Revision 0.91
June 24, 2005 8:47 pm
Status: Draft for Review

Mt. Fuji Commands for Multimedia Devices Version 6

SFF8090i v6

This document was developed by an industry group known as the Mt. Fuji Group. This group consisted of optical disc drive manufacturers, operating system vendors, independent software developers, and other optical disc affiliated companies. This document provides for commands to implement CD-R, CD-RW, DVD-ROM, DVD-RAM, DVD-R, DVD-RW, and AS-MO.

This document is the basis for changes made to INF-8090i Rev 5.5 to generate INF-8090i Rev 6.0. The distribution for public review is via the SFF Committee.

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SFF Committee Information Specifications

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1.0 Introduction

This document provides a command set for a variety of multimedia devices. Previous standards contained descriptions applicable to only one interface, such as ATAPI or SCSI. This specification documents how to command a logical unit regardless of the type of interface used. However, while every attempt was made to make the command sets common across interfaces, different operating behavior of various transports led to implementation differences. These differences are highlighted in annexes.

DVD is the successor to CD. New CD/DVD (C/DVD) logical units are capable of storing extremely large amounts of data, and in some cases will be able to play movies. Logical units conforming to this specification will be backward compatible with CD logical units. This specification combines the capabilities and command set of the CD with the new capabilities of DVD.

HD DVD is the successor to DVD. Interface between a host and a HD DVD logical units is designed to keep the good compatibility with DVD as possible. The followings are the basic concept of HD DVD.

- HD DVD-ROM is based on DVD-ROM.
- HD DVD-R is based on DVD-R.
- HD DVD-Rewritrable is based on DVD-RAM (not DVD-RW).

1.1 Abstract

This document defines a standard method for interfacing a storage device to a host using various transports including ATAPI, SCSI, and IEEE 1394.

1.2 Scope

This document is intended to be used with external standards for the transport of commands and data. It also lists several peer command set standards as normative references. In the event of a conflict between one of the base documents and this document, the interpretation of this document ***shall*** prevail ***only if this document acknowledges that a conflict exists between the documents***.

1.3 Audience

This document is intended for use by computer system, host software, storage peripheral, and interface chip set vendors.

1.4 Normative references

The following standards contain provisions which, when referenced in the text of this specification, constitute provisions of this Specification. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this Specification are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

- American National Standard Institute INCITS T10/1048D Revision 10.0a March 12, 1997, MMC
- DVD/HD DVD Book, DVD Forum
- ISO/IEC 10149:1989, Information technology - Data Interchange on Read-only 120 mm Optical Data Disks.
- IEC 908:1987, Compact Disc Digital Audio System.
- American National Standard Institute INCITS T13/2008D ATA/ATAPI-4.

1.5 Prerequisites and related documents

The reader is expected to have a basic understanding of the ATA/SCSI hardware and software interfaces as well as the ATA/SCSI Documents. Specifically, the following documents are required for understanding and implementing an ATA C/DVD because this document is based on them:

- CBEMA, ATA (AT Attachment) ANSI Draft Standard, Revision 9482K, December 2, 1994, Document Number X3T10/948, Computer and Business Equipment Manufacturer's Association. This is referred to as the ATA Document.
- ANSI X3T9.2/375R, Small Computer System Interface
- Red, Yellow, Green, Orange Books and CD-ROM XA Specification.

1.6 Layout of the document

This document is broken into several sections as shown in Table 1.

Table 1 - Layout of the document

Section 1.0, "Introduction" on page 39	Introduction, scope, purpose etc.
Section 2.0, "Conventions" on page 43	Describes conventions used in the document, and a definitions of terms and signals.
Section 3.0, "CD model" on page 57	Description of command and media supported by C/DVD/HD DVD logical units. This section provides a tutorial on the technology of CD as well as specific requirements for a logical unit that supports the CD media.
Section 4.0, "DVD model" on page 69	Description of command and media supported by C/DVD/HD DVD logical units. This section provides a tutorial on the technology of DVD as well as specific requirements for a logical unit that supports the DVD media.
Section 5.0, "HD DVD model" on page 241	Description of command and media supported by C/DVD/HD DVD logical units. This section provides a tutorial on the technology of HD DVD as well as specific requirements for a logical unit that supports the HD DVD media.
Section 6.0, "AS-MO model" on page 317	Description of the use of AS-MO media.
Section 7.0, "AACS content protection" on page 323	Description of AACS content protection and authentication process.
Section 8.0, "Real-Time Stream recording/playback model" on page 327	Description of real-time streaming recording/playback on optical media.
Section 9.0, "Logical unit assisted software defect management model" on page 333	Description of software defect management with enhanced defect reporting capable logical unit.
Section 10.0, "Changer Model" on page 347	Description of the requirements and operation of logical units that is able to select from a number of internally stored media.
Section 11.0, "Write protection model" on page 353	Description of the operations for write protection for the C/DVD/HD DVD logical unit.
Section 12.0, "Power management model" on page 355	Description of the requirements for power management for the C/DVD/HD DVD logical unit.
Section 13.0, "Time-out and Reset models" on page 361	Description of the requirements for time-outs and resets for the C/DVD/HD DVD logical unit.
Section 14.0, "Features" on page 369	Description of specific functionality that is implemented in groupings.
Section 15.0, "Profiles" on page 379	Description of Groupings of Features that may be supported.
Section 16.0, "Packet commands" on page 389	Description of packet based commands for C/DVD/HD DVD logical units.

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Appendix A - "Error Reporting and Sense Codes (Normative)" on page 721	Descriptions of error behavior and Sense Key, ASC, and ASCQ assignments
Appendix B - "ATAPI Implementation Notes (Normative)" on page 739	Overview of the Packet Interface and how the "Layering" of Packets and ATA occurs.
Appendix C - "SCSI Implementation Notes (Normative)" on page 749	Integration notes for logical units that make use of the SCSI interface.
Appendix D - "IEEE 1394 Implementation Notes (Normative)" on page 755	Implementation notes for using this command set with IEEE 1394.
Appendix E - "Example Event Implementation Notes (Informative)" on page 759	Notes on using and implementing the GET EVENT/STATUS NOTIFICATION command.
Appendix F - "Command Implementation Notes (Informative)" on page 761	Notes on using and implementing the READ DISC INFORMATION and READ TRACK/RZONE INFORMATION commands.
Appendix G - "CD-Text Format in the Lead-in Area (Informative)" on page 767	Description of the CD-Text format.
Appendix H - "Mt. Fuji revision history (Informative)" on page 771	Revision history of the Mt. Fuji documents
Appendix I - "Sample Applications of Events (Informative)" on page 779	Application of Events
Appendix J - "UDF Key Structure (Informative)" on page 789	Notes on how to use this command set to read UDF written media.

1.7 Document conventions

This document was written for both the drive firmware designer and host software designers. Media specific information is given when it is helpful to the software designer, as it is assumed that the firmware designers have access to the appropriate media standards. All such information is informative, and where a conflict occurs between this documentation and the media documentation, the media documentation ***shall*** prevail.

A complete set of commands is documented. However, logical units are not required to implement all commands. The specific requirements for implementing commands is listed within the Features of the GET CONFIGURATION command. If a command is implemented, it ***shall*** be implemented as defined.

1.8 Patents

The developers of this specification have requested that holders of patents that may be required for the implementation of the specification, disclose such patents to the publisher. However, neither the developers nor the publisher have undertaken a patent search in order to identify which, if any, patents apply to this specification.

No position is taken with respect to the validity of any claim or any patent rights that may have been disclosed. Details of submitted statements may be obtained from the publisher concerning any statement of patents and willingness to grant a license under these rights on reasonable and nondiscriminatory terms and conditions to applicants desiring to obtain such a license.

1.9 Change history

- Mt.Fuji Ver. 6 Revision 0.5 created and distributed February 22, 2005. All modifications are applied to and based on Mt.Fuji5 Rev.1.6 document.
    - Commands and model for DVD-R Dual Layer media were added.
    - The name of READ DVD STRUCTURE/SEND DVD STRUCTURE command was changed to READ DISC STRUCTURE/SEND DISC STRUCTURE command for the extension of its usage.
- Mt.Fuji Ver. 6 Revision 0.7 created and distributed March 16, 2005.
    - Commands and model for AACS were added.

- Mt.Fuji Ver. 6 Revision 0.8 created and distributed April 27, 2005.
    - Some clarifications were added to DVD-R Dual Layer model section.
    - The LJRS bit in Track Information Block was specified.
    - Some descriptions were updated to match DVD-R for General Ver. 2.1 and DVD-RW Ver. 1.2.
    - Some corrections related to AACS model and commands was applied.
- Mt.Fuji Ver. 6 Revision 0.9 created and distributed May 27, 2005.
    - Commands and model for HD DVD media were added.
- Mt.Fuji Ver. 6 Revision 0.91 created and distributed June 24, 2005.
    - Many editorial corrections on DVD-R Dual Layer related sections and commands.
    - Some corrections on HD-DVD model sections and commands

2.0 Conventions

2.1 Document conventions

Certain words and terms used in this document have specific meaning beyond the normal English meaning. These words and terms are defined either in this section or in the text where they first appear and are indicated with an initial capital. Names of signals, commands, status, and sense keys are in all uppercase (e.g., REQUEST SENSE). Lower case is used for words having the normal English meaning.

Fields containing only one bit are usually referred to as the <name> bit instead of the <name> field. Numbers that are not immediately followed by a lower case b or h are decimal. Numbers immediately followed by a lower case b are in binary, and numbers immediately followed by a lower case h are in hexadecimal. The notation "Hex" may appear in the headings of tables, indicating that all numbers in the column are written in hexadecimal. (NNh for Hexadecimal, where NN refers to two hexadecimal digits 0-9, A-F.) All Sense Key information (written as N/NN/NN) is in Hexadecimal.

2.2 Definitions

2.2.1 AACS (Advanced Access Content System)

A system for managing content stored on the prerecorded and recorded optical media for consumer use with PCs and CE devices.

2.2.2 Absolute M/S/F Field

See "MSF Address."

2.2.3 AGID (Authentication Grant ID)

A value used for resource control during key management. Individual key management threads are identified through the use of AGID.

2.2.4 ATA (AT Attachment)

ATA defines the physical, electrical, transport, and command protocols for the internal attachment of block storage devices.

2.2.5 ATAPI (AT Attachment Packet Interface)

A device which complies with INCITS 317:199x, the AT Attachment Packet Interface. In this document such devices are referred to as devices implementing the Packet command feature set.

2.2.6 Audio Sector

See "Sector."

2.2.7 BCA (Burst Cutting Area)

Provides a unique physical identification mark for individual DVD media. This area is not directly addressable by the user.

2.2.8 BCD (Binary Coded Decimal)

The number system used on the physical CD-ROM and CD-DA media. Numbers that use this notation have the "bcd" suffix attached. A byte has two 4-bit values, each of which may have a value from 0 to 9. The maximum value is 99bcd (99 decimal). BCD is only used on the physical CD media.

2.2.9 Block

The term "Block" refers to data sent to/from the host. The Block is data addressed by a Logical Block Address (LBA). Generally the amount of data in a Block is controlled by the command.

2.2.10 Block SYNC (SY0)

First frame SYNC (SY0) of the first sector of an ECC block.

2.2.11 Book

Term that is used to indicate a book that specifies a CD, DVD or HD DVD standard.

2.2.12 Bordered Area

A contiguous area of a disc that contains user data which is located between Lead-in/Border-in Area and Lead-out/ Border-out Area.

2.2.13 Border-in Area

The area that contains the pointer to the next Border Zone and is located immediately following Border-out.

2.2.14 Border-out Area

The area that follows each Bordered Area and contains the latest RMD copies and so on. This area is used to avoid pickup overrunning for DVD/HD DVD logical units.

2.2.15 Border recording

A method that is used for interchange of DVD-R media between DVD-R logical unit and DVD read-only logical unit with Border Zone during Incremental recording mode or Layer Jump recording mode. For HD DVD, a method that is used for interchange of HD DVD-R media between HD DVD-R logical unit and HD DVD read-only logical unit with Border Zone.

2.2.16 Border Zone

A generic term that is named for Border-out and Border-in.

2.2.17 B-RMZ

The RMZ located in the Border-in Area.

2.2.18 BSGA (Block SYNC Guard Area)

A BSGA is an ECC block that is located at the beginning of a recorded area. The BSGA is required where the recorded area immediately follows an unrecorded area. The BSGA is used to guarantee that the following ECC block(s) is(are) readable.

2.2.19 CD-DA

Compact Disc-Digital Audio (CD-DA) is a standardized medium for recording digital/audio information. The “Red Book” defines CD-DA media. See IEC 908:1987.

2.2.20 CD-R

Compact Disc-Recordable (CD-R) is a standardized medium defined by the “Orange Book Part 2.” The CD-R system gives the opportunity to write once and read many times CD information. The recorded CD-R disc may be Red Book compatible, so it is able to be played back on any conventional CD-player. The CD-R format gives the possibility for both Audio and Data recording.

2.2.21 CD-ROM

Compact Disc-Read Only Memory (CD-ROM) is a standardized medium for recording digitized audio and digital data. CD-ROM is used to describe media with digital data rather than discs that encode audio only. The ISO/IEC 10149 standard defines CD-ROM media.

2.2.22 CD-RW

Compact Disc-Rewritable (CD-RW) is a standardized medium defined by the "Orange Book Part 3." The CD-RW system gives the opportunity to write, erase, overwrite and read CD information. The recorded CD-RW disc has a lower reflectivity than a `Red Book compatible' disc, so it ***shall*** be played back on CD-RW enabled (MultiRead) CD-players. The CD-RW enabled CD-player can therefore read out CD-RW discs as well as CD-R and conventional CD discs. The CD-RW format gives the possibility for both Audio and Data recording.

2.2.23 CD-R/RW

Either a CD-R or CD-RW logical unit.

2.2.24 CD Control Field

The CD Control Field is a 4-bit field in the Q sub-channel data indicating the data type. It indicates audio versus data and the type of audio encoding, etc. The control field is also found in the table of contents entries.

2.2.25 CD Data Mode

A byte in the header of CD data sectors. This indicates if data is present and the format of the data.

2.2.26 CD media

Term that is used when referring to media that conforms to the CD standards.

2.2.27 CD Standard

Comprised of one or more of the following documents available from Sony and Philips:

- Red Book, CD -DA
- Yellow Book, (ISO/IEC 10149) CD-ROM
- Orange book part 2, CD-Recordable and part 3 CD-Rewritable
- White book, CD-Video
- Green Book, CD Interactive, CD-I
- CD-ROM XA
- Enhanced Music CD Extra
- Multi-session CD

2.2.28 CD Text

A method for storing text information on a CD-DA disc.

2.2.29 CDB (Command Descriptor Block)

The structure used to communicate commands from a host to a logical unit.

2.2.30 C/DVD media

Term that is used when referring to media that conform either to the CD or DVD standards.

2.2.31 C/DVD/HD DVD media

Term that is used when referring to media that conform to the CD, DVD or HD DVD standards.

2.2.32 Cell

Term that is used in DVD-Video specification. The Cell is the basic presentation unit to be played back. See DVD Book Part 3.

2.2.33 Challenge key

Data used during an authentication key exchange process.

2.2.34 Changer

"Changer" is a mechanical device which allows a single C/DVD/HD DVD device to load and unload multiple C/DVD/HD DVD media without user intervention.

2.2.35 CIRC (Cross Interleaved Reed-Solomon Code)

CIRC is the error detection and correction technique used within small frames of CD audio or data. The CIRC bytes are present in all CD-ROM data modes. The error correction procedure which uses the CIRC bytes is referred to as the CIRC based algorithm. In most CD-ROM logical units, this function is implemented in hardware.

2.2.36 Command Packet

"Command Packet" is a structure used to communicate commands from a host to a logical unit. See Command Descriptor Block.

2.2.37 CPPM (Content Protection for Pre-Recorded Media)

A system for protecting DVD-Audio content on DVD-ROM media.

2.2.38 CPRM (Content Protection for Recordable Media)

A system for protecting audio-visual content on recordable DVD media.

2.2.39 CSS (DVD-Video Content Scramble System)

A system for protecting DVD-Video content on DVD-ROM media.

2.2.40 Data Area

The area between the Lead-in Area and the Lead-out Area in which user data is recorded. In case of Border recording, the Data Area contains Border Zones.

2.2.41 Data Recordable Area

The area that is available to record user data.

2.2.42 Data Sector

See "Sector."

2.2.43 Defect Management

Methods for handling the defective areas on media. The defective areas may or may not be readable.

2.2.44 Disc

Media that adheres to one of the CD, DVD or HD DVD standards.

2.2.45 Disc at once recording

A method in which Lead-in, user data and Lead-out are recorded sequentially without interruption, and no pointer to a next possible session exists.

2.2.46 Disc Key

A value used during the encryption/decryption process of title key data on DVD media.

2.2.47 Double Sided

DVD/HD DVD disc structure is two transparent substrates joined together such that the recorded Layers are on the inside. A double sided disc has two recorded sides.

2.2.48 Drive Test zone

This zone is used mainly for the power calibration and located in Data Lead-in Area and Data Lead-out Area. This zone is called PCA in the case of DVD-R.

2.2.49 Dual Layer

When there are exactly two recording Layers accessible from a given side of the media. L0 is closest to the read-out side of the media and Layer 1 is further away.

2.2.50 DVD Control Data Zone

The DVD Control Data Zone 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.

2.2.51 DVD Copyright Information

The DVD Copyright Information is recorded in the DVD Control Data Zone and contain information supplied by the content provider.

2.2.52 DVD+RW

DVD+ReWritable (DVD+RW) is a standardized medium defined by ECMA-337. The media may be written and read many times over the recording surface of the disc using the phase-change rewritable effect.

2.2.53 DVD-R

DVD Recordable (DVD-R) is a standardized medium defined by the “DVD-Book” and ECMA-279.

2.2.54 DVD-RAM

DVD-Random Access Memory (DVD-RAM) is a standardized medium defined by the “DVD-Book” and ECMA-272. The media is to be written and read many times over the recording surface of the disc using the phase-change rewritable effect.

2.2.55 DVD-ROM

DVD-Read Only Memory (DVD-ROM) is a standardized medium defined by the “DVD-Book” and ECMA-267 for recording digital data, including Digital Video Movie data.

2.2.56 DVD-RW

DVD Re-recordable (DVD-RW) is a standardized medium defined by the “DVD-Book” and ECMA -338. The media may be written and read many times over the recording surface of the disc using the phase-change rewritable effect.

2.2.57 DVD Disc Manufacturing Information

The DVD Disc Manufacturing Information is recorded in the DVD Control Data Zone and contain information supplied by disc manufacturer.

2.2.58 DVD media

Term that is used when referring to media that conforms to the DVD standards.

2.2.59 DVD Reference Code

The DVD Reference code is comprised of 2 ECC blocks (32 sectors) in the Lead-in Area and used for the adjustment of the equalizer system of the drive hardware.

2.2.60 DVD Standard

Comprised of one or more of the following documents available from the DVD Forum:

- DVD Specification for Read only Disc part one Physical Specifications
- DVD Specification for Read only Disc part two File system specifications
- DVD Specification for Read only Disc part three Video Specifications
- DVD Specification for Read only Disc part four Audio Specifications
- DVD Specification for Recordable Disc part one Physical Specifications
- DVD Specification for Recordable Disc part two File system specifications
- DVD Specifications for Recordable Disc for Authoring Part one Physical Specifications
- DVD Specifications for Recordable Disc for Authoring Part two File system Specifications
- DVD Specifications for Recordable Disc for General Part one Physical Specifications
- DVD Specifications for Recordable Disc for General Part two File system Specifications
- DVD Specifications for Recordable Disc for Dual Layer (DVD-R for DL) Part one Physical Specifications
- DVD Specification for Rewritable Disc part one Physical Specifications
- DVD Specification for Rewritable Disc part two File system specifications
- DVD Specification for Re-recordable Disc (DVD-RW) part one Physical specifications
- DVD Specification for Re-recordable Disc (DVD-RW) part two File system specifications
- DVD Specification for Rewritable/Re-recordable Discs part three Video Recording (DVD-VR)

2.2.61 EAN (European Article Number)

Controlled by the EAN International located at 145 rue Royale B - 1000 Brussels, Belgium.

2.2.62 ECC (Error Correction/Correcting Code)

Code for detecting and correcting errors in a data field.

2.2.63 ECC block

An ECC block is a self-contained block of data and error correction codes. On DVD media, this is a group of 16 DVD sectors. On HD DVD media, this is a group of 32 HD DVD sectors.

2.2.64 EDC (Error Detection Code)

Code for detecting an error in a data field.

2.2.65 Field

A Field is a group of one or more contiguous bits.

2.2.66 Format

The arrangement or layout of information on C/DVD/HD DVD media.

2.2.67 Frame

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

2.2.68 Groove

The wobbled guidance track on recordable media. (e.g., CD-R and DVD-R).

2.2.69 Hardware Defect Management

A Defect Management that the defect list is managed by the logical unit. See 2.2.43 Defect Management.

2.2.70 HD DVD Control Data Zone

The HD DVD Control Data Zone is comprised of 192 ECC blocks in the System Lead-in Area of a HD DVD medium. The content of 32 sectors in each Block is repeated 192 times. This area contains information concerning the disc.

2.2.71 HD DVD Disc Manufacturing Information

The HD DVD Disc manufacturing information is recorded in the HD DVD Control Data Zone and contain information supplied by disc manufacturer.

2.2.72 HD DVD media

Term that is used when referring to media that conforms to the HD DVD standards.

2.2.73 HD DVD Reference Code

The HD DVD Reference code is comprised of 1 ECC block (32 sectors) in the Lead-in Area and used for the adjustment of the equalizer system of the drive hardware.

2.2.74 HD DVD Standard

Comprised of one or more of the following documents available from the DVD Forum:

- HD DVD Specification for Read only Disc part one Physical Specifications
- HD DVD Specification for Read only Disc part two File system specifications
- HD DVD Specification for Read only Disc part three Video Specifications
- HD DVD Specification for Recordable Disc part one Physical Specifications
- HD DVD Specification for Recordable Disc part two File system specifications
- HD DVD Specification for Rewritable Disc part one Physical Specifications
- HD DVD Specification for Rewritable Disc part two File system specifications
- HD DVD Specification for Rewritable/Re-recordable Discs part three Video Recording (HD DVD-VR)

2.2.75 Hold Track State

When a C/DVD/HD DVD logical unit enters the hold track state the optical pick-up is maintained at an approximately constant radial position on media. This allows a paused operation to be resumed without latency due to seeking. However, rotational latency may be incurred.

2.2.76 ID

A four byte field in the header of DVD/HD DVD sectors which contains sector information and a physical sector number.

2.2.77 IED (ID Error Detection code)

Code for detecting errors in an ID field on DVD/HD DVD media.

2.2.78 Incremental recording

Recording of the disc by several distinct recording actions (for example, at different times using different recording logical units). For DVD-R, in this recording mode, the specified linking scheme either 2KB link or 32KB link is used. For HD DVD-R, lossless linking scheme is used at any time.

2.2.79 Index

An index is a subdivision of a logical track. A track may have indices from 0 to 99. Index numbers within a track are sequential.

2.2.80 Invalid

Invalid refers to a reserved or unsupported field or code value.

2.2.81 Last Recorded Address (LRA)

Last Recorded Address is the Logical Block Address of the last recorded user data Block in an RZone.

2.2.82 Layer

The recorded information is in Layers as seen from one side of a DVD/HD DVD Disc. There are Single and Dual Layer discs. In the case of Dual Layer discs the data is recorded using either OTP or PTP. Layers are numbered sequentially, starting from 0. See 2.2.135 Single Layer and 2.2.49 Dual Layer.

2.2.83 Layer Jump Address

The Layer Jump Address is the logical block address on a Layer that cause NWA transition to the other Layer in an RZone during the Layer Jump recording. In the case of DVD-R Dual Layer discs, the end logical block address of User Data Area on L0 and the logical block address that is located immediately before the Shifted Middle Area are also Layer Jump Addresses.

2.2.84 Layer Jump recording

A kind of sequential recording to perform recording on Layer 0 and Layer 1 alternately on a Dual Layer medium. On DVD-R Dual Layer discs, the Format 4 RMD is used to perform Layer Jump recording.

2.2.85 LBA (Logical Block Address)

The LBA defines a mapping mode to a linear address space.

2.2.86 Lead-in Area

The CD Lead-in Area is the area on a CD disc preceding the first track. The area 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 but is not directly addressable via the command set. 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.

The HD DVD Lead-in Area is the area consists of 3 parts; System Lead-in Area, Connection area and Data Lead-in Area.

2.2.87 Lead-out Area

The CD Lead-out Area is the area on a CD disc beyond the last information track. The main channel in the Lead-out Area contains audio or data null information. This area is coded as track AAbcd but is not directly addressable via the command set.

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 Layer discs and Dual Layer PTP (Parallel Track Path) discs, or 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) discs.

The HD DVD Lead-out Area consists of 1 or 3 parts as follows:

- HD DVD-ROM (OTP) Lead-out Area consists of System Lead-out Area, Connection area and Data Lead-out Area.
- HD DVD-ROM (PTP)/R/Rewritable Lead-out Area consists of Data Lead-out Area only.

2.2.88 L-EC

Layered Error Correction (L-EC) is an error correction technique used with CD-ROM sectors.

2.2.89 Linking Loss Area

For DVD-R/-RW, area that is used for linking the new recording data after the previous recording data when Incremental recording or Layer Jump recording mode are selected.

