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INFORMATION TECHNOLOGY – SMALL COMPUTER SYSTEM INTERFACE (SCSI) –

Part 362: Multimedia commands-2 (MMC-2)

FOREWORD

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International Standard ISO/IEC 14776-362 was prepared by subcommittee 25: Interconnection of information technology equipment, of ISO/IEC joint technical committee 1: Information technology.

This International Standard has been approved by vote of the member bodies, and the voting results can be obtained from the address given on the title page.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

ISO/IEC 14776 consists of the following parts, under the general title *Information technology – Small computer system interface (SCSI)*:

- Part 112: Parallel interface-2 (SPI-2)
- Part 113: Parallel interface-3 (SPI-3)
- Part 115: Parallel interface-5 (SPI-5)
- Part 150: Serial attached SCSI (SAS)
- Part 222: Fibre channel protocol for SCSI, second version (FCP-2)
- Part 232: Serial bus protocol-2 (SBP-2)
- Part 321: Block commands (SBC)
- Part 322: Block commands-2 (SBC-2)
- Part 326: Stream commands (SSC)
- Part 341: Controller commands (SCC)
- Part 342: Controller commands-2 (SCC-2)
- Part 351: Medium changer commands (SMC)
- Part 362: Multimedia commands-2 (MMC-2)
- Part 381: Optical memory card device commands (OMC)
- Part 411: Architecture model commands (SAM)
- Part 412: Architecture model-2 (SAM-2)
- Part 452: Primary commands-2 (SPC-2)

INTRODUCTION

Requests for interpretation, suggestions for improvement and addenda or defect reports are welcome. They should be sent to IEC Central Office, see address on the title page.

INFORMATION TECHNOLOGY – SMALL COMPUTER SYSTEM INTERFACE (SCSI) –

Part 362: Multimedia commands-2 (MMC-2)

1 Scope

This part of ISO/IEC 14776 defines the SCSI command set extensions to access multimedia features for all classes of SCSI devices.

The commands specified within this standard define standard access and control of those features of the device that are used in multimedia applications.

The SPC command set and its extensions are transport independent and may be implemented across a wide variety of environments for which a SCSI command mapping and delivery vehicle has been defined. To date, these include Fibre Channel, SCSI Parallel Interface, High Performance Serial Bus, Serial Storage Architecture and ATA/ATAPI.

This command set gives and/or enables the following.

- a) A definition of the command formats and functions independently of delivery, protocol/signalling or transport mechanism. Architectural constraints regarding command functions, over the various transports are addressed in the document specific to the physical transport.
- b) Standardized access to common Features of SCSI devices employed in multimedia applications.
- c) System software/firmware independence across device classes. Thus, different tape drives, optical media drives and other devices can be added to the system without requiring modifications to generic system hardware and software. Provision is made for the addition of special Features and functions through the use of vendor-specific options. Reserved Opcodes are provided for future standardization.
- d) Provides compatibility such a way that properly conforming ISO/IEC 9316 devices may inter-operate with subsequent devices provided that the system engineering is correctly done. SCSI protocol extensions are designed to be permissive of rejections by conforming ISO/IEC 9316 devices and thus allow the ISO/IEC 9316 device to continue operation without requiring the use of the extension.

2 References

2.1 Normative references

2.1.0 General

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

2.1.1 Approved references

The following approved international and regional standards (ISO, IEC, CEN/CENELEC and ITU-T) may be obtained from the international and regional organizations that control them.

IEC 60908, *Audio recording – Compact disc digital audio system*

ISO/IEC 646:1991, *Information technology – ISO 7-bit coded character set for information interchange*

ISO/IEC 14776-232, *Information technology – Small Computer System Interface (SCSI) – Part 232: Serial Bus Protocol-2 (SBP-2)* [NCITS.325:1998]

ISO/IEC 14776-321, *Information technology – Small Computer System Interface-3 (SCSI-3) – Part 321: Block commands (SBC)* [NCITS.306:1998]

ISO/IEC 10149, *Information technology – Data interchange on read-only 120 mm optical data discs (CD-ROM)*

ISO 3901, *Information and documentation – International Standard Recording Code (ISRC)*

2.1.2 References under development

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

ISO/IEC 14776-351, *Information technology – Small Computer System Interface (SCSI) – Part 351: SCSI-3 Medium Changer Commands (SMC)* [X3T10/0999-D]

2.2 Other references

The following standards and specifications were also consulted.

ANSI INCITS 269-1996, *Information technology – SCSI-3 Fibre Channel protocol (FCP), (R2001)*

ANSI INCITS 301-1997, *Information technology – SCSI-3 Primary Commands (SPC), (R2002)*

ANSI INCITS 317-1998, *Information Technology – AT Attachment with Packet Interface Extension (ATA/ATAPI-4), (R2003)*

3 Definitions, abbreviations and acronyms

3.0 General

Certain words and terms used in this standard have a specific meaning beyond the normal English meaning and are indicated in upper case. These words and terms are defined either in the glossary or in the text where they first appear. Lower case is used for words having the normal English meaning.

3.1 Definitions of terms

3.1.1

absolute MSF field

See 3.1.65.

3.1.2

algorithm type

refers to various copy protection techniques

3.1.3**appendable disc**

if the last non-empty session contains a pointer to the next possible session, then the disc is appendable

3.1.4**ATA (AT attachment)**

ATA defines the physical, electrical, transport and command protocols for the internal attachment of block storage devices [NCITS 317:1998]

3.1.5**ATAPI (AT attachment packet interface)**

An extension of the ATA interface that permits the use of command descriptor blocks. [NCITS 317:1998]

3.1.6**ATIP**

absolute time in pre-groove

3.1.7**AGID (authentication grant ID)**

value used for resource control during key management

Individual key management threads are identified through the use of AGID.

3.1.8**bcd**

binary coded decimal

number system used on the physical CD media

Numbers using this notation have the 'bcd' suffix attached. A byte has two four-bit values each with a value from 0 to 9. The maximum value is 99bcd (99 decimal).

3.1.9**bootable CD**

CD capable of providing boot records

3.1.10**bordered area**

recorded area of DVD-R media

See 4.3.3.2.

3.1.11**BCA (burst cutting area)**

provides a unique physical identification mark for individual DVD medium

This area is not directly addressable by the user.

3.1.12**C/DVD media**

media that conform to the CD or DVD specifications

3.1.13**challenge key**

data used during an authentication key exchange process

3.1.14

CDB (command descriptor block)

structure used to communicate commands from an Initiator to C/DVD Logical Units

3.1.15

command packet

structure used to communicate commands from an Initiator to a C/DVD device

See 3.1.14.

3.1.16

complete session

session that contains a completed (written) Lead-in and Lead-out area

In DVD-R a complete session contains a completed Border-in and a Border-out.

