buffer at offset 4 shall be ignored. If this field is set to 00h, then no data shall be transferred. If any other value is supplied, then the request shall be rejected with CF=1b and AH=01h
3	Byte	Reserved.
4	DWord	Address of host transfer buffer. This is the host buffer that Read/Write operations shall use to transfer the data. This is a 32-bit host address of the form Seg:Offset. If this field is set to FFFFh:FFFFh then the address of the transfer buffer shall be found at offset 10h.
8	QWord	<p>Starting logical block address on the target device of the data to be transferred. This is a 64-bit unsigned linear address. If the device supports LBA addressing this value should be passed unmodified. If the device does not support LBA addressing the routine making the INT 13h call shall convert this LBA to a CHS address using the current geometry in the following formula:</p> $LBA = (C_1 * H_0 + H_1) * S_0 + S_1 = 1$ <p>Where:</p> <ul style="list-style-type: none"> C₁ = Selected Cylinder Number H₀ = Number of Heads (Maximum Head Number + 1) H₁ = Selected Head Number S₀ = Maximum Sector Number S₁ = Selected Sector Number <p>For ATA compatible devices with less than or equal to 15,482,880 logical sectors, the H₀ and S₀ values are supplied by words 3 and 6 of the data returned as a result of an IDENTIFY DEVICE command.</p>
10h	QWord	64-bit unsigned linear address of the host transfer buffer. This is the host buffer that Read/Write operations shall use to transfer the data if the data at offset 4 is set to FFFFh:FFFFh, or the data at offset 2 is set to FFh.
18h	DWord	Total number of blocks to transfer when the data at offset 2 is set to FFh
1Ch	DWord	Reserved.
<p>Note 1 - The options described in table 1 allow a host to use a 7-bit transfer size with a 32-bit or 64-bit memory address for the transfer buffer. Table 1 also allows a 32-bit transfer size in conjunction with a 64-bit address. A 32-bit transfer size shall not be used in conjunction with a 32-bit memory address.</p>		

6.3 Removable Media

The distinction between "removable" disks numbered 00h through 7Fh and "fixed" disks numbered 80h through FFh differs from conventional INT 13h functions. Devices numbered 0 through 7Fh are not changed. They follow conventional INT 13h standards for floppy disk operation. Devices numbered 80h through FFh include traditional fixed disks, and now also include removable media devices that support media change notification as well as software locking and unlocking capabilities. Functions in this standard support these devices. The values returned in the AL register upon completion of an INT 13h Function are vendor specific. Table 10 describes the return codes that are supported for removable media devices.

Table 10 — Removable Media Return Codes

Return Code	Description
B0h	Media Not Locked In Device
B1h	Media Locked In Device
B2h	Media Not Removable
B3h	Media In Use
B4h	Lock Count Exceeded
B5h	Valid Eject Request Failed
B6h	Media Present but Read Protected

6.4 INT 13h Interface Subsets

6.4.1 Overview

It is permissible for BIOS to support only certain subsets of the INT 13h extensions. These subsets are defined in this standard. If a subset is supported then all functions within that subset shall be supported. The supported subsets shall be determined via the Check Extensions Present function. If a function is not supported and that function is subsequently invoked; then the function rejects the request with CF = 1b and AH = 01h. There are three subsets defined. At least one of these shall be supported.

NOTE 1 — Conventional INT 13h may be used for media accessing if the Fixed Disk Access Subset is not present.

6.4.2 Fixed Disk Access Subset

These functions support basic access to devices using the device address packet structure (see table 11).

Table 11 — Fixed Disk Access

Function	Code
Check Extensions Present (see 8.14)	41h
Extended Read (see 8.15)	42h
Extended Write (see 8.16)	43h
Verify Sectors (see 8.17)	44h
Obsolete	47h
Get Device Parameters (see 8.20)	48h

6.4.3 Device Locking and Ejecting Subset

These functions support software control of media locking and ejecting (see table 12).

Table 12 — Locking and Ejecting

Function	Code
Check Extensions Present (see 8.14)	41h
Lock/Unlock Media (see 8.18)	45h
Eject Removable Media (see 8.19)	46h
Get Device Parameters (see 8.20)	48h
Get Extended Disk Change Status (see 8.21)	49h
The INT 15h Removable Media Eject Intercept (see clause 9)	na

6.4.4 Enhanced Disk Drive (EDD) Support Subset

These functions provide EDD support (see table 13).

Table 13 — EDD Support

Function	Code
Check Extensions Present (see 8.14)	41h
Get Device Parameters (see 8.20)	48h

7 CD/DVD Boot

7.1 Overview

CD and DVD media shall be bootable if the media follows the formatting described here. This format is based on ISO-9660, but does not require the media to be ISO-9660 compliant. Boot media shall have an ISO-9660 Boot Volume Descriptor (BVD) at sector 17 relative to the start of the last session on the CD or DVD media. See clause 7.2.1 for a description of the BVD. Other ISO-9660 constructs, such as the "Primary Volume Descriptor" and the "Set Terminator" are not required for compliance to EDD, but are required if the CD or DVD contains material that can be accessed by ISO-9660 compliant drivers. Figure 4 shows a standard ISO-9660 image overview.

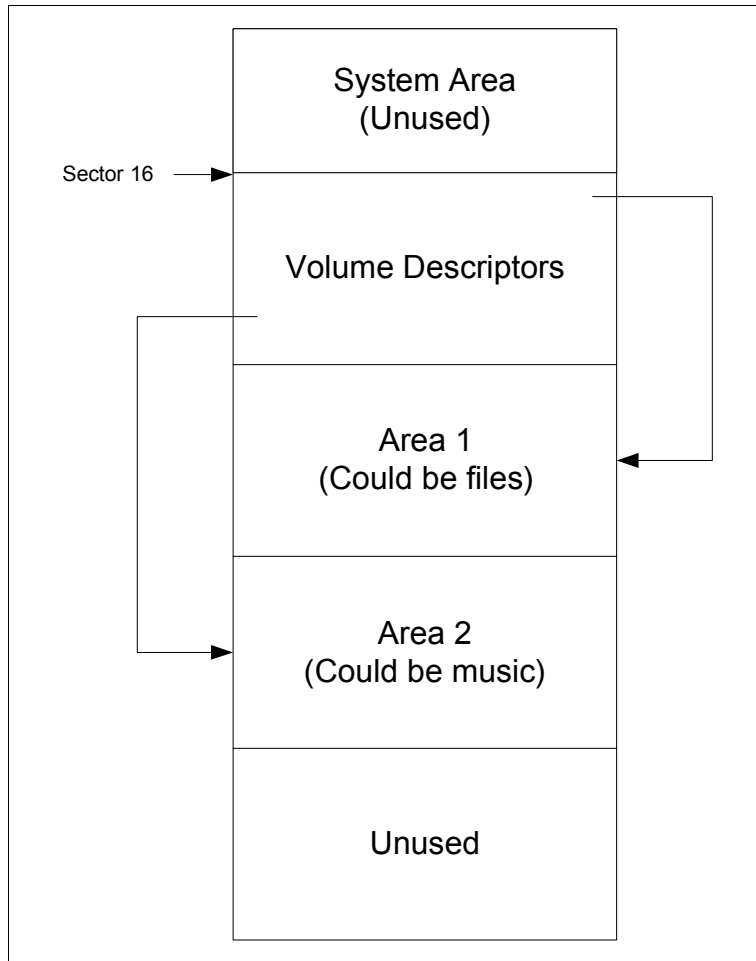


Figure 4 — ISO 9660 CD Layout

Figure 5 Describes a CD or DVD with an Initial/Default Entry but no section or additional boot images. This format is common for CD's or DVD's that are used for installing an operating system.

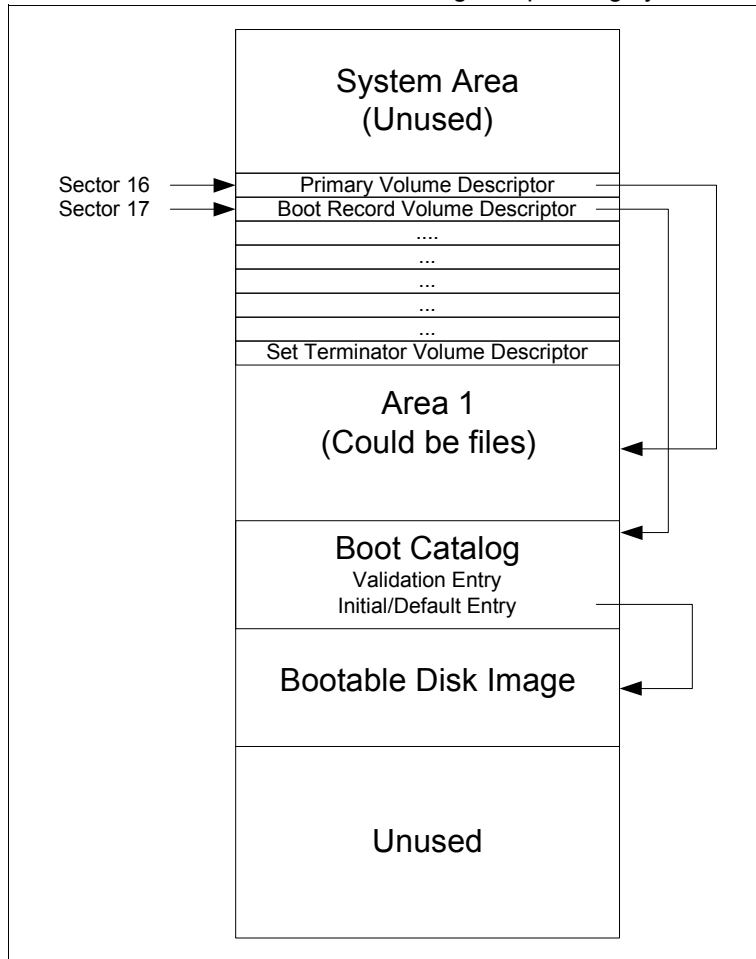


Figure 5 — Boot CD or DVD with a single boot image

Figure 6 illustrates a multi-session CD or DVD with several boot images. This type of CD or DVD may be used in a recovery environment that has several different system types. The Initial/Default entry could be a program that determines the system type and then chooses the appropriate boot image.