2.2.90 Logical Block

See “Block.”

2.2.91 Logical Track

A track is a logical sub-division of the CD media. A disc has from one to ninety-nine tracks. The data within a track is always of the same type. A track may be either CD-ROM or CD-Audio. A disc may start at any track number.

2.2.92 logical unit

A physical or virtual peripheral device addressable through a device.

2.2.93 LPP (Land Pre-pit)

Pits embossed on land during the manufacture of a DVD-R disc substrate which contains address information.

2.2.94 L-RMZ

RMZ located in the Data Lead-in Area.

2.2.95 LUN (logical unit Number)

The address of a logical unit.

2.2.96 Magazine

A container for multiple discs or cartridges.

2.2.97 Medium

A single Disc.

2.2.98 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 Dual Layer media.

2.2.99 Morph

An Event that occurs whenever the data that would be reported by a GET CONFIGURATION command changes.

2.2.100 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 bcd values from 0 through 79 in the user Data Area.

2.2.101 Next Border Marker

The sector that is a flag to indicate whether the next Border-in Area, Bordered Area and Border-out Areas exist or not.

2.2.102 Next Writable Address (NWA)

Data appendable address during sequential recording and Restricted Overwrite mode with intermediate state.

2.2.103 One

"One" represents a true signal value or a true condition of value.

2.2.104 OPC (Optimum Power Calibration)

A process to determine the optimum recording power for a given disc/logical unit system.

2.2.105 OTP (Opposite Track Path)

An OTP disc has a Lead in, two separated user areas, Lead-out, and a Middle Area. The physical sector number (PSN) of sectors in L0 increases toward the Middle Area. The physical sector number (PSN) of sectors in Layer 1 are numbered with the complement of the L0 sector below it. The sector numbering in Layer 1 increases from the Middle Area to the Lead-out Area.The relation between the Logical Block Address and the physical sector number is shown in Figure 7 - *Physical and logical layout of Opposite Track Path DVD-ROM/R Dual Layer media* on page 73 and Figure 107 - *Physical and logical layout of Opposite Track Path HD DVD-ROM media* on page 245.

2.2.106 Output Port

The Output Port is a means for connecting to data ports other than the host interface, e.g., Audio.

2.2.107 Packet

A recording unit which includes an integer number of contiguous sectors. For CD media, a Packet includes a Link block, four Run-in blocks, two Run-out blocks and User Data blocks. For DVD/HD DVD media, a Packet includes ECC block(s).

2.2.108 Page

Several commands use regular parameter structures that are referred to as pages. These pages are identified with a value known as a page code.

2.2.109 Pause Area

A “Pause Area” is a transition area at the beginning or end of a CD audio track encoded with audio silence. This transition area is required where the CD audio track immediately precedes a CD data track.

2.2.110 PCA (Power Calibration Area)

Area used for Optimum Power Calibration. This area ends at the start of the RMA or PMA.

2.2.111 Phase-change

A physical effect in which a laser beam irradiated area of a recording film is heated so as to reversibly change from an amorphous state to a crystalline state, and vice versa.

2.2.112 Physical Track

A concept of a continuous spiral where the physical track begins at a point in the spiral continuing for 360 degrees along the spiral. A spiral contains multiple physical tracks.

2.2.113 PI error correction

An error correction process of user data in an ECC block using inner-code parity (PI) of the ECC block.

2.2.114 PMA (Program Memory Area)

PMA is the area for temporary storage of Table of Contents entries. This area starts right after the PCA and it ends at the start of the Lead-in.

2.2.115 PO error correction

An error correction process of user data in an ECC block using outer-code parity (PO) of the ECC block.

2.2.116 Post-gap Area

Post-gap Area is a transition area at the end of a data track and is encoded with null information. This transition area is required where the data track immediately precedes an audio track.

2.2.117 Pre-gap Area

Pre-gap Area is a transition area at the beginning of a data track and is encoded with null information. This transition area is required where the data track immediately follows an audio track.

2.2.118 Pre-Groove

The wobbled guidance track on recordable media. (e.g., CD-R and DVD-R).

2.2.119 Program Area

Contains the user data on CD media.

2.2.120 PSN (Physical Sector Number)

Each sector on DVD/HD DVD media is addressable by the logical unit using an address called the Physical Sector Number or PSN. Not all of these sectors are addressable using an LBA. In the SCSI world this address is normally called the Physical Block Address or PBA.

2.2.121 PTP (Parallel Track Path)

A PTP disc has a Lead in, user area and Lead-out in each layer respectively. The physical sector number (PSN) of both layers increase to the Lead-out in parallel. The relation between the Logical Block Address and the physical sector number is shown in Figure 6 - *Physical and logical layout of Parallel Track Path DVD-ROM Dual Layer media* on page 72 and Figure 106 - *Physical and logical layout of Parallel Track Path HD DVD-ROM media* on page 244.

2.2.122 RDZ (RMD duplication zone)

RDZ is the zone for recording the latest RMD. This zone starts right after the Guard track zone and ends at the start of the RMZ.

2.2.123 Read/Modify/Write

Read/Modify/Write operation is a type of write operation and performs the following operation.

- Read data from a medium into a data buffer using the smallest writable unit. e.g., Packet/ECC block.
- Modify portions of that data with the data from the host.
- Write these data to the medium using the smallest writable unit.

2.2.124 Reed-Solomon code

An error detection and/or correction code which is particularly suited to the correction of errors which occur in bursts or are strongly correlated.

2.2.125 Region Code

A value used to identify a region of the world for DVD. Currently, there are only six regions defined.

2.2.126 Relative M/S/F Field

See “MSF Address.”

2.2.127 RMA (Recording Management Area)

RMA is the area for recording RMD. This area starts right after the PCA and it ends at the start of the Lead-in.

2.2.128 RMD (Recording Management Data)

The data to be stored in RMA/RMZ/RDZ.

2.2.129 RMZ (Recording management zone)

RMZ is the zone for recording RMD. Three kinds of RMZ formats are defined, L-RMZ, B-RMZ and U-RMZ.

2.2.130 RPC (Regional Playback Control)

The technique used to prevent CSS movie content from being viewed outside the content provider’s specified region(s) of the world.

2.2.131 RZone

The RZone is a collection of logical blocks with a defined sequence of recording. The RZone is a structure to manage a data appendable point. The logical blocks on a layer in an RZone are contiguous.

In case of Layer Jump recording capable medium, LBA may be discontinuous at a Layer transition point in an RZone.

2.2.132 Sector

For CD media, "Sector" refers to the data contained in one frame. In the CD-ROM standard document the term Block is used for this unit. Equivalent to an MSF Frame.

For DVD/HD DVD media, "Sector" is the smallest addressable part of a medium.

2.2.133 Sequential Recording

A method for recording sectors contiguously onto the media.

2.2.134 Session

A contiguous area of a Disc that contains a Lead-in, a Program Area (PA), and a Lead-out.

2.2.135 Single Layer

There is exactly one recording layer accessible from a given side of the media.

2.2.136 Single Sided

The DVD/HD DVD disc mechanical structure of two transparent substrates joined together such that the recorded layers are on the inside. Single sided discs have one recorded side and one unrecorded side.

2.2.137 Software Defect Management

A Defect Management that the defect list is managed by the host. See 2.2.41 Defect management.

2.2.138 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 drive, such as the control field and MSF addresses.

2.2.139 SY0

See "Block Sync."

2.2.140 Title Key

A value used during the encryption/decryption process of user data on DVD media.

2.2.141 TOC (Table Of Contents)

The table of contents has information on the type of disc and the starting address of the tracks. This information is encoded in the Q sub-channel, in the Lead-in Area of CD media.

2.2.142 Track Relative Logical Address

An address of a Logical Blocks relative to the beginning of a logical track.

2.2.143 Transition Area

Sector at the beginning or end of logical tracks e.g., Pause Area, Pre-Gap, Lead-out, Post-gap that are coded with null information are called transition areas. Where required by the media standards, these areas have minimum lengths. The maximum lengths are not specified. Transition areas at the beginning of a logical track are encoded with index zero.

2.2.144 UPC (Universal Product Code)

Controlled by the UC Council, Inc., located at 1009 Lenox Drive, Suite 202 Lawrenceville, NJ 08648.

2.2.145 U-RMZ

RMZ located in the User Data Area.

2.2.146 User Data

The data that is normally transferred across the logical unit interface by and for read and write commands.

2.2.147 Volume

1. A side of a medium. 2. The perceived loudness of audio.

2.2.148 Write back cache

During write operation, the data that is to be written to the medium is first stored in the cache memory, then written to the medium at a later time. The command may complete prior to the data being written to the medium.

2.2.149 Zero

Zero is a false signal value or a false condition of a variable.

2.3 Keyword definitions

Several keywords are used to differentiate between different levels of requirements and optionality, as follows:

2.3.1 expected

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

2.3.2 may

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

2.3.3 shall

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

2.3.4 should

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

2.3.5 obsolete

A keyword indicating items that were defined in prior standards but have been removed from this document.

2.3.6 mandatory

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

2.3.7 optional

A keyword that describes features which are not required to be implemented by this specification. However, if any optional feature defined by the specification is implemented, it ***shall*** be implemented as defined by the specification. Describing a feature as optional in the text is done to assist the reader. If there is a conflict between text and tables on a feature described as optional, the table ***shall*** be accepted as being correct.

2.3.8 Reserved

A key word 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 specification. A reserved bit, byte, word or field ***shall*** be set to zero, or in accordance with a future extension to this specification. 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.

2.4 Symbols, abbreviations and acronyms

Table 2 - The list of symbols, abbreviations and acronyms

Symbols /abbreviation	Definition
Border	Bordered Area
Border-in	Border-in Area
Border-out	Border-out Area
CDZ	Control Data Zone
DAO	Disc-at-Once
L0	Layer 0
L1	Layer 1
Lead-in	Lead-in Area
Lead-out	Lead-out Area
LLA	Linking Loss Area
LRA	Last Recorded Address
LSB	Least Significant Bit
MSB	Most Significant Bit
NWA	Next Writable Address
SAO	Session-at-Once
TAO	Track-at-Once

3.0 CD model

Data transfer may begin with any of the consecutively numbered logical blocks. Data on CD logical units is addressed the same as for (magnetic) direct-access logical units. Some CD logical units support a separate information stream (e.g., audio and/or video but referred to as audio in this Section) transmitted via a connection other than the ATA Bus. This specification defines commands for controlling these other information streams for CD logical units.

CD logical units are designed to work with any disc that meets IEC 908. Many new logical units read CD data discs, digital audio discs, and audio-combined discs (i.e. some Tracks are audio, some Tracks are data).

Note: Important notice to implementor of CD-R and CD-RW applications
There are still large number of logical units that can only record to CD-R and CD-RW media, and they are mostly MMC-1 compatible. This specification defines many commands, but implementor of this specification need to be notified that Legacy CD-R/RW logical units may only recognize the MMC-1 command scheme.
Typical commands that are supported in this category of logical units are as follows:

BLANK
CLOSE TRACK/SESSION
FORMAT UNIT
INQUIRY
MODE SELECT
MODE SENSE
PREVENT/ALLOW MEDIUM REMOVAL
READ BUFFER CAPACITY
READ DISC INFORMATION
READ TOC/PMA/ATIP
READ TRACK INFORMATION
REQUEST SENSE
RESERVE TRACK
SET CD SPEED
START/STOP UNIT
SYNCHRONIZE CACHE
TEST UNIT READY
WRITE (10)

3.1 CD media organization

The formats written on the CD-ROM and CD-DA (Digital Audio) media require special interfacing considerations.

Discs may contain either audio, data or a mixture of the two. Table 3 gives an example of an audio-combined disc to illustrate the relationship between the logical block addresses reported and the MSF address encoded on the media.

Note: The term "Frame" is used in two different ways in the CD media standards. The intended meaning can only be determined from the context. Whenever possible, this description replaces the larger data unit with the more familiar term sector. The primary exception to this policy is the use of frame when referring to the MSF address. In the MSF context, one frame (F field unit) equals one sector. On a typical two channel CD-DA media, each frame (F field unit) is played in 1/75th of a second.

Table 3 - Example mixed mode CD disc layout

Block Description	Logical Address (Decimal)	Absolute MSF Address[a] (Hex)	Track and Index	Sector is Info or is Pause	Mode Audio or Data	CD-ROM Data Mode[b]
Lead-in Area[c]	---	---	0/-	---	Audio	---
Pre-gap[c]	---	00/00/00	1/0	Pause	Data	Null
1st Track data	0000[d]	00/02/00[e]	1/1	Info	Data	L-EC
2nd Track data	6000[d]	01/16/00[e]	2/1	Info	Data	L-EC
	7500	01/2A/00	2/2	Info	Data	L-EC
Post-gap	9000	02/02/00	2/3	Pause	Data	Null
Pause-silence	9150	02/04/00	3/0	Pause	Audio	---
3rd Track audio	9300	02/06/00	3/1	Info	Audio	---
	11400	02/22/00	3/2	Info	Audio	---
4th Track audio	21825	04/35/00	4/1	Info	Audio	---
Pre-gap part 1	30000	06/2A/00	5/0	Pause	Audio	---
Pre-gap part 2	30075	06/2B/00	5/0	Pause	Data	Null
5th Track data	30225	06/2D/00	5/1	Info	Data	L-EC
Last information	263999	3A/29/4A	5/1	Info	Data	L-EC
Post-gap	264000	3A/2A/00	5/2	Pause	Data	Null
Lead-out Track	264150	3A/2C/00[f]	AA/0	Pause	Audio	---

a. Absolute MSF address repeated in the header field of data blocks.

b. The CD-ROM data mode is stored in the header of data Tracks. This indicates that the block is part of a data pre-gap or post-gap (null), that this is a data block using the auxiliary field for L-EC symbols (ECC - CD-ROM data mode one), or that this is a data block using the auxiliary field for user data (CD-ROM data mode two).

c. Table of contents information is stored in the sub-channel of Lead-in Area. The Lead-in Area is coded as Track zero. Track zero and the initial 150 sector pre-gap (or audio pause) are not accessible with logical addressing.

d. Exact value returned by READ TOC/PMA/ATIP command.

e. Value stored in Table of Contents with zero tolerance.

f. Value stored in Table of Contents; exact, if Lead-out Track is coded as data, or plus or minus 75 blocks if coded as audio.

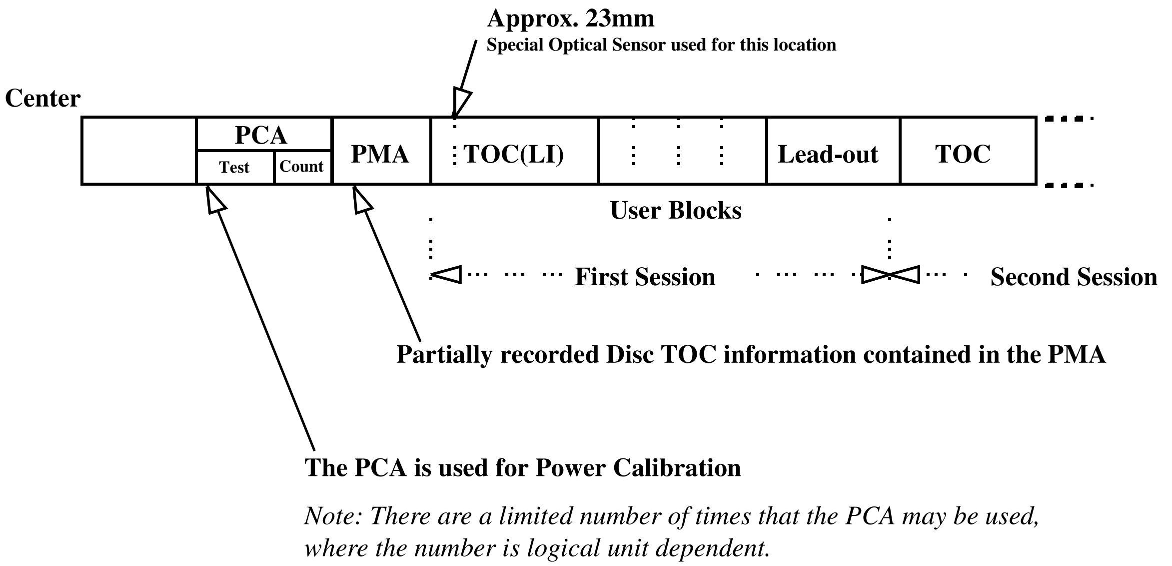


Figure 1 - CD-R/RW disc layout

The physical format defined by the CD-ROM media standards provides 2352 bytes per sector. For usual computer data applications, 2048 bytes are used for user data, 12 bytes for a synchronization field, 4 bytes for a sector address tag field and 288 bytes - the auxiliary field - for L-EC (CD-ROM data mode 1). In less critical applications, the auxiliary field may also be used for user data (CD-ROM data Mode 2 / Form 2).

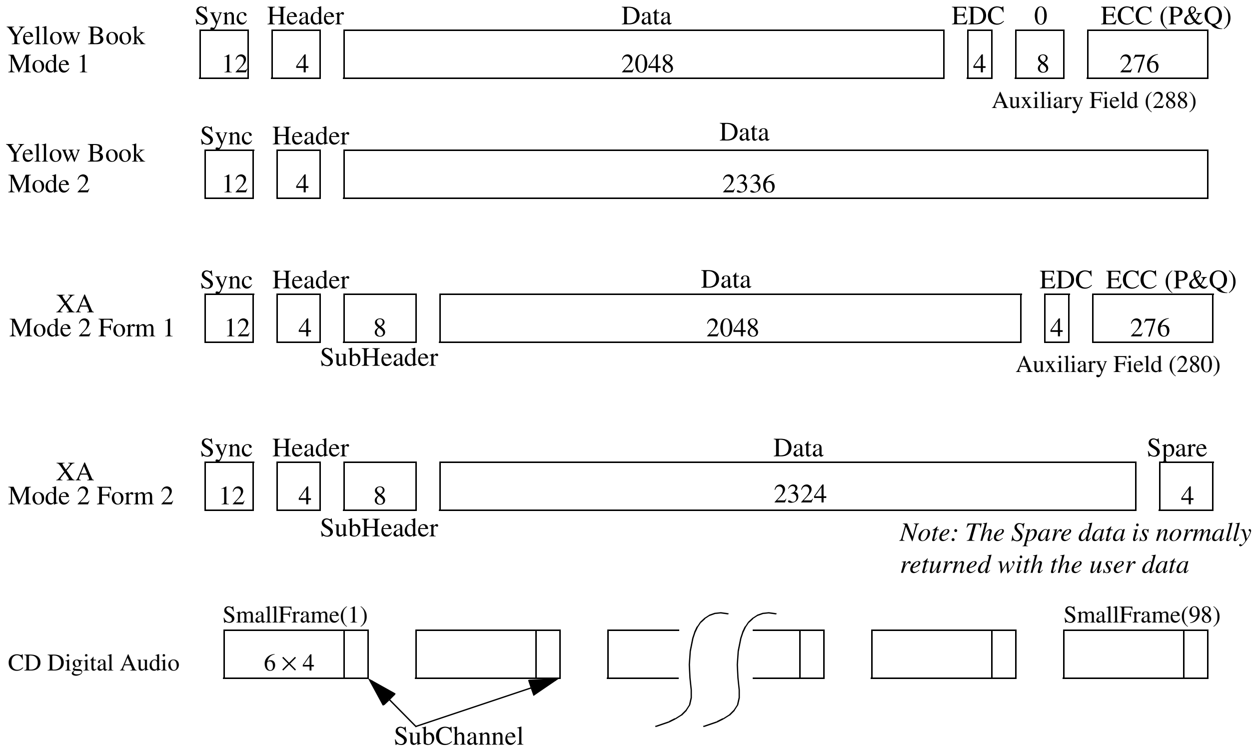


Figure 2 - CD-ROM sector formats

A CD logical sector size is 2048, 2052, 2056, 2324, 2332, 2336, 2340 or 2352 bytes per sector. These values correspond to the user data plus various configurations of header, subheader and EDC/ECC.

This same area of the CD-ROM or CD audio media may store 1/75th of a second of two channel audio information formatted according to the CD-DA specification. (These audio channels are usually the left and right components of a stereo pair.) An audio only density code value may be used to declare an area of the media to be invalid for data operations.

For data and mixed mode media (those conforming to ISO/IEC 10149), logical block address Zero ***shall*** be assigned to the block at MSF address 00/02/00. For audio media (those conforming only to IEC 908), logical block address Zero ***shall*** be assigned to the actual starting address of Track 1. This may be approximated by using the starting address of Track 1 contained in the Table of Contents (TOC) or by assigning logical block address Zero to the block at MSF address 00/02/00.

A Track may be viewed as a partition of the CD address space. The CD media contains from one to ninety-nine Tracks. All information sectors of a Track are required to be of the same type (audio or data) and mode. Each change in the type of information on the disc requires a change in Track number. A disc containing both audio and data would have at least two Tracks, one for audio and one for data.

The Tracks of a CD media are numbered consecutively with values between 1 and 99. However, the first information Track may have a number greater than 1. Tracks have a minimum length of 300 sectors including any transition area that is part of a Track.

The CD media standards require transition areas between Tracks encoded with different types of information. In addition, transition areas may be used at the beginning or end of any Track. For audio Tracks the transition areas are called pause areas. For data Tracks, transition areas are called pre-gap and post-gap areas. See Table 3 - *Example mixed mode CD disc layout* on page 58 for an example. The IEC 908 and ISO/IEC 10149 standards specify minimum time durations for these areas. Maximum time durations are not specified.

Transition areas are formatted and the logical address continues to increment through transition areas. Some media (i.e. discs with only one Track) may not have transition areas. The means to determine the location of the transition areas is vendor or application-specific and is addressed by other standards (e.g., ISO 9660).

CD is unique in the respect that some logical blocks on a disc may not be accessible by all commands. SEEK commands may be issued to any logical block address within the reported capacity of the disc. READ (10) commands cannot be issued to logical blocks that occur in some transition areas, or to logical blocks within an audio Track. PLAY AUDIO (10) commands cannot be issued to logical blocks within a data Track.

CD media have Lead-in and Lead-out Areas. These areas are outside of the user-accessible area as reported in the READ CAPACITY command data. The Lead-in Area of the media is designated Track zero. The Lead-out Area is designated Track AAh. The sub-channel Q in the Lead-in Track contains a Table of Contents (TOC) of the disc.

Note: The READ FORMAT CAPACITIES command returns the logical block address of the last block prior to the Lead-out Area. This location may be in a transition area and therefore not a valid address for read operations.

The Table of Contents gives the absolute MSF location of the first information sector of each Track. Control information (e.g., audio/data, method of audio encoding) for each Track is also given in the TOC. However, the TOC does not distinguish between the different modes of data Tracks (i.e. CD-ROM Data Mode 1 vs. CD-ROM Data Mode 2).

The MSF locations of the beginning of data Tracks in the TOC are required to be accurate; however, the TOC values for audio Tracks have a tolerance of plus or minus 75 sectors. Information from the TOC can be used to reply to a READ CAPACITY command. When this is done, the logical unit implementor ***shall*** consider the possible tolerances and return a value that allows access to all information sectors.

An index is a partition of a Track. Pre-gap areas are encoded with an index value of zero. Pause areas at the beginning of audio Tracks are also encoded with an index value of zero. The first information sector of a Track has an index value of one. Consecutive values up to 99 are permitted. Index information is not contained in the TOC. Not all sectors are encoded with the index value in the Q-sub-channel data (the requirement is 9 out of 10). A sector without an index value is presumed to have the same index as the preceding sector.

Tracks and indexes are not defined to be any particular length, (except for a minimum Track length of 300 sectors.) A CD disc may be created with a single information Track that has a single index; or with 99 information Tracks, each with 99 indices.

The sub-channel information which is part of each sector includes a Track relative MSF location value giving the distance from the first information sector of the Track. On the media, this value decreases during the pre-gap area (sectors with index values of 0) and increases for the rest of the Track. The data, returned by the READ SUBCHANNEL command with MSF bit set to zero, converts this to a Track relative logical block address (TRLBA). The TRLBA is continually increasing over the whole Track, and pre-gap areas ***shall*** return negative values. When the MSF bit in the READ SUBCHANNEL command is set to one, the MSF Track relative location value from the media is reported without change.

*Note: The purpose of accessing MSF addresses less than 00/02/00 MSF is to retrieve information, such as packet size, from incrementally written discs. This information exists in the Track Descriptor Block in the pre-gap area. Users can read this information by scanning the area between 00/01/00 MSF to 00/02/00 MSF. While the media may contain multiple redundant copies of the pre-gap data, the logical unit **shall** only return one copy. The logical unit may not be able to read 00/00/00 MSF since there is no Sub-Q information before this frame. See the Orange Book Part 2 for additional details.*

3.2 CD physical data format

The physical format of CD-ROM and CD-DA media uses a smaller unit of synchronization than the more familiar magnetic or optical recording systems. The basic data stream synchronization unit is a small frame. This is not the same large frame (sector) as referred to in the MSF unit. Each small frame consists of 588 bits. A sector on CD media consists of 98 small frames.

A CD small frame consists of:

1. 1 synchronization pattern (24+3 bits)
2. 1 byte of sub-channel data (14+3 bits)
3. 24 bytes of data ($24 \times (14+3)$ bits)
4. 8 bytes of CIRC code ($8 \times (14+3)$ bits) Total: 588 bits.

Data, sub-channel and CIRC bytes are encoded with an 8-bit to 14-bit code; then three merging bits are added. The merging bits are chosen to provide minimum low-frequency signal content and optimize phase lock loop performance.