3.1.17

CD-DA (compact disc digital audio system)

[see IEC 60908]

3.1.18

CD (compact disc)

family of related optical storage media

3.1.19

CD-ROM (compact disc read only memory)

a CD-ROM stores digitized audio and digital data

CD-ROM is used to describe media with digital data rather than discs that encode audio only.
[ISO/IEC 10149]

3.1.20

CD control field

4-bit field in the Q Sub-channel data indicating the type of information encoded on the current track

Indicates audio versus data and the type of audio encoding, etc. The control field is also found in the table of contents entries.

3.1.21

CD data mode

byte in the header of CD data sectors

CD data mode indicates if data is present and if layered error correction information is present

3.1.22

CD-RW (CD rewritable)

a CD that can be re-written

3.1.23

CD-R (CD recordable)

a CD that can be written only once

3.1.24

CD R/RW

a CD-R or a CD-RW or both

3.1.25

CD-text

method for storing text information on CD-DA disc

3.1.26**CIRC (cross interleaved reed-solomon code)**

error detection and correction technique used on a CD

The CIRC bytes are present in all CD modes. The error correction procedure that uses the CIRC bytes is referred to as the CIRC based algorithm

3.1.27**defect management**

method for providing apparent error free media

3.1.28**direct-overwrite**

process or capability of writing over previously written data without an erase cycle

3.1.29**disc key**

value used during the scrambling process of the title key data on DVD media

3.1.30**double sided**

medium with two independently addressed sides

3.1.31**dual layer**

two surfaces that can be accessed from the same side

On dual layer Discs the data is recorded using either OTP or PTP.

3.1.32**DVD**

family of related optical storage media and Logical Units

3.1.33**DVD control area**

the DVD Control area is comprised of 192 ECC blocks in the Lead-in Area of a DVD medium. The content of 16 sectors in each block is repeated 192 times. This area contains information concerning the disc

3.1.34**DVD disc manufacturing information**

the DVD Disc Manufacturing Information is recorded in the DVD Control Area and contains information supplied by the disc manufacturer

3.1.35**DVD ECC-block**

self-contained block of data and error correction codes that are grouped into a sequential series of 16 DVD sectors

3.1.36**DVD-R (DVD recordable)**

DVD medium that can be written once [DVD-R]

3.1.37**DVD-RAM (DVD-random access memory)**

DVD that can be re-written

3.1.38

DVD-ROM (DVD-read only memory)

standardized medium defined by the DVD specification for recording digital data, including digital video movie data

3.1.39

DVD+RW (DVD rewritable)

DVD that can be re-written

3.1.40

EAN (European article number)

controlled by the EAN Council located at Rue des Colonies, 54-BTE8, 1000 Brussels, Belgium

3.1.41

ECC (error correction code)

code for detecting and correcting errors

3.1.42

EDC (error detection code)

code for detecting an error

3.1.43

EFM

8 bit to 14 bit modulation

3.1.44

field

group of two or more contiguous bits

Fields containing only one bit are referred to as the “named” bit instead of the “named” field.

3.1.45

fixed packet track

track that contains a TDB indicating that the track is a fixed track and has user packets of a fixed size specified in the TDB

3.1.46

format

arrangement or layout of information on a medium

3.1.47

frame

sector on CD media. Also the F field unit of a MSF CD address. The smallest addressable unit

3.1.48

hex

indicates a binary value represented in base 16

This value may extend across multiple bytes.

3.1.49

hold track state

when a C/DVD device enters the hold track state the optical pick-up is maintained at an approximately constant radial position on the media

3.1.50**ID**

4-byte field in the header of DVD sectors that contains sector information and a physical sector number

3.1.51**IED (ID error detection)**

code for detecting errors in an ID field

3.1.52**incomplete session**

session without Lead-in and Lead-out written

3.1.53**index**

subdivision of a track

3.1.54**layer**

recorded information is in layers as seen from one side of a DVD disc. There are single and dual layer discs

3.1.55**lead-in**

on CD media, the area that contains the TOC data and precedes each program area

The main channel in the Lead-in area contains audio or data null information. This area is coded as track zero. The Q Sub-channel in this area is coded with the Table of Contents information.

The DVD Lead-in area is the area comprising physical sectors 1,2 mm wide or more adjacent to the inside of the Data area. The area contains the Control data and precedes the Data area.

3.1.56**lead-out**

on CD media, the area that follows each program area

The main channel in the Lead-out area contains audio or data null information. This area is coded as track AAh.

The DVD Lead-out area is the area comprising physical sectors 1,0 mm wide or more adjacent to the outside of the data area in single layered disc for PTP (Parallel Track Path) disc. Or, it is the area comprising physical sectors 1,2 mm wide or more adjacent to the inside of the data area in layer 1 of OTP (Opposite Track Path) disc.

3.1.57**L-EC (layered error correction)**

second level of error correction used on CD data

3.1.58**logical block**

an initiator addressable unit of data

3.1.59**LBA (logical block address)**

defines a mapping mode to a linear address space

3.1.60

logical unit

physical or virtual peripheral device addressable through a target

3.1.61

LUN (logical unit number)

address of a Logical Unit

3.1.62

magazine

multiple disc changer unit

3.1.63

medium

a single disc

3.1.64

middle area

area comprising physical sectors 1,0 mm wide or more adjacent to the outside of the Data Area in OTP (Opposite Track Path) disc on both layers of DVD media

3.1.65

MSF address (minute/second/frame)

the physical address, expressed as a sector count relative to either the beginning of the medium (absolute) or to the beginning of the current track (relative)

As defined by the CD standards, each F field unit is one sector; each S field unit is 75 F field units; each M field unit is 60 S field units. Valid contents of F fields are binary values from 0 through 74. Valid contents of S fields are binary values from 0 through 59. Valid contents of M fields are binary values from 0 through 74.

3.1.66

OPC (optimum power calibration)

procedure performed by the device to calibrate laser power

Values from this calibration are used for subsequent write operation.

3.1.67

OTP (opposite track path)

dual layer disc that has a Lead-in, two separated user areas, Lead-out and a Middle area

The physical sector number (PSN) of layer 0 increases to the Lead-out and the one of layer 1 that is complement of layer 0 address increases from the Lead-out to Lead-in.

3.1.68

output port

means for connecting to data ports other than the initiator interface

3.1.69

PTP (parallel track path)

a dual layer disc that has a Lead-in, user area and Lead-out in each layer respectively

The ID sector number of both layers increases to the Lead-out in parallel.

3.1.70

packet

set of recorded link, run-in, data and run-out blocks

A typical packet is shown in Figure 11.