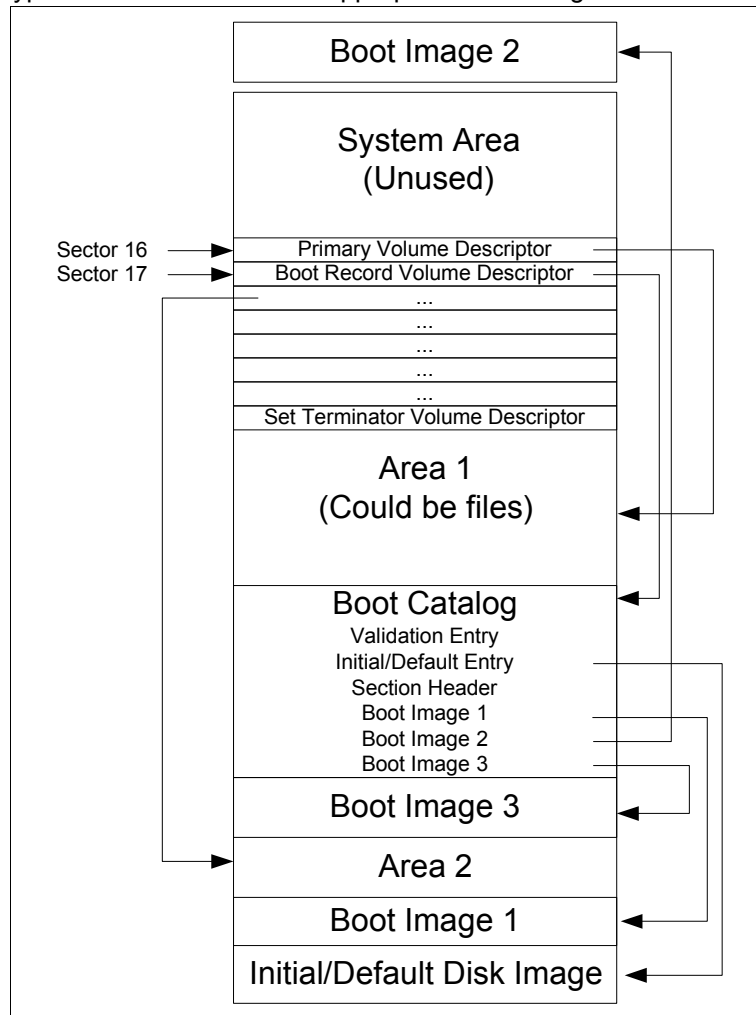


Figure 6 — Boot CD or DVD with multiple boot images

7.2 Boot Methods

7.2.1 Overview

Bootable CD's and DVD's shall have bootable images that follow one of the following media types.

- a) No Emulation Boot
- b) 1.22MB Floppy
- c) 1.44MB Floppy
- d) 2.88MB Floppy
- e) Hard Disk

Each of these formats has different requirements for booting. INT 13h FNs 00h through 3Fh shall operate in the emulated sector size of 512 bytes. Addressing for these functions shall be in 512 byte increments relative to the start of the emulated image. For example, if a boot image starts at sector 100 on a CD, INT 13h sectors zero through three would reside at sector 100 offset 0, 512, 1024, and 1536 bytes respectively on the CD.

7.2.2 Emulation Process

CD's and DVD's use a sector size that is 2KB. Floppy disks and hard drives commonly use a sector size of 512 bytes. In an emulated bootable CD or DVD environment, the system BIOS shall assign a device number to the bootable image. INT 13h FNs 00h through 3Fh shall continue to operate with a 512-byte sector size. The data

that is on the floppy or hard disk drive (HDD) shall be packed four sectors of data to each sector on the CD or DVD. This packing shall be performed in a linear fashion so that floppy or HDD sectors zero through three become the first sector in the image on the CD or DVD. Packing shall continue so that floppy or HDD sectors four through seven are the second sector on the CD or DVD, floppy or HDD sectors 8 through 11 are the third sector in the image on the CD or DVD. This process is repeated until all the data is on the CD or DVD. INT 13h FNs 00h through 3Fh shall then unpack the data based on the calling parameters. This method allows software on the CD or DVD to use the system BIOS without taking into account the CD or DVD hardware or sector size. This method also allows a floppy or HDD image to be tested and debugged using a normal floppy or HDD. Once the image on the media is booting and operating properly, the image may then be transferred to the CD or DVD with a high degree of confidence that it will function properly.

INT 13h Functions 41h through 49h access the CD or DVD using non-emulated sector LBA's in the native sector size of the CD or DVD. INT 13h FN 48h shall return the total number of 2KB sectors on the CD or DVD and shall set the flag that indicates the geometry is invalid. This capability allows software to use generic ISO-9660 or other file system drivers without requiring a CD or DVD hardware specific driver. This capability allows the software to boot and run, provided the software uses INT 13h functions exclusively, regardless of the interface bus type. This means that a CD or DVD boot image may be constructed that works the same on ATAPI, Fibre Channel, SCSI, USB, 1394, and other buses. If the system is EDD-3 compliant, the Initial/Default Image may make an INT 13h FN 48h call, determine the interface bus type, and then boot an image with native CD or DVD drivers to perform the requested operation.

7.2.3 No Emulation Boot

If an image is marked as No Emulation Boot, the system BIOS shall load the specified number of sectors and jump to the specified segment number to start the boot program executing. Since this is a no emulation boot, the system BIOS shall not provide access to the media through INT 13h FNs 00h through 3Fh. The system BIOS shall assign the CD-ROM drive a device number. A common industry number is A0h. This is outside the range of normal BIOS hard drive numbers (above 9Ah), but still within INT 13h range limitation.

7.2.4 Floppy Boot

When the system attempts to boot a Floppy based image, it shall assign device number 0 to the image. If there are one or more standard floppy drives present in the system, they shall be sequentially numbered by the BIOS starting from one and increasing.

EDD-4 supports 3 different floppy formats: 1.2MB, 1.44MB, and 2.88MB. All of these formats can be created on a floppy disk first, tested, and then transferred to the target CD or DVD. Table 14 describes the geometries INT 13h FN 8h shall return for each floppy type.

Table 14 — Floppy Geometries

Type	Cylinders	Heads	Sectors
1.2MB	80	2	15
1.44MB	80	2	18
2.88MB	80	2	36

The total capacity of a CD is more than 600MB. Many floppy images may be embedded on one CD or DVD, since floppy images shall be 2.88MB or less. One reason for making a bootable floppy image is to boot the system, load a CD or DVD specific device driver and then provide access to all the media. This capability allows a simple OS, such as DOS, to be used for accessing a self-contained CD. One application for this capability is system recovery or system restore.

7.2.5 Hard Drive Boot

When the system attempts to boot a Hard Disk Drive (HDD) based image, it shall assign device number 80h to the image. If there are one or more standard disk devices present in the system, they shall be numbered sequentially starting at 81h and increasing.

The geometry returned by INT 13h FN 08h is based on the partition table embedded in the first sector of the HDD image. The partition type of HDD images shall include cylinder-head-sector (CHS) addresses. Any partition type

that supports CHS is acceptable (e.g., FAT-16 or FAT-32) The partition table shall only have one partition defined.

7.3 CD/DVD Format

7.3.1 Overview

The system BIOS can boot from a CD or DVD only if the format of the media has been predefined. ISO-9660 is a basic CD-ROM file system that has been incorporated into current CD and DVD file system standards. CD/DVD boot uses ISO 9660 as a framework to provide boot capability. ISO 9660 requires that a set of volume descriptors reside on the media starting at sector 10h. For data CD's, there will usually be a "Primary Volume Descriptor" at sector 10h followed by a "Set Terminator" at sector 11h. The "Primary Volume Descriptor" provides a pointer to the directory structures. ISO 9660 has also defined a "Boot Volume Descriptor" (BVD). BIOSes check the BVS to determine if a CD or DVD is bootable. A CD or DVD shall have a BVS at sector 11h on the media. The "Set Terminator" shall reside at sector 12h or higher. ISO 9660 requires that a "Set Terminator" be present. ISO 9660 formatting need not be present for a CD or DVD to be bootable. The only requirement is that a BVS be present at sector 11h.

7.3.2 Boot Volume Descriptor (BVD)

ISO 9660 does not define the payload for its BVD. This standard provides the necessary formatting to enable bootability. The BIOS shall check the data in the BVD to determine if boot is possible. Table 15 describes the BVD format.

Table 15 — Boot Volume Descriptor

Offset	Type	Description
00h	Byte	Boot Record Indicator: this field shall be set to 00h
01h-05h	Byte	ISO-9660 specification identifier: this field shall be set to 43h 44h 30h 30h 31h ("CD001")
06h	Byte	Descriptor Version: this field shall be set to 01h
07h-26h	Byte	This field shall be set to: 45h 4Ch 20h 54h 4Fh 52h 49h 54h 4Fh 20h 53h 50h 45h 43h 49h 46h 49h 43h 41h 45h 49h 4Fh 4Eh 00h, 00h, 00h, 00h, 00h, 00h, 00h, 00h, 00h ("EL TORITO SPECIFICATION" padded to the right with zeros).
27h-46h	Byte	Reserved
47h-4Ah	DWord	Absolute pointer to the first sector of the boot catalog
4Bh-7FFh	Byte	Reserved

7.3.3 Validation Entry

The first entry in the boot catalog is a validation entry. The validation entry shall be used to determine that a valid boot catalog is on the disk and to determine the manufacturer of the CD. If this entry is valid, the remainder of the boot catalog should be valid. Table 16 describes the format of a validation entry.

Table 16 — Validation Entry

Offset	Type	Description								
00h	Byte	01h - header ID								
01h	Byte	Platform ID <table border="0" style="margin-left: 40px;"> <tr> <td>ID</td> <td>Description</td> </tr> <tr> <td>0</td> <td>80x86</td> </tr> <tr> <td>1</td> <td>Power PC</td> </tr> <tr> <td>2</td> <td>Mac</td> </tr> </table>	ID	Description	0	80x86	1	Power PC	2	Mac
ID	Description									
0	80x86									
1	Power PC									
2	Mac									
02-03h	Word	Reserved								
04h-1Bh	Byte	ID String. This shall indicate the manufacturer or developer of the CD.								
1Ch-1Dh	Word	Checksum Word. This is the 2's compliment of all the words in this record. The sum of all the words from 00h through 1Eh shall equal zero.								
1Eh	Byte	Key Byte 55h								
1Fh	Byte	Key Byte AAh								

7.3.4 Initial/Default Entry

Every boot catalog shall have an Initial/Default entry. This entry contains the starting address of the initial boot image. The default entry is started if the system BIOS does not have the capability to boot from other boot images in the boot catalog. Normally, a system BIOS does not check for additional boot images. If there are multiple boot image possibilities, the Initial/Default entry may be a program that has the appropriate selection mechanism for choosing the proper boot image. See Table 8 for a description of the Initial/Default Entry.