3.2.1 Frame format for audio

Each small frame of an audio Track on a two-channel CD-DA or CD-ROM media consists of six digitized 16-bit samples of each audio channel. These 24 bytes of data are combined with a synchronization pattern, CIRC bytes and a sub-channel byte to make a frame. Each frame takes approximately 136.05 µs to play. This gives a sampling rate of 44.1 kHz for each channel. The sub-channel information creates the higher level sector grouping for audio Tracks.

3.2.2 Sector format for data

The data bytes of 98 small frames comprise the physical unit of data referred to as a sector. (98 small frames times 24 bytes per small frame equals 2352 bytes of data per sector.)

A sector that contains CD-ROM Data Mode 1 data has the following format:

1. 12-byte synchronization field
2. 4-byte CD-ROM data header:
   - Absolute M field
   - Absolute S field
   - Absolute F field
   - CD-ROM data mode field
3. 2048-byte user data field
4. 4-byte error detection code
5. 8 bytes zero
6. 276-byte layered error correction code

A sector that contains CD-ROM Data Mode 2 data has the following format:

1. 12-byte synchronization field
2. 4-byte CD-ROM data header
   - Absolute M field
   - Absolute S field
   - Absolute F field
   - CD-ROM data mode field
3. 2336-byte user data field (2048 bytes of mode 1 data plus 288 bytes of auxiliary data)

Note: Many logical unit*s are capable of returning CD-ROM data mode one data in a CD-ROM data mode two format. This allows the user to investigate the error detection and error correction codes. However data encoded as CD-ROM data mode two cannot be read as CD-ROM data mode one data.*

3.2.3 Sub-channel information formats

The sub-channel byte of each frame is assigned one bit for each of the 8 sub-channels, designated P, Q, R, S, T, U, V, W.

Sub-channel P is a simple flag bit that may be used for audio muting control and Track boundary determination.

Sub-channel Q has a higher level of structure. All the sub-channel Q bits of a sector define the sub-channel Q information block. (For audio Tracks, decoding the Q sub-channel is the only way to distinguish sector boundaries.)

The sub-channel Q block consists of 98 bits, one bit from each small frame in a sector. Three formats are defined for the sub-channel Q information block. The first format provides location information and is defined as follows:

1. 2-bit sub-channel synchronization field
2. 4-bit ADR field (defines the format)
3. 4-bit control field (defines the type of information in this sector)
4. 8-bit Track number
5. 8-bit index number
6. 24-bit Track relative MSF address
7. 8 bits Reserved (0)
8. 24-bit Absolute MSF address
9. 16-bit CRC error detection code

This format is required to exist in at least nine out of ten consecutive sectors.

The second and third formats are optional. If used, they ***shall*** exist in at least one out of 100 consecutive sectors. They include the absolute frame byte of the MSF address to provide location information continuity.

The second format gives the catalogue number of the disc (UPC/EAN bar code number). This information is constant over the whole media.

The third format gives the International Standard Recording Code (ISRC) for each Track. The ISRC is defined in ISO 3901. This format is not present on Lead-in or Lead-out Tracks and may change only after the Track number changes.

3.3 CD audio error reporting

PLAY AUDIO commands with the immediate bit set in the audio control mode return status as soon as the command has been validated (which may involve a seek to the starting address). The playback operation continues and may complete without notification to the host. Error termination of audio operations ***shall not*** be reported to the host.

The status of the play operation may be determined by issuing a REQUEST SENSE command. The sense key is set to NO SENSE and the audio status is reported in the Additional Sense Code Qualifier field.

3.4 CD READY condition/NOT READY condition

The READY condition occurs after a disc is inserted and the logical unit has performed its initialization tasks. These tasks may include reading the Lead-in information from the media. This “READY” is different from and should not be confused with the ATA READY status. A CHECK CONDITION status ***shall*** be returned for the NOT READY condition only for commands that require or imply a disc access.

A NOT READY condition may occur for the following reasons:

1. There is no disc mounted.
2. The logical unit is unable to load or unload the disc.
3. The logical unit is performing an extended operation as the result of an Immediate mode command such as FORMAT UNIT or BLANK. This condition is defined in Logical Unit Not Busy condition/Busy condition.

The logical unit ***shall*** spin up and make the disc ready for media accesses when a new disc is detected.

After the logical unit becomes ready, the logical unit may enter the power state in which the logical unit was when the previous medium was removed.

Any media access that occurs when the logical unit is not spinning ***shall*** spin the media up and not generate an error. Any media access that is requested while a deferred operation is in progress (i.e. writing from a write cache) ***shall not*** generate an error.

Note: Accesses to the media can be satisfied from the logical unit’s cache and may not require the media to be spinning.

Some commands are allowed to generate a “NOT READY” CHECK CONDITION, and others are not. Table 183 - *NOT READY error & Time-out UNIT ATTENTION reporting (by command)* on page 362.

3.5 Logical Unit Not Busy condition/Busy condition

While a logical unit is in Logical Unit Busy condition after the logical unit becomes READY condition, the logical unit may not be able to execute some commands and will respond with CHECK CONDITION status. The following Sense Key/ASC/ASCQ are defined for possible Logical Unit Busy condition.

- 2/04/04 LOGICAL UNIT NOT READY, FORMAT IN PROGRESS,
- 2/04/07 LOGICAL UNIT NOT READY, OPERATION IN PROGRESS
- 2/04/08 LOGICAL UNIT NOT READY, LONG WRITE IN PROGRESS.

Some commands (e.g., RESERVE TRACK/RZONE/RMZ command, SEND OPC INFORMATION command) that do not have IMMED bit in their Command Descriptor Block may cause a Logical Unit Busy condition.

There are several cases that are not Logical Unit Busy conditions.

1. Commands that have an IMMED bit set to one in their Command Descriptor Block may cause a Logical Unit Busy condition. During cached recording when the write buffer has become full, a logical unit may respond to a WRITE command with CHECK CONDITION status, 2/04/08 LOGICAL UNIT NOT READY, LONG WRITE IN PROGRESS. This case is not a Logical Unit Busy condition.
2. While a logical unit is recognizing a medium at the medium insertion, the logical unit responds to a TEST UNIT READY command with CHECK CONDITION status, 2/04/01 LOGICAL UNIT IS IN PROCESS OF BECOMING READY. This case is not a Logical Unit Busy condition. It is because that the logical unit may not be Ready condition if the logical unit does not support the inserted medium. The logical unit cannot show the remaining time to be not busy before the logical unit recognizes the medium.
3. A logical unit may become Busy under the conditions described above, however, the logical unit is not required to become Busy. For example, if the host sends a CLOSE TRACK/RZONE/SESSION/BORDER command with IMMED bit set to one to close a track and the track is already closed, the logical unit may terminate the command with GOOD status and never enter the Logical Unit Busy condition.

3.6 CD address reporting formats (MSF bit)

Several CD specific commands can return addresses either in logical block address or in MSF format. The READ SUBCHANNEL, and READ TOC/PMA/ATIP commands have this feature.

Table 4 - MSF address format

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

An MSF bit of zero requests that the logical block address format be used for the absolute address field or for the offset from the beginning of the current Track expressed as a number of logical blocks in a CD Track relative address field.

An MSF bit of one 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. The M, S, and F Fields are expressed as binary numbers.

3.7 Error reporting

If any of the following conditions occur during the execution of a command, the CD logical unit ***shall*** return CHECK CONDITION status. The appropriate sense key and additional sense code ***shall*** 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 5 - Error conditions and Sense Keys

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
Device reset or medium change since last command	UNIT ATTENTION
Self diagnostic failed	HARDWARE ERROR
Unrecorded 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 logical units. The following cases ***shall*** cause CHECK CONDITION status, 5/63/00 END OF USER AREA ENCOUNTERED ON THIS TRACK:

1. a post-gap area is encountered (i.e., a block with CD-ROM Data Mode 0);
2. a pre-gap area is encountered (i.e., a block with index equal to 0);
3. The information type (e.g., Data Mode vs. Audio) changes.

When not performing audio playback, if the logical block address requested is not within a data Track, the command ***shall*** be terminated with CHECK CONDITION status, 5/64/00 ILLEGAL MODE FOR THIS TRACK. This applies to audio-combined and audio media.

3.8 Recording for CD media

There are several kinds of writing method of recording data in CD media. Session At Once, Track At Once, and Packet Writing are all used as methods of recording CD media. There is a special case of Session At Once recording known as Disc At Once. Packet Writing can be further classified into Variable Packet Writing and Fixed Packet Writing.

3.8.1 Packet layout for CD

The layout of a Packet on CD media is shown in Figure 3. Each packet starts with Link block followed by four Run-in blocks. The User data blocks are placed directly after the Run-in blocks. Finally, two Run-out blocks are located following the User data blocks. In the case of Fixed packet writing, the size of each Packet in a Track is constant in length.

.

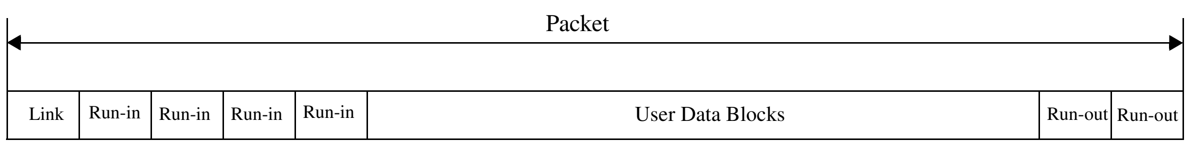


Figure 3 - Packet Layout

Figure 4 shows an example of the layout of packet written Track.

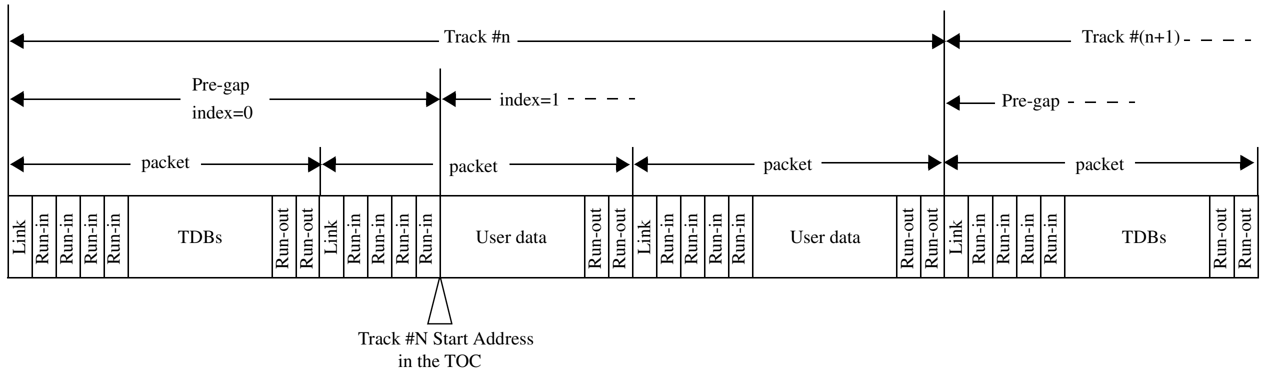


Figure 4 - Example of Packet written Track layout

3.8.2 Addressing method

For CD media, there are two kinds of addressing. Except for the space within a Fixed Packet written Track, the Logical Block Address has a one-to-one relationship to the physical block number. This type of addressing is called “Method 1 Addressing” and Logical Block Numbers are assigned to Link, Run-in, and Run-out blocks as well as User Data Blocks. In Fixed Packet written Tracks, the Logical Block Address is converted to the physical block number using “Method 2 Addressing.” In this case, Logical Block Addresses are not assigned to Link, Run-in, and Run-out blocks.

3.8.3 Track Descriptor Block (TDB)

Information about current Track attributes is encoded in the Pre-gap in a Track Descriptor Block (TDB). Optionally, all preceding Track attributes are included in the TDB. The TDB is recorded in all sectors in the second half of the Pre-gap. The TDB starts at byte 0 in the user data field of each sector. The TDB consists of Track descriptor table and Track descriptor unit(s). The Track descriptor unit gives the information such as the writing method of the Track and the packet size. The Track descriptor unit ***shall*** be used by the logical unit to determine Packet type and Packet size for a Packet recorded Track. If the disc is recorded using Session At Once, the TDB may not be present.

Table 6 - Track Descriptor Block

Bit / Byte	7	6	5	4	3	2	1	0
0 - 7	Track Descriptor Table							
0 - N	Track Descriptor Unit(s)							

Track Descriptor Table consists of 8 bytes and is structured as shown below.

Table 7 - Track Descriptor Table

Bit / Byte	7	6	5	4	3	2	1	0
0	Track Descriptor Identification (54h)							
1	Track Descriptor Identification (44h)							
2	Track Descriptor Identification (49h)							
3	Pre-Gap Length							
4								
5	Type of Track Descriptor Unit							
6	Lowest Track Number							
7	Highest Track Number							

The Track Descriptor Identification fields contain the Hexadecimal code: ’54 44 49’ (ASCII “TDI”).

The Pre-Gap Length field contain the number of blocks of the second part of this Pre Gap, encoded in BCD.

The Type of Track Descriptor Unit field indicates which Track Descriptor Units are present. When this field set to 00h, indicates that Track Descriptor Units of previous Tracks are present in this Track Descriptor Block. When this field set to 01h, indicates that only the Track Descriptor Units of the current Track is present in this Track Descriptor Block. All other values are reserved for future use.

The Lowest Track Number field indicates that the lowest Track number described in this Track Descriptor Block, encoded in BCD.

The Highest Track Number field indicates that the highest Track number described in this Track Descriptor Block, encoded in BCD.

Track Descriptor Unit describes the data attributes of the Track and consists of 16 bytes. The contents of these 16 bytes are shown in Table 8.

Table 8 - Track Descriptor Unit

Bit / Byte	7	6	5	4	3	2	1	0
0	Track Number							
1	(MSB)			Write Method of the Track				(LSB)
2	Packet Size							
3								
4								
5	Reserved							
:								
15								

The Track Number field contains that the number of the Track to which this Track Descriptor Unit belongs, BCD encoded.

The Write Method of the Track field when Bit 7 through Bit 4 set to 1000b, indicates that the Track is an uninterrupted written data Track that consists of only one packet. In this case, Bit 3 through Bit 0 are reserved and set to 0000b.

When the Bit 7 through Bit 4 set to 1001b, indicates that the Track is an incrementally written data Track that consists of more than one packet. In this condition, when Bit 3 through Bit 0 set to 0000b, indicates that the packet size is variable length. And if Bit 3 through Bit 0 set to 0001b, indicates that the packet size is fixed length. All other values for Bit 3 through Bit 0 are reserved.

When the Bit 7 through Bit 4 set to 0000b, indicates that the Track is an uninterrupted written audio Track. In this condition, Bit 3 through Bit 0 are reserved and set to 0000b.

All other values for Bit 7 through Bit 4 are reserved. And any corresponded values for Bit 3 through Bit 4 are also reserved.

The Packet Size field ***shall*** be interpreted as follows:

For Incremental written Tracks with fixed Packet Size (Byte 1 = 91h), these bytes contains the BCD encoded Packet Size in sectors (MSBytes first). For Incremental written Tracks with variable Packet Size (Byte 1='90' hex), and Uninterrupted written Data Tracks (Byte 1 = 80h), these three bytes contain the code FFFFFFh.

3.8.4 High speed CD-RW media recording

High speed CD-RW is defined in Orange Book Part 3 volume 2. High speed CD-RW recording speed ranges are from 4× to 10× recording and also allows CAV recording. Upon CAV recording, write speed needs to be set for each track. If the logical unit is not capable of recording continuous track in CAV, then the logical unit ***shall*** use CLV mode with initial speed of CAV recording. For example, if the 4×-10× CAV recording is attempted for track at once (TAO) mode, but the logical unit does not support CAV for TAO mode, then the logical unit ***shall*** choose 4× CLV recording for that track. This condition is not considered as an error.

High speed CD-RW media cannot be recorded using logical units that comply with only Orange Book Part 3 volume 1. Upon write attempt to the High speed CD-RW media using Orange Book Part 3 volume 1 complying logical unit, some logical units returns CHECK CONDITION status, 7/27/00 WRITE PROTECTED[1], or 3/02/00 NO SEEK COMPLETE. Recommended error code for this case is to return 5/30/05 CANNOT WRITE MEDIUM - INCOMPATIBLE FORMAT.

In order to minimize the impact to the large number of MMC-1 based CD-R/RW logical units and software, extensions of SET CD SPEED command and *C/DVD Capabilities & Mechanical Status* Mode Page (2Ah) are defined as an optional Feature. Also SET STREAMING command and GET PERFORMANCE command for CD-R/RW implementation are defined.

Command Sequence example:

Upon media insertion, host issues READ TRACK/RZONE INFORMATION command to find the NWA. Then either *C/DVD Capabilities & Mechanical Status* Mode Page (2Ah) or GET PERFORMANCE command are used to identify the logical unit's capability for the mounted media.

Host then issues either SET CD SPEED command or SET STREAMING command for the track to be recorded. Also the host sets an appropriate write parameters, and ready to write data.

1. Some CD-RW logical units may return 05/27/00.

4.0 DVD model

The DVD model is the description for the DVD media (DVD-ROM, DVD-R/-RW, DVD-RAM). See *2.2.58, "DVD media"* on page 47. For DVD+RW/+R media, refer to the latest version of MMC (http://www.t10.org).

The DVD has been selected by the industry to be the replacement for the CD. It has many advantages over the CD technology. The DVD media format is not backward compatible with the CD devices. The primary reason for this change was driven by the need for large amounts of data for Digital Video (Movies). Simple increase in density would not accomplish this.

Like CD logical units/media there are three types of DVD logical unit/media: Read Only (DVD-ROM), Write only Once (DVD-R), and Write Multiple times (DVD-RAM, DVD-RW). Each of these media has the possibility of one or two sides, and DVD-ROM/DVD-R may have one or two Layers per side.

A DVD logical unit may be capable of reading CD-ROM, CD-R and CD-RW media. This backwards compatibility allows a DVD logical unit to replace a CD-ROM logical unit in most systems. Although the DVD logical unit may be capable of reading the older CD media, it may not support the same commands as the CD-ROM logical unit. There are some simplifications to the command set supported. Commands that were necessary only for legacy support for the existing CD-ROM drivers have been removed.

The play mechanism may be removed from some DVD logical units. The DVD media provides several and better types of audio. It is likely that the host system will provide the needed support for these new and more capable audio data streams.

A DVD logical unit will look different to the host depending on the type of media that is currently being used. The host system will now need to deal with a logical unit that changes the commands that are possible, based on the type of media that is currently in the logical unit. This type of operation will be handled via the use of Features, Profiles, and Events. This new concept will allow the logical unit to implement various capabilities. The host will detect and configure the logical unit given the various capabilities that are possible.

4.1 DVD media description

- DVD media can contain information on one side (Single Sided) or on both sides (Double Sided).
- DVD-ROM/R disc has two types of Layer structure: Single Layer and Dual Layer.
- Each Layer on either side contains a spiral track. This track contains a Lead-in, Data Area, and a Middle Area or a Lead-out.
- DVD-ROM Dual Layer discs have two types of track path: Parallel Track Path and Opposite Track Path. DVD-R Dual Layer discs have only Opposite Track Path.
- One ECC block, having 37856 bytes, consists of 16 sectors.
- There is no TOC nor Sub-channel.
- Addressing from the host is LBA (Logical Block Address) only.
- Information concerning error correction that has been performed is not usually returned to the host.
- Some data on DVD media is used only inside of the DVD logical unit and is not transferred to the host computer. This is due in part because the Physical Addresses (PSN) that the DVD uses are not allowed across the Interface.
- The host Read & Write unit (User Data) is 2 Kilobytes (2048 Bytes).

4.1.1 DVD specifications

Table 9 specifies some DVD parameters.

Table 9 - General Parameters of DVD discs

<table>
<tr><th colspan="2"></th><th>Capacity (120 mm disc) [Gbytes]</th><th>Capacity (80 mm disc) [Gbytes]</th><th>Wavelength for read [nm]</th><th>Wavelength for write [nm]</th><th>Data Bit Length [µm]</th><th>Channel bit length [µm]</th><th>Min Pit/Mark length [µm]</th><th>Max Pit/Mark length [µm]</th><th>Track Pitch [µm]</th><th>User data per sector [bytes]</th><th>Error Correction Code</th><th>ECC Constraint Length</th><th>correctable burst error length [mm]</th><th>scan velocity (Ref.) [m/s]</th><th>channel bit rate [Mbps]</th><th>user data bit rate [Mbps]</th></tr>
<tr><td colspan="2">DVD-ROM Single Layer</td><td>4.70</td><td>1.46</td><td rowspan="15">635/
650</td><td rowspan="2">N/A</td><td>0.267</td><td>0.133</td><td>0.400</td><td>1.866</td><td rowspan="4">0.74</td><td rowspan="15">2048</td><td rowspan="15">RS (208,192,17) × RS (182,172,11)</td><td rowspan="15">16 sectors</td><td>6.0</td><td>3.49</td><td rowspan="7">26.16</td><td rowspan="7">11.08</td></tr>
<tr><td colspan="2">DVD-ROM Dual Layer</td><td rowspan="3">8.54</td><td rowspan="3">2.66</td><td rowspan="4">0.293</td><td rowspan="4">0.147</td><td rowspan="4">0.440</td><td rowspan="4">2.054</td><td rowspan="4">6.5</td><td>3.84</td></tr>
<tr><td colspan="2" rowspan="2">DVD-R Dual Layer Ver.3.0</td><td rowspan="2">650</td><td>3.84
(play back)</td></tr>
<tr><td>7.68
(recor ding)</td></tr>
<tr><td colspan="2">DVD-R Ver.1.0</td><td>3.95</td><td>1.23</td><td>635</td><td>0.80</td><td>3.84</td></tr>
<tr><td colspan="2">DVD-R for Authoring Ver.2.0</td><td>4.70</td><td>1.46</td><td>635</td><td rowspan="5">0.267</td><td rowspan="5">0.133</td><td rowspan="5">0.400</td><td rowspan="5">1.866</td><td rowspan="5">0.74</td><td rowspan="5">6.0</td><td>3.49</td></tr>
<tr><td rowspan="2">DVD-R for General Ver.2.1</td><td>1x-speed</td><td rowspan="2">4.70</td><td rowspan="2">1.46</td><td rowspan="9">650</td><td>3.49</td></tr>
<tr><td>4x-speed[a]</td><td>13.96</td><td>104.64</td><td>44.32</td></tr>
<tr><td rowspan="2">DVD-RW Ver.1.2</td><td>1x-speed</td><td rowspan="2">4.70</td><td rowspan="2">1.46</td><td>3.49</td><td>26.16</td><td>11.08</td></tr>
<tr><td>2x-speed[a]</td><td>6.98</td><td>52.32</td><td>22.16</td></tr>
<tr><td colspan="2">DVD-RAM Ver.1.0</td><td>2.6</td><td>N/A</td><td>0.409
0.435</td><td>0.205
0.218</td><td>0.614
0.653</td><td>2.863
3.045</td><td>0.74</td><td>9.2</td><td>5.96
6.35</td><td>26.16</td><td>11.08</td></tr>
<tr><td rowspan="4">DVD-RAM Ver.2.1</td><td>2x-speed</td><td rowspan="2">4.70</td><td rowspan="2">-</td><td rowspan="2">0.280
0.291</td><td rowspan="2">0.140
0.146</td><td rowspan="2">0.420
0.437</td><td rowspan="2">1.960
2.037</td><td rowspan="4">0.615</td><td rowspan="4">6.3</td><td>8.16
8.49</td><td>58.36</td><td>22.16</td></tr>
<tr><td>3x-speed[a]</td><td>12.24
12.73</td><td>87.55</td><td>33.24</td></tr>
<tr><td>2x-speed</td><td rowspan="2">-</td><td rowspan="2">1.46</td><td rowspan="2">0.280
0.295</td><td rowspan="2">0.140
0.148</td><td rowspan="2">0.420
0.443</td><td rowspan="2">1.960
2.065</td><td>8.16
8.61</td><td>58.36</td><td>22.16</td></tr>
<tr><td>3x-speed[a]</td><td>12.24
12.92</td><td>87.55</td><td>33.24</td></tr>
</table>

a. Defined in Optional specifications for each media

Note: The ranged values for DVD-RAM in Table 9 reflect its Zoned CLV format.

4.2 Track structure

There are two types of track path for DVD-ROM Dual Layer discs, either parallel or opposite. When the path is parallel each track has its own Lead-in and Lead-out.

There are two addresses used in the DVD system, the Block address contained in the sector headers (Physical Sector Number), and the address used to reference the blocks from the host system (LBA). The address used from the host starts at 0 and progresses up through the end of the recorded information on the disc. LBA 0 corresponds with the sector address of 030000h on DVD-ROM media. Only the Data Area is generally addressable using an LBA.

Figure 5 through Figure 9 show examples of LBA to Physical Sector Number translations for DVD media.