3.1.71**packet size**

the number of Data Blocks in a packet

3.1.72**packet track**

track written as a concatenation of a pre-gap, written as one or two packets and some non-zero number of user packets

3.1.73**physical sector number**

unique address assigned to a physical location; it is not modifiable

3.1.74**post-gap**

transition area located at the end of a data track

3.1.75**pre-gap**

transition area located at the beginning of a data track

3.1.76**program area(s)**

a logical address space

3.1.77**PMA (program memory area)**

contains information about the recordings on a recordable disc

3.1.78**regional code**

value used to identify one or more regions of the world

Currently there are six regions defined.

3.1.79**region playback control (RPC)**

limits the playback of DVD-ROM content to specific regions of the world

3.1.80**relative MSF field**

See 3.1.65.

3.1.81**RZone**

logical subdivision of a DVD-R, similar to a Track on CD

See 4.3.3.1.

3.1.82**scramble flag**

indication that there is scrambled data on the media

3.1.83

sector

in the case of CD media, Sector refers to the data contained in one frame

in the case of DVD media, Sector is the smallest user addressable part of the media. The user data contained within a sector is 2 048 bytes

NOTE In IEC/ISO 10149 the term block is used for this unit.

3.1.84

session

a contiguous area of the disc that contains a Lead-in, a Program Area and a Lead-out

3.1.85

single sided

a single sided DVD disc has exactly one recorded or recordable side

3.1.86

small frame

1/98 of a frame

3.1.87

sub-channel

CD media have a main channel and a Sub-channel

The Sub-channel area has eight parts called P, Q, R, S, T, U, V and W. The Q Sub-channel contains information useful to the controller and device, such as the control field and MSF addresses. The data rate of each Sub-channel (P, Q, etc.) is 1/192nd of that of the main channel.

3.1.88

TOC (table of contents)

has information on the type of session and the starting address of the tracks

This information is encoded in the Q Sub-channel in the Lead-in area.

3.1.89

title key

value used during the scrambling process of movie data on DVD media

3.1.90

track descriptor block (TDB)

contains information on the attributes of the current track

3.1.91

track

a logical sub-division of the media

3.1.92

track at once

when a track, including its pre-gap, is written as a single packet

3.1.93

track relative logical address

value used to address logical blocks relative to the beginning of a track

3.1.94**transition area**

sectors at the beginning or end of tracks

For example: Pause Area, Pre-Gap, Lead-out, Post-Gap.

3.1.95**UPC (uniform product code)**

barcode, controlled by the UPC Council (see bibliography)

3.1.96**user packet**

packet that contains only user data blocks as the data blocks

User data blocks consist of data transferred to the device during a write command.

3.1.97**writable disc**

disc that is blank, appendable, or contains an incomplete session

3.1.98**yellow book**

[see ISO/IEC 10149]

3.2 Conventions

Various conventions are used throughout this standard and are identified in this subclause.

3.2.1**Error codes**

Recommended error code tables defined within each command subclause use the following:

- errors shown in mixed case indicate that all errors, in that class, are valid;
- errors shown in uppercase refer to the identified specific error condition.

3.2.2**Decimal values**

Numbers that are not immediately followed by lowercase “b”, “h” or “bcd” are decimal values.

Numbers immediately followed by lowercase “b” (xxb) are binary values.

Numbers immediately followed by lowercase “h” (xxh) are hexadecimal values.

Numbers immediately followed by lowercase “bcd” (xxbcd) are binary coded decimal values.

3.3 Keywords

Several keywords are used to differentiate between levels of requirements and options, as listed below.

3.3.1**expected**

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

3.3.2**may**

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

3.3.3

shall

A keyword indicating a mandatory requirement. Designers are required to implement all such mandatory requirements to ensure interoperability with other standard conforming products.

3.3.4

should

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

3.3.5

obsolete

A keyword indicating items that were defined in prior versions of this standard and that are intended to be removed from future versions of this standard.

3.3.6

mandatory

A keyword indicating items required to be implemented as defined by this standard.

3.3.7

optional

A keyword that describes features that are not required for compliance to this standard. However, if any optional feature defined is implemented, it shall be implemented as defined by this standard.

3.3.8

reserved

A keyword referring to 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 set to zero or in accordance with any 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 an error.

4 C/DVD models

4.1 General

The following subclauses provide an overview of the operations and functionality of all CD and DVD types.

4.1.1 CD address reporting formats (MSF bit)

Several CD commands can report addresses either in logical block address or in MSF format (see Table 1). The READ HEADER, READ SUB-CHANNEL and READ TOC/PMA/ATIP commands have this Feature.

An MSF bit of zero, in the above listed commands, requests that the logical block address format be used for the CD absolute address field or for the offset from the beginning of the current track expressed as a number of logical blocks in a CD-ROM track relative address field. This track relative logical block address (TRLBA) value is reported as a negative value in two's-complement notation for transition areas that have decreasing MSF encoded relative addresses.

An MSF bit of one, in the above listed commands, requests that the MSF format be used for these fields. In certain transition areas, the relative MSF addresses are decreasing positive values. The absolute MSF addresses are always increasing positive values.

Table 1 – MSF address format

Bit Byte	7	6	5	4	3	2	1	0
0	Reserved							
1	M field							
2	S field							
3	F field							

The M, S and F fields are expressed as binary numbers. The values match those on the media, except for the encoding.

NOTE For a logical block size of 512 bytes, the MSF address returned is that for the physical block containing the specified logical blocks.

4.1.2 Logical blocks

Blocks of data are stored on the medium along with additional information that the Logical Unit uses to manage the storage and retrieval. The format of the additional information is unique and is hidden from the Initiator during normal read or write operations. This additional information is often used to identify the physical location of the blocks of data and the address of the logical block and to provide protection against the loss of user data.

The address of the first logical block is zero. The address of the last logical block is $[n-1]$, where $[n]$ is the number of logical blocks available on the medium. A READ CAPACITY command may be issued to determine the value of $[n-1]$. If a command is issued that requests access to a logical block not within the capacity of the medium, the command shall be terminated with CHECK CONDITION status and the sense key set to ILLEGAL REQUEST and additional sense code set to LOGICAL BLOCK ADDRESS OUT OF RANGE.

The number of bytes of data contained in a logical block is known as the block length. Each logical block has a block length associated with it. The block descriptor in the MODE SENSE data describes the block length that is used on the medium. Note that the block descriptor shall not be present for an ATAPI C/DVD Logical Unit. In addition the Block Descriptor for SCSI Logical Units has been made Obsolete in this standard.

The location of a logical block on the medium is not required to have a specific relationship to the location of any other logical block. However, in a typical Logical Unit the logical blocks are located in an ascending order. The time to access the logical block at address $[x]$ and then the logical block at address $[x+1]$ need not be less than time to access $[x]$ and then $[x+100]$.