Table 17 — Initial/Default Entry

Offset	Type	Description
00h	Byte	88h - Header ID indicates a bootable image is present. 00h indicates that a non-bootable image is present
01h	Byte	<p>Boot media type. The boot image shall fall into one of three categories: Floppy, Hard Drive, or None.</p> <p>ID Description</p> <p>0 No Emulation</p> <p>1 1.2MB diskette</p> <p>2 1.44MB diskette</p> <p>3 2.88MB diskette</p> <p>4 Hard Drive</p> <p>05h-FFh Reserved</p>
02-03h	Word	Load Segment. This shall be the segment address where the first emulated sector of data is loaded into system memory. If this field cleared to zero, the default value of 07C0h shall be used. For flat memory model architectures (such as Motorola), this is the memory address divided by 10h.
04h	Byte	System type. This shall be a copy of byte 5 (system type) from the partition table found in the boot image.
05h	Byte	Reserved
06h-07h	Word	Sector Count. This shall be the number of emulated sectors the system shall transfer from the CD to the Load Segment address in system memory during the boot process. This field will normally be set to 01h for 80x86 systems that are booting a floppy or hard drive image. For No Emulation Booting, this field could potentially ask for 32MB of data to be loaded from the CD or DVD before jumping to the boot address.
08h-0Bh	DWord	Load Block. This shall be the absolute start sector on the CD or DVD of the image to be used in the emulation.
0Ch-1Fh	Byte	Reserved

7.3.5 Section Header

If the CD or DVD has boot images in addition to the Initial/Default image, pointers to the images are grouped into sections. The identification string in the section header shall be used to determine if the image pointers in that section point to bootable images. If the BIOS is not setup to use a specific section as identified by the ID string, then the section shall be ignored. A good example of a section would be to identify a specific language for the

boot images. Another example of a section would be to identify a specific model and manufacturer of a PC. This would allow the PC to boot software specific to the system. Table 18 describes the section header.

Table 18 — Section Header

Offset	Type	Description	
00h	Byte	Header ID	
		ID	Description
		90	Type is Section Header, there shall be more sections following this one
		91	Type is Section Header, this is the final section
01h	Byte	Platform ID	
		ID	Description
		0	80x86
		1	Power PC
		2	Mac
02h-03h	Word	Number of section entries. This is the number of Section Entries and Section Entry Extensions following this header. There shall be at least one Section Entry (see 7.2.5xxx for more information) in each section. If the Header ID is 90h then a Section Header shall follow the last section entry. If the Head ID is 91h then the last section entry shall be the last entry in the boot catalog.	
04h-1Fh	Byte	ID String. This identifies the section and serves as the section name.	

7.3.6 Section Entry

Section entries shall follow Section Headers. The Section Entry identifies a single boot image. This entry shall be the same as the Initial/Default entry with one exception: the reserved bytes at the end of the entry contain selection criteria. The Section Header ID string identifies the section type, and the section type determines how the selection criteria bytes are interpreted. An example would be a section titled "Languages", the 19 bytes could then be language identifiers. If the system language were set to a language, such as French or Japanese, the system may then boot using an image designed for that language. Table 19 describes a Section Entry.

If the 19 bytes provided for selection criteria are insufficient, Section Entry Extensions may be used. There are a possible 30 bytes of information available per extension, see 7.2.6 for more information on Section Entry Extensions.

Table 19 — Section Entry

Offset	Type	Description
00h	Byte	88h - Header ID indicates a bootable image is present. 00h indicates that a non-bootable image is present
01h	Byte	<p>Boot media type. The boot image shall fall into one of three categories: Floppy, Hard Drive, or None.</p> <p>ID Description</p> <p>0 No Emulation</p> <p>1 1.2MB diskette</p> <p>2 1.44MB diskette</p> <p>3 2.88MB diskette</p> <p>4 Hard Drive</p> <p>05h-FFh Reserved</p>
02-03h	Word	Load Segment. This shall be the segment address where the first emulated sector of data is loaded into system memory. If this field cleared to zero, the default value of 07C0h shall be used. For flat memory model architectures (such as Motorola), this is the memory address divided by 10h.
04h	Byte	System type. This shall be a copy of byte 5 (system type) from the partition table found in the boot image.
05h	Byte	Reserved
06h-07h	Word	Sector Count. This shall be the number of emulated sectors the system shall transfer from the CD to the Load Segment address in system memory during the boot process. This field will normally be set to 01h for 80x86 systems that are booting a floppy or hard drive image. For No Emulation Booting, this field could potentially ask for 32MB of data to be loaded from the CD or DVD before jumping to the boot address.
08h-0Bh	DWord	Load Block. This shall be the absolute start sector on the CD or DVD of the image to be used in the emulation.
0Ch	Byte	<p>Selection Criteria. The selection criteria determines the format for the selection criteria. The following formats are currently assigned:</p> <p>Type Description</p> <p>00h No selection criteria</p> <p>01h Language and version information (IBM format)</p> <p>02h-FFh Reserved</p>
0Dh-1Fh	Byte	Selection Criteria

7.3.7 Section Entry Extension

Section Entry Extensions may follow Section Entries. Section Entry Extensions provide more space for selection criteria when the 13h bytes provided by the Section Entry are insufficient. There may be one or more extensions following each Section Entry. This means that a section provides 13h bytes of selection information. A section with one extension provides 43 bytes, and a section with two extension provides 73 bytes, etc. Table 20 describes a Section Entry Extension.

Table 20 — Section Entry Extension

Offset	Type	Description
00h	Byte	44h - Header ID, indicates a Section Entry Extension
01h	Byte	Extension continuation information Bit Description 00h-04h Reserved 05h Shall be cleared to zero if this is the final extension for this section. Shall be set to one if more extensions follow this extension. 06h-07h Reserved
02-1Fh	Byte	Additional selection criteria

8 INT 13h Function Definitions

8.1 Overview

These function definitions include conventional, extended, and CD/DVD functions. The functions are differentiated by their function numbers and register usage. The extended functions use DS:SI as a pointer to a command packet. The conventional functions use ES:BX as a pointer to their transfer buffer. Functions 0-3Fh are conventional functions. Functions 40h through 49h are extended functions. Functions 4Ah through 4Dh are CD/DVD boot functions. Functions 4Eh through 50h are hardware control functions.

The values in all registers that are not explicitly defined in the following sections shall be preserved at the completion of each function call.

In the following clauses Entry specifies the contents that shall be in the x86 registers prior to making the specified function call. Exit specifies the contents that shall be in the x86 registers when the function call is complete. Carry clear indicates that CF=0b and carry set indicates that CF=1b.

Unlisted values in entry and exit condition may have result in indeterminate behavior.

Error codes which are not listed are outside the scope of this standard.

8.2 Reset Disk Subsystem (FN 00h)

This function shall be used to reset all the devices controlled by the INT 13h interface.

Entry

AH 00h

DL BIOS device number

Exit

Carry Clear Function completed without error

AH Shall be cleared to zero

Carry Set Function completed with an error

AH Shall be set to the error code

8.3 Get Status of Last Operation (FN 01h)

This function shall be used to return the status of the last INT 13h command executed.

Entry

AH 01h

DL BIOS device number

Exit

Carry Clear The Get Status of Last Operation function was successful

AH Shall be cleared to zero

AL shall be set to the status of the last INT 13h operation

Carry Set The Get Status of Last Operation function completed with an error

AH Shall be set to the error code

8.4 Read Sectors into Memory (FN 02h)

This function shall be used to read data from the device into the host memory buffer beginning at the location specified by the contents of the ES:BX registers. If the command transfers some of the data and then returns a failure, carry is set, the buffer pointed to by ES:BX shall contain the partial data transfer, and AH shall contain an error code. When there is a partial data transfer, there is no reliable indication of what part of the data was successfully transferred. Some systems use DMA to return the data in an out-of-order fashion. This function does not have a mechanism to report what data is valid in the case of a partial transfer. In some conventional systems when a partial transfer occurs, AL contains the number of sectors transferred.

Entry

AH 02h

AL Number of sectors to read, shall be greater than 0 and less than 128

CH Low order 8 bits of the cylinder number

CL

Bit Description

7:6 high order 2 bits of the cylinder

5:0 sector number

DH Head number

DL BIOS device number

ES:BX Pointer to destination buffer in memory

Exit

Carry Clear Function completed without error

AH Shall be cleared to zero

AL Number of sectors read

ES:BX Pointer to buffer filled with read data

Carry Set Function completed with an error

AH Shall be set to the error code

AL Vendor Specific

ES:BX Pointer to buffer partially filled with read data

8.5 Write Sectors From Memory (FN 03h)

This function shall be used to transfer data from the host buffer beginning at the location specified by the contents of the ES:BX registers.

Entry

AH 03h

AL Number of sectors to write, shall be greater than 0 and less than 128

CH Low order 8 bits of the cylinder number

CL

Bit Description

7:6 high order 2 bits of the cylinder

5:0 sector number

DH Head number

DL BIOS device number

ES:BX Pointer to source buffer in memory

Exit

Carry Clear Function completed without error

AH Shall be cleared to zero

AL Number of sectors written

Carry Set Function completed with an error

AH Shall be set to the error code

AL Vendor Specific

8.6 Verify Sectors (FN 04h)

This function shall be used to check the sectors in the specified range on the device for errors. No data is transferred between the host and device by this command.

Entry

AH 04h

AL Number of sectors to verify, shall be greater than 0 and less than 128

CH Low order 8 bits of the cylinder number

CL

Bit Description

7:6 high order 2 bits of the cylinder

5:0 sector number

DH Head number

DL BIOS device number

Exit

Carry Clear Function completed without error

AH Shall be cleared to zero

AL Number of sectors verified

Carry Set Function completed with an error

AH Shall be set to the error code

AL Vendor Specific

8.7 Get Drive Parameters (FN 08h)

This function shall be used to find the CHS geometry used by INT 13h functions 2, 3, and 4 to access the drive.

Entry

AH 08h

DL BIOS device number

Exit

Carry Clear Function completed without error

AH Shall be cleared to zero

BL Vendor Specific

CH Low order 8 bits of the maximum cylinder number

CL

Bit Description

7:6 high order 2 bits of the cylinder

5:0 sector number

DH Maximum head number

DL Total number of INT 13h devices with an INT 13h device number greater than 7Fh

ES:DI Vendor Specific

Carry Set Function completed with an error

AH Shall be set to the error code

8.8 Read Buffer (FN 0Eh)

This function shall be used to read 512 bytes of data from the specified device's sector buffer.