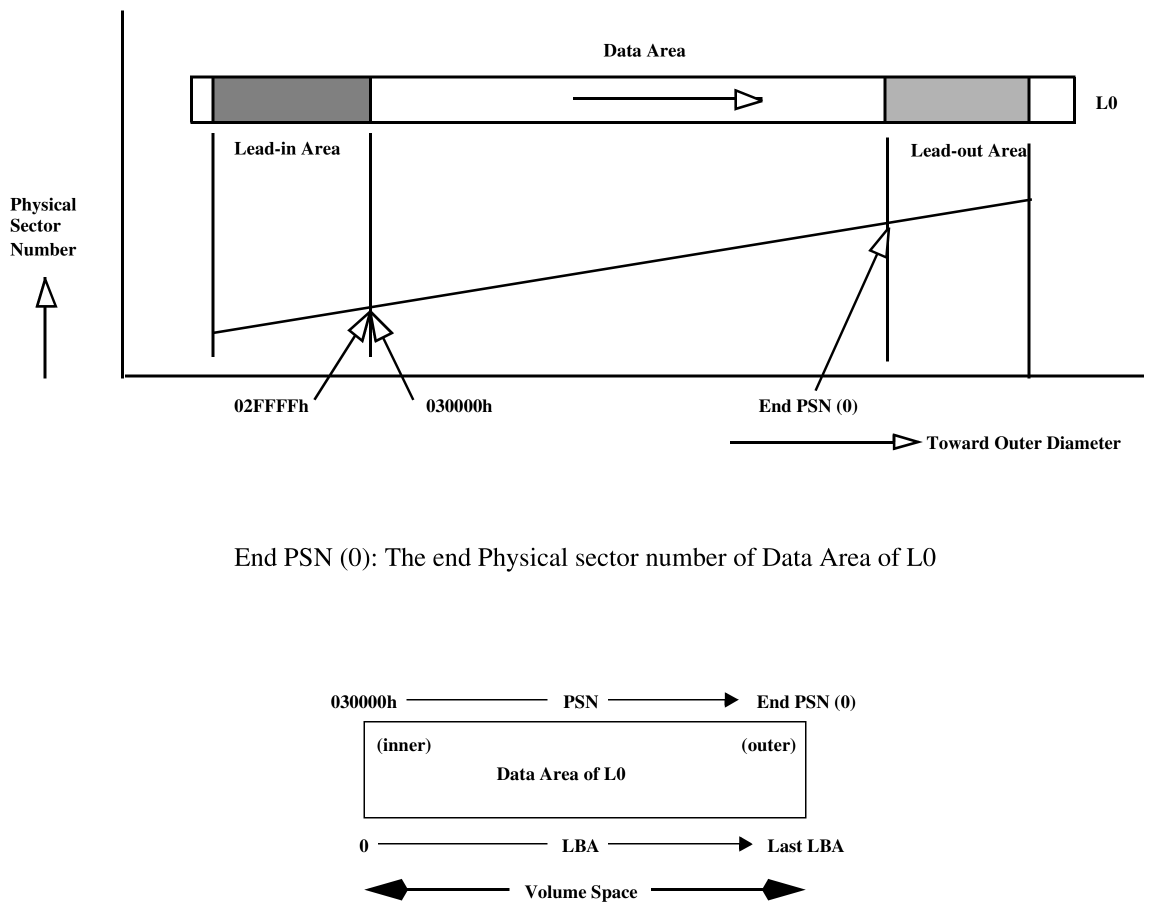
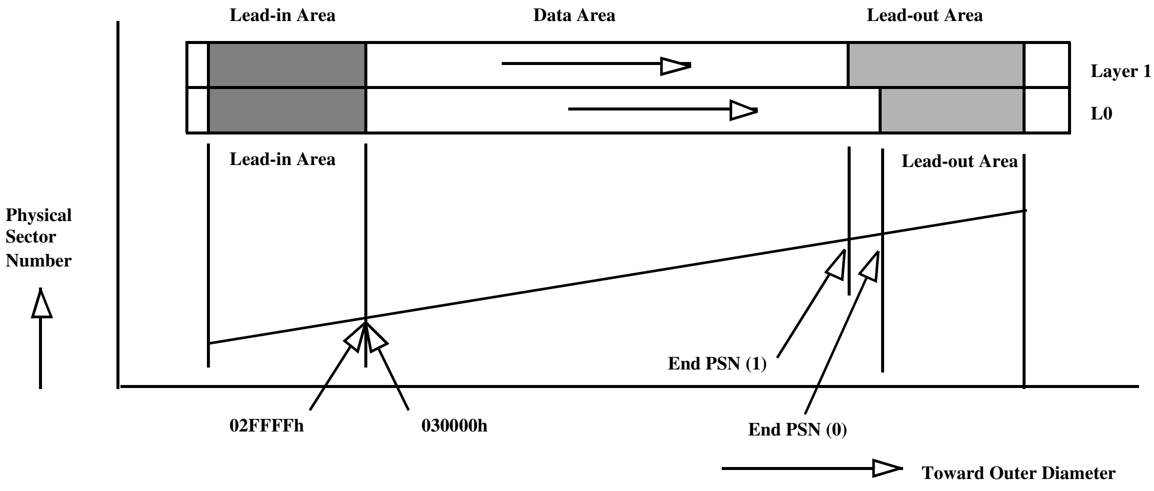


Figure 5 - Physical and logical layout of DVD-ROM Single Layer media



End PSN (0): The end Physical sector number of Data Area of L0

End PSN (1): The end Physical sector number of Data Area of Layer 1

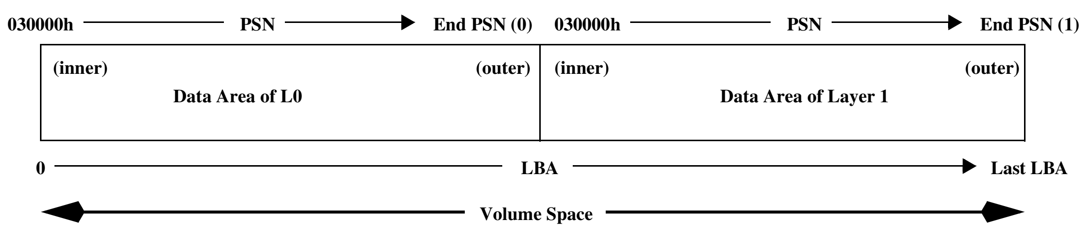
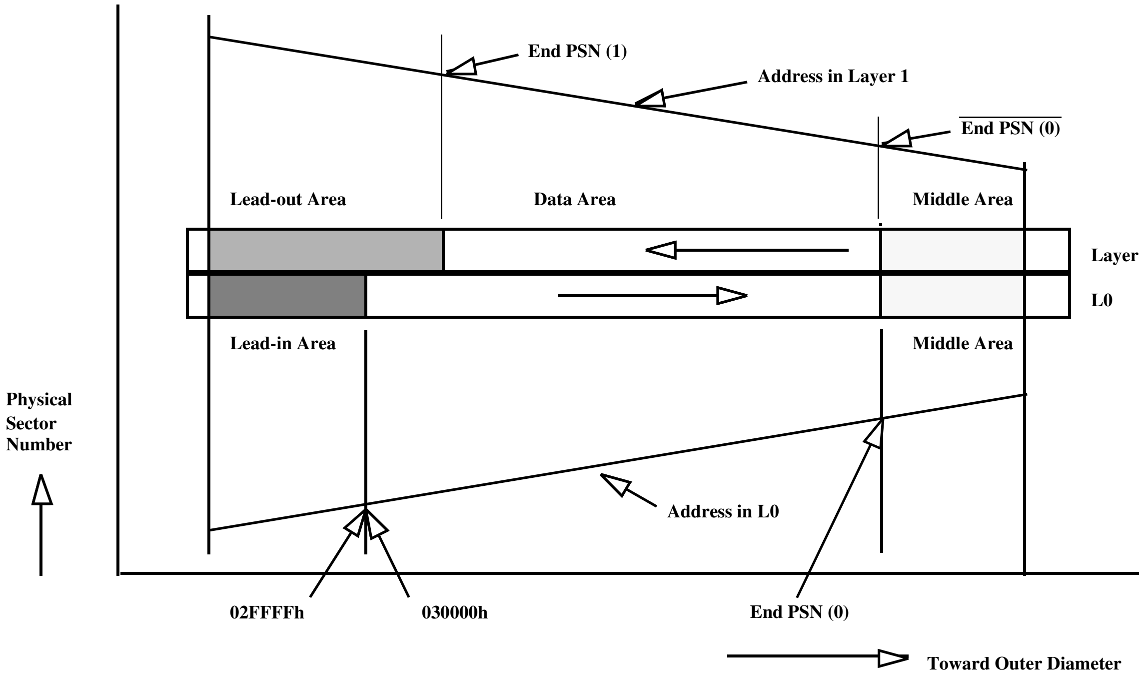


Figure 6 - Physical and logical layout of Parallel Track Path DVD-ROM Dual Layer media



End PSN (0): The end Physical sector number of Data Area of L0. The End PSN (0) is a multiple of 16.

$\overline{\text{End PSN (0)}}$: The number calculated so that each bit of the End PSN (0) is inverted.

End PSN (1): The end Physical sector number of Data Area of Layer 1

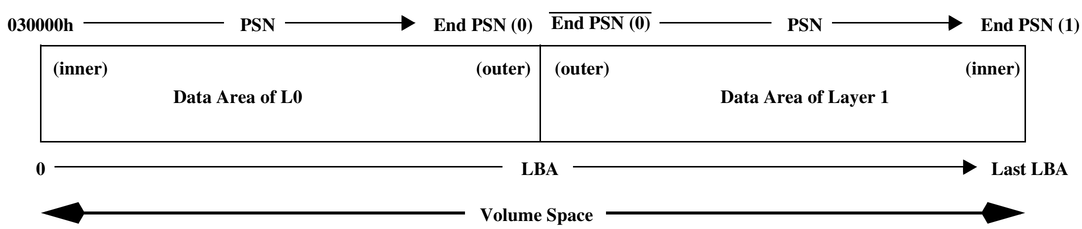
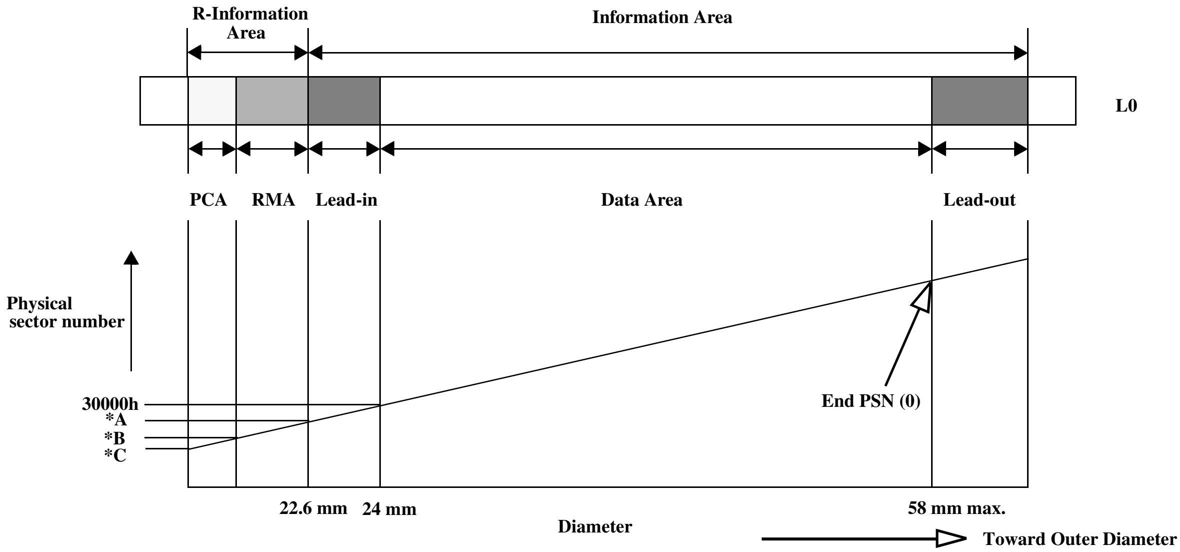


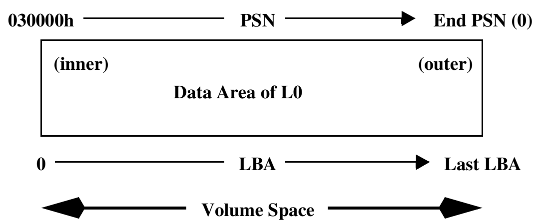
Figure 7 - Physical and logical layout of Opposite Track Path DVD-ROM/R Dual Layer media



*A (Lead-in start address) 24FA0h: DVD-R Book Ver.1.0
22FA0h: DVD-RW Book Ver.1.2
DVD-R for Authoring Ver.2.0
DVD-R for General Ver.2.1

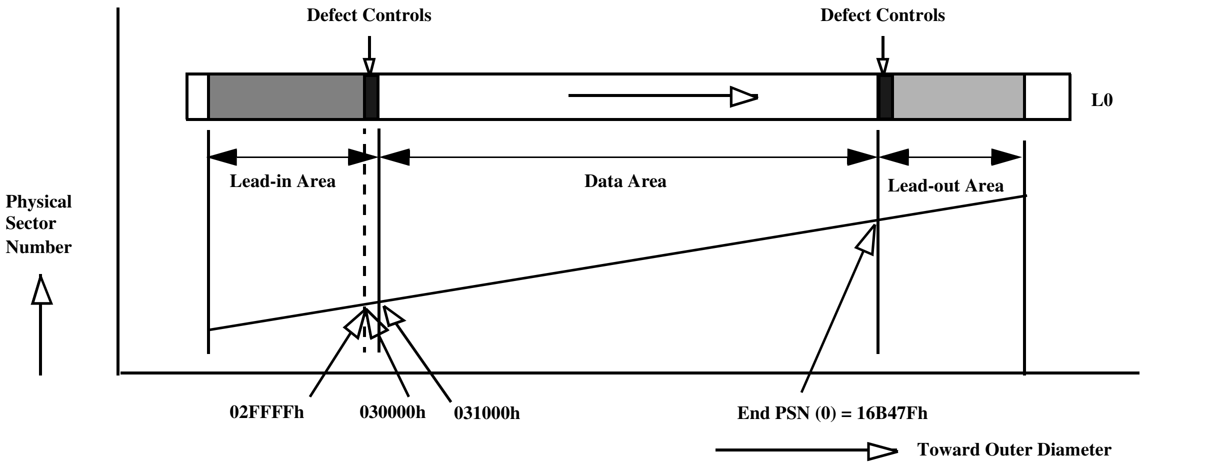
*B (RMA Start address) 223C0h: DVD-R Book Ver.1.0
203C0h: DVD-RW Book Ver.1.2
DVD-R for Authoring Ver.2.0
DVD-R for General Ver.2.1

*C (PCA start address) 20800h: DVD-R Book Ver.1.0
1E800h: DVD-RW Book Ver.1.2
DVD-R for Authoring Ver.2.0
DVD-R for General Ver.2.1



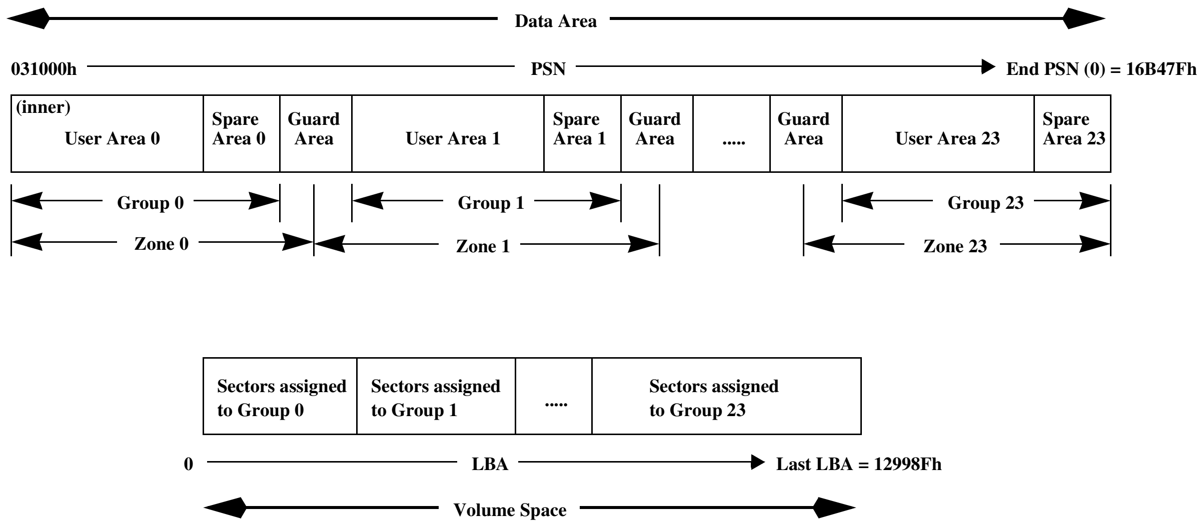
End PSN (0): The end Physical sector number of Data Area of L0

Figure 8 - Physical and logical layout of DVD-R/-RW Single Layer media



End PSN (0): The end Physical sector number of Data Area of L0

Defect Controls are non user addressable blocks, used for drive controlled defect management. These blocks contain Defect management Areas (DMAs). Defect controls begins 030000h. This is the Data Area for DVD-ROM and for DVD-R. The Data Area begins 031000h for DVD-RAM.



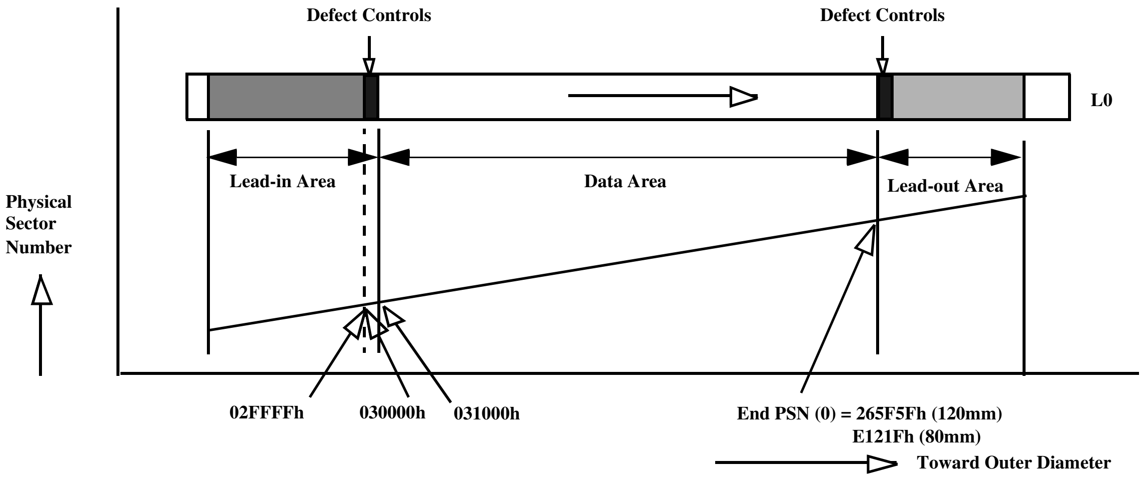
- DVD-RAM Ver.1.0 media contains 24 zones.

- Each of these zone has equal radial size, therefore number of ECC blocks per zone increase from 1662 at the Inner Diameter to 4475 at the Outer Diameter.

- The number of sectors in each Spare Area allocated per zone is proportional to the number of sectors in each User Area, approximately 5%.

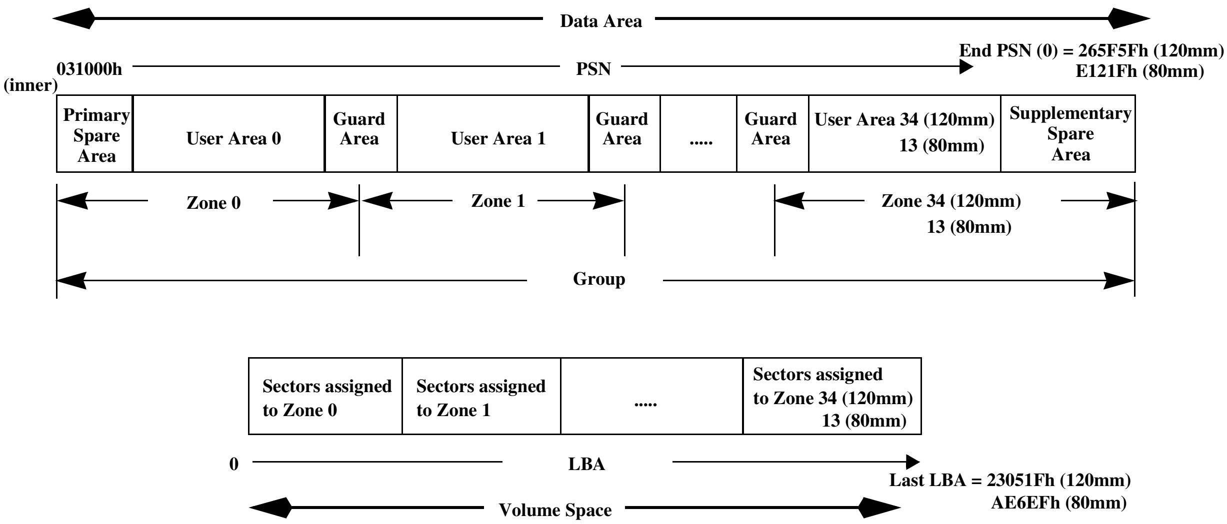
- The User Area may contain defective sectors which are replaced by sectors in the Spare Area; therefore, the number of user accessible sectors in each zone is kept at a predetermined number.

Figure 9 - Physical and logical layout of DVD-RAM Ver.1.0 media



End PSN (0): The end Physical sector number of Data Area of L0

Defect Controls are non user addressable blocks, used for drive controlled defect management. These blocks contain Defect management Areas (DMAs). Defect controls begins 030000h. This is the Data Area for DVD-ROM and for DVD-R. The Data Area begins 031000h for DVD-RAM.



- DVD-RAM Ver.2.1 media contains 35 zones in the case of 120mm and 14 zones in the case of 80mm.
- Each of these zone has equal radial size except Zone 34 in the case of 120mm and Zone 13 in the case of 80mm, therefore number of ECC blocks per zone increase from 2450 at the Inner Diameter to 6608 in the case of 120mm and 5852 in the case of 80mm at the Outer Diameter.
- There are two types of Spare Area, Primary Spare Area (PSA) and Supplementary Spare Area (SSA).
- DVD-RAM Ver.2.1 media has PSA, and may have SSA. Pre-assigned SSA is selectable and SSA is expandable after Formatting.
- The User Area may contain defective sectors which are replaced by sectors in the Spare Area; therefore, the number of user accessible sectors in each zone is kept at a predetermined number.

Figure 10 - Physical and logical layout of DVD-RAM Ver.2.1 media

4.3 ECC block

The user data is contained in ECC blocks. Each ECC block is made up of 16 sectors and is used to provide error correction. To read any data, the whole ECC block ***shall*** be read and error correction applied. When the ECC block is written during formatting or normal write operation, the user data and the ECC information is encoded and written to sectors as a whole ECC block.

4.4 Sector configuration

4.4.1 Physical sector

The data recorded to the DVD media is in a format called “Data Unit 3,” which consists of 2048 bytes of User Data, 12 bytes of Data ID and others, 4 bytes of error detection code (EDC), 302 bytes of ECC and 52 bytes of SYNC. During the formation of the Data Unit 3, there are intermediate products which are called “Data Unit 1” and “Data Unit 2” according to the stage of signal processing as shown in Figure 11. The Data Unit 3 is identical among DVD-ROM, DVD-R/-RW, and DVD-RAM. In the case of DVD-ROM, and DVD-R/-RW, only the Data Unit 3 is recorded. DVD-RAM media has other fields in between each Data Unit 3 as shown in Figure 13.

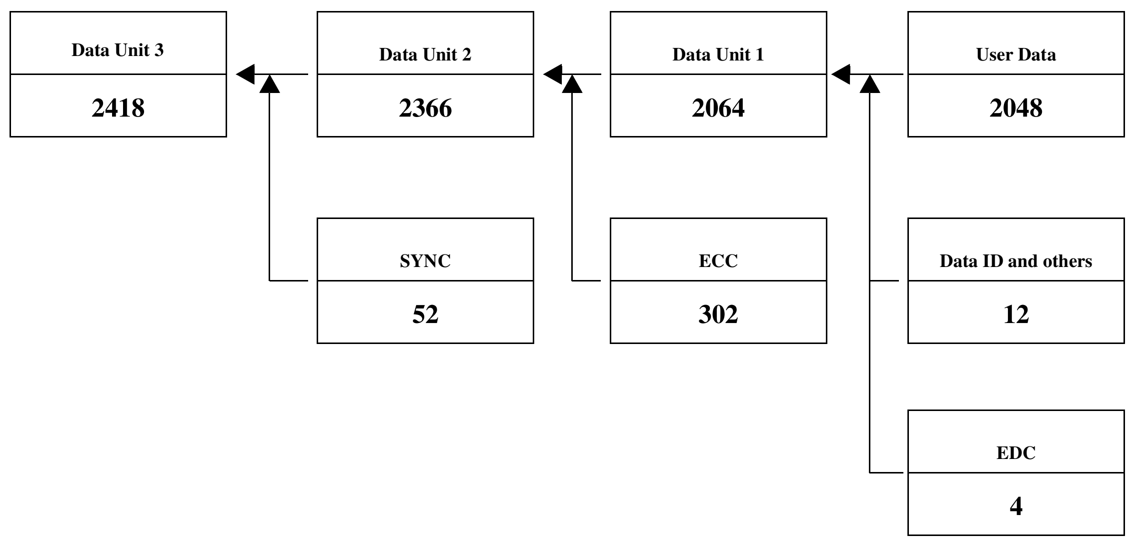


Figure 11 - Formation of Data Unit 3

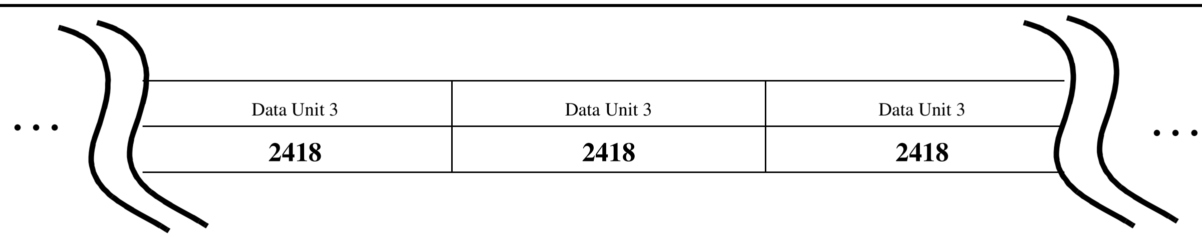


Figure 12 - Physical sector of DVD-ROM and DVD-R/-RW media

The physical sector of DVD-RAM consists of Data Unit 3, preceding fields and succeeding fields to it and embossed fields. The Data Unit 3 is identical with that for DVD-ROM. The Header field contains four physical IDs. In the case of

DVD-RAM, there are two sets of IDs. One that is contained in the Data Unit 1 and another that is pre-recorded. Addressing of sectors for DVD-RAM will only use the physical (pre-recorded) ID. After formatting, it is possible for the ID in Data Unit 1 to contain an invalid address.