4.1.3 Data cache

Some Logical Units implement cache memory. A cache memory is usually an area of temporary storage in the Logical Unit with a fast access time that is used to enhance performance. It exists separately from the blocks of data stored and is normally not directly addressable by the Initiator. Use of cache memory for write or read operations typically reduces the access time to a logical block and can increase the overall data throughput.

During read operations, the Logical Unit uses the cache memory to store blocks of data that the Initiator may request at some future time. The algorithm used to manage the cache memory is not part of this specification. However, parameters are provided to advise the Logical Unit about future requests or to restrict the use of cache memory for a particular request.

Sometimes the Initiator may request that the blocks of data read from the medium instead of from the cache memory. The force unit access (FUA) bit is used to indicate that the Logical Unit shall access the physical medium. For a write operation, setting FUA to one causes the

Logical Unit to complete the data write to the physical medium before completing the command. For a read operation, setting FUA to one causes the logical blocks to be retrieved from the physical medium.

Commands may be implemented by the Logical Unit that allow the Initiator to control other behaviour of the cache memory:

- The MODE SENSE (10) Command defines a page for the control of cache behaviour and handles certain basic elements of cache replacement algorithms.
- The SYNCHRONIZE CACHE Command is used by the Initiator to guarantee that data in the cache has been moved to the media.

4.1.4 RESETS

4.1.4.1 General

Within this standard there are three resets identified. These resets are named:

- Power-On Reset
- Hard Reset
- Device Reset

These resets are defined differently in different parts of ISO/IEC 14776. For this part of ISO/IEC 14776 the following definitions apply

4.1.4.2 Power-on reset

When power is applied, the device executes a series of electrical circuitry diagnostics, resets Logical Unit specific parameters (mode pages) to default values and if media are present, may spin up and make the Logical Unit ready for use. In addition, power management and key management are reset to their default states.

4.1.4.3 Hard reset

For each physical interface the detection of Hard Reset is different. The device executes a series of electrical circuitry diagnostics, resets Logical Unit specific parameters (mode pages) to default values, and if media are present, may spin up and make the Logical Unit ready for use. In addition power management and key management are reset to their default states. The behaviour of the Logical Unit when Hard Reset is received is the same as for Power-On Reset.

Hard Reset is used to reset devices or even a whole interface bus, not individual Logical Units.

4.1.4.4 Device reset

For each physical interface the detection of Device Reset is different. The Device Reset is used to bring a non-responding Logical Unit into an operable state. Device Reset is different from Power-On or Hard Reset. With the Device Reset the parameters being used by the Logical Unit are not set to the defaults. In some cases this may not be possible and the Logical Unit may need to reset to the default conditions. If a reset to default conditions occurs as a result of a Device Reset, a Unit Attention and Power Management Event Notification shall be generated. Logical Unit should:

- reset Initiator interface circuitry;
- perform hardware initialization and device-internal diagnostics, only if necessary;
- not revert to the default conditions, Logical Unit Number or TOC information;

- stay in the current Power State;
- make sure that persistent Prevent state remains unchanged;
- make sure that the key management is reset to the default state.

4.1.5 Error reporting

If any of the conditions in Table 2 occur during the execution of a command, the target shall return CHECK CONDITION status. The appropriate sense key and additional sense code should be set. The following list illustrates some error conditions and the applicable sense keys. The list does not provide an exhaustive enumeration of all conditions that may cause the CHECK CONDITION status.

Table 2 – Sense key responses for error reporting

Condition	Sense Key
Invalid Logical Block Address	ILLEGAL REQUEST
Unsupported option requested	ILLEGAL REQUEST
Attempt to read a blank block	ILLEGAL REQUEST
Attempt to play a data block as audio	ILLEGAL REQUEST
Target reset or medium change since last command	UNIT ATTENTION
Self-diagnostic failed	HARDWARE ERROR
Un-recovered read error	MEDIUM ERROR/HARDWARE ERROR
Recovered read error	RECOVERED ERROR
Overrun or other error that might be resolved by repeating the command	ABORTED COMMAND

In the case of an invalid logical block address, the sense data information field shall be set to the logical block address of the first invalid address.

In the case of an attempt to read a blank or previously unwritten block, the sense data information field shall be set to the logical block address of the first blank block encountered. The data read up to that block shall be transferred.

There are other special error situations for CD devices. In the following cases the sense key shall be set to ILLEGAL REQUEST and the additional sense code set to END OF USER AREA ENCOUNTERED ON THIS TRACK:

- a pre-gap area is encountered (i.e. a block with index equal to 0);
- a post-gap area is encountered;
- the information type (data versus audio) changes.

When the command is other than an audio playback operation, the command shall be terminated with CHECK CONDITION status if the Logical Block Address requested is not within a data track. The sense key shall be set to ILLEGAL REQUEST and the additional sense code set to ILLEGAL MODE FOR THIS TRACK. This applies to audio and audio-combined media.

4.1.6 Deferred errors

Error code 71h (deferred error) indicates that the CHECK CONDITION status returned is the result of an error or exception condition that occurred during execution of a previous command for which GOOD status has already been returned. Such commands are associated

with use of the immediate bit, with some forms of caching. C/DVD Logical Units that implement these Features shall implement deferred error reporting.

A deferred error may be indicated by returning CHECK CONDITION status to the Initiator as described below. The subsequent execution of a REQUEST SENSE command shall return the deferred error sense information.

If an I/O Command terminates with CHECK CONDITION status and the subsequent sense data returns a deferred error, that I/O command shall not have been executed. After the C/DVD Logical Unit detects a deferred error condition on a Logical Unit, it shall return a deferred error according to the rules described below:

- a) if a deferred error can be recovered with no external system intervention, a deferred error indication shall not be posted unless required by the error handling parameters of the MODE SELECT command. The occurrence of the error may be logged if statistical or error logging is supported;
- b) if a deferred error can be associated with a particular function or a particular subset of data and the error is either un-recovered or required to be reported by the mode parameters, a deferred error indication shall be returned to the Initiator.

Deferred errors may indicate that an operation was unsuccessful long after the command performing the data transfer returned GOOD status. If data that cannot be replicated or recovered from other sources is being stored using buffered write operations, synchronization commands should be performed before the critical data is destroyed in the Initiator. This is necessary to be sure that recovery actions can be taken if deferred errors do occur in the storing of the data.

4.1.7 Removable medium

A disc has an attribute of being mounted or de-mounted on a suitable transport mechanism. A disc is mounted when the Logical Unit is capable of performing read operations to the medium. A mounted disc may not be accessible by an Initiator, if it has been reserved by another Initiator. A disc is de-mounted at any other time (e.g. during loading, unloading or storage).