Entry

AH 0Eh

DL BIOS device number

ES:BX Pointer to destination buffer in memory

Exit

Carry Clear Function completed without error

AH Shall be cleared to zero

Carry Set Function completed with an error

AH Shall be set to the error code

8.9 Write Buffer (FN 0Fh)

This function shall be used to write 512 bytes of data to the specified device's buffer.

Entry

AH 0Fh

DL BIOS device number

ES:BX Pointer to source buffer in memory

Exit

Carry Clear Function completed without error

AH Shall be cleared to zero

Carry Set Function completed with an error

AH Shall be set to the error code

8.10 Get Disk Type (FN 15h)

This function shall be used to find the device type. This function is called by some versions of DOS during the boot process.

Entry

AH 15h

DL BIOS device number

Exit

Carry Clear Function completed without error

AH

Value Description

00h Removable media device present

03h Fixed media device present

CX:DX Number of sectors on the media

Carry Set Function completed with an error

AH Shall be set to the error code

8.11 Set Media Type (FN 18h)

This function shall be used to force the BIOS to use a specific media type. This function is called by some versions of DOS.

Entry

AH 18h

CH Low order 8 bits of the cylinder number

CL

Bit Description

7:6 high order 2 bits of the cylinder

5:0 sector number

DL BIOS device number

Exit

Carry Clear Function completed without error

AH Shall be cleared to zero

ES:DI Pointer to parameter table. Formatting and definition of the parameter table is outside the scope of the standard.

Carry Set Function completed with an error

AH Shall be set to the error code

NOTE 2 — This function does not set the number of heads

8.12 Park Heads (FN 19h)

This function shall be used to park the device heads.

Entry

AH 19h

DL BIOS device number

Exit

Carry Clear Function completed without error

AH Shall be cleared to zero

Carry Set Function completed with an error

AH Shall be set to the error code

8.13 Identify Device Information (FN 25h)

This function shall be used return IDENTIFY DEVICE information from the device.

Entry

AH 25h

DL BIOS device number

ES:BX Pointer to 512 byte buffer for IDENTIFY DEVICE information. See ACS-2 for details.

Exit

Carry Clear Function completed without error

AH Shall be cleared to zero

ES:BX Pointer to IDENTIFY DEVICE information

Carry Set Function completed with an error

AH Shall be set to the error code

8.14 Check Extensions Present (FN 41h)

This function shall be used to check for the presence of INT 13h extensions. If CF=1b, the extensions are not supported for the requested device. If CF=0b, BX shall be checked to confirm that it contains the value AA55h indicating that the extensions are present. If BX = AA55h, the value of CX shall be checked to determine what subsets of this interface are supported for the requested device. At least one subset shall be supported. The version of the extensions shall be 30h. This indicates that the INT 13h extensions are compliant with this standard.

Entry

AH 41h
 BX 55AAh
 DL BIOS device number

Exit

Carry Clear Function completed without error

AH Version of extensions. Shall be set to 30h
 AL Vendor Specific
 BX AA55h
 CX Interface support bit map (see table 21)

Carry Set Function completed with an error

AH Shall be set to the error code 01h (Invalid Command)

Table 21 — Interface Support Bit Map

Bit	Description
0	If the content of this bit is one, then the Fixed disk access subset shall be supported.
1	If the content of this bit is one, then the Device locking and ejecting subset shall be supported.
2	This bit shall be set to one to indicate that the Enhanced disk drive support subset is present.
3	If the content of this bit is one, then the 64-bit extensions are present. When the 64-bit extensions are present, the fields starting at offset 10h in the Device Address Packet are valid.
15:4	Reserved.

8.15 Extended Read (FN 42h)

This function shall transfer sectors from the device to memory. In the event of an error, the block count field of the device address packet contains the number of good blocks read before the error occurred.

Entry

AH 42h

DL BIOS device number

DS:SI Pointer to Device Address Packet (see table 9)

Exit

Carry Clear Function completed without error

AH Shall be cleared to zero

Carry Set Function completed with an error

AH Shall be set to the error code

8.16 Extended Write (FN 43h)

This function shall transfer sectors from memory to the device. If the device does not support the WRITE VERIFY command, this function rejects the request with AH = 01h and CF = 1b. FN 48h shall be used to detect if the device supports the WRITE VERIFY command. In the event of an error, the block count field of the device address packet contains the number of blocks transferred before the error occurred. The calling software should not assume that the data transferred is validly written to the media. AL also contains the values 00h, 01h, or 02h. This function rejects all other values with AH = 01h and CF = 1b.

Entry

AH 43h

AL

Value Description

00h write with no verify operation

01h write with no verify operation

02h write with verify operation

03h-FFh Reserved

DL BIOS device number

DS:SI Pointer to Device Address Packet (see table 9)

Exit

Carry Clear Function completed without error

AH Shall be cleared to zero

Carry Set Function completed with an error

AH Shall be set to the error code

8.17 Verify Sectors (FN 44h)

This function verifies sectors without transferring data between the device and system memory. When an error is reported the block count field of the device address packet shall be filled in with the number of blocks verified before the error occurred.

Entry

AH 44h

DL BIOS device number

DS:SI Pointer to Device Address Packet (see table 9)

Exit

Carry Clear Function completed without error

AH Shall be cleared to zero

Carry Set Function completed with an error

AH Shall be set to the error code

8.18 Lock/Unlock Media (FN 45h)

This function locks or unlocks removable media in a specific device. All removable media devices numbered 80h and above shall implement this function. If a fixed disk (non-removable device) supports the media locking and ejecting subset, this function shall return with success (i.e., AH = 00h and CF = 0b). There shall be support for 255 locks per device. A device shall not be unlocked until all locks to that device have been released with unlock commands. Excess unlock calls shall return with CF = 1b and AH = B0h. If the number of locks supported value is exceeded on a lock request, this function shall reject the request with CF = 1b and AH = B4h. Locking a device without media present shall be a valid operation. On return from a lock or unlock request, AL shall contain the lock state of the media as maintained by the BIOS. This provides for unlock requests when the lock count is greater than zero. In this case, the media shall remain locked. Any physical locking and unlocking of the media shall be implementation dependent, but the caller may operate on the assumption that locked media cannot be removed without an unlock request. After power-on, or a system reset, all devices shall automatically enter an unlocked state.

Entry

AH 45h

AL

Value Description

00h Lock media in device

01h Unlock media in device

02h Return lock/unlock status

03h-FFh Reserved

DL BIOS device number

Exit

Carry Clear Function completed without error

AH Shall be cleared to zero

AL

Value Description

00h Device is not locked

01h Device is locked

02h-FFh Reserved

Carry Set Function completed with an error

AH Shall be set to the error code

8.19 Eject Removable Media (FN 46h)

This function shall eject media from the specified device. If a fixed disk (non-removable device) supports the media locking and ejecting interface subset, this function shall always return with "Volume Not Removable" (i.e., CF = 1 and AH = B2h). An attempt to eject media locked in a device shall return with "Media Locked In Device" (i.e., CF = 1 and AH = B1h). Actual ejection shall be implementation dependent, but system software that issues or observes this function should flush any buffers it is holding. If this function is issued for a device without media the request shall be returned with "No Media In Device" (i.e., CF = 1b and AH = 31h). If this call is issued to an unlocked removable media device that has media present, an INT 15h, FN 52h (removable media eject) shall be issued to determine if eject removable media may proceed with the ejection request. If INT 15h returns an error, the ejection request shall be rejected. If the ejection request is accepted, followed by an unrecoverable error, this function shall return with "Valid Eject Request Failed" (i.e., CF = 1b and AH = B5h).

Entry

AH 46h

AL 00h

DL BIOS device number

Exit

Carry Clear Function completed without error

AH Shall be cleared to zero

Carry Set Function completed with an error

AH Shall be set to the error code (see table 10)

8.20 Get Device Parameters (FN 48h)

8.20.1 Overview

This function returns default device parameters. It shall be mandatory regardless of the interface subset that is supported. Table 22 defines the result buffer. On entry the first word of the result buffer shall be the buffer length in bytes.

Entry

AH 48h

DL BIOS device number

DS:SI Address of result buffer (see table 22)

Exit

Carry Clear Function completed without error

AH Shall be cleared to zero

DS:SI Address of result buffer (see table 22)

Carry Set Function completed with an error

AH Shall be set to the error code

Table 22 — Result Buffer

Offset	Type	Description
0	Word	The caller shall set this value to the maximum Result Buffer length, in bytes. If the length of this buffer is less than 30 bytes, this function shall not return the pointer to Drive Parameter Table (DPT) extension. If the buffer length is 30 or greater on entry, it shall be set to 30 on exit. If the buffer length is between 26 and 29, it shall be set to 26 on exit. If the buffer length is less than 26 on entry an error shall be returned.
2	Word	Information Flags. A value of one in a bit indicates that the feature shall be available. A value of zero in a bit indicates the feature shall be not available and shall operate in a manner consistent with the conventional INT 13h interface. Bit Description 15:8 Reserved 7 BIOS calls INT13h FN 50h to access the device 6 Device geometry shall be set to maximum and no media shall be present when this bit is set to one 5 Media shall be lockable 4 Device has media change notification 3 Device supports write verify 2 Media shall be removable. Bits 4-6 are not valid if this bit is cleared to zero 1 The geometry returned in bytes 4-15 shall be valid 0 DMA boundary errors are handled transparently
4	DWord	Number of default cylinders. The content of this field shall be one greater than the maximum cylinder number. INT 13h FN 08h shall be used to find the logical number of cylinders.
8	DWord	Number of default heads. The content of this field shall be one greater than the maximum head number. INT 13h FN 08h shall be used to find the logical number of heads.
12	DWord	Number of default sectors per track. The content of this field shall be the same as the maximum sector number because sector addresses are 1 based. INT 13h FN 08h shall be used to find the logical number of sectors per track.