Embossed Field		Recording field							
Header field	Mirror field	Gap field	Guard1 field	VFO3 field	PS field	Data Unit 3	PA3 field	Guard2 field	Buffer field
128	2	10+J/16	20+K	35	3	2418	1	55-K	25-J/16

J is varied randomly from 0 to 15 to shift recording position of Data Unit 3 in a unit of 1 channel bit.

K is varied randomly from 0 to 7 to shift recording position of Data Unit 3 in a unit of 1 byte.

Figure 13 - Physical sector of DVD-RAM (Ver.1.0 and 2.1)

4.4.2 Data Unit 1

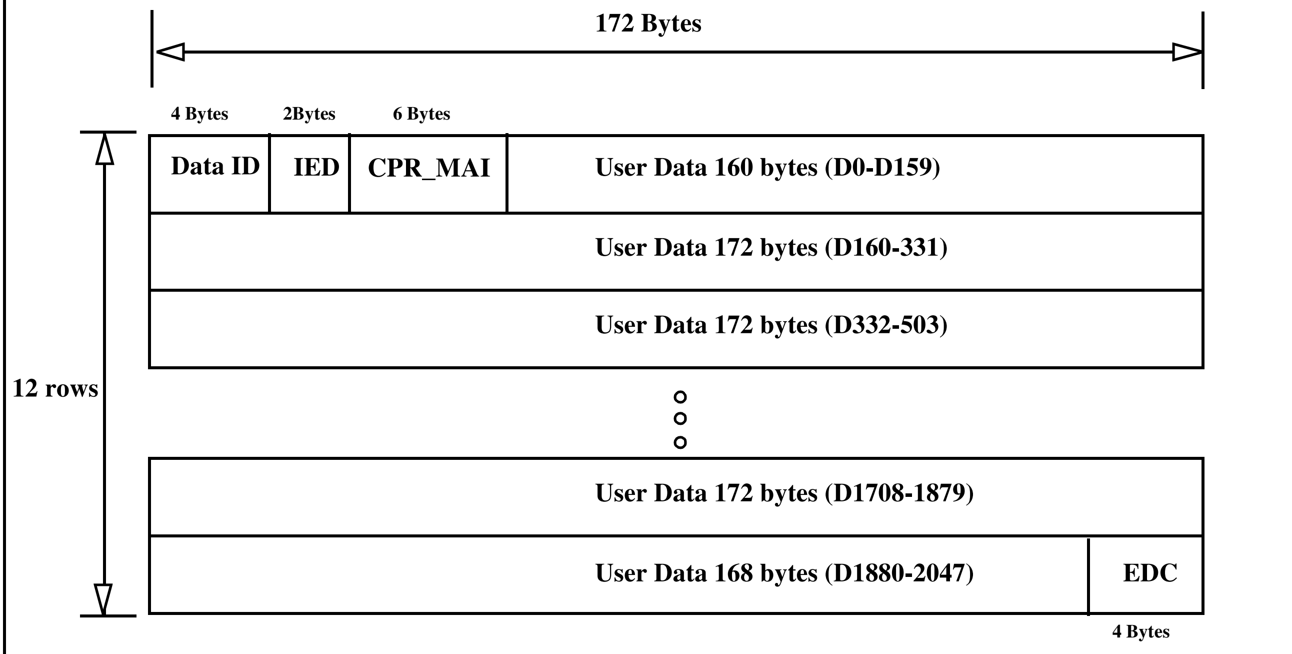


Figure 14 - Data Unit 1

4.4.3 Data configuration of Data ID field

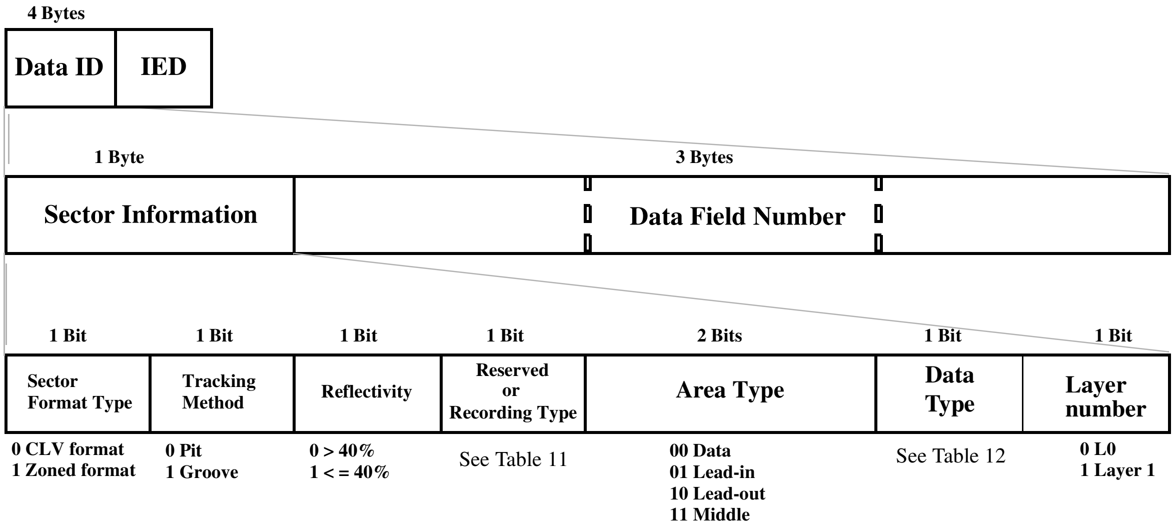


Figure 15 - Data ID field definition

The Data Field Number comprises PSN for DVD-ROM, and DVD-R/-RW. In the case of DVD-RAM, see Table 10.

Table 10 - Data Field Number for DVD media

Area	Media Type	Description	Contents
Lead-in and Lead-out	ROM, -R, RAM, -RW	Pre-recorded information or written for DVD-R/-RW media	PSN
Data Area	ROM, -R, -RW	Pre-recorded information or Written for DVD-R/-RW media	PSN (LBA + 30000h)
	RAM	ECC block written by the host	LBA + 31000h
		ECC block not written by the host after formatting	Any of the following three cases (1) Initialization pattern (2) Unrecorded (3) Old value of LBA + 31000h assigned before previous re-formatting

Table 11 - Recording Type bit definition for DVD-RAM Ver.2.1 media [a]

<table>
<tr><th colspan="2">Area</th><th>Definition</th></tr>
<tr><td colspan="2">Embossed data zone</td><td>Reserved</td></tr>
<tr><td rowspan="2">Rewritable data zone</td><td>Lead-in Area, Lead-out Area</td><td>Reserved</td></tr>
<tr><td>Data Area</td><td>0b: General data[b]
1b: Real-time data[c]</td></tr>
</table>

a. The definition of the bit for other than DVD-RAM Ver.2.1 media is Reserved.
b. General data: Linear replacement algorithm is applied to a Block containing the corresponding sector if the Block is defective.
c. Real-time data: Linear replacement algorithm is not applied to a Block containing the corresponding sector even if the Block is defective.

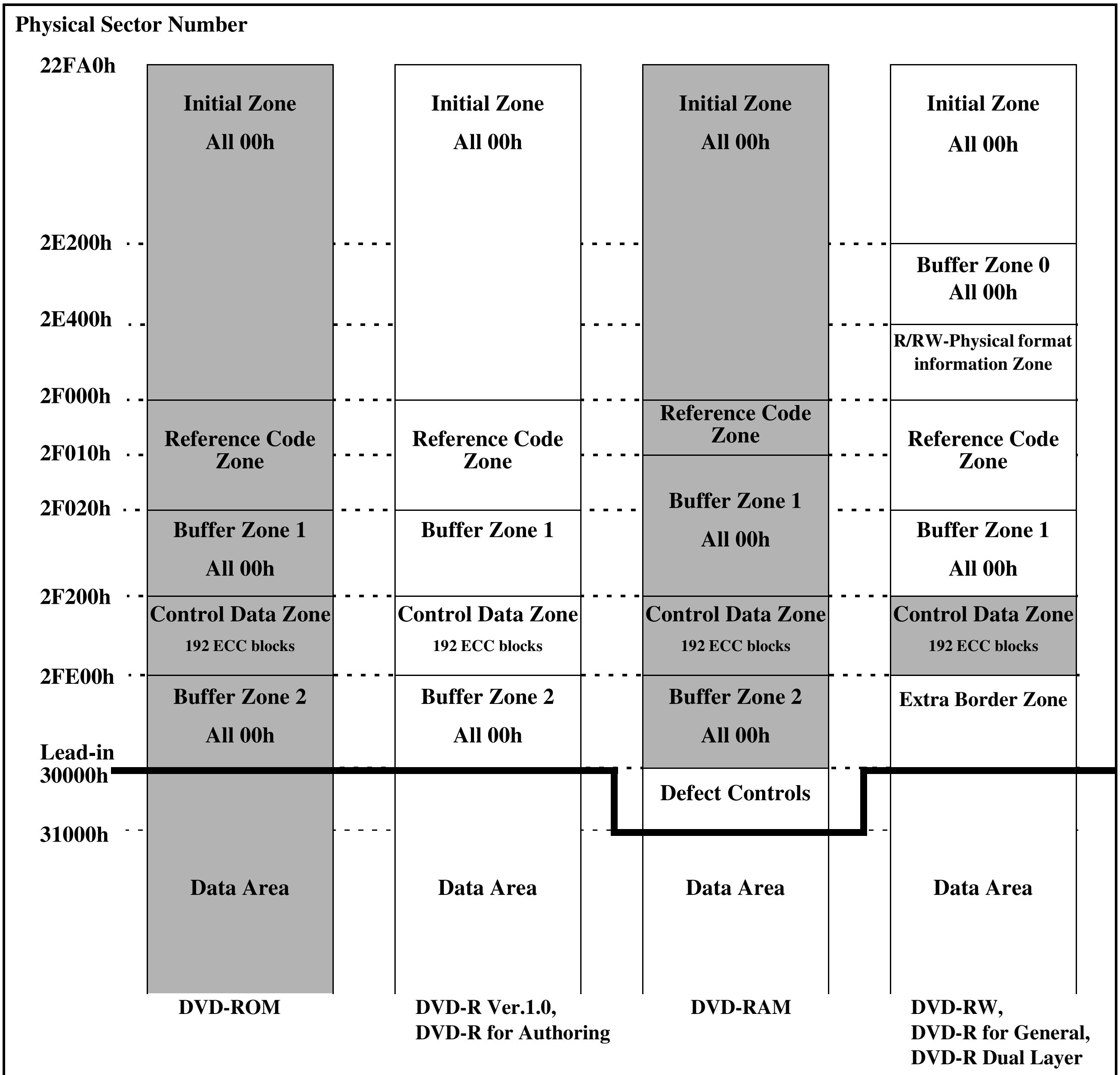
The Data Type bit specifies the data type of a sector as defined in Table 12.

Table 12 - Data Type bit definition

Media Type	Data Type bit	
	0	1
ROM	Read-only data	N/A
RAM	Embossed data	Rewritable data
-R	Read-only data	Next sector is Linking data
-RW	Re-recordable data	Next sector is Linking data

4.5 Data structure of Lead-in Area

Figure 16 shows the Lead-in structure of each type of DVD medium.



Shaded portions have embossed Data Unit 3 for DVD-ROM and RAM.

For DVD-R for Authoring, Buffer Zone 1 may contain manufacturer specific authoring information. Otherwise, Buffer Zone 1 contains all 00h data.

For DVD-R for General/DVD-R Dual Layer, shaded portion is pre-recorded or embossed.

For DVD-RW, shaded portion is embossed. In case of Ver.1.0 media, the embossed portion may not be readable.

Reference Code Zone contains repetition of the Data Symbol “172” with added scrambled data. It is about one revolution long.

For DVD-R Dual Layer, the Initial Zone starts at PSN 24440h.

Figure 16 - Data structure of Lead-in Area

4.5.1 Control Data Zone

The Control Data Zone contains 192 ECC blocks. The Control Data Zone comprises repetition of a Control Data Block which size is 16 sectors (= 1 ECC block). See Table 13 for a Control Data Block structure.

For DVD-RW media, the Control Data Zone is embossed. In case of DVD-RW Ver.1.0 media, the embossed portion may not be readable. The logical unit may use RW-Physical format information Zone or Extra Border Zone instead of Control Data Zone. See 4.5.2.

For DVD-R media[1], the Control Data Zone is pre-recorded or embossed by disc manufacturer.

The Disc manufacturing information field ***shall*** be ignored by logical units.

Table 13 - Structure of a Control Data Block

Sector Number	Description
0	Physical format information
1	Disc manufacturing information
2-15	Reserved

4.5.1.1 Physical format information

Physical format information is structured as shown in Table 14.

Table 14 - Physical format information in Control Data Block

<table>
<tr><th>Bit
Byte</th><th>7</th><th>6</th><th>5</th><th>4</th><th>3</th><th>2</th><th>1</th><th>0</th></tr>
<tr><td>0</td><td colspan="4">Book Type</td><td colspan="4">Part Version[a]</td></tr>
<tr><td>1</td><td colspan="4">Disc Size</td><td colspan="4">Maximum Transfer Rate</td></tr>
<tr><td>2</td><td>Reserved</td><td colspan="2">Number of Layers</td><td>Track Path</td><td colspan="4">Layer Type</td></tr>
<tr><td>3</td><td colspan="4">Linear Density</td><td colspan="4">Track Density</td></tr>
<tr><td>4-15</td><td colspan="8">Data Area Allocation</td></tr>
<tr><td>16</td><td>BCA Flag[b]</td><td colspan="7">Reserved</td></tr>
<tr><td>17-2047</td><td colspan="8">Medium unique data</td></tr>
</table>

a. For DVD-R Dual Layer media, the name of this field is defined as Compatible Part Version.
b. For DVD-RW and DVD-R media, the name of this bit is defined as NBCA Flag.

The Book Type field identifies the type of media specification. The definition is described in Table 15.

1. DVD-R Ver.1.0 and DVD-R for Authoring discs are exceptions. See Figure 16.

Table 15 - Book Type field definition

Value	Definition
0000b	DVD-ROM
0001b	DVD-RAM
0010b	DVD-R
0011b	DVD-RW
1001b	DVD+RW
1010b	DVD+R
others	Reserved

The Part Version field identifies the version number within a Book Type.

Table 16 - Part Version field definition

Value	Definition
0000b	Version 0.9x for test use only, not for consumer product
0001b	Version 1.0x
0010b	Version 1.1x
0100b	Version 1.9x for test use only, not for consumer product
0101b	Version 2.0x, when byte 27 is 00h. Version 2.0x compatible, when byte 27 is not 00h and specifies actual version.
0110b	Version is higher than 2.0 and specified at byte 27
others	Reserved

The Disc Size field, when set to 0000b, indicates a 120 mm disc. When set to 0001b, indicates an 80 mm disc. All other values are reserved.

The Maximum Transfer Rate field identifies the maximum data transfer rate found in the contents (e.g., video data) on the medium. See Table 17.

Table 17 - Maximum Transfer Rate field definition

Value	Definition
0000b	2.52 Mbps
0001b	5.04 Mbps
0010b	10.08 Mbps
0011b-1110b	Reserved
1111b	No maximum transfer rate is specified.

The Number of Layers field identifies the number of Layers on the current side. 00b indicates one Layer, 01b indicates two Layers, and other values are reserved.

The Track Path field, when set to 0b, indicates a PTP or Single Layer disc. When set to 1b, indicates an OTP disc.

The Layer Type field identifies the Layer according to Table 18.

Table 18 - Layer Type field definition

Bit	Definition
0	When set to one, the Layer contains embossed user Data Area
1	When set to one, the Layer contains recordable user Data Area
2	When set to one, the Layer contains re-writable user Data Area
3	Reserved

The Linear Density field identifies the bit density according to Table 19.

Table 19 - Linear Density field definition

Value	Definition
0000b	0.267 µm/bit
0001b	0.293 µm/bit
0010b	0.409-0.435 µm/bit
0100b	0.280-0.291µm/bit
1000b	0.353 µm/bit
others	Reserved

The Track Density field identifies the track density according to Table 20.

Table 20 - Track Density field definition

Value	Definition
0000b	0.74 µm/track
0001b	0.80 µm/track
0010b	0.615 µm/track
others	Reserved

Table 21 describes the contents of the Data Area Allocation field.

Table 21 - Data Area Allocation field definition

<table>
<tr><th>Byte</th><th>Single Layer/ PTP DVD-ROM</th><th>OTP DVD-ROM/ DVD-R Dual Layer</th><th>DVD-R Ver.1.0/ DVD-R for Authoring (Disc-at-once)</th><th>DVD-R Ver.1.0 (incremental)</th><th>DVD-RW/ DVD-R for General</th><th>DVD-RAM</th></tr>
<tr><td>4</td><td colspan="6">00h</td></tr>
<tr><td>5</td><td colspan="5" rowspan="3">Starting PSN of Data Area (030000h)</td><td rowspan="3">Starting PSN of Data Area (031000h)</td></tr>
<tr><td>6</td></tr>
<tr><td>7</td></tr>
<tr><td>8</td><td colspan="6">00h</td></tr>
<tr><td>9</td><td colspan="3" rowspan="3">End PSN of Data Area</td><td rowspan="3">Last Recorded Sector Number of the last RZone in the Bordered Area</td><td rowspan="3">Outer limit of Data Recordable area[a]</td><td rowspan="3">End PSN of Data Area</td></tr>
<tr><td>10</td></tr>
<tr><td>11</td></tr>
<tr><td>12</td><td colspan="6">00h</td></tr>
<tr><td>13</td><td rowspan="3">000000h</td><td rowspan="3">End PSN of L0</td><td colspan="4" rowspan="3">000000h</td></tr>
<tr><td>14</td></tr>
<tr><td>15</td></tr>
</table>

a. A DVD logical unit that does not support reading of R/RW-Physical format information Zone or Extra Border Zone on DVD-R for General or DVD-RW media, may report this value as recorded capacity, e.g., returned data of READ CAPACITY command, even if data is not fully recorded in Data Recordable area. In this case, reading of the last addressable LBA may cause pick-up over-run. See *Appendix J-2 "Read compatibility issue of AVDP and VAT ICB at end LBA"* on page 790.
For DVD-RW Ver.1.0 media, the name of this field is defined as 'Last address of Data Recordable area'.

For DVD-RAM, the end PSN is the PSN for the last spare sector of the last zone. It should not be used for counting user capacity.

The BCA Flag identifies the existence of Burst Cutting Area (BCA)/NBCA on the medium. 0b indicates non-existence of BCA/NBCA, 1b indicates existence of BCA/NBCA on the medium.

Table 22, Table 23, Table 24, Table 26, Table 27 and Table 28 show the format unique descriptors for each media type.

Table 22 - DVD-ROM unique part of Physical format information

Bit / Byte	7	6	5	4	3	2	1	0
17-2047	Reserved							

Table 23 - DVD-R Ver.1.0/R for Authoring Ver.2.0 unique part of Physical format information

Byte \ Bit	7	6	5	4	3	2	1	0
17-31	Reserved							
32-35	Start PSN of the current Border-out							
36-39	Start PSN of the next Border-in							
40-2047	Reserved							

Table 24 - DVD-R for General Ver.2.1 unique part of Physical format information

Byte \ Bit	7	6	5	4	3	2	1	0
17	Revision number of maximum recording speed							
18	Revision number of minimum recording speed							
19-25	Revision number table of recording speed							
26	Class							
27	Extended Part Version							
28-31	Reserved							
32-35	Start PSN of the Extra Border Zone (= 02FE10h)							
36-39	Start PSN of Physical format information blocks in Extra Border Zone (= 02FFA0h)							
40-511	Reserved							
512-2047	Extended pre-recorded information							

Table 25 - DVD-RW Ver.1.2 unique part of Physical format information

Byte \ Bit	7	6	5	4	3	2	1	0
17	Revision number of maximum recording speed							
18	Revision number of minimum recording speed							
19-25	Revision number table of recording speed							
26	Class							
27	Extended Part Version							
28-31	Reserved							
32-35	Start PSN of the Extra Border Zone (= 02FE10h)							
36-39	Start PSN of Physical format information blocks in Extra Border Zone (= 02FFA0h)							
40-511	Reserved							
512-2047	Extended embossed information							

The Revision number of maximum recording speed field identifies the Revision number of maximum applicable recording speed of this disc. The bit 7 to bit 4 of this field indicates the major revision number of the Optional Specification. The bit 3 to bit 1 of this field indicates the minor revision number of the Optional Specification. This field is set to 00h if the Class field is set to 00h.

The Revision number of minimum recording speed field identifies the Revision number of minimum applicable recording speed of this disc. The bit 7 to bit 4 of this field indicates the major revision number of the Optional

Specification. The bit 3 to bit 1 of this field indicates the minor revision number of the Optional Specification. This field is set to 00h if the Class field is set to 00h.

Example of Revision number:
0000 0000b means Revision 0.0
0001 0000b means Revision 1.0

The Revision number table of recording speed field identifies all revision numbers supported by this disc other than the revision numbers specified in the Revision number of maximum recording speed field and the Revision number of minimum recording speed field. The bit 7 to bit 4 of each byte in this field indicates the major revision number of the Optional Specification. The bit 3 to bit 1 of each byte in this field indicates the minor revision number of the Optional Specification. In this field, a byte value of 00h means "unused" and does not mean Revision number 0.0.

The Class field identifies all supported basic recording speeds by this disc. Each bit assignment and its Basic recording speed is specified in applicable DVD book.

The Extended Part Version field identifies actual Book Part Version. The bit 7 to bit 4 of this field indicates the major Version number of the Extended Part Version. The bit 3 to bit 0 of this field indicates the minor Version number of the Extended Part Version.

Example of Version number:
0010 0001b means Version 2.1
0010 1001b means Version 2.9 (for test use only, not for consumer product)
0011 0000b means Version 3.0

Table 26 - DVD-R Dual Layer Ver.3.0 unique part of Physical format information

Bit / Byte	7	6	5	4	3	2	1	0
17	Revision number of maximum recording speed							
18	Revision number of minimum recording speed							
19-25	Revision number table of recording speed							
26	Class							
27	Extended Part Version							
28-31	Reserved							
32-35	Start PSN of the Extra Border Zone (= 02FE10h)							
36-39	Start PSN of Physical format information blocks in Extra Border Zone (= 02FFA0h)							
40	Pre-recorded information code							
41	Tracking polarity flag and AR flag							
42-511	Reserved							
512-2047	Extended pre-recorded information							

Table 27 - DVD-RAM Ver.1.0 unique part of Physical format information

Byte \ Bit	7	6	5	4	3	2	1	0
17-31	Reserved							
32	Disc Type Identification							
33-47	Reserved							
48	Velocity 1							
49-65	Write conditions at Velocity 1							
66-479	Reserved for write conditions at velocity of Velocity 2 to Velocity 24							
480-2047	Reserved							

Table 28 - DVD-RAM Ver.2.1 unique part of Physical format information

Byte \ Bit	7	6	5	4	3	2	1	0
32	Disc Type Identification							
33-499	Reserved							
500	Velocity							
501-548	Write conditions at Velocity							
549-596	Disc manufacture’s name							
597-612	Disc manufacture’s supplementary information							
613-623	Write power control parameters							
624-699	Reserved							
700	3x-speed Velocity (optional)							
701-757	Write condition at 3x-speed Velocity (optional)							
758-2047	Reserved							

4.5.2 R/RW-Physical format information Zone

The R/RW-Physical format information Zone is defined for DVD-R[1] and DVD-RW media. The R/RW-Physical format information Zone contains 192 ECC blocks. The R/RW-Physical format information Zone comprises repetition of a R/RW-Physical format information Block which size is 16 sectors (= 1 ECC block).

The structure of an R/RW-Physical format information Block is shown in Table 29.

Table 29 - Structure of an R/RW-Physical format information Block

Sector Number	Description
0	Reserved
1	Manufacturing information
2	Physical format information
3 - 15	Reserved

The structure of Physical format information in the R/RW-Physical format information Block is shown in Table 30. The field definitions are same as that of Physical format information in the Control Data Block unless otherwise specified.