An Initiator may check whether a disc is mounted by issuing a TEST UNIT READY command. In addition, there now exists a MEDIA STATUS NOTIFICATION Feature. This allows the Initiator to prevent the removal of any media, as well as sensing requests from the user to remove media.

The PREVENT ALLOW MEDIUM REMOVAL command allows an Initiator to restrict the de-mounting of the disc. This is useful in maintaining system integrity. If the Logical Unit implements cache memory, it shall ensure that all logical blocks of the medium contain the most recent data prior to permitting de-mounting of the disc. If the Initiator issues a START STOP UNIT command to eject the disc and is prevented from de-mounting by the PREVENT ALLOW MEDIUM REMOVAL command, the START STOP unit command is rejected by the Logical Unit.

When the Persistent Prevent state is entered, the media shall remain locked in the Logical Unit, until the Initiator issues an eject request, or a power on or hard reset condition occurs. The Persistent Prevent state shall be maintained after the eject request. New media that is inserted into the Logical Unit shall be locked in the Logical Unit after the Logical Unit reports the NEW MEDIA event. Prior to reporting the NEW MEDIA event, the Logical Unit may eject media without an explicit eject command from the Initiator. This allows the user to remove incorrectly inserted media without having to wait for Initiator intervention.

While in the Persistent prevent state, the Logical Unit shall generate Events upon receipt of a User Eject request. The Logical Unit shall not eject the media on receipt of these requests, if the Logical Unit has already reported a NEW MEDIA event for this media. When the Initiator receives the Eject Request and determines that it is safe to eject the medium, an eject command will be issued, at that time the Logical Unit shall eject the medium.

The Logical Unit shall only generate GET EVENT/STATUS NOTIFICATION (EJECT REQUEST) events after reporting a GET EVENT/STATUS NOTIFICATION (NEW MEDIA) event and prior to reporting a GET EVENT/STATUS NOTIFICATION (MEDIA REMOVAL) event for the given media.

To maintain compatibility with existing BIOS implementations and operating systems, the Logical Unit shall default to Persistent Prevent disabled. When the Initiator enables the support using the PREVENT ALLOW command, the Logical Unit shall respond as described in this specification. When the Initiator disables this Feature, the Logical Unit shall default to normal operating modes. A power on or hard reset shall cause the Logical Unit to the default Persistent Prevent state.

If the Logical Unit is unable to maintain media status information across a reset or power cycle, the Logical Unit shall generate a NEW MEDIA event.

Commands shall be processed exactly the same as they would be if Persistent Prevent was not enabled. For compatibility reasons, UNIT ATTENTION status conditions shall still be returned. However, the Logical Unit shall not return the UNIT ATTENTION status on a GET EVENT/STATUS NOTIFICATION command. For example, if the user inserts a new medium and the Logical Unit is accessed with a command, the CHECK CONDITION with UNIT ATTENTION shall be reported, but the Logical Unit shall also report the NEW MEDIA Event with the next available GET EVENT/STATUS NOTIFICATION (Media Status) command.

4.2 CD device model

4.2.0 General

The CD device model is driven by the CD media organization and data formats.

4.2.1 Recorded CD media structure

4.2.1.0 General

A CD medium is an 80 mm or 120 mm disc with a continuously recorded physical track beginning near a diameter of 50 mm and spiraling outward to a diameter near 78 mm or 118 mm.

4.2.1.1 CD Frame structure

Data is recorded in a continuous stream of Small Frames. Each byte of a Small Frame is encoded with an 8 bit to 14 bit modulation (EFM) code. Three merging bits are appended. The merging bits are chosen to provide minimum low-frequency signal content and optimize phase lock loop performance. Each Small Frame consists of 588 EFM bits (see Table 3). A Small Frame is defined in Table 3.

Table 3 – Small Frame layout and definition

1 syn- chronization pattern (24 + 3 bits)	1 byte of Sub- channel data (14 + 3 bits)	12 bytes of main channel data (12 × (14 + 3) bits)	4 bytes of CIRC code (4 × (14 + 3) bits)	12 bytes of main channel data (12 × (14 + 3) bits)	4 bytes of CIRC code (4 × (14 + 3) bits)
588 bits					

A CD frame consists of 98 contiguous Small Frames. This yields $24 \times 98 = 2\,352$ bytes of main channel data per frame and 98 bytes of Sub-channel data per CD frame. A recorded CD is a succession of CD frames. For audio, the bounds of a CD frame are defined by the Sub-channel bytes and for data, they are determined by the sync bytes in the main channel data.

The 98 Sub-channel bytes are separated into 2 bytes of synchronization and 96 bytes of data. Each CD frame begins with the first Sub-channel sync byte and ends with the 96th Sub-channel data byte. A CD frame is constructed from Small Frames as shown in Table 4. This is

a logical representation since Small Frames are physically interleaved. This means that precise CD frame boundaries do not exist.

Table 4 – CD Frame Structure from Small Frames

F	.	.	.
R	.	.	.
A	Small Frame 94	Sub-channel data byte 92	24 bytes main channel data
M	Small Frame 95	Sub-channel data byte 93	24 bytes main channel data
E	Small Frame 96	Sub-channel data byte 94	24 bytes main channel data
	Small Frame 97	Sub-channel data byte 95	24 bytes main channel data
N	Small Frame 98	Sub-channel data byte 96	24 bytes main channel data
F	Small Frame 1	Sub-channel sync byte 1	24 bytes main channel data
R	Small Frame 2	Sub-channel sync byte 2	24 bytes main channel data
A	Small Frame 3	Sub-channel data byte 1	24 bytes main channel data
M	Small Frame 4	Sub-channel data byte 2	24 bytes main channel data
E	.	.	.
	.	.	.
N+1	Small Frame 97	Sub-channel data byte 95	24 bytes main channel data
	Small Frame 98	Sub-channel data byte 96	24 bytes main channel data
F	Small Frame 1	Sub-channel sync byte 1	24 bytes main channel data
R	Small Frame 2	Sub-channel sync byte 2	24 bytes main channel data
A	Small Frame 3	Sub-channel data byte 1	24 bytes main channel data
M	Small Frame 4	Sub-channel data byte 2	24 bytes main channel data
E	Small Frame 5	Sub-channel data byte 3	24 bytes main channel data
	.	.	.
N+2	.	.	.

4.2.1.2 Sub-channel

Each non-sync byte of Sub-channel is labeled according to bit position, as shown in Table 5.

Table 5 – Sub-Channel byte layout

Small Frame Sub-channel Byte							
P	Q	R	S	T	U	V	W
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0

Over the 98 Small Frames, the Sub-channel is separated into bytes associated with the Sub-channel letter. The Sub-channel sync bytes are not a part of Sub-channel data, so there are 96 bytes of Sub-channel. For example, the P Sub-channel is separated into bytes as shown in Table 6.