Table 22 — Result Buffer

Offset	Type	Description
16	QWord	Number of sectors. This shall be one greater than the maximum sector number. If this field is greater than 15,482,880 then word 2, bit 1 shall be cleared to zero.
24	Word	Number of bytes in a sector.
26	DWord	Pointer to the Device Parameter Table Extension (DPTE). This field follows the seg:offset address format. The DPTE shall only be present if INT 13h, FN 41h, CX register bit 2 is set to one. This field points to a temporary buffer that the BIOS may invalidate on subsequent INT 13h calls. If the length of this result buffer is less than 30, the DPTE shall not be present. This field is only used for INT 13h based systems configured with ATA or ATAPI devices.
30	Word	0BEDDh - Key, indicates presence of Device Path Information
32	Byte	Length of Device Path Information including the key. The content of this byte shall be 2Ch
33	Byte	Reserved
34	Word	Reserved
36	ASCII	Host bus type, 4 bytes. ASCII data shall be left justified and padded with the value 20h PCI PCI Local Bus 50h 43h 49h 20h ISA Conventional 16 bit fixed bus 49h 53h 41h 20h PCIX PCI-X Bus 50h 43h 49h 58h IBND Infiniband 49h 42h 4Eh 44h XPRS PCI Express 58h 50h 52h 53h HTPT HyperTransport 48h 54h 50h 54h
40	ASCII	Interface type, 8 bytes. ASCII data shall be left justified and padded with the value 20h ATA ATA/ATAPI compliant device using ATA commands 41h 54h 41h 20h 20h 20h 20h 20h ATAPI ATA/ATAPI compliant device using ATAPI commands 41h 54h 41h 50h 49h 20h 20h 20h SCSI SCSI compliant device 53h 43h 53h 49h 20h 20h 20h 20h USB USB Mass Storage compliant device 55h 53h 42h 20h 20h 20h 20h 20h 1394 1394 Mass Storage device 31h 33h 39h 34h 20h 20h 20h 20h FIBRE Fibre Channel 46h 49h 42h 52h 45h 20h 20h 20h I ₂ O Intelligent Input/Output 49h 32h 4Fh 20h 20h 20h 20h 20h RAID Redundant Array of Inexpensive Disks (RAID) member 52h 41h 49h 44h 20h 20h 20h 20h SATA Serial ATA device in non-PATA emulation mode 53h 41h 54h 41h 20h 20h 20h 20h SAS Serial Attached SCSI 53h 41h 53h 20h 20h 20h 20h 20h
48		Interface Path (see table 23)
56		Device Path (see table 24)
72	Byte	Reserved
73	Byte	Checksum for Device Path Information includes the 0BEDDh signature. The content of this field shall be the two's complement of the unsigned sum of offset 30 through 72. The unsigned sum of offset 30 through 73 shall be 0.

8.20.2 Interface Path

The Interface Path field at offset 48 allows software external to a system BIOS to locate mass storage device interface chips. The format of this field shall be dependent on the Host Bus type, offsets 36 through 39 of the result buffer.

Table 23 — Interface Path Definitions (part 1 of 2)

Host Bus Type	Offset	Type	Definition
ISA	48	Word	16-bit base address
	50	Word	Reserved
	52	DWord	Reserved
PCI	48	Byte	PCI bus number. Values 00h through FEh shall represent a valid PCI bus. Value FFh shall indicate that this field is not used.
	49	Byte	PCI slot number. Values 00h through FEh shall represent a valid PCI slot. Value FFh shall indicate that this field is not used.
	50	Byte	PCI function number. Values 00h through FEh shall represent a valid PCI function. Value FFh shall indicate that this field is not used.
	51	Byte	Channel number. If more than one interface of the same type is accessed through a single Bus, Slot, Function, then the channel number shall identify each interface. If there is only one interface, the content of this field shall be cleared to zero. If there are two interfaces, such as an ATA Primary and Secondary interface, the primary interface shall be zero, and the secondary interface shall be one. Values 00h through FEh shall represent a valid Channel Number. FFh shall indicate that this field is not used. If the device is connected to a SATA controller functioning in non-PATA emulation mode, this byte shall be FFh.
	52	DWord	Reserved

Table 23 — Interface Path Definitions (part 2 of 2)

Host Bus Type	Offset	Type	Definition
PCI-X	48	Byte	PCI-X bus number. Values 00h through FEh shall represent a valid PCI bus. Value FFh shall indicate that this field is not used.
	49	Byte	PCI slot number. Values 00h through FEh shall represent a valid PCI slot. Value FFh shall indicate that this field is not used.
	50	Byte	PCI function number. Values 00h through FEh shall represent a valid PCI function. Value FFh shall indicate that this field is not used.
	51	Byte	Channel number. If more than one interface of the same type is accessed through a single Bus, Slot, Function, then the channel number shall identify each interface. If there is only one interface, the content of this field shall be cleared to zero. If there are two interfaces, such as an ATA Primary and Secondary interface, the primary interface shall be zero, and the secondary interface shall be one. Values 00h through FEh shall represent a valid Channel Number. Value FFh shall indicate that this field is not used. If the device is connected to a SATA controller functioning in non-PATA emulation mode, this byte shall be FFh.
	52	DWord	Reserved
Infiniband	48h	Qword	Reserved
PCI Express	48h	Qword	See PCI
HyperTransport	48h	Qword	See PCI

8.20.3 Device Path

The Device Path at offset 56 combined with the Interface Path allows software external to a system BIOS to locate a specific mass storage device. The Device Path field provides a path from an interface to a specific device. The format of the Device Path at offset 40 through 47 is dependent on the Interface type.

Table 24 — Device Path Definitions (part 1 of 2)

Interface Type	Offset	Type	Definition
ATA	56	Byte	<p>Value Description</p> <p>00h ATA Device 0</p> <p>01h ATA Device 1</p> <p>02h..FFh Reserved</p>
	57	Byte	Reserved
	58	Word	Reserved
	60	DWord	Reserved
	64	QWord	Reserved
ATAPI	56	Byte	<p>Value Description</p> <p>00h ATAPI Device 0</p> <p>01h ATAPI Device 1</p> <p>02h..FFh Reserved</p>
	57	Byte	Logical Unit Number
	58	Byte	Reserved
	59	Byte	Reserved
	60	DWord	Reserved
	64	QWord	Reserved
SCSI	56	Word	Physical Unit Number/SCSI ID
	58	QWord	Logical Unit Number
	66	Word	Reserved
	68	DWord	Reserved
USB	56	QWord	64-bit Serial Number as defined in the USB Mass Storage specifications
	64	QWord	Reserved
1394	56	QWord	64-bit Extended Unique Identifier (EUI-64)
	64	QWord	Reserved
FIBRE	56	QWord	64-bit Worldwide Identifier (WWID)
	64	QWord	Logical Unit Number
I ₂ O	56	QWord	64-bit Identity Tag
	64	QWord	Reserved
RAID	56	DWord	RAID array number of which this device is a member
	60	DWord	Reserved.
	64	QWord	Reserved

Table 24 — Device Path Definitions (part 2 of 2)

Interface Type	Offset	Type	Definition
SATA	56	Byte	Port number Value Description 00h..1Fh SATA controller port number to which the device is connected. If the device is behind a port multiplier then SATA controller port number shall represent the SATA controller port number to which the port multiplier is connected. 20h..FFh Reserved
	57	Byte	Port Multiplier number Value Description 00h If device is connected directly to the SATA controller, this byte shall be 00h 01h..0Fh Port Multiplier port number 10h..FFh Reserved
	58	Word	Reserved
	60	DWord	Reserved
	64	QWord	Reserved
SAS	56	QWord	64-bit SAS address
	64	QWord	Logical Unit Number

8.20.4 Device Parameter Table Extension (DPTE)

The DPTE provides hardware configuration information to applications that bypass INT 13h for addressing an ATA device.

Table 25 — Device parameter table extension

Offset	Type	Description
0-1	Word	I/O port base address
2-3	Word	Control port address
4	Byte	Device register Bit Description 7 1 6 LBA enable (1 = enabled) 5 1 4 ATA DEV bit 3:0 0
5	Byte	BIOS Vendor Specific.
6	Byte	IRQ number for this device
7	Byte	Block count for ATA READ/WRITE MULTIPLE commands
8	Byte	DMA information Bit Description 7:4 DMA type 3:0 DMA channel
9	Byte	PIO information Bit Description 7:4 0 3:0 PIO type

Table 25 — Device parameter table extension

Offset	Type	Description
10-11	Word	BIOS selected hardware specific option flags Bit Description 15:14 Reserved 13 48-bit LBA addressing enabled 12 HPA Active 11 Ultra DMA accessing enabled 10:9 Translation type 8 ATAPI device uses command packet interrupt 7 32-bit transfer mode 6 ATAPI device 5 Removable media 4 LBA translation enabled 3 CHS translation enabled 2 ATA READ/WRITE MULTIPLE accessing enabled 1 DMA accessing enabled 0 PIO accessing enabled
12-13	Word	Reserved
14	Byte	30h, version level of this table.
15	Byte	Checksum, 2's complement of the 8 bit unsigned sum of bytes 0-14

8.20.4.1 Offset 0-1 - I/O port base

This word is the 16-bit address in I/O space of the data register in the ATA Command Block. Any application that provides a proprietary interface to the device may use this base address.

8.20.4.2 Offset 2-3 - control port base

This word is the 16-bit address in I/O space of the device control register. Any application that provides a proprietary interface to the device may use this address.

8.20.4.3 Offset 4 - head prefix

The upper four bits of this byte shall be logically ORed with the head number, or upper four bits of the LBA, each time the disk is addressed. It contains the ATA DEV bit and the LBA addressing bits that are preset, and makes these functions transparent to any software using this extension. The LBA addressing bit is set for each disk access and shall not be used to determine the LBA capability of the system. See the LBA translation enabled bit described in clause 8.24.3.9.5 for system LBA capability.

8.20.4.4 Offset 5 - BIOS use only

BIOS use only.

8.20.4.5 Offset 6 - IRQ number

Each ATA channel requires an assigned Interrupt number. This byte identifies which IRQ is used by this device's channel.

8.20.4.6 Offset 7 - READ/WRITE MULTIPLE command block count

If the device was configured to use the READ/WRITE MULTIPLE command, then this field shall contain the block size of the transfer, in sectors, used by the BIOS.

8.20.4.7 Offset 8 - DMA channel/Multiword DMA Type

If the BIOS has configured the system to perform multiword DMA data transfers in place of PIO transfers, this field shall specify the DMA mode in the upper four bits, as per the definition in ATA/ATAPI-6 or later, and the DMA Channel in the lower four bits. ATA channels that support PCI DMA bus mastering shall set the DMA channel to zero. Note that the DMA Type field does not follow the format of the data returned by the device. The value of the DMA mode shall not be limited to two.

8.20.4.8 Offset 9 - PIO type

If the BIOS has configured the system to perform PIO data transfers other than mode 0, this field shall specify the PIO mode as per the definition in ATA-5 or later.

8.20.4.9 Offset 10-11 - BIOS selected hardware specific option flags

These bytes specify the current hardware options enabled by the BIOS, a bit for each of the options listed below.

8.20.4.9.1 Bit 0 - fast PIO

If the system is configured for a PIO mode greater than 0, this bit shall be set to one and byte 9 (PIO Type) shall be used to configure the system. If this bit is cleared to zero, the PIO-Type field shall be ignored.