Table 30 - Physical format information in an R/RW-Physical format information Block

Byte \ Bit	7	6	5	4	3	2	1	0
0	Book Type[a]				Compatible Part Version[a] / DL indicator[b]			
1	Disc Size[a]				Maximum Transfer Rate			
2	Reserved	Number of Layers[a]		Track Path[a]	Layer Type[a]			
3	Linear Density[a]				Track Density[a]			
4-15	Data Area Allocation							
16	NBCA flag[a]	Reserved						
17-2047	Media unique data							

a. These fields are copied from pre-recorded Physical format information in Control Data Block.
b. The definition of the DL indicator field is valid only for DVD-R Dual Layer disc.

The static information in R/RW-Physical format information Block are basically copied from the Control Data Block in pre-recorded/embossed Control Data Zone. Some dynamic information (e.g., the Maximum Transfer Rate field, the Data Area Allocation fields, Border Zone location information) ***shall*** be recorded with the latest appropriate value.

The DL indicator field indicates that the mounted disc is Dual Layer disc. This definition is only applicable to DVD-R Dual Layer disc. If DVD-R Dual Layer disc is mounted, this field ***shall*** be set to 1111b to indicate the disc is Dual Layer disc. All other values are reserved.

The definition of the Data Area Allocation field in R/RW-Physical format information Block is shown in Table 31.

1. DVD-R Ver.1.0 and DVD-R for Authoring discs are exceptions. See Figure 16.

Table 31 - Data Area Allocation field in R/RW-Physical format information Block

Byte	DVD-R for General/DVD-RW (Disc-at-once)	DVD-R for General / DVD-RW (Incremental) and DVD-RW (Restricted Overwrite)	DVD-R Dual Layer
4	00h	00h	00h
5 6 7	Starting PSN of Data Area (= 30000h)	Starting PSN of Data Area (= 30000h)	Starting PSN of Data Area (= 30000h)
8	00h	00h	00h
9 10 11	End PSN of Data Area	Last Recorded Sector Number of the last RZone in the Bordered Area[a]	Maximum recorded address of the Data Area
12	00h	00h	00h
13 14 15	000000h	000000h	Maximum recorded address of the Data Area on Layer 0[b]

a. When the Lead-in or Border-in is recorded in Restricted Overwrite mode, and when the last Bordered Area is in an Intermediate state, this field ***shall*** be set to 30000h.

b. When the Data Area on Layer 1 is not recorded, the value of this field is same as the value of the Maximum recorded address of the Data Area field when Format 1 RMD is used. When Format 4 RMD is used, this field indicates End PSN of Layer 0.

Table 32, Table 33 and Table 34 show the unique part of R/RW-Physical format information for each media type. When the Lead-in is recorded in the Disc-at-once recording mode, this field contains all 00h data.

Table 32 - DVD-R for General Ver.2.1 unique part of R-Physical format information

Byte \ Bit	7	6	5	4	3	2	1	0
17	Revision number of maximum recording speed[a]							
18	Revision number of minimum recording speed[a]							
19-25	Revision number table of recording speed[a]							
26	Class[a]							
27	Extended Part Version[a]							
28-31	Reserved							
32-35	Start PSN of the current Border-out							
36-39	Start PSN of the next Border-in							
40-511	Reserved							
512-2047	Copy of Extended pre-recorded information[a]							

a. These fields are copied from pre-recorded Physical format information in Control Data Block.

Table 33 - DVD-R Dual Layer Ver.3.0 unique part of R-Physical format information

Byte \ Bit	7	6	5	4	3	2	1	0
17	Revision number of maximum recording speed[a]							
18	Revision number of minimum recording speed[a]							
19-25	Revision number table of recording speed[a]							
26	Class[a]							
27	Extended Part Version[a]							
28-31	Reserved							
32	Reserved							
33	Start PSN of the current Border-out							
34								
35								
36	Reserved							
37	Start PSN of the next Border-in							
38								
39								
40	Pre-recorded information code[a]							
41	Tracking polarity flag and AR flag[a]							
42	Reserved				RBVF4	RBVF3	RBVF2	RBVF1
43-511	Reserved							
512-2047	Extended pre-recorded information[a]							

a. These fields are copied from pre-recorded Physical format information in Control Data Block.

The RBVF#n bits indicates the validity of the nthAnchor Point Data (APD#n) recorded in Superficial Border Zone and Extra Border-in. If set to 0b, the APD#n is not used for remapping. If set to 1b, the APD#n is valid and is used to return as the remapping data.

Table 34 - DVD-RW Ver.1.2 unique part of RW-Physical format information

Byte \ Bit	7	6	5	4	3	2	1	0
17	Revision number of maximum recording speed[a]							
18	Revision number of minimum recording speed[a]							
19-25	Revision number table of recording speed[a]							
26	Class[a]							
27	Extended Part Version[a]							
28-31	Reserved							
32-35	Start PSN of the current Border-out							
36-39	Start PSN of the next Border-in							
40-511	Reserved							
512-2047	Copy of Extended embossed information[a]							

a. These fields are copied from pre-recorded Physical format information in Control Data Block.

4.5.3 Extra Border Zone

The Extra Border Zone is defined for DVD-RW and DVD-R[1] media.

The structure of Extra Border Zone is similar to Border Zone. However, the length of Extra Border Zone is only 32 ECC blocks and there are no Next Border Markers and Stop Blocks. The Extra Border Zone structure is shown in Figure 17.

In case of DVD-R Dual Layer disc Ver. 3.0 media, here are same amount of buffer zone on Layer 1 called Superficial Extra Border Zone. It has same kind of structure as Superficial Border-out and Superficial Border-in. See *4.17.9, "Border Zone for DVD-R Dual Layer media"* on page 190

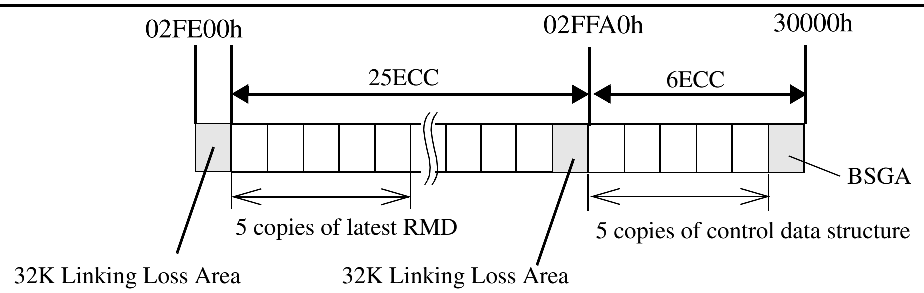


Figure 17 - Structure of Extra Border Zone

4.6 DVD READY condition/NOT READY condition

The READY condition occurs after a disc is inserted and the logical unit has performed its initialization tasks. These may include reading the Lead-in information from the media. This “READY” is different from and should not be confused with the ATA READY status. A CHECK CONDITION status ***shall*** be returned for the NOT READY condition only for commands that require or imply a disc access.

A NOT READY condition may occur for the following reasons:

1. There is no disc mounted, see *4.10, "Removable medium"* on page 95
2. The logical unit is unable to load or unload the disc.
3. The logical unit is performing an extended operation as the result of an Immediate mode command such as FORMAT UNIT or BLANK. This condition is defined in *Section 4.7, "Logical Unit Not Busy condition/Busy condition"* on page 92.

The logical unit ***shall*** attempt to spin up and make the disc ready for media accesses when a new disc is detected.

After the logical unit becomes ready, the logical unit may enter the power state in which the logical unit was when the previous medium was removed.

Any media access that occurs when the logical unit is in the IDLE or STANDBY state ***shall*** spin the media up and not generate an error. Any media access that is requested while a deferred operation is in progress (i.e. writing from a write cache) ***shall not*** generate an error. Any media access that is requested while the logical unit is processing an Immediate command, e.g., BLANK or FORMAT UNIT with the Immediate bit set, may result in a NOT READY condition.

Note: Accesses to the media can be satisfied from the logical unit’s cache and may not require the media to be spinning.

4.7 Logical Unit Not Busy condition/Busy condition

Logical Unit Not Busy condition/Busy condition are defined for DVD. See *Section 3.5, "Logical Unit Not Busy condition/Busy condition"* on page 63

1. DVD-R Ver.1.0 and DVD-R for Authoring discs are exceptions. See Figure 16.

4.8 DVD content protection

DVD Content Protection is made up of two basic concepts. The first is to scramble the content of the data such that it is unscrambled before it can be used. The capability to unscramble the content is provided only under conditions that require products that follow rules governing the copying, playback, and output of the content. The second basic concept is to use an “Authentication” process to exchange protected information (such as cryptographic Keys) required for the unscramble operation. This process ensures the integrity of such information during transfer from the logical unit to the host.

4.8.1 Content protection for read-only DVD

The DVD-Video Content Scrambling System (CSS) is used to protect DVD-Video content on read-only Discs. Content Protection for Prerecorded Media (CPPM) is used to protect DVD-Audio content on read-only Discs. For discs containing CSS or CPPM protected content (or both), the same authentication process is used. Thus, logical unit that support CSS authentication will also support CPPM without modification. Any read by the host to a disc that contains CSS scrambled content and a sector with a Title Key present, when the Authentication Success Flag (ASF) is set to zero ***shall*** be terminated with a CHECK CONDITION status, 5/6F/03 READ OF SCRAMBLED SECTOR WITHOUT AUTHENTICATION. For more information on the authentication process, see Figure 18. For more information on the Authentication Success Flag, see Figure 19.

Note: Although CSS and CPPM use the same authentication process for transferring the Disc Key or Album ID, CPPM protected sectors do not contain a Title Key. Thus for CPPM, the TITLE KEY Format is not used, and the Authentication Success Flag is not relevant.

For CSS protected content (DVD-Video) only, playback of the content is limited to specific regions of the world, as described in *Section 4.14, "Region Playback Control (RPC)"* on page 97.

4.8.2 Content protection for recordable and rewritable DVD

Content Protection for Recordable Media (CPRM) is used to protect audio and video content on recordable and rewritable DVD discs. The interface between the host and logical unit for CPRM is similar to that for CPPM, with the following differences:

- CPRM uses a “MEDIA IDENTIFIER” to bind protected content to the disc on which it is recorded. Before encrypting or decrypting such content the host reads the MEDIA IDENTIFIER value using the READ DISC STRUCTURE command with Format Code code 06h.
- The CPRM "MEDIA KEY BLOCK" is located in the Lead-in Area, and is read by the host using the READ DISC STRUCTURE command with Format Code code 07h.

The CPRM “MEDIA IDENTIFIER” and “MEDIA KEY BLOCK” are protected during transfer to the host using the same Authentication process used for CSS and CPPM, with the addition of a Message Authentication Code (MAC) algorithm described in the CPRM specification. For more information on the authentication process, see Figure 18.

4.8.3 Authentication process

Host ***shall*** reset hung authentication processes in the logical unit by invalidating the corresponding AGID. The host may detect lost grants by refusal of the Start Authentication Process operation. This diagram assumes the appropriate CSS/CPPM/CPRM media is loaded. See Figure 18 and Figure 19.

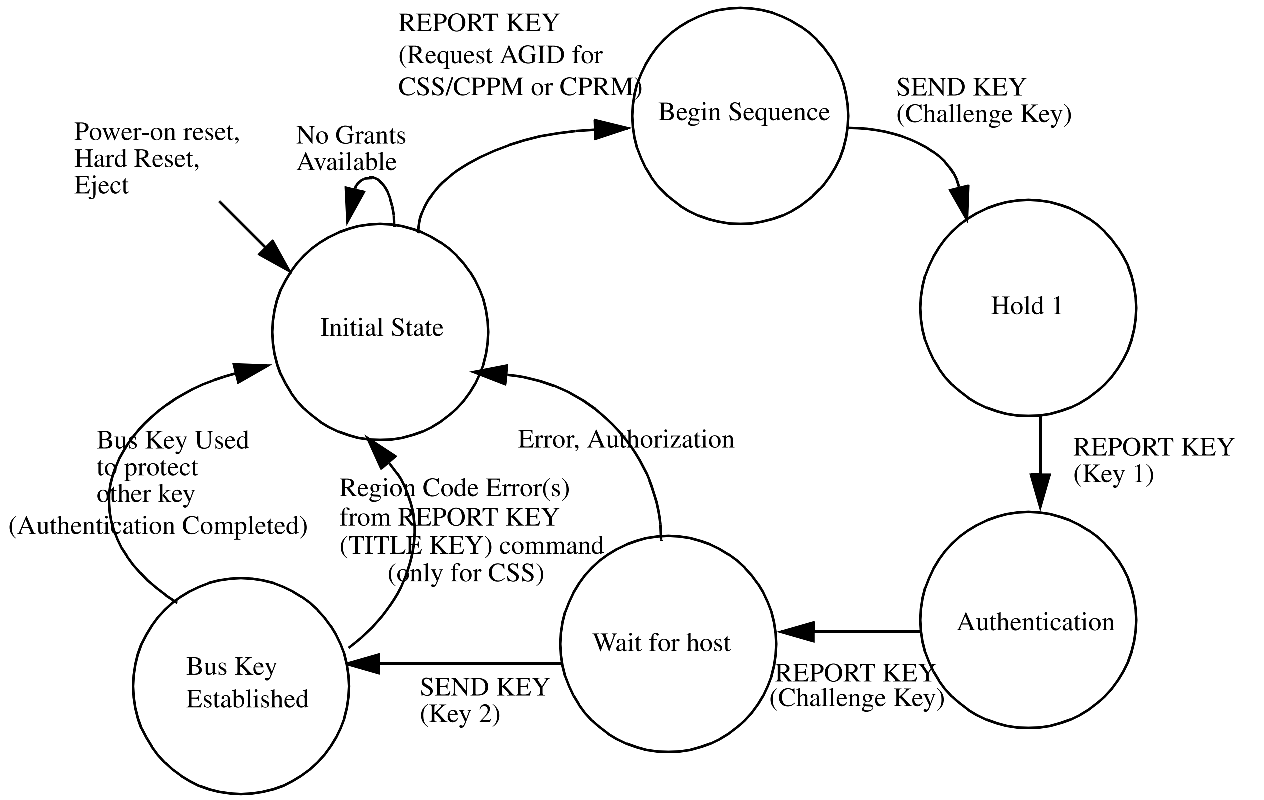


Figure 18 - Device Key Exchange and Authentication State Diagram

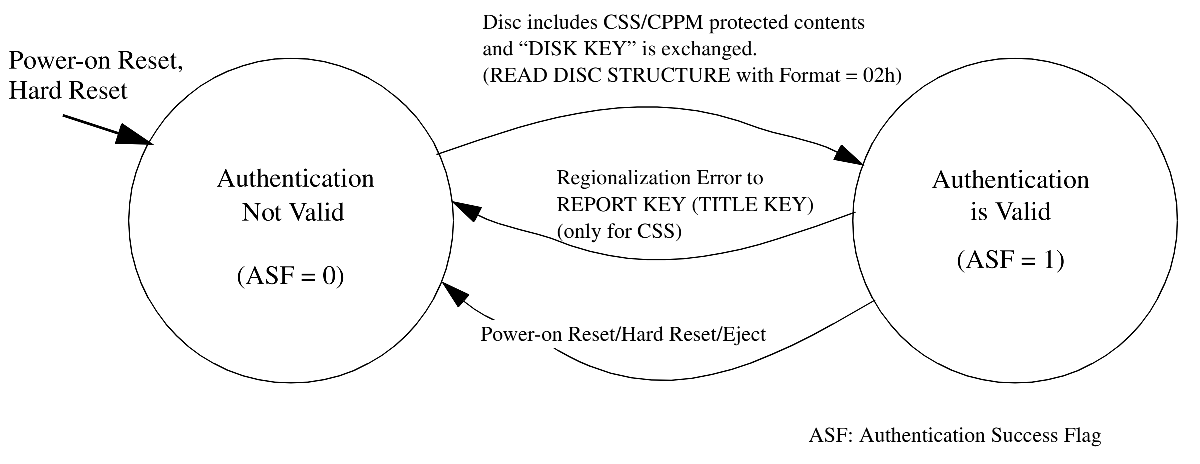


Figure 19 - Authentication Flag Sequence

4.9 Error reporting

If any of the following conditions occur during the execution of a command, the logical unit ***shall*** return CHECK CONDITION status. The appropriate Sense Key and additional sense code ***shall*** 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 35 - Error conditions and Sense Keys

Condition	Sense Key
Invalid logical block address	ILLEGAL REQUEST
Unsupported option requested	ILLEGAL REQUEST
Attempt to read a blank block (where illegal)	ILLEGAL REQUEST
Attempt to play a data block as audio	ILLEGAL REQUEST
Logical unit reset or medium change since last command	UNIT ATTENTION
Self diagnostic failed	HARDWARE ERROR
Unrecovered 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.

4.10 Removable medium

DVD medium is sometimes contained within a cartridge to prevent damage to the recording surfaces. The combination of medium and optional cartridge is often called a volume.

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 or is able to format it. A mounted disc may not be accessible by a host if it has been reserved by another host. A disc is de-mounted at any other time (e.g., during loading, unloading, or storage).

A host may check whether a disc is mounted by issuing a TEST UNIT READY command. In addition, there now exists the Removable Medium Feature. This Feature allows the host 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 a host to restrict the demounting 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 demounting of the disc. If the host issues a START/STOP UNIT command to eject the disc, and is prevented from demounting by the PREVENT/ALLOW MEDIUM REMOVAL command, the START/STOP UNIT command is rejected by the logical unit.

4.11 Logical blocks

Blocks of data are stored on the medium along with additional information that the controller uses to manage the storage and retrieval. The format of the additional information is unique and is hidden from the host 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 the 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 FORMAT CAPACITIES 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 is terminated with CHECK CONDITION status, 5/21/00 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 length ***shall not*** be different for each logical block on the medium. The block descriptor in the MODE SENSE (10) data describes the block length that is used on the medium. The block descriptor ***shall not*** be present for an ATAPI C/DVD logical unit. In addition, the Block Descriptor has been made Obsolete in this specification.

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].

4.12 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 accessible by the host. 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 host 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 host may wish to have 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 host to control other behavior of the cache memory:

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

4.13 Seek

The SEEK command provides a way for the host to position the logical unit in preparation for access to a particular logical block at some later time. Since this positioning action is implicit in other commands, the SEEK command may not be useful with some logical units.

4.14 Region Playback Control (RPC)

There is an additional copy management capability used for Copy Protected DVD-ROM media that limits the playback of content to specific regions of the world. The capability is called Region Playback Control (RPC) or Regionalization.

4.14.1 Playback limitations by world region

The use of Regionalization is limited to Discs that employ CSS. There are two places that contain region information, one in the logical unit and another for each media that contains CSS Scrambled Title(s). When the region in the logical unit and that of the CSS Title are different, the system ***shall*** prevent the playback of that title (movie).

When a REPORT KEY command with KEY Format Code of 04h (Title Key) is received by a logical unit that is in the Bus Key Established state (see Figure 18 - *Device Key Exchange and Authentication State Diagram* on page 94), and the region code of the current media is not playable in the current region set in the logical unit, the command ***shall*** be terminated with CHECK CONDITION status, 5/6F/04 MEDIA REGION CODE IS MISMATCHED TO LOGICAL UNIT REGION. Regionalized CSS media ***shall*** be deemed not playable if the region of the logical unit is not set.

If the Region Code Mismatch error is generated, the Authentication Success Flag (ASF) ***shall*** be reset to zero.

The logical unit will report the current RPC state using the REPORT KEY command with KEY Format Code 08h. The logical unit ***shall not*** report an error concerning media to this KEY Format code.

Note: Some current logical units may return the error concerning media. In this case, host should ignore this error and host should proceed to the next step. The logical unit may support RPC. When "5/6F/04 MEDIA REGION CODE IS MISMATCHED TO LOGICAL UNIT REGION" error is reported, host should check the logical unit RPC setting.

4.14.2 Region code setting

Two methods have been defined for setting the region code in the DVD logical unit. Each method has the same end result, specifying which region ***shall*** be used to determine if it is allowable to play a movie which has a region code included within the information on the disc in this drive.

The logical unit has the following four Region States according to the Drive Region setting (see Figure 20):

1. NONE state	The Drive Region has not been set and the host Computer ***shall*** set the initial Drive Region value in the logical unit. The region setting counter ***shall*** be 5. The logical unit ***shall*** respond to the REPORT KEY command, KEY Format 01000b, with successful command completion and a Region Mask value of FFh.
2. SET state	The Drive Region has been set and the change of the Region is acceptable. The region setting counter ***shall*** initially be 4, decrementing to 2.
3. LAST CHANCE state	The Drive Region has been set and the change of the Region is acceptable. In order to change the Drive Region using a command method, an inserted disc ***shall*** have the same single region with the requested Region. The region setting counter ***shall*** be 1.
4. PERMANENT state	The Drive Region has been set and the change of the Region is not acceptable. The region setting counter ***shall*** be 0. However, the Drive Region can be re-initialized by the vendor to become the NONE state.

4.14.2.1 Initial setting

In the NONE state, the Drive Region has not been set and the host ***shall*** set the initial Drive Region value in the logical unit. The region setting counter ***shall*** be 5. The logical unit ***shall*** respond to the REPORT KEY command, KEY Format 01000b, with successful command completion and a Region Mask value of FFh.

The Drive Region ***shall*** be set by one of the two methods specified. In case of the command method, the drive ignores the region code of the inserted medium. In the command method, the host ***shall*** set a preferable region, the value of which is specified in the Preferred Drive Region Code field of the SEND KEY command with KEY Format = 000110b. On execution of this command, the drive ignores the region code of the inserted medium.

After the successful execution of setting the Drive Region, the region setting counter ***shall*** be decremented to 4 and the drive ***shall*** enter SET state.

4.14.2.2 Changing of the Drive Region

In the SET state, the Drive Region has been already set and may be changed by one of the following two methods. After the successful execution of changing the Drive Region, the region setting counter ***shall*** be decremented. When the region setting counter is 1, the drive ***shall*** enter into the LAST CHANCE state.

In the LAST CHANCE state, the Drive Region may be changed by one of the following two methods. In the case of command method with a disc, the inserted disc ***shall*** have the same single Region Code value as the Preferred Drive Region Code specified in the SEND KEY command. After the successful execution of the Drive Region change, the region setting counter ***shall*** be zero and the drive ***shall*** enter into the PERMANENT state.

In the PERMANENT state, the user cannot change the Drive Region.

4.14.2.2.1 Command method for changing the Drive Region with a CSS enabled disc

To set the Drive Region, the procedure ***shall*** be executed as follows;

1. Insert a disc having the requested Region, (this is not required for the Initial Setting)
2. Issue a SEND KEY command with the KEY Format = 000110b. The requested Region Code value ***shall*** be specified in the Preferred Drive Region Code field.

When the logical unit receives the SEND KEY command correctly, the Drive Region is changed to the requested region.

If the disc does not have the same region code value as the Preferred Drive Region Code specified in the SEND KEY command, then the command ***shall*** be terminated with CHECK CONDITION status, 5/6F/04 MEDIA REGION CODE IS MISMATCHED TO LOGICAL UNIT REGION.

4.14.2.2.2 Setting disc method for changing the Drive Region

The Drive Region may be set by inserting a special disc which contains a specific region code. This special disc does not require any command intervention.

4.14.3 Limits on Drive Region changes

Any of the methods defined in this specification may be used up to five times to set a logical unit's region. If the new region is the same as the old region, the region setting process ***shall*** be treated as if it had not occurred.

If an attempt by the user is made to change the Drive Region more than five times, the SEND KEY command ***shall*** terminate with CHECK CONDITION status, 5/6F/05 DRIVE REGION MUST BE PERMANENT/REGION RESET COUNT ERROR.

For more information on the region code setting process, see Figure 20.