Table 6 – P-Sub-Channel Layout

Small Frame	P bit	P BYTE
1	SYNC 0	–
2	SYNC 1	–
3	7	0
4	6	
5	5	
6	4	
7	3	
8	2	
9	1	
10	0	
11	7	1
12	6	
13	5	
14	4	
15	3	
16	2	
17	1	
18	0	
.	.	.
.	.	.
.	.	.
91	7	11
92	6	
93	5	
94	4	
95	3	
96	2	
97	1	
98	0	

The byte construction for Q Sub-channels is identical.

P and Q Sub-channels provide information about the recording.

R-W Sub-channel is defined only for audio tracks. It is most often unused and is set to zeros. When used, it carries line graphics, MIDI Control or text. See 6.1.23, READ SUB-CHANNEL Command.

4.2.1.3 Physical track topology – Single session disc

CD players and readers follow the physical track by following the path of recorded EFM data. When there is no EFM data, the player/reader is unable to follow the physical track.

The physical track is divided into 3 logical entities from the inner radius:

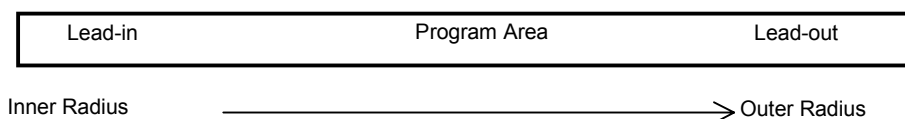


Figure 1 – Single session disc

LEAD-IN – The Lead-in is a zone of protection from unrecorded areas near the disc center. The Lead-in also contains the table of contents (TOC) for the disc's Program Area.

PROGRAM AREA – This is also known as the user area of the disc. For example, on an audio CD, this is where the music is recorded.

LEAD-OUT – The Lead-out is a zone of protection from unrecorded areas toward the disc's outer edge.

4.2.2 Physical track topology – Multi-session disc

4.2.2.0 General

A Session is the recorded sequence: Lead-in, program area, Lead-out. The multi-session allows a single disc to have several concatenated sessions.

CD-ROM devices are not typically capable of reading through unrecorded areas on the medium. The CD-ROM device needs EFM data in order to find and stay in the physical track. This means that to ensure that a CD-ROM Logical Unit is capable of accessing all areas of a Program Area, the Program Area needs the protection zones of Lead-in and Lead-out.

On a recorded disc, sessions may appear as shown in Figure 2.

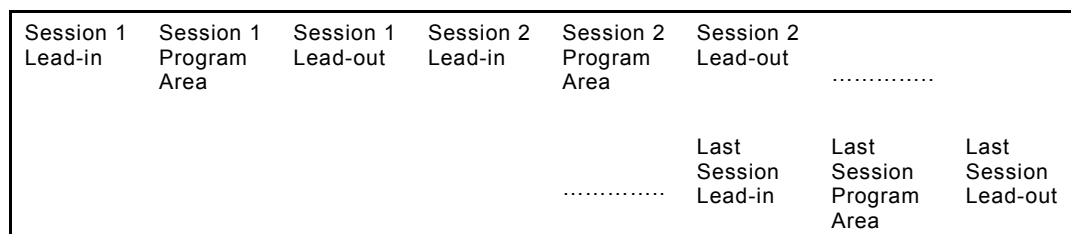


Figure 2 – Multi-session Recorded Disc

In order to assure readability by CD-ROM Logical Units, the recording system should always close the session with the most recently added program area before attempting interchange.

Additional information is needed in order to locate all of the program areas. This is accomplished by using Mode-5 Q in the Lead-in areas.

4.2.2.1 Tracks

The Program Area of the disc is divided into logically separated areas called tracks. There shall be at least one track in the Program Area. There may be gaps between tracks, primarily to provide a zone of digital silence between audio program selections. P Sub-channel is reserved for identifying these transition areas between tracks. The normal value for P is 0. During a transition area, the value for P is 1.

4.2.2.2 Frame addressing

CD was originally developed for playing digital audio that has two channels of 16-bit samples at 44,1 kHz. The number of frames per second of play is 75:

$$4 \text{ bytes/sample} \times 44\,100 \text{ Samples/s} = 176\,400 \text{ bytes/s}$$

$$176\,400 \text{ bytes/s} / 2\,352 \text{ bytes/frame} = 75 \text{ frames/s}$$

Given this, CD frames are addressed in terms of audio play time, i.e. Minute, Second and Frame (MSF). The traditional value of 60 s per minute is followed.

In all cases, when an address appears as part of the CD format, it is in MSF format using 2 bcd digits per time unit. This limits the time addressing on the disc to 99bcd minutes. The representation for a time based address is MM:SS:FF, where MM = minutes, SS = seconds, and FF = frames.

Addressing in the program area begins with 00:00:00. This advances up through the Lead-out.

The last frame in the Lead-in is 99:59:74 and decreases as the physical track is followed toward the center of the disc. The Lead-in is typically 3 min to 4 min in length.

4.2.2.3 Q Sub-channel

Since an audio CD frame has no address field built into the main channel, the address is carried in the Q Sub-channel. Q Sub-channel may also carry information about the logical structure of the disc, disc identification and music track identification. The general format of a Q Sub-channel record is shown in Table 7.

Table 7 – Q Sub-channel record format

Field name	Definitions
S0, S1	Sub-channel synchronization
CONTROL	The Control Field has 4 bits that define the type of information in the frame: 00x0b = 2 audio channels without pre-emphasis 00x1b = 2 audio channels with pre-emphasis of 50/15 µs 10x0b = 4 audio channels without pre-emphasis 10x1b = 4 audio channels with pre-emphasis of 50/15 µs 01x0b = Data track, recorded uninterrupted 01x1b = Data track, recorded increment 11xxb = reserved xx0xb = digital copy prohibited xx1xb = digital copy permitted The bits of the control field (except for the copy bit) may change during a pause (X=00) of at least 2 s and during the Lead-in area only.
ADR	4 bits of identification for DATA-Q. This is also known as the Mode (ADR) Q.
DATA Q	72 bits of data
CRC	A 16 bit CRC for the Control, ADR, and DATA-Q Fields. On the disc the CRC bits are inverted. The remainder has to be checked at zero. Polynomial = $P(X)=X^{16}+X^{12}+X^5+1$

Because the sync bits and the two bytes of CRC are overhead, the valid Q information length is actually 10 bytes.