8.20.4.9.2 Bit 1 - fast DMA

If the system is configured for DMA, this bit shall be set to one and byte 8 (DMA Channel/DMA Type) should be used to configure the system. If this bit and bit 11, clause 8.24.3.9.11, are cleared to zero, then the DMA Channel/DMA Type field shall be ignored.

8.20.4.9.3 Bit 2 - ATA READ/WRITE MULTIPLE

If the system is configured for multi-sector transfers, this bit shall be set to one and byte 7 (sector count) specifies the number of sectors used for each data transfer. If block PIO is disabled, ignore the block count field.

8.20.4.9.4 Bit 3 - CHS translation

If the device reports more than 1024 cylinders in the IDENTIFY DEVICE command data, this bit shall be set to one. See 8.20.4.9.10 to determine the method of geometry translation.

8.20.4.9.5 Bit 4 - LBA translation

If the system is configured for LBA type addressing, this bit shall be set to one and the Extended INT 13h interface (FN 41h through 48h) shall pass LBA values directly to the device. The conventional INT 13h interface shall ignore this bit and shall use CHS. LBA-type addressing shall be available on devices with less than 1024 cylinders, and therefore bit 3 (CHS translation) shall be independent from bit 4 (LBA translation).

8.20.4.9.6 Bit 5 - removable media

If the device supports removable media, this bit shall be set to one and the extended INT 13h device locking and ejecting subset shall also be supported.

8.20.4.9.7 Bit 6 - ATAPI device

If this ATA device implements the PACKET command feature set (ATAPI) as defined in ATA/ATAPI-5, this bit shall be set to one.

8.20.4.9.8 Bit 7 - 32-bit transfer mode

If the BIOS has configured the host adapter to perform 32-bit wide data transfers, this bit shall be set to one.

8.20.4.9.9 Bit 8 - ATAPI device uses command packet interrupt

If bit 6 is cleared to zero, then this field shall be ignored and shall be zero. If bit 6 is set to one, this bit indicates how the ATAPI device signals it is ready to receive a packet command. When this bit is set to one, it indicates that the ATAPI device returns an interrupt, and sets DRQ, when it is ready for a packet. When this bit is cleared to zero, it indicates that the ATAPI device sets DRQ, without an interrupt, when it is ready for a packet.

8.20.4.9.10 Bits 9-10 - translation type

If bit 3 is cleared to zero then this field shall be ignored and shall be zero. If bit 3 is set to one then this field identifies the geometric translation shown in table 26.

Table 26 — Translation Type

Bits 9-10	Description
00b	Bit-shift translation
01b	LBA assisted translation
10b	Reserved
11b	Vendor specific translation

8.20.4.9.11 Bit 11 - Ultra DMA

If the system is configured for Ultra DMA, this bit shall be set to one and byte 8 (DMA Channel/DMA Type) should be used to configure the system. If this bit and bit 1, (Bit 1 = fast DMA, clause 8.24.3.9.2) are cleared to zero, then the DMA Channel/DMA Type field shall be ignored.

8.20.4.9.12 Bit 12 - HPA Active

The HPA Active bit shall be set to one if the Host Protected Area (HPA) is active. The HPA is active if a volatile or non-volatile SETMAX has been issued with a value other than the NATIVE MAX address. This bit shall be cleared to zero if NATIVE MAX sectors can be accessed using read and/or write commands.

8.20.4.9.13 Bit 13h - 48-bit LBA addressing enabled

The 48-bit LBA addressing enabled bit shall be set to one if the INT 13h handler is using 48-bit extended commands to access the device. The 48-bit LBA addressing enabled bit shall be cleared to 0 if the INT 13h handler is not using 48-bit extended commands to access the device.

8.20.4.9.14 Bits 14-15 - Reserved**8.20.4.10 Offset 12-13h - Reserved****8.20.4.11 Offset 14 - table revision**

The table version shall be set to 30h indicating compliance with this standard.

8.20.4.12 Offset 15 - checksum

This shall be the two's complement of the 8-bit unsigned sum of bytes 0 through 14. Adding bytes 0 through 15 shall in all cases produce an 8-bit result of zero.

8.21 Get Extended Media Change Status (FN 49h)

This function returns media change status. If it returns with CF = 1b, the media may not have been changed. The media change notification may be activated by unlocking and locking the device door without removing the media. This function corresponds to INT 13h FN 16h, but explicitly allows any device number to be passed in. If a non-removable device supports the Device Locking and Ejecting interface subset, this function shall return with success, AH = 00h, CF = 0b. This function shall clear the media change notification on exit.

Entry

AH 49h

DL BIOS device number

Exit

Carry Clear Function completed without error

AH Shall be cleared to zero to indicate change-line inactive

Carry Set Function completed with an error

AH Shall be set to 06h to indicate that change-line is active. Other values indicate other error conditions.

8.22 Initiate Disk Emulation (FN 4Ah)

This function uses the CD Specification Packet to create an emulated disk drive. The emulated device shall have the device number supplied in the CD Specification Packet and can be accessed using INT13h FNs 0-49h.

Entry

AH 4Ah

AL 00h

DS:SI Pointer to CD Specification Packet (see table 27)

Exit

Carry Clear Function completed without error, emulation request was successful

AH Shall be cleared to zero

Carry Set Function completed with an error, emulation not initiated

AH Shall be set to the error code

Table 27 — CD Specification Packet

Offset	Type	Description
0	Byte	13h (e.g., Packet size in bytes)
1	Byte	<p>Boot Media Type</p> <p>Bit Description</p> <p>7 Emulated image requirements</p> <p>Value Description</p> <p>0b Emulated image is not driver dependent</p> <p>1b Emulated image contains SCSI drivers for CD/DVD-ROM, bytes 8 and 9 refer to a SCSI interface</p> <p>6 Emulated image requirements</p> <p>Value Description</p> <p>0b Emulated image is not driver dependent</p> <p>1b Emulated image contains ATAPI drivers for CD/DVD-ROM, bytes 8 and 9 refer to an ATAPI interface</p> <p>5:4 Reserved</p> <p>3:0 Type of image to be booted</p> <p>Value Emulation</p> <p>0 No Emulation</p> <p>1 1.2MB Diskette</p> <p>2 1.44MB Diskette</p> <p>3 2.88MB Diskette</p> <p>4 Hard Disk</p> <p>5-Fh Reserved</p>
2	Byte	INT 13h device number. This shall be the INT 13h number of the device which shall be started or terminated. This value shall be zero for a floppy image, 80h for a bootable hard disk, and 81h through FFh for a non-bootable or no emulation device.
3	Byte	Controller Index. This shall be the controller number of the to which the CD/DVD-ROM drive is attached. If there are several controllers in a system, their number is system dependent.
4-7	DWord	Logical Block Address of the disk image to be emulated. This shall be the absolute sector address of the image on the CD or DVD media.
8-9	Word	Device Number. SCSI controllers shall use byte 8 as the Logical Unit Number (LUN) and byte 9 as the Physical Unit Number (PUN) of the CD or DVD drive. ATA/ATAPI controllers shall use bit 0 of byte 8 to indicate device 0 or device 1.
10-11	Word	User Buffer Segment. If this field is non-zero, the system may use a supplied buffer for caching CD/DVD reads. This buffer shall be at least 3k in size. The buffer begins at segment:0
12-13	Word	Load Segment. This field is only used for booting (INT 13h FN 4Ch). If the value is zero, the system shall use 7C0h as the load address and start address for booting. if the value is non-zero, the system shall load the boot image at segment:0 and initiate the boot process by jumping to segment:0

Table 27 — CD Specification Packet

Offset	Type	Description
14-15	Word	Sector Count. This field is only used for booting (INT 13h FN 4Ch). The sector count is the number of emulated sectors to load, starting at the load segment (see offset 12-13) during the initial boot procedure.
16	Byte	This shall match the value returned in CH when INT 13h FN - 8h is invoked. This field is Bits 0-7 of the cylinder count.
17	Byte	This shall match the value returned in CL when INT 13h FN - 8h is invoked. This field contains the number of sectors per track in bits 0-5 and the high order 2 bits (bits 8 and 9) of the cylinder count
18	Byte	This shall match the value returned in DH when INT 13h FN - 8h is invoked. This field contains the number of heads.

8.23 Terminate Disk Emulation (FN 4Bh)

This function returns the system to a configuration that does not include the emulated devices. If the CD booted as a floppy disk, and the system floppy drive was pushed to be the second drive, or B:, the system floppy drive shall now become the first drive, or A:. This could have implications for currently loaded drivers and software. Affected drivers and software shall account for the change in this access method. If the CD booted as a hard disk, the system hard disk was pushed to the second drive to allow the emulated hard disk to be the boot device. If the emulation is terminated, the system hard disk shall move to become the first hard disk. This could have implications for currently loaded drivers and software. Affected drivers and software shall account for the change in this access method.

When the system is booted from a CD, software can determine the CD/DVD ROM drive that booted the system by issuing Terminate Disk Emulation with AL=01h. This shall return a completed CD Specification Packet (see table 27).

Entry

AH 4Bh

AL 00h, return status and terminate emulation, 01h = return status only, do not terminate emulation.

DL Device number to terminate, 7Fh means terminate all devices.

DS:SI Pointer to empty CD Specification Packet (see table 27)

Exit

Carry Clear Function completed without error, emulation request was successful

AH Shall be cleared to zero

DS:SI Pointer to populated CD Specification Packet (see table 27)

Carry Set Function completed with an error, emulation not initiated

AH Shall be set to the error code

8.24 Initiate Disk Emulation & Boot (FN 4Ch)

This function uses the CD Specification Packet to create an emulated disk drive. The emulated device shall have the device number supplied in the CD Specification Packet and can be accessed using INT13h FNs 0-49h. Once the emulation has been initiated, the system shall be rebooted using the emulated device. This capability allows a CD to have a default selection program which may allow the user to choose from a variety of boot images on the CD. Once the choice is made, the system can be rebooted using the new image.

Entry

AH 4Ch

AL 00h

DS:SI Pointer to CD Specification Packet (see table 27)

Exit

Carry Clear This condition shall not happen. If the function is successful this system shall reboot causing the calling software to be terminated.

Carry Set Function completed with an error, emulation not initiated

8.25 Return Boot Catalog (FN 4Dh)

This function returns the Boot Catalog from the CD or DVD media. See clause 7 for a description of the Boot Catalog.