4.14.4 RPC states

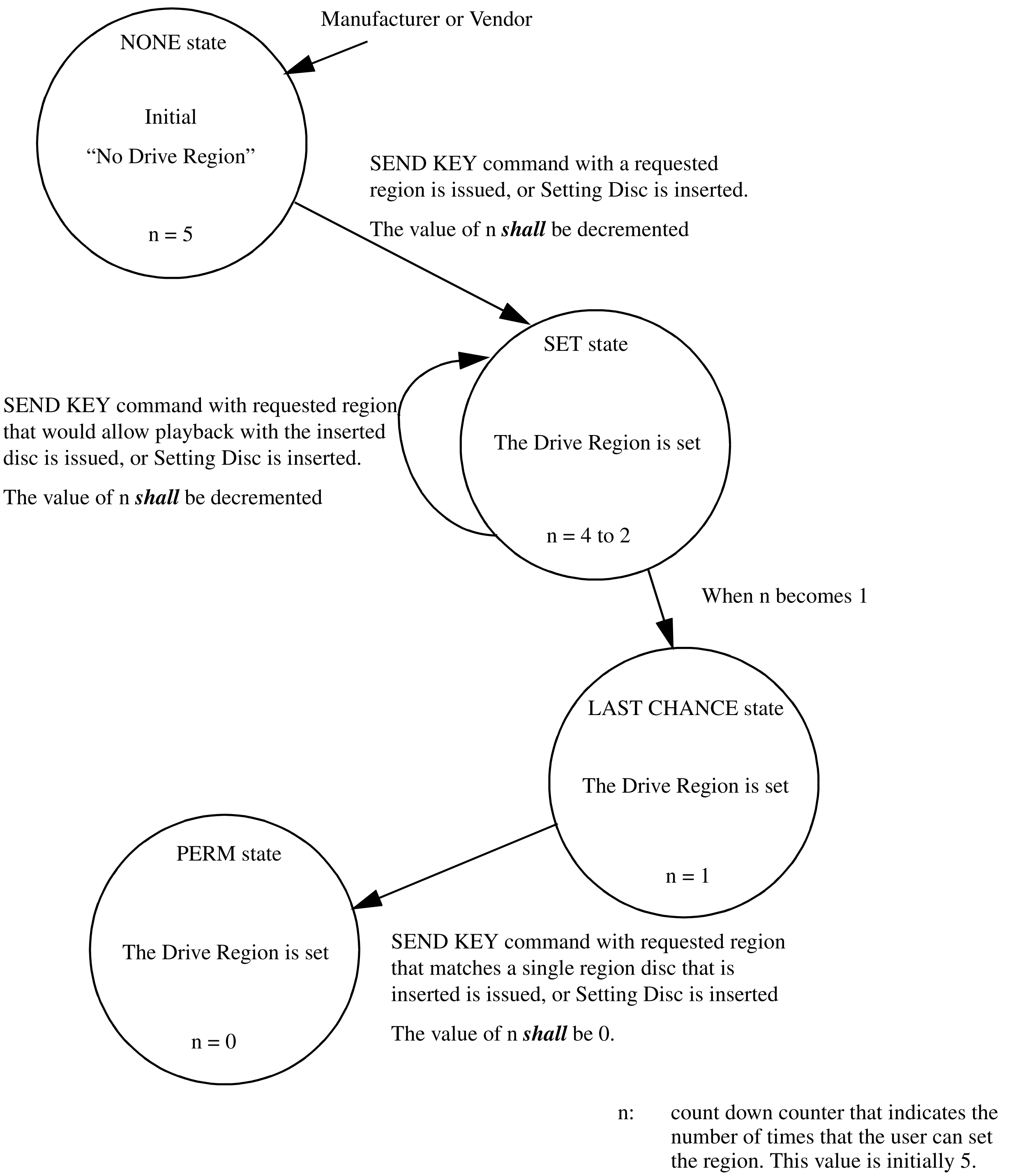


Figure 20 - Region state diagram

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4.15 Recording and reading for DVD-RAM media

DVD-RAM media is directly addressable by a logical block address and permits reading and writing from any of the consecutively numbered logical blocks. Though the Logical Block Addresses are consecutive, the actual data may not be stored in a consecutive manner because of defect management and the existence of physical sectors which do not directly correspond to logical blocks. Such physical sectors comprise spare sectors and unused sectors.

4.15.1 Logical layout of DVD-RAM media

DVD-RAM media is divided into multiple Zones. The first sector of each revolution in these Zones always align. The data is recorded using a constant angular velocity within each Zone, thus the actual size of the "bits" within a zone increase from the beginning of a zone toward the end of the zone. This keeps the data rate constant for reading and writing within each Zone with constant rotational speed. Each Zone has a fixed radius in width and as such each contains a different number of sectors.

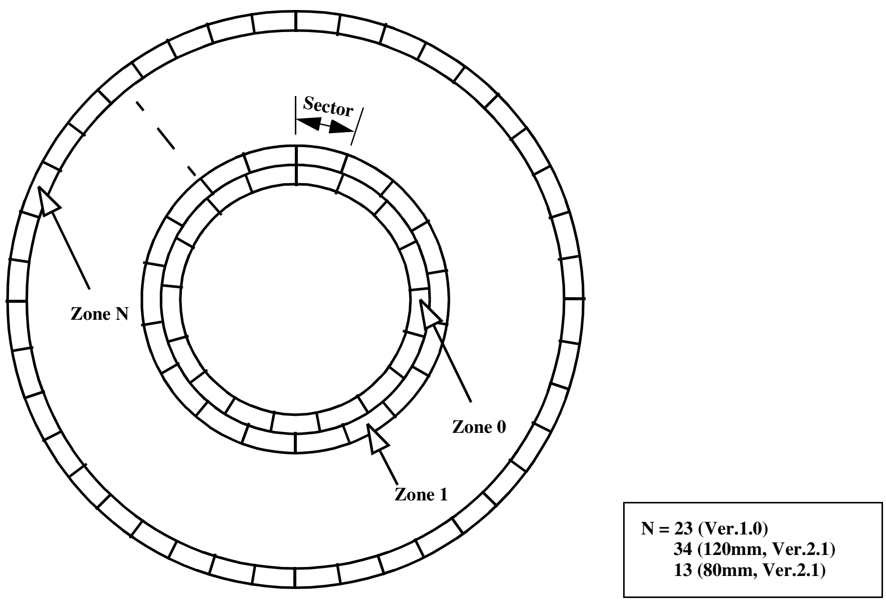


Figure 21 - Zoning of DVD-RAM media

The Data Area begins at 031000h for DVD-RAM, apart from DVD-ROM and DVD-R, where Data Areas begin at 030000h. This is caused by the existence of Defect Controls. There are two Defect Controls: one is located immediately before the Data Area and starts at 030000h, and the other is located immediately after the Data Area. The Defect Controls are non-user addressable areas. These blocks contain Defect Management Areas (DMAs).

The DMA contains Disc Definition Structure (DDS) for the recording method used for formatting of the disc, a Primary Defect List (PDL) for recording defective sectors identified at formatting of the disc, and a Secondary Defect List (SDL) for recording defective ECC blocks identified during writing/reading user data.

1. DVD-RAM Ver.1.0
   Each Zone has 3 areas: User Area, Spare Area and Guard Area. See Figure 9 - *Physical and logical layout of DVD-RAM Ver.1.0 media* on page 75. The User Area and Spare Areas contain user accessible sectors addressed by an LBA. The LBAs increase toward the Outer Diameter. Defective sectors are replaced by sectors in the Spare Area, thus the number of user accessible sectors in each zone is kept at a fixed and predetermined number. The last LBA is 12998Fh.
   The number of sectors in the Spare Area allocated per zone is proportional to the number of sectors in each User

Area. The total number of Spare sectors is 65392. The combination of the User Area and Spare Area is called a Group. The Guard Area is located at the boundary to prevent signal crosstalk between Zones. (See Table 36)

2. DVD-RAM Ver.2.1
   The Data Area has one or two Spare Areas. There are two types of Spare area, Primary Spare Area (PSA) and Supplementary Spare Area (SSA). See Figure 10 - *Physical and logical layout of DVD-RAM Ver.2.1 media* on page 76. Primary Spare Area is always pre-assigned at Initialization/Re-initialization. Pre-assigned Supplementary Spare Area is selectable at Initialization/Re-initialization. And Supplementary Spare Area is expandable after Initialization/Re-initialization. The User Area and Spare Areas contain user accessible sectors addressed by an LBA. The LBAs increase toward the Outer Diameter. Defective sectors are replaced by sectors in the Spare Area. The last LBA is 23051Fh in the case of 120mm and AE6EFh in the case of 80mm.
   The location of Primary Spare Area is written in the DDS and the location of Supplementary Spare Area is written in the SDL.
   The total number of sectors in Primary Spare Area is 12800 in the case of 120mm and 5120 in the case of 80mm. DVD-RAM Ver.2.1 has only one group. The total number of sectors in Supplementary Spare Area is from 0 to 97792 in the case of 120mm and 89088 in the case of 80mm. The Guard Area is located at the boundary to prevent signal crosstalk between Zones (See Table 37). LBA of first Sector in the Group in Table 37 is the case of no defects in the media.

4.15.2 Supplementary Spare Area

As long as a disc is used with a cartridge, PSA has enough size to ensure user data. PSA is allocated in inner area of the Data Area regardless of formatting type. A block in the PSA is used as a replacement block of a defective block in the user Data Area according to Slipping Replacement Algorithm or Linear Replacement Algorithm.

When a disc is used without a cartridge, defective blocks caused by contamination may increase unexpectedly. In order to supplement insufficiency of spare blocks, SSA can be allocated on formatting or after formatting. SSA is allocated in the most outer area of the Data Area and may grow toward inner radius.

On formatting of a disc, the host can allocate SSA with FORMAT UNIT command with Format Type field of 00h in the Format Descriptor. See Figure 22. The number of blocks to be used for user data recording is specified with Number of Blocks field in the Format Descriptor, and the rest of Data Area is assigned for SSA. All allocatable number of blocks ***shall*** be returned in Formattable Descriptors with Format Type field of 00h in response to READ FORMAT CAPACITIES command. On the formatting with Format Type with 00h, defect management information may be changed and user data written before the formatting is not guaranteed.

If the number of available spare blocks decreases because of many replacement operation, SSA is expandable after formatting of a disc. The logical unit ***shall*** report CHECK CONDITION status, 1/5D/03 FAILURE PREDICTION THRESHOLD EXCEEDED - Predicted Spare Area Exhaustion in response to the command after detecting consumption of available spare blocks. If the host receives the Recovered Error for consumption of spare area, the host should issue FORMAT UNIT command with Format Descriptor that contains Format Type field of 01h and the Number of Blocks field. The Format Descriptor, that is sent with FORMAT UNIT command ***shall*** be one of the Formattable Descriptors returned by READ FORMAT CAPACITIES command. All allocatable number of blocks ***shall*** be returned in Formattable Descriptors with Format Type field of 01h in response to READ FORMAT CAPACITIES command, but Formattable Descriptors that contain the Number of Blocks larger than or equal to the current Number of Blocks ***shall not*** be returned. If the area that is newly allocated to the SSA includes user data, the host should move the user data and update file management information. On expansion operation of SSA, user data that is included in the LBA Space after expansion ***shall*** be retained and defect management information ***shall not*** be changed.

SSA ***shall*** be used after PSA exhaustion. See Figure 23. The Spare Area is used in descending Block order in each of Spare Areas, and the defective sectors in the Spare Area and the corresponding replacement sectors, which have been already registered in the PDL or the SDL, ***shall not*** be used as spare sectors.

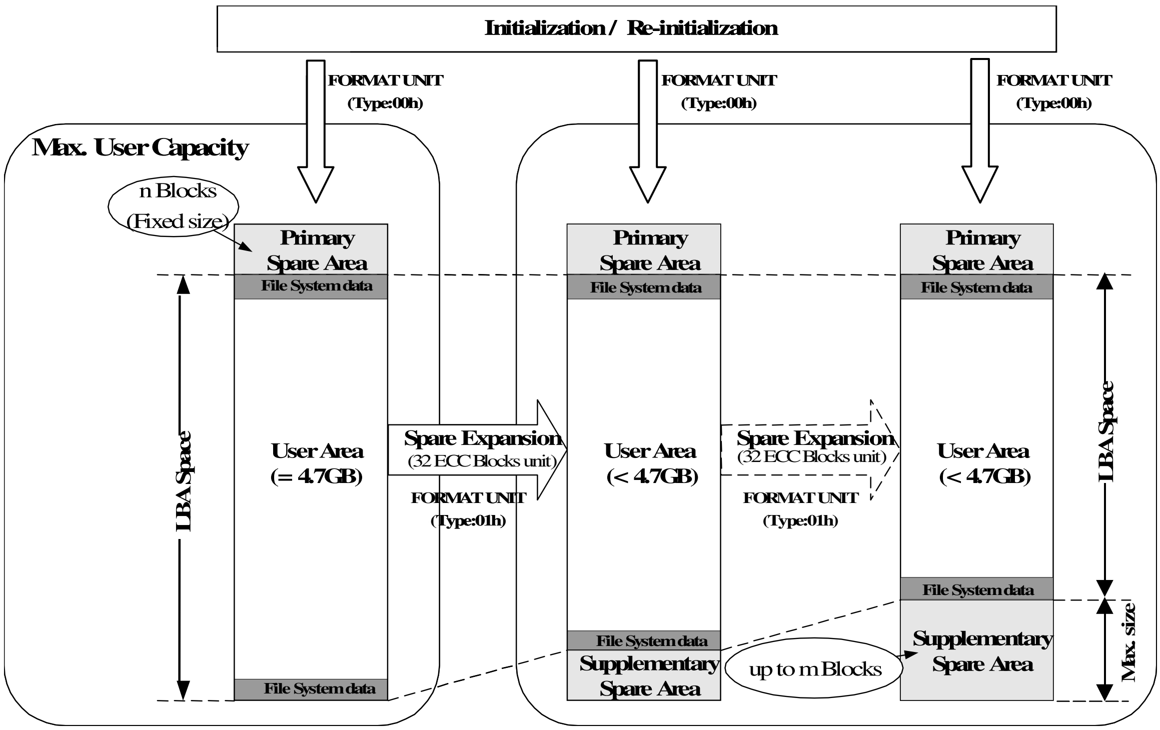


Figure 22 - Supplementary Spare Area example (120 mm, Ver.2.1)

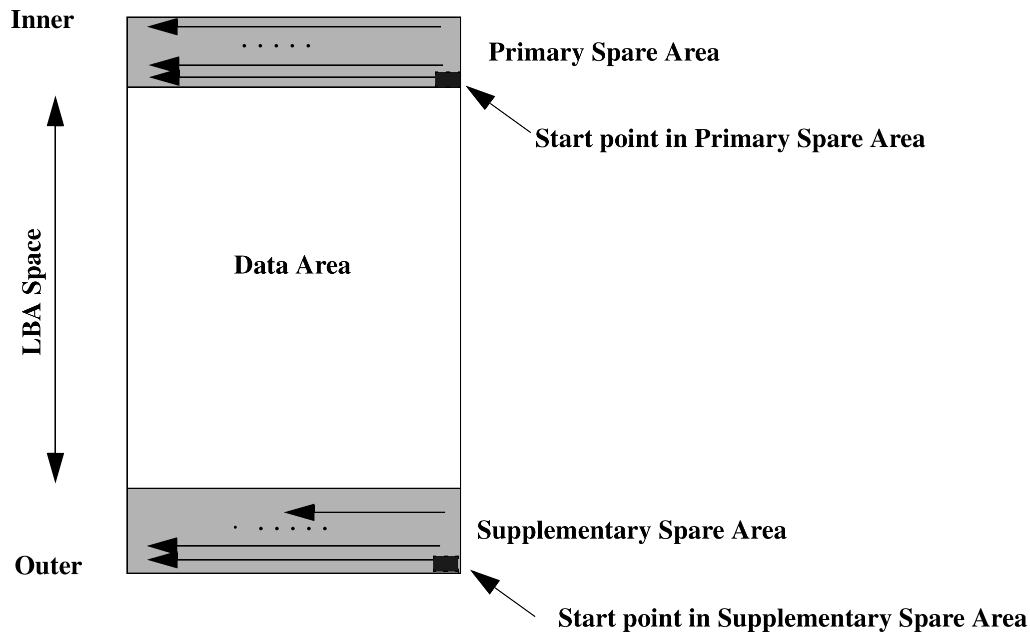


Figure 23 - Usage of Spare Area (Ver.2.1)

Table 36 - Allocation of Data Area of DVD-RAM Ver.1.0 media

Zone No.	Group No.	No. of Physical Sectors				LBA of first Sector in the Group
		Guard Area	User Area	Spare Area	Guard Area	
0	0	0	26592	1360	48	0
1	1	48	32160	1728	48	26592
2	2	48	33952	1824	48	58572
3	3	48	35744	1920	48	92704
4	4	48	37536	2016	48	128448
5	5	48	39328	2112	48	165984
6	6	48	41120	2208	48	205312
7	7	48	42912	2304	48	246432
8	8	64	44672	2400	64	289344
9	9	64	46464	2496	64	334016
10	10	64	48256	2592	64	380480
11	11	64	50048	2688	64	428736
12	12	64	51840	2784	64	478784
13	13	64	53632	2880	64	530624
14	14	64	55424	2976	64	584256
15	15	64	57216	3072	64	639680
16	16	80	58976	3168	80	696896
17	17	80	60768	3264	80	755872
18	18	80	62560	3360	80	816640
19	19	80	64352	3456	80	879200
20	20	80	66144	3552	80	943552
21	21	80	67936	3648	80	1009696
22	22	80	69728	3744	80	1077632
23	23	80	71600	3840	0	1147360
Total	N/A	1488	1218960	65392	1456	N/A

Table 37 - Allocation of Data Area of DVD-RAM Ver.2.1 media (120 mm)

Zone No.	Group No.	No. of Physical Sectors				LBA of first Sector in the Zone[a]
		Guard Area	User Area	Spare Area	Guard Area	
0	0	0	22240	12800	64	0
1	0	64	40640	0	64	22240
2	0	64	42208	0	64	62880
3	0	64	43776	0	64	105088
4	0	64	45344	0	64	148864
5	0	64	46912	0	64	194208
6	0	64	48480	0	64	241120
7	0	64	50048	0	64	289600
8	0	80	51584	0	80	339648
9	0	80	53152	0	80	391232

Table 37 - Allocation of Data Area of DVD-RAM Ver.2.1 media (120 mm) (Continued)

Zone No.	Group No.	No. of Physical Sectors				LBA of first Sector in the Zone[a]
		Guard Area	User Area	Spare Area	Guard Area	
10	0	80	54720	0	80	444384
11	0	80	56288	0	80	499104
12	0	80	57856	0	80	555392
13	0	80	59424	0	80	613248
14	0	80	60992	0	80	672672
15	0	80	62560	0	80	733664
16	0	96	64096	0	96	796224
17	0	96	65664	0	96	860320
18	0	96	67232	0	96	925984
19	0	96	68800	0	96	993216
20	0	96	70368	0	96	1062016
21	0	96	71936	0	96	1132384
22	0	96	73504	0	96	1204320
23	0	96	75072	0	96	1277824
24	0	112	76608	0	112	1352896
25	0	112	78176	0	112	1429504
26	0	112	79744	0	112	1507680
27	0	112	81312	0	112	1587424
28	0	112	82880	0	112	1668736
29	0	112	84448	0	112	1751616
30	0	112	86016	0	112	1836064
31	0	112	87584	0	112	1922080
32	0	128	89120	0	128	2009664
33	0	128	90688	0	128	2098784
34	0	128	105600-M[b]	M	0	2189472
Total	N/A	3136	2295072-M	12800+M	3072	N/A

a. “LBA of first Sector in the Zone” is for a defect free disc.

b. Where ’M’ is the number which is multiple of 512 sectors (32 ECC blocks), and maximum number of ’M’ is 97792.

Table 38 - Allocation of Data Area of DVD-RAM Ver.2.1 media (80 mm)

Zone No.	Group No.	No. of Physical Sectors				LBA of first Sector in the Zone[a]
		Guard Area	User Area	Spare Area	Guard Area	
0	0	0	29920	5120	64	0
1	0	64	40640	0	64	29920
2	0	64	42208	0	64	70560
3	0	64	43776	0	64	112768
4	0	64	45344	0	64	156544
5	0	64	46912	0	64	201888
6	0	64	48480	0	64	248800
7	0	64	50048	0	64	297280
8	0	80	51584	0	80	347328
9	0	80	53152	0	80	398912
10	0	80	54720	0	80	452064
11	0	80	56288	0	80	506784
12	0	80	57856	0	80	563072
13	0	80	93552-M[b]	M	0	620928
Total	N/A	928	714480-M	5120+M	912	N/A

a. “LBA of first Sector in the Zone” is for a defect free disc.
b. Where ’M’ is the number which is multiple of 512 sectors (32 ECC blocks), and maximum number of ’M’ is 89088.

4.15.3 DVD-RAM ECC block boundary issue

The location of logical sectors is derived from the defect list information. When a physical sector is found defective and newly slipped during formatting, a result is that the ECC block boundaries change and thus the addressing of all the following sectors in that zone changes. Following any new “slipping” of a physical sector, all the following ECC blocks in that zone ***shall*** be written with new ECC block boundaries before reading. The only exception is a case when all the following ECC blocks have been written with the initialization pattern used at certification which can be determined by the Data ID of the logical block. In this case, the logical unit discriminates the initialization pattern even when the ECC block boundaries are incorrect and ***shall*** treat these ECC blocks as if all zero data has been written.

4.15.4 Unrecorded ECC blocks

A DVD-RAM disc which has not been certified may contain unrecorded ECC blocks to which user data has not been written. The logical unit ***shall*** return all zero data in response to an attempt to read logical blocks from such unrecorded ECC blocks. Further, a logical block may contain an initialization pattern used at certification which can be discriminated by the Data ID of the logical block. The logical unit also returns all zero data in response to an attempt to read such Logical Blocks containing the initialization pattern.

4.15.5 Read Modify Write

Any attempt to write data less than one ECC block causes a read-modify-write operation in the logical unit, which requires more than one rotation to write the data, if data is not cached.

1. Reading an ECC block containing the designated logical blocks (First path)
2. Overlay the data to be written onto the read out ECC block data
3. Writing the modified ECC block data back to the same addresses (Second path)

When an ECC block designated for Read-Modify-Write operation is physically unwritten or contains the initialization pattern used at certification, which can be discriminated by the Data ID of the Logical Block, the logical unit writes all zero data to the logical blocks in the ECC block other than the designated Logical Blocks from the host.

A technique to provide better performance with DVD-RAM media is to write data in sizes that are a multiple of 32768 bytes starting at a logical block address that is a multiple of 16, which results in a one path direct overwrite operation. These values can be determined from the Random Readable Feature Descriptor (see *16.4.2.6, "Feature 0010h: Random Readable"* on page 420).

4.15.6 Data ID

DVD-RAM has major differences from DVD-ROM, DVD-R/-RW, DVD+RW in that embossed Headers are used to identify the physical sectors. The address used by the logical unit to read or write sectors is the “physical” address, not the Data ID.

4.15.7 Defect management for DVD-RAM media

Defective physical sectors in the Data Area of DVD-RAM media are managed by the logical unit according to the defect management scheme specified in the DVD Book for Rewritable Disc, Part 1: Physical Specifications.

Two replacement methods are defined for defective physical sectors:

Slipping replacement is the first method in which a defective physical sector is replaced by the first non-defective physical sector following the defective physical sector. The slipping replacement is performed in units of a physical sector. Defective sectors replaced by the slipping replacement are listed in Primary Defect List (PDL) recorded on the DVD-RAM media during formatting. Contents of the PDL on DVD-RAM media can be changed only by formatting. The number of sectors in a group to be listed in the PDL ***shall not*** exceed the number of sectors in the Spare Area in that group. Entries of the PDL consist of three categories: P-list, G_1-list and G_2-list.

- Defective physical sectors encountered by media manufacturer before shipment of the DVD-RAM media are listed in the P-list. A defect is registered to the P-list in a unit of 1 physical sector. Time to perform the slipping replacement for a defective sector listed in the P-list is minimal, because it requires time only to pass the defective sector. The P-list ***shall*** be preserved during any formatting and ***shall*** be always used in order to avoid possible change of ECC block framing by formatting.
- Defective physical sectors encountered by certification after shipment of the DVD-RAM media are listed in the G_1-list. A defect is registered to the G_1-list in a unit of 1 physical sector. Time to perform the slipping replacement for a defective sector listed in the G_1-list is minimal as in the P-list. The G_1-list ***shall*** be always used and ***shall*** only be changed with certification in order to avoid possible change of ECC block framing by formatting.
- Defective physical sectors transformed from the SDL by formatting are listed in the G_2-list. A defect registered to the G_2-list consumes 16 entries at once. Time to perform the Slipping Replacement for defective sector listed in the G_2-list is longer than the time for P-list or G_1-list, because it requires time to pass 16 consecutive sector. However, it is still much faster than Linear Replacement because it does not require a Seek operation to the Spare Area. The G_2-list can be changed without certification, however, the G_2-list ***shall*** be disposed at certification in order to avoid possible change of ECC block framing by formatting

Linear Replacement is the second method in which a defective physical sector is replaced by the first available physical sector out of spare sectors. The linear replacement is performed in a unit of 16 physical sectors (an ECC block). An ECC block found to be defective is replaced by the first available good spare ECC block of the group. If there is no spare ECC block left in that group, the first available good spare ECC block of another group is used (DVD-RAM Ver.2.1 has only one group). Defective ECC blocks replaced by the Linear Replacement are listed in the Secondary Defect List (SDL) recorded on the DVD-RAM media. Contents of the SDL on DVD-RAM media are updated whenever an ECC block is found to be defective. When a replacement ECC block is found to be defective, a new replacement ECC block will be substituted and the SDL will be updated on the media. Chaining of replacement will not be performed, direct pointer method will be applied. Time to perform the Linear Replacement is longest because it requires seek operation to the Spare Area and writing/reading the replacement ECC block. However, this is the only method to register a new defect without formatting the media.