4.2.2.4 Q Sub-channel in the Program Area

4.2.2.4.0 General

During the program area 3 types of Q Sub-channel may be encountered, Mode-1 Q, Mode-2 Q or Mode-3 Q.

ADR=1 (0001b) – Mode-1 Q

Mode-1 Q occupies at least 9 out of 10 successive CD frames. Mode-1 Q in the program area is also referred to as current position Q. The Mode-1 Q format during data and audio tracks is shown in Figure 3.

ADR	DATA-Q								
0001	TNO	INDEX	MIN	SEC	FRAME	ZERO	AMIN	ASEC	AFRAME

Figure 3 – Q Sub-channel Mode-1 Format recorded in Program Area

- TNO = 01 to 99bcd is the track number
- INDEX = 00 to 99bcd is the Index to TNO. An audio track may be divided into up to 99 sections, identified by a non-zero index. The first indexed area in a track shall be 01. Most audio discs have only one indexed area per track. The pre-gap is the part of a track-to-track gap that belongs to the following track. In a track's pre-gap, the track number is that of the following track and the INDEX is 00.
- MIN, SEC, FRAME = Is the relative time within the track encoded as 6 bcd digits. This is 00:00:00 at track start and advances through the track. During the pre-gap the time decreases.
- ZERO = 8 bits of zero (00000000b)
- AMIN, ASEC, AFRAME = Is the program area absolute time address expressed in 6 bcd digits.

ADR=2 (0010b) – Mode-2 Q

Mode-2 Q is optional. If Mode-2 Q is present, it shall occupy 1 out of each 100 successive frames. The Mode-2 Q data format is shown in Figure 4.

ADR	DATA-Q														
0010	N1	N2	N3	N4	N5	N6	N7	N8	N9	N10	N11	N12	N13	ZERO	AFRAME

Figure 4 – Q Sub-channel Mode-2 Format

The DATA-Q field is 52 bits long, organized as 13 nibbles (N1 – N13), each carrying a single bcd digit. The resulting bcd string is the Media Catalog Number (MCN). The catalog number does not change on a disc. In case no catalog number is encoded according to the UPC/EAN code, N1 – N13 are all zero, or Mode-2 can be deleted from the disc.

The ZERO field contains 12 bits of zero (000000000000b).

AFRAME is as defined in Q Sub-channel Mode-1 (two bcd digits running from 00 to 74). During the Lead-in (TNO = 00), these 8 bits are zero.

4.2.2.4.1 ADR=3 (0011b) – Mode-3 Q

Mode-3 Q is optional. If Mode-3 is present, it occupies at least 1 out of 100 successive sub-coding blocks. Mode-3 is used to give a unique number to an audio track. This is done by means of the International Standard Recording Code (ISRC). The ISRC, as recorded on the media, is defined in Figure 5. If no ISRC is used, Mode-3 shall be deleted. During the Lead-in and Lead-out, Mode-3 is not present on the disc. The ISRC may only change immediately after the Track Number (TNO) has been changed. The Mode-3 data format is shown in Figure 5.

ADR	DATA-Q															
0011	I1	I2	I3	I4	I5	0	0	I6	I7	I8	I9	I10	I11	I12	ZERO	AFRAME

Figure 5 – Q Sub-channel, Mode-3 Format

The Country-Code is given in fields I1 through I2, the owner-code in fields I3 to I5. The year of recording in fields I6 to I7 and the I8 through I12 contain the serial number of the recording. The characters I1 to I5 are 6-bit cells, coded as shown in Table 8. The characters I6 to I12 are coded in 4 bit bcd numbers.

I1 to I12 define the ISRC.

The ZERO Field contains 4 bits of zero (0000b).

A FRAME is defined in Q Sub-channel Mode-1 Q (two bcd digits running from 00 to 74). During the Lead-in area (TNO = 00), these 8 bits are zero.

Table 8 – ISRC 6 bit character codes (in hexadecimal)

CHAR	CODE	CHAR	CODE
0	00	I	19
1	01	J	1A
2	02	K	1B
3	03	L	1C
4	04	M	1D
5	05	N	1E
6	06	O	1F
7	07	P	20
8	08	Q	21
9	09	R	22
A	11	S	23
B	12	T	24
C	13	U	25
D	14	V	26
E	15	W	27
F	16	X	28
G	17	Y	29
H	18	Z	2A

4.2.2.5 Q Sub-channel in the Lead-out Area

Q Sub-channel in the Lead-out area is similar to Q Sub-channel in the program area. The differences are:

- Mode-1 Q Sub-channel: TNO = AAh, INDEX = 01bcd
- Mode-2 Q Sub-channel: No differences.

No other Q Sub-channel modes are allowed in the Lead-out area.

4.2.2.6 Q Sub-channel in the Lead-in Area

4.2.2.6.0 General

Q Sub-channel in the Lead-in area is referred to as the Table of Contents (TOC).

Three modes of Q are allowed in the Lead-in area: Mode-1 Q, Mode-2 Q and Mode-5 Q.

4.2.2.6.1 Mode-1 Q

The Mode-1 Q format during the Lead-in is shown in Figure 6. TNO is always 00 during the Lead-in and ZERO is always 00 during the Lead-in. Variations of Mode-1 Q are defined by the value of POINT.

ADR	DATA-Q								
0001	TNO=00	POINT	MIN	SEC	FRAME	ZERO=00	PMIN	PSEC	PFRAME

Figure 6 – Q Sub-channel Mode-1 Format recorded in Lead-in

POINT = 01bcd – 99bcd is the track number of the track being defined

MIN, SEC, FRAME = Running time in the Lead-in, encoded as bcd

PMIN, PSEC, PFRAME = Track start time, encoded as bcd

POINT=A0h

MIN, SEC, FRAME = Running time in the Lead-in, encoded as bcd

PMIN = the track number of the first track in the program area, encoded as bcd

PSEC = the program area format:

00h – CD-DA or CD-ROM

10h – CD-I

20h – CD-ROM-XA

PFRAME = 00

POINT=A1h

MIN, SEC, FRAME = Running time in the Lead-in, encoded as bcd

PMIN = the track number of the last track in the program area, encoded as bcd

PSEC = 00

PFRAME = 00

POINT=A2h

MIN, SEC, FRAME = Running time in the Lead-in, encoded as bcd

PMIN, PSEC, PFRAME = the start time, encoded as bcd, of the Lead-out area

4.2.2.6.2 Mode-2 Q

Mode-2 Q Sub-channel is defined the same in the Lead-in, program area and Lead-out.

4.2.2.6.3 Mode-5 Q

Mode-5 Q Sub-channel provides additional information about CD-R and CD-RW recordings. The format of a Mode-5 Q Sub-channel is shown in Figure 7. TNO is always 00 during the Lead-in. Variations of Mode-5 Q are defined by POINT.