Entry

AH 4Dh

AL 00h

DS:SI Pointer to empty CD Command Packet (see table 28)

Exit

Carry Clear Function completed without error

AH Shall be cleared to zero

Carry Set Function completed with an error

AH Shall be set to the error code

Table 28 — CD Command Packet

Offset	Type	Description
0	Byte	8 (e.g., Packet size in bytes)
1	Byte	Sector count. Number of sectors in the boot catalog to transfer
2-5	DWord	Pointer to the buffer where the boot catalog shall be stored
6-7	Word	Beginning sector to transfer. This number shall be relative to the start of the boot catalog. This value shall be cleared to zero to retrieve the first sector.

8.26 Set Hardware Configuration (FN 4Eh)

The purpose of this function is to allow non-hardware-specific software to configure host adapter and devices for optimal operation. ATA channels may have two devices attached, but this function operates on a single-device basis. This shall be accommodated by the value that is returned in AL. If the host adapter supports the requested sub-function on a device basis, AL shall be cleared to 00h. If the host adapter only supports the setting on an ATA channel basis, AL shall be set to 01h. Once this function has been invoked, all subsequent INT 13h device-access functions shall use the mode specified by this invocation. This means that if "DMA Maximum" is enabled, INT 13h FN 02h shall read from the device using DMA transfers. The DMA/PIO selections are mutually exclusive. When "DMA Maximum" is enabled, "PIO Maximum" shall be disabled. If the requested mode change is not supported this function shall return with CF = 1b and AH = 01h.

Entry

AH 4Eh

AL Hardware configuration sub-function (see table 29)

DL BIOS device number

Exit

Carry Clear Function completed without error

AH Shall be cleared to zero

AL 00h if command was safe, 01h if other devices are affected

Carry Set Function completed with an error

AH Shall be set to the error code

Table 29 — Hardware Configuration Sub-Functions

AL	Description
0h	Enable prefetch
1h	Disable prefetch
2h	Set maximum PIO transfer mode.
3h	Set PIO mode 0.
4h	Return to default PIO transfer mode. Return the system to the PIO mode enabled by the BIOS setup utility.
5h	Enable INT 13h DMA maximum mode. Set the maximum rate allowed by both the host adapter and the device.
6h	Disable INT 13h DMA

8.27 Send Packet Command (FN 50h)

8.27.1 Overview

This function defines a service that the system BIOS shall call for sending data to and from a device implementing a protocol using packet transfers. The BIOS shall provide this service before the OS is loaded. When an operating system takes control of the device controller it replaces the BIOS routine for this service to provide a seamless transfer of control from the BIOS to the operating system. This service allows several BIOS level services to continue functioning, even after the OS has taken control of the device controller, for example:

- a) The INT 13h mass storage interface
- b) Power Management
- c) Suspend to disk

The BIOS is single threaded. This means that the BIOS shall not process asynchronous requests from other devices. The BIOS shall send commands to devices and wait for responses. This means that the operating system may take control of the serial interface with no hand-off information from the system BIOS. The operating system shall reconfigure the interface and hook the service described above. The system BIOS may provide INT 13h FN 50h for the 1394, USB, and any other packet oriented bus.

The format of the packet shall be determined by the requirements of the target bus and is beyond the scope of this document. In the case of USB, the packet format shall be determined by the USB specification. In the case of 1394, IEEE 1394-1995 shall determine the size of a packet with payload information defined in SBP-2.

Entry

AH 50h

AL D7h

DL BIOS device number

ES:SI Pointer to formatted command packet (see table 30)

Exit

Carry Clear Function completed without error

AH Shall be cleared to zero

Carry Set Function completed with an error

AH AH = 01 - Function not implemented, 80h - Command failed to complete, 97h - Subfunction D7h not supported for this device, C3h - Formatted Command Packet is too short

Table 30 — Formatted Command Packet

Offset	Type	Description
0	Word	Length of this record in bytes
2-n	Byte	Formatted protocol specific data

8.27.2 Packet Sending Service (PSS) For SCSI Command Descriptor Blocks (CDB)

8.27.2.1 Overview

The purpose of the PSS is to allow an application to send SCSI CDB's using BIOS INT 13h calls to a device, regardless of the bus on which the device resides. This interface is currently defined for ATAPI, SCSI, 1394, and USB devices. Future buses that use SCSI CDB's may also adopt this mechanism for transporting commands

This interface shall not retry any operation. If an error occurs either in command format, or operation of the device, an error shall be returned by INT 13h. The application may choose to retry a command by issuing it again.

This PSS shall add transport specific information (e.g., header information and CRC) and modify the CDB where necessary with bus specific information. If the secondary bus is a hot-plug bus such as 1394 or USB, the PSS shall insert device addresses or EUI-64 as necessary. In the event that a device address changes due to a bus reset or re-enumeration, the PSS shall connect with the device without generating an error.

8.27.2.2 Formatted Protocol Specific Data

Table 31 defines the format of the data passed in ES:SI (see 8.27.1) to INT 13h FN 50h.

Table 31 — Formatted Protocol Specific Data

Offset	Type	Description
0	Word	Packet length in bytes including this word
2	Byte	Information flags Bit Description 7:6 Data direction. 00 = No data exchanged with device (command only) 01 = Receive data from device 10 = Send data to device 11 = Reset Interface. 5:0 Reserved
3	Byte	Bytes in command packet, or zero if no command is to be sent.
4	DWord	Pointer to command packet. This field follows the seg:offset address format. This field is ignored if offset 3 is zero.
8	DWord	Number of bytes to transfer following command complete. Shall be a multiple of the sector size of the media, as returned by Function 48h. If the data direction bits in the flags register do not indicate a send or receive data command, then this field shall be ignored. Otherwise, if this value shall be zero, then a zero byte transfer shall occur.
10h	DWord	Pointer to the start of the data stream to transfer. This field follows the seg:offset address format.
14	Word	Access timeout. Maximum time in milliseconds to wait for command start. Command start includes sending the command to the devices and waiting for the first data byte to transfer. If this field contains the value of 0000h, an 80h error (see table 32) shall result.
16	Word	Sector timeout increment. The PSS shall divide the amount of data transferred by the sector size, round up, multiply by this value, and add to the Access Timeout (offset 14), the maximum result is limited to FFFFh. This shall be the total timeout for the specified CDB. This value shall be ignored for command-only and bus-reset calls.

8.27.2.3 Output Parameters

The following output parameters (see table 32), match the parameters defined in 8.27.1. No other return parameters are necessary for this transport.

Table 32 — Output Parameters

Out	Description														
AL	Undefined														
AH	<table border="1"> <thead> <tr> <th>Value</th> <th>Description</th> </tr> </thead> <tbody> <tr> <td>00h</td> <td>No Error</td> </tr> <tr> <td>01h</td> <td>AX = 50D7h not implemented</td> </tr> <tr> <td>80h</td> <td>A condition has occurred which prevented successful command completion. This may be due to a busy device, a timeout, a bus reset, short packet, or other event. The host should issue a Request-Sense-type command in the required protocol.</td> </tr> <tr> <td>97h</td> <td>There is no support for the indicated logical drive, although Function 50D7h is recognized.</td> </tr> <tr> <td>C3h</td> <td>PSSP is too short.</td> </tr> <tr> <td>Remaining Values</td> <td>Reserved</td> </tr> </tbody> </table>	Value	Description	00h	No Error	01h	AX = 50D7h not implemented	80h	A condition has occurred which prevented successful command completion. This may be due to a busy device, a timeout, a bus reset, short packet, or other event. The host should issue a Request-Sense-type command in the required protocol.	97h	There is no support for the indicated logical drive, although Function 50D7h is recognized.	C3h	PSSP is too short.	Remaining Values	Reserved
Value	Description														
00h	No Error														
01h	AX = 50D7h not implemented														
80h	A condition has occurred which prevented successful command completion. This may be due to a busy device, a timeout, a bus reset, short packet, or other event. The host should issue a Request-Sense-type command in the required protocol.														
97h	There is no support for the indicated logical drive, although Function 50D7h is recognized.														
C3h	PSSP is too short.														
Remaining Values	Reserved														
All other registers	Preserved														
Carry flag	0b if AH is cleared to zero 1b if AH is 1through FFh.														

8.28 Security Protocol Commands (FN 51h)

The purpose of this function is to support the Trusted Computing feature set (see ACS-2), the SECURITY PROTOCOL IN command (see SPC-4), and the SECURITY PROTOCOL OUT command (see SPC-4).

Entry

AH 51h

AL Flags

Bit Description

7 Direction

0 = Send data to the device

1 = Receive data from the device

6:0 Reserved

CX Security Protocol Specific

Specifies data which varies based on the Security Protocol ID. (See ACS-2 or SPC-4)

DH Security Protocol ID

Specifies which security protocol is to be used. (See ACS-2 or SPC-4)

DL BIOS device number

ES:BX QWord-aligned pointer to data buffer in memory (see table 33)

Exit

Carry Clear Function completed without error

AH Shall be cleared to zero

AL Shall be set to the status of the last INT 13h operation

ES:BX Shall be set to the QWord-aligned pointer to data buffer in memory (see table 33)

Carry Set Function completed with an error

AH Shall be set to the error code

ES:BX Shall be set to the QWord-aligned pointer to data buffer in memory (see table 33)

Table 33 — Data Buffer for Security Protocol Commands

Offset	Type	Description
00h	DWord	Length (bytes) of the Payload Data On Entry: If the Direction bit is set to one, then this field contains the number of bytes to be sent to the device. If Direction bit is cleared to zero, then this field contains the expected number of bytes to be received from the device, and the buffer shall be large enough to accommodate this number, plus 8 bytes. On Exit: If the Direction bit is cleared to zero, this field contains the actual number of bytes received from the device
04h	DWord	Reserved
08h..(Length of Payload Data+8)	Byte	Payload Data The content of this data depends on the selected Security Protocol.

9 INT 15h Removable Media Eject

This function shall be called by the BIOS in response to a software request (INT 13h, AH=46h, Eject Device) to eject media from a removable media device.

A user may press an eject button or use a software command to request that a particular media be ejected. By default the INT 15h handler returns with ejection accepted status. A disk cache program may replace this INT 15 call and return acceptance or rejection based on the state of its buffers for this disk. This function may also be used by operating system software as a media change request.

Entry

AH 52h

DL BIOS device number

Exit

Carry Clear Function completed without error

AH Shall be cleared to zero. ejection may proceed

Carry Set Function completed with an error

AH Shall be set to the error code, B1h or B3h, ejection is rejected

Annex A
(informative)

Hybrid MBR boot

A.1 Hybrid MBR boot overview

This annex describes how MBR boot code called hybrid MBR boot code may be constructed to support a GPT disk layout (see UEFI-2.3) in a legacy BIOS system.

A.2 GPT support for hybrid MBR boot code

When using hybrid MBR boot code, the GPT disk layout includes one GPT partition with the Legacy BIOS Bootable bit set to one in the Attributes field (see UEFI-2.3).

The Protective MBR defined in UEFI-2.3 is modified as shown in table A.1 to include hybrid MBR boot code.

Table A.1 — Protective MBR with hybrid MBR boot code

Mnemonic	Byte Offset	Byte Length	Contents
Boot Code	0	440	Hybrid MBR boot code (see A.3)
Unique MBR Disk Signature	440	4	See UEFI-2.3
Unknown	444	2	See UEFI-2.3
Partition Record	446	16 * 4	See UEFI-2.3
Signature	510	2	See UEFI-2.3
Reserved	512	Logical Block Size - 512	See UEFI-2.3

Figure A.1 shows an example of a GPT disk layout with hybrid MBR boot code.

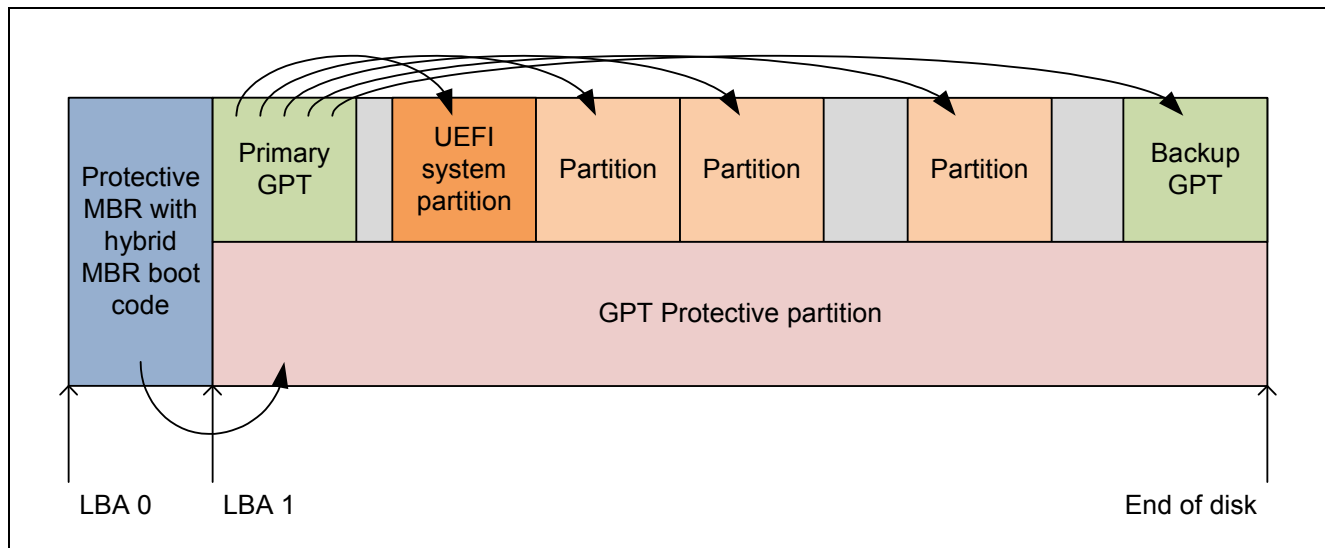


Figure A.1 — GPT disk layout with hybrid MBR boot code example

Figure A.2 shows an example of a GPT disk layout with hybrid MBR boot code on a disk with an ending LBA greater than FFFF_FFFFh. The MBR partition record is not able to describe the LBAs above FFFF_FFFFh.

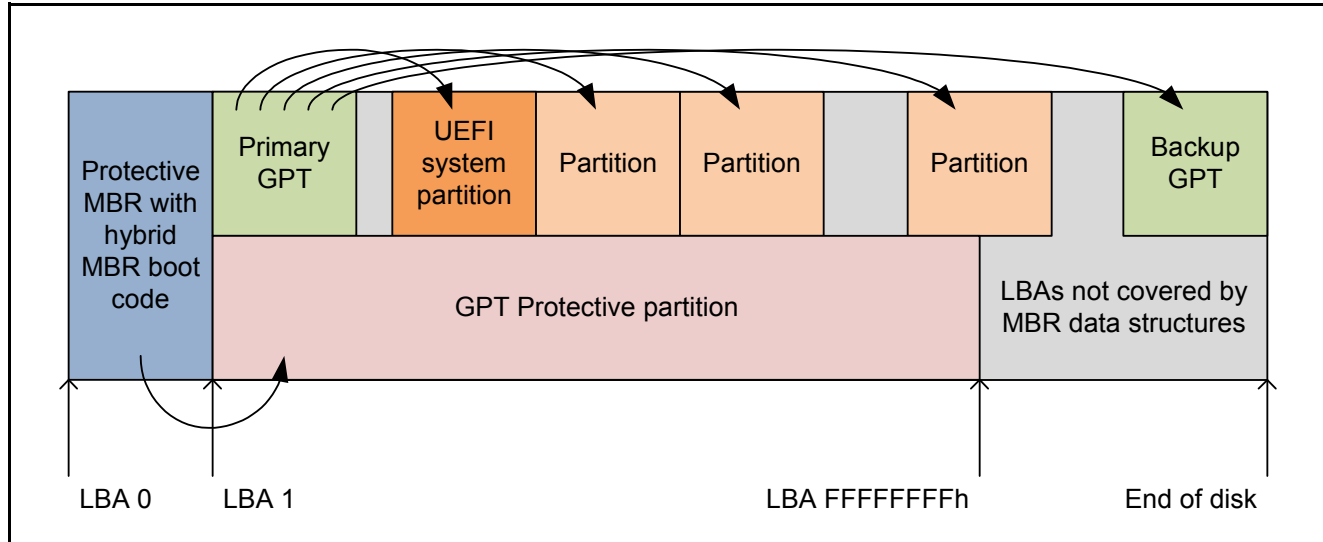


Figure A.2 — GPT disk layout with hybrid MBR boot code truncation example

A.3 Hybrid MBR boot code

Hybrid MBR boot code performs the following steps:

- 1) use the Extended Read function (i.e., INT 13h FN 42h) (see 8.15) to load the Primary GPT Header. The Device Address Packet (see table 9) includes:
 - A) the LBA field set to 00000000 00000001h; and
 - B) the Number of Blocks field set to 01h;
- 2) calculate the CRC32 of the GPT Header and verify that it equals the Header CRC32 field;
- 3) if the Header CRC32 field is incorrect, use the Extended Read function to load the backup GPT Header. The Device Address Packet includes:
 - A) the LBA field set to the last LBA of the disk; and
 - B) the Number of Blocks field set to 01h;

NOTE 3 — Due to the limited size (i.e., 440 bytes) of the MBR boot code, the hybrid MBR boot code may not perform all the checks that EFI system firmware would perform.

- 4) use the Extended Read function to load the GPT Partition Entry Array pointed to by the selected GPT Header. The Device Address Packet includes:
 - A) the LBA field set to the value specified in the Partition Entry LBA field; and
 - B) the Number of Blocks field set to (Number Of Partition Entries * Size Of Partition Entry) / Logical Block Size;
- 5) calculate the CRC32 of the GPT Partition Entry Array and verify that it equals the Partition Entry Array CRC32 field in the GPT Header;
- 6) if the Partition Entry Array CRC32 field is incorrect and the Primary GPT Partition Entry Array was selected, use the Extended Read function to load the backup GPT Header from the last LBA of the disk (see step 3), load the backup GPT Partition Entry Array (see step 4), and calculate the CRC32 (see step 5). If the CRC32 is incorrect again, report an error and stop;
- 7) search the GPT Partition Entry Array for a partition with the Legacy BIOS Bootable bit set to one in the Attributes field. The code may also check for a special value in the Partition Type GUID field when selecting the partition;
- 8) use the Extended Read function to load the first logical block of the selected partition into memory address 7C00h; and

- 9) set the IA-32 registers according to the hybrid MBR boot code hand over procedure (see A.4) and jump to 7C00h.

NOTE 4 — In contrast, legacy MBR boot code searches the MBR Partition Records for a partition with the Boot Indicator field set to 80h, then loads the VBR based on the Starting LBA field and passes the Size In LBA field to the VBR.

A.4 Hybrid MBR boot code endeavor procedure

Hybrid MBR boot code fills in the IA-32 registers according to table A.2 before jumping to 7C00h.

Table A.2 — Hybrid MBR endeavor IA-32 register values

Register	Description	Differences from legacy MBR hand over
DL	Disk number	No change
ES:DI	Pointer to \$PnP	No change
EAX	54504721h (i.e., "!GPT"). Indicates that the hybrid MBR hand over structure is being passed with DS:SI rather than the legacy MBR Partition Record	New
DS:SI	Pointer to the hybrid MBR hand over structure (see table A.3)	New

Table A.3 defines the Hybrid MBR boot code hand over structure.

NOTE 5 — With legacy MBR boot code, this structure included fields from the MBR Partition Record of the boot partition. Since the GPT partition may be located at an LBA beyond the 32-bit LBA addressing boundary, additional fields are added to communicate the full information to the VBR.

Table A.3 — Hybrid MBR boot code hand over structure

Mnemonic	Byte Offset	Byte Length	Description	Differences from legacy MBR hand over structure
Boot Indicator	0	1	Set to 80h (i.e., bootable).	Fixed value
Starting CHS	1	3	Set to FF_FFFFh. The VBR boot code should ignore this field.	Fixed value
OS Type	4	1	Set to the OS Type of the bootable partition (i.e., that would have been assigned had the partition been installed in an MBR disk layout).	No change
Ending CHS	5	3	Set to FF_FFFFh. The VBR boot code should ignore this field.	Fixed value
Starting LBA	8	4	Set to FFFF_FFFFh.	Fixed value
Size In LBA	12	4	Set to FFFF_FFFFh.	Fixed value
Size Of Partition Entry	16	4	Set to the Size Of Partition Entry field of the GPT Partition Header.	New value
GPT Partition Entry	20	Partition Entry Size	Set to the GPT Partition Entry of the boot partition	New value

A.5 Hybrid VBR boot code

Hybrid VBR boot code is responsible for booting the OS, and is usually OS-specific. If EAX is set to "!GPT", then hybrid VBR boot code uses the GPT Partition Entry field to identify its partition.

NOTE 6 — In contrast, legacy VBR boot code only recognizes the MBR disk layout and uses the Starting LBA field and Size In LBA field to identify its partition.

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