ADR	DATA-Q								
0101	TNO	POINT	MIN	SEC	FRAME	ZERO	PMIN	PSEC	PFRAME

Figure 7 – Q Sub-channel Mode-5 Format recorded in Lead-in

POINT= B0h (This identifies a multi-session disc.)

MIN, SEC, FRAME = the start time for the next possible session's program area. A final session is indicated when either the Mode-5 point B0 is absent or when MSF = FF:FF:FF.

ZERO = the number of different Mode-5 pointers present.

PMIN, PSEC, PFRAME = the maximum possible start time of the outermost Lead-out.

POINT=B1h (Audio only: This identifies the presence of skip intervals.)

MIN = 00

SEC = 00

FRAME = 00

ZERO = 00

PMIN = the number of skip interval pointers

PSEC = the number of skip track assignments in POINT=B2, B3, and B4

PFRAME = 0

POINT=B2h, B3h, B4h (Audio only: This identifies tracks that should be skipped during playback.)

ZERO = 00..09bcd is a label of the frame number in the PMA unity

MIN = 01..99bcd track number to skip upon playback

SEC = 00..99bcd track number to skip upon playback, 00 if no skip track is specified

FRAME = 00..99bcd track number to skip upon playback, 00 if no skip track is specified

PMIN = 00..99bcd track number to skip upon playback, 00 if no skip track is specified

PSEC = 00..99bcd track number to skip upon playback, 00 if no skip track is specified

PFRAME = 00..99bcd track number to skip upon playback, 00 if no skip track is specified

NOTE Skip intervals are seldom written by recorders and typically ignored by readers.

POINT=01...40 (Audio only: This identifies a specific playback skip interval.)

ZERO = 00

MIN, SEC, FRAME = Skip interval stop time in 6 bcd digits

PMIN, PSEC, PFRAME = Skip interval start time in 6 bcd digits

POINT=C0h (Together with POINT=B0h, this is used to identify a multi-session disc)

ZERO = 00

MIN, SEC, FRAME = ATIP values from Special Information 1, ID=101 (See 4.2.3.)

PMIN, PSEC, PFRAME =Start time of the first Lead-in area of the disc.

4.2.2.7 CD Main channel block formats

4.2.2.7.1 General

Although some are rarely used, there are 6 main channel frame formats defined. Audio blocks are recorded unmodified.

Data blocks are given a synchronization field at the beginning of the block. The pattern is shown in Figure 8.

00h	FFh	FFh	FFh	FFh	FFh	FFh	FFh	FFh	FFh	FFh	00h
-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----

Figure 8 – Synchronization Field pattern

The synchronization field is followed by a 4 byte header defined in Table 9. After the sync pattern the remaining bytes of the data block are scrambled with a feedback mechanism. This is done with a 15-bit shift register fed back according to the polynomial $X^{15}+X+1$.

Table 9 – Sync pattern block header

Header offset	Header byte	Content
0	Minute	Program area time of block, minute component (00.-.79 bcd)
1	Second	Program area time of block, second component (00.-.59 bcd)
2	Frame	Program area time of block, frame component (00.-.74 bcd)
3	Mode	Bits 1, 0 = Data Mode, bits 7 – 5 = block indicator field, bits 4 to 2 = Reserved. When bits 7 – 5 = 000 indicates user data.

Mode byte Format is shown below:

Bits 7,6,5

- =000 – User Data block
- =001 – Fourth Run-in block
- =010 – Third Run-in block
- =011 – Second Run-in block
- =100 – First Run-in block
- =101 – Link block. Physical linking of EFM data
- =110 – Second Run-out block
- =111 – First Run-out block

Bits 4,3,2

- =000 – Reserved

Bits 1,0

- =00 – Mode 0 Data
- =01 – Mode 1 Data
- =10 – Mode 2 Data
- =11 – Reserved

4.2.2.7.2 Block format for audio

Audio is streamed, so only user data resides within the frame. See the READ CD command description for byte ordering.

4.2.2.7.3 Block format for mode 0 data

Mode 0 is a rarely used format as it is zero filled in the entire user data area. Mode zero data (Table 10) has the following format.

Table 10 – Mode zero data format

Byte offset	Field length	Content
0	12	Data Block Sync pattern
12	3	Block MSF address (bcd)
15	1	Data mode = 0
16	2 336	User data (each byte is zero)

4.2.2.7.4 Block format for mode 1 data

Mode 1 data (Table 11) is most prevalent in CD-ROM applications. The sync pattern, header and user data are protected by a 32-bit CRC. The header and user data are covered by two additional layers of error correction, P and Q, collectively called Level 3 correction. This is also referred to as Layered error correction (L-EC or C3) .

Table 11 – Mode 1 data format

Byte offset	Field length	Content
0	12	Data Block Sync pattern
12	3	Block MSF address (bcd)
15	1	Data mode = 01
16	2 048	User data
2 064	4	CRC ($P = (X^{16} + X^{15} + X^2 + X^1) \cdot (X^{16} + X^2 + X + 1)$) Bytes 0 to 2 063
2 068	8	Zero fill
2 076	172	P parity symbols
2 248	104	Q parity symbols

The coverage of the CRC is the sync pattern, Header and the User Data.

The coverage of Level 3 P is Header, User Data, CRC and the zero fill.

The coverage of Level 3 Q is Header, User Data, CRC, the zero fill and the P parity.

4.2.2.7.5 Block format for mode 2 formless data

The Mode 2 formless block format (see Table 12) is rarely used. There is no defined CRC or additional correction.

Table 12 – Mode 2 formless block format

Byte offset	Field length	Content
0	12	Data Block Sync pattern
12	3	Block MSF address (bcd)
15	1	Data mode = 2
16	2 336	User data

4.2.2.7.6 Block format for mode 2 form 1 data

Mode 2 form 1 data is regularly used in recorder applications and Video CD movies. The Mode 2 form 1 format is very similar to Mode 1 format. The differences are:

- the 8 zero fill bytes have been moved to between the header and user data as two copies of a 4 byte sub-header;
- the CRC, P-parity and Q-parity do NOT cover the block header. This assures the ability of relocating data, including all parity symbols.

Table 13 – Mode 2 form 1 data format

Byte offset	Field length	Content
0	12	Data Block Sync pattern
12	3	Block MSF address (bcd)
15	1	Data mode = 2
16	4	Sub-header, first copy
20	4	Sub-header, second copy
24	2 048	User data
2 072	4	CRC ($P = (X^{16}+X^{15}+X^2+X^1)(X^{16}+X^2+X+1)$) Bytes 16 – 2 071
2 076	172	P parity symbols
2 248	104	Q parity symbols

The format of the sub-header is shown in Table 14.

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