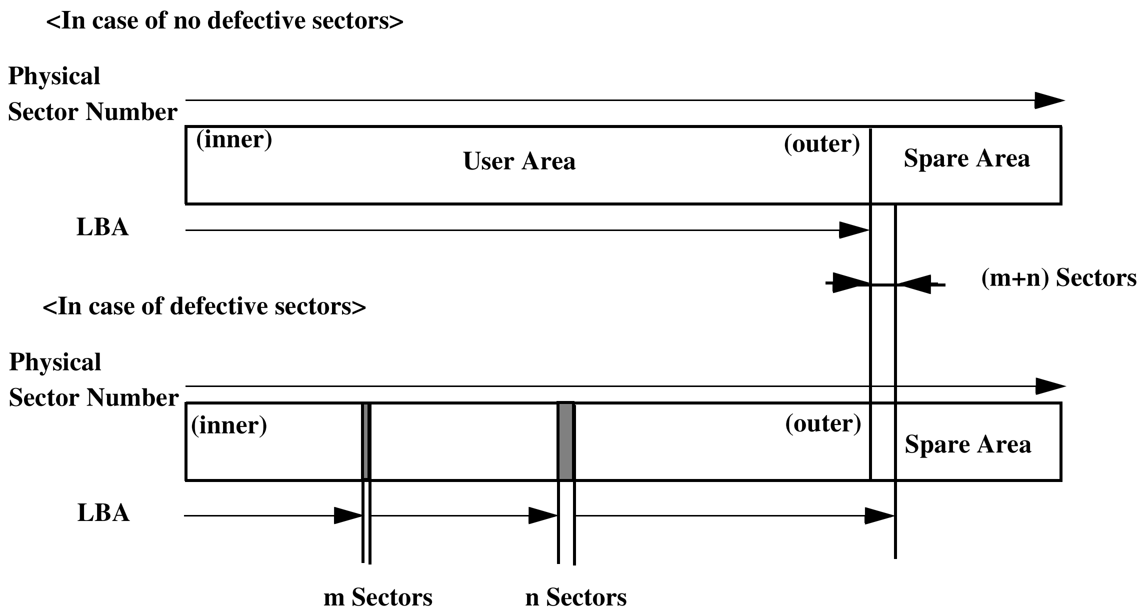
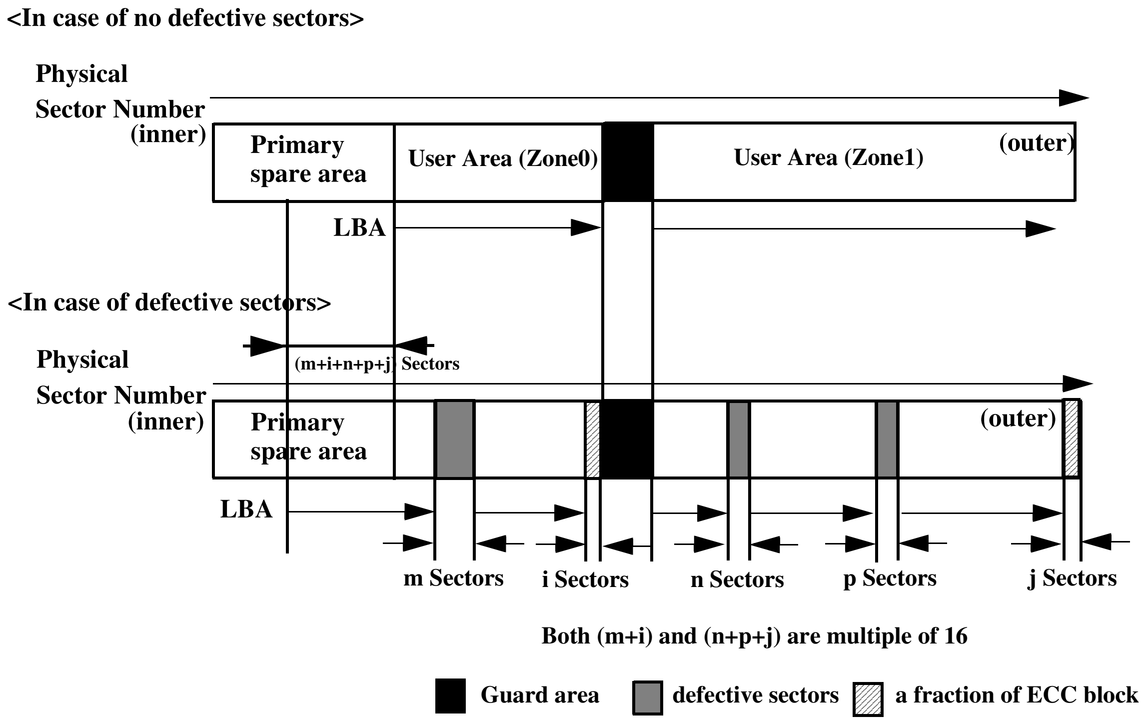


Figure 24 - Slipping Replacement Example (Ver.1.0)



Each defective sector causes a slip towards the top of the Data Area. The defective sectors in each zone may make a fraction of an ECC block, this fraction ***shall*** be moved to just before the Guard area at the end of the zone. The ECC block fraction ***shall not*** be used for recording user data. Only Primary Spare Area ***shall*** be used for the Slipping Replacement.

Figure 25 - Slipping Replacement Example (Ver.2.1)

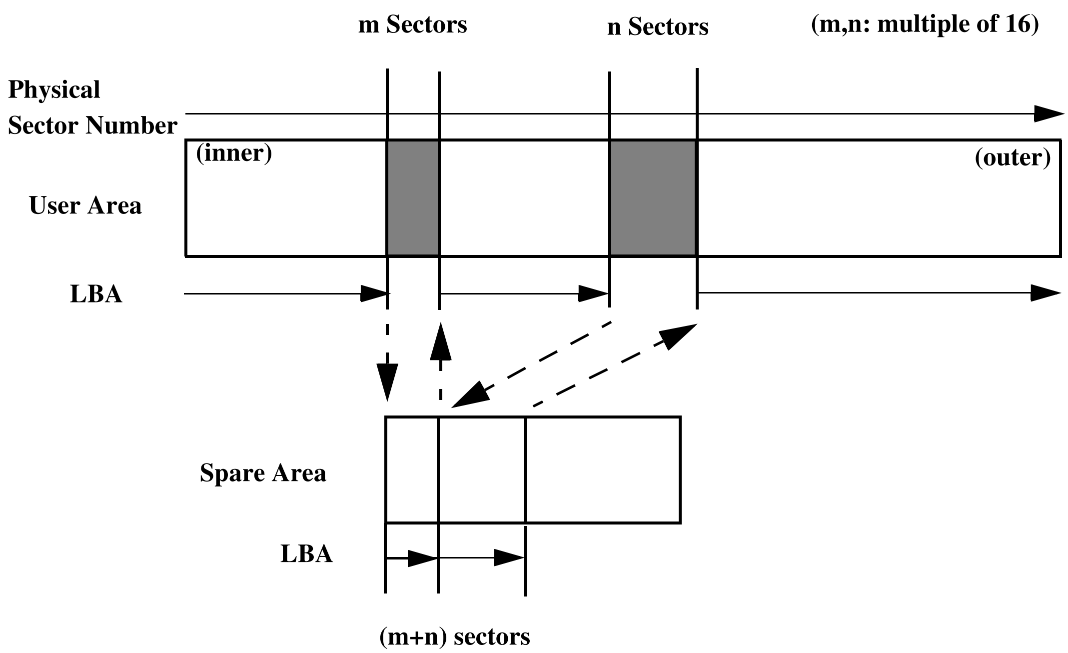


Figure 26 - Linear Replacement Example (Ver.1.0)

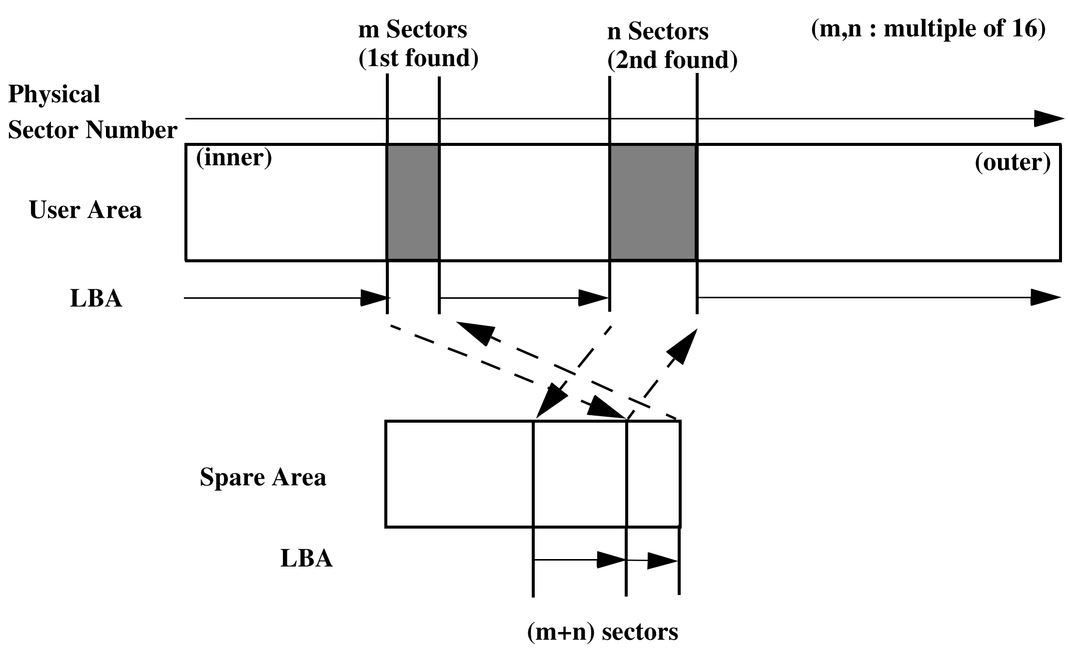


Figure 27 - Linear Replacement Example (Ver.2.1)

4.15.8 DMA information

The Defect Management Area (DMA) consists of two ECC blocks. The first ECC block contains the Disc Definition Structure (DDS) for the recording method used for formatting of the disc, and the Primary Defect List (PDL) for recording defective sectors identified at formatting of the disc. The DDS contains the following information.

- In-process (In-progress, in the case of DVD-RAM Ver.2.1) flag indicating formatting operation is completed or not. This flag enables to recover a suspended formatting operation.
- A flag indicating the media has been certified by media manufacturer or not.
- A flag indicating the media has been certified by the logical unit or not.

The PDL contains information of defective sectors to be replaced by the slipping replacement. Though the PDL has a capacity to hold defective sector information for up to 7679 sectors in the case of 120mm and 4095 sectors in the case of 80mm, there is another limitation of the maximum number. See Figure 29 - *Limitation of maximum number of sectors for PDL and SDL* on page 114.

The second ECC block contains the Secondary Defect List (SDL) for recording defective ECC blocks identified during writing/reading user data. Though the SDL has a capacity to hold the defective ECC block information up to 3837 ECC blocks which corresponds to 61392 sectors, there is another limitation of the maximum number. See Figure 29 - *Limitation of maximum number of sectors for PDL and SDL* on page 114.

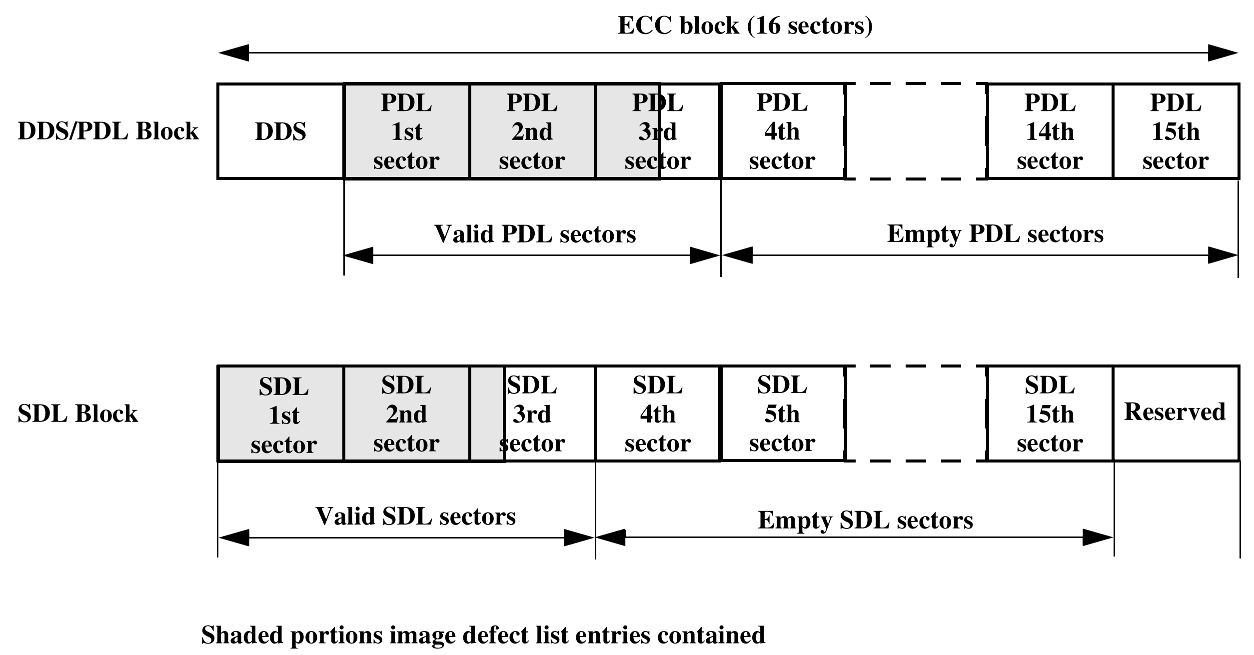


Figure 28 - DDS/PDL Block and SDL Block

Table 39 - DDS information (Ver.1.0)

Bit / Byte	7	6	5	4	3	2	1	0
0 - 1	DDS Identifier (0A0Ah)							
2	Reserved							
3	Disc Certification Flag							
4 - 7	DDS/PDL Update Counter							
8 - 9	Number of Groups (0018H)							
10 - 15	Reserved							
16	Group Certification Flag for Group 0							
17	Group Certification Flag for Group 1							
18	Group Certification Flag for Group 2							
19	Group Certification Flag for Group 3							
20	Group Certification Flag for Group 4							
21	Group Certification Flag for Group 5							
22	Group Certification Flag for Group 6							
23	Group Certification Flag for Group 7							
24	Group Certification Flag for Group 8							
25	Group Certification Flag for Group 9							
26	Group Certification Flag for Group 10							
27	Group Certification Flag for Group 11							
28	Group Certification Flag for Group 12							
29	Group Certification Flag for Group 13							
30	Group Certification Flag for Group 14							
31	Group Certification Flag for Group 15							
32	Group Certification Flag for Group 16							
33	Group Certification Flag for Group 17							
34	Group Certification Flag for Group 18							
35	Group Certification Flag for Group 19							
36	Group Certification Flag for Group 20							
37	Group Certification Flag for Group 21							
38	Group Certification Flag for Group 22							
39	Group Certification Flag for Group 23							
40-2047	Reserved							

Table 40 - DDS information (Ver.2.1)

Byte \ Bit	7	6	5	4	3	2	1	0
0 - 1	DDS Identifier (0A0Ah)							
2	Reserved							
3	Disc Certification Flag							
4 - 7	DDS/PDL Update Counter							
8 - 9	Number of Groups (0001H)							
10 - 11	Number of zones							
12 - 79	Reserved							
80 - 87	Location of Primary spare area							
88 - 91	Location of LSN0							
92 - 255	Reserved							
256 - 259	Start LSN for Zone0							
260 - 263	Start LSN for Zone1							
:	:							
308 - 311	Start LSN for Zone13							
312 - 315	Start LSN for Zone14 (Reserved in the case of for 80mm)							
:	:							
392 - 395	Start LSN for Zone34 (Reserved in the case of for 80mm)							
396 - 2047	Reserved							

Table 41 - Disc Certification Flag format (Ver.1.0)

Bit							
7	6	5	4	3	2	1	0
Formatting in-process	Certification full/partial	Formatting for the whole disc/ group	Reserved			The whole disc has been certified by user	The disc has been certified by disc manufacturer

Table 42 - Disc Certification Flag format (Ver.2.1)

Bit							
7	6	5	4	3	2	1	0
Formatting in-progress	Reserved					The whole disc has been certified by user	The disc has been certified by disc manufacturer

Table 43 - Group Certification Flag format (Only Ver.1.0)

Bit							
7	6	5	4	3	2	1	0
Zoned Formatting in-process	Certification full/partial	Reserved				This Group has been certified by user	Reserved

The size of the defect lists will be limited by several factors. As the information about all defects in the PDL and the SDL ***shall*** be used to access LBAs, the defect lists would normally be kept in the logical unit's memory. So that this does not become a problem for some logical units, the total size will have a maximum. The total defect list (memory) size ***shall not*** exceed 32 Kbytes (60Kbytes in the case of 120mm, 46Kbytes in the case of 80mm, in Ver.2.1). As there are two defect lists, the size of each will be considered. Each list will always contain data from a whole number of sectors. For example, if a single PDL entry is used, the memory size will be 2048 bytes, not 4 only.

$S_{PDL} + S_{SDL} \leq 16$, in the case of DVD-RAM Ver.1.0

$(1 \leq S_{PDL} \leq 15,\ 1 \leq S_{SDL} \leq 15)$, in the cases of both DVD-RAM Ver.1.0 and 2.1 (120 mm)

$(1 \leq S_{PDL} \leq 8,\ 1 \leq S_{SDL} \leq 15)$, in the cases of both DVD-RAM Ver.2.1 (80 mm)

$$S_{PDL} = INT\left[\frac{(E_{PDL} \times 4 + 4) + 2047}{2048}\right]$$

$$S_{SDL} = INT\left[\frac{(E_{SDL} \times 8 + 24) + 2047}{2048}\right]$$

S_{PDL} is the number of sectors used to hold PDL entries
S_{SDL} is the number of sectors used to hold SDL entries
E_{PDL} is the number of PDL entries
E_{SDL} is the number of SDL entries

Figure 29 - Limitation of maximum number of sectors for PDL and SDL

4.15.9 Scheduling of Linear Replacement

The DVD-RAM format is designed to enable the following Linear Replacement methods, with some consideration for issues of real-time data recording, where for example the reassignments are disabled during some operations.

- When recording data with verification by the WRITE AND VERIFY (10) command, the logical unit has an opportunity to evaluate the written data and if the data is found defective, the logical unit may perform a Linear Replacement.
- For data recorded without verification, the logical unit has an opportunity to evaluate the written data when the host attempts to read the data from that LBA and if the data is found defective but correctable by ECC, the logical unit may perform the Linear Replacement operation, if read reassignment is enabled.
- For data recorded without verification, the logical unit has an opportunity to evaluate the written data when the host attempts to read the data from that LBA and if the data is found defective but correctable by ECC, the logical unit may mark the ECC block defective to enable future Linear Replacement operation when the host writes new data to that LBA, if read reassignment is disabled. This marking scheme by the logical unit is possible to be applied only for DVD-RAM version 1.0 media.
- For data recorded without verification, the logical unit has an opportunity to evaluate the written data when the host makes an attempt to read the data from that LBA and if the data is found defective and uncorrectable by ECC, the logical unit can mark the ECC block defective to enable future Linear Replacement operation when the host writes new data to that LBA. This marking scheme by the logical unit is possible to be applied only for DVD-RAM Ver.1.0 media.

4.15.10 Formatting

Formatting is required at the beginning of use of DVD-RAM media. During formatting, the logical unit defines correspondence between LBAs and physical addresses and records relevant information in the Defect Management Areas. All the user data in the formatted extent is lost during the formatting. Media certification may be included as a part of the formatting. No defect list ***shall*** be transferred from the host, i.e. there ***shall*** be no D-list for DVD-RAM media.

The certification process included in the formatting should not be confused with media certification from a media manufacturer. The logical unit controlled “certification” allows the logical unit to write and verify all the sectors on the media. This operation allows some defects to be registered in the G_1-list for the Slipping Replacement. These are not the same as certification defects from the media manufacture which is recorded in the P-list. The result of the “certification” process of the FORMAT UNIT command is to leave every sector with a special ID content called the “Initialization pattern.” This type of ECC block ***shall*** be treated as though all zero data has been written. This is the same as an unwritten ECC block.

There are two cases where the spare sectors available are exhausted:

- During a re-formatting, when SDL entries are converted to G_2-list entries.
- During a formatting with certification, when new defects are found that exceed the available spare sectors in that zone (ver.1.0 only).

When these happen, the logical unit ***shall*** place the overflow sectors into the SDL and replace these sectors with spare sectors from another zone. During re-formatting, SDL entries that cannot be converted to PDL entries will be kept in the SDL, but the replacement location may change. During a formatting with certification, when new PDL entries are added that cannot be used because there are not enough spare sectors in that zone, a new SDL entry ***shall*** be created. In both cases, the SDL may not be empty after the FORMAT UNIT command completes.

If the total number of spare sectors are exhausted during a FORMAT UNIT command, the format operation will not stop, but will ignore those defects that cannot be replaced and a RECOVERED ERROR ***shall*** be reported at the completion.

If the size of the PDL & SDL are going to exceed the limit in Figure 29, the logical unit ***shall*** discard defect entries until the size does not exceed that limit.

There can be considered four kinds of formatting depending on how the certification performed and how the old defect list (G_1-list and G_2-list) is treated:

4.15.10.1 Formatting Type 1 - Slow Initialization (Ver.1.0 and 2.1)

The purpose of Formatting Type 1 is to initialize the medium using the media manufacturer's defect list (P-list), assuming that the media has defects not in the P-list. The logical unit performs its own certification. The execution time is long, at least one hour or more. Every physical sector should be written with initialization pattern and verified.

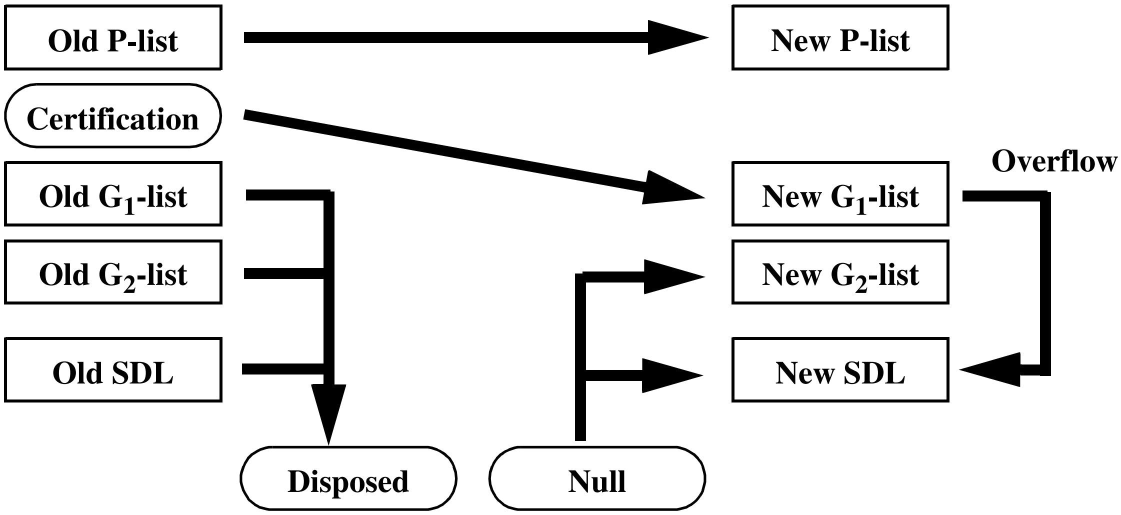


Figure 30 - Formatting Type 1 - Slow Initialization

4.15.10.2 Formatting Type 2 - Quick Improvement (Ver.1.0 and 2.1)

The purpose of Formatting Type 2 is to remove reassigned sectors for Linear Replacement and change them to Slipping Replacement. The total number of Spare sectors available remains the same. The execution time is very little, only several seconds is expected.

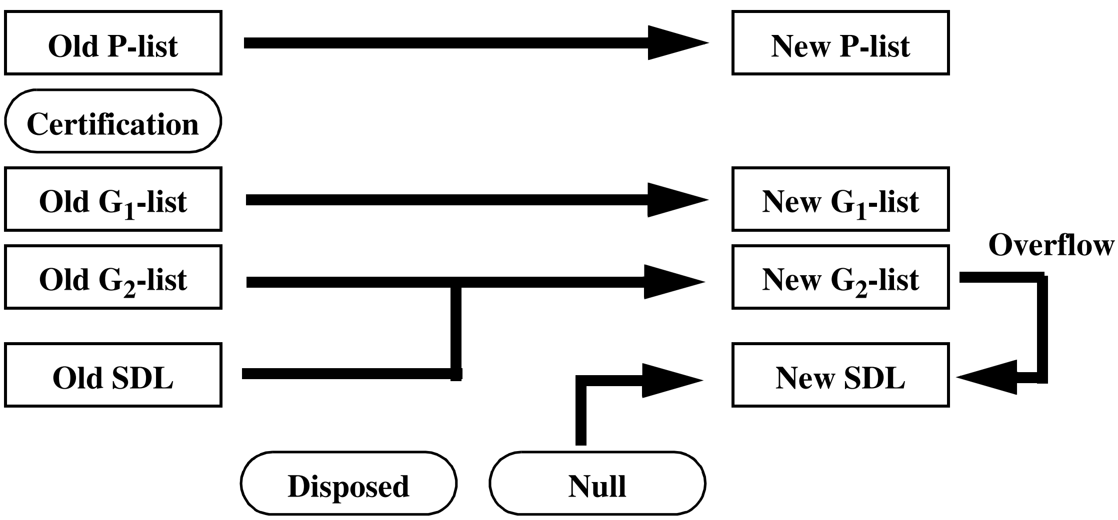


Figure 31 - Formatting Type 2 - Quick Improvement

4.15.10.3 Formatting Type 4 - Quick Clearing (Ver.1.0 and Ver.2.1)

The purpose of Formatting Type 4 is to initialize the media for use, using only media manufacturer defect information. Another purpose is to return the media to the latest certified state by removing reassigned sectors for Linear Replacement and the G_2-list. The execution time is very little; only several seconds is expected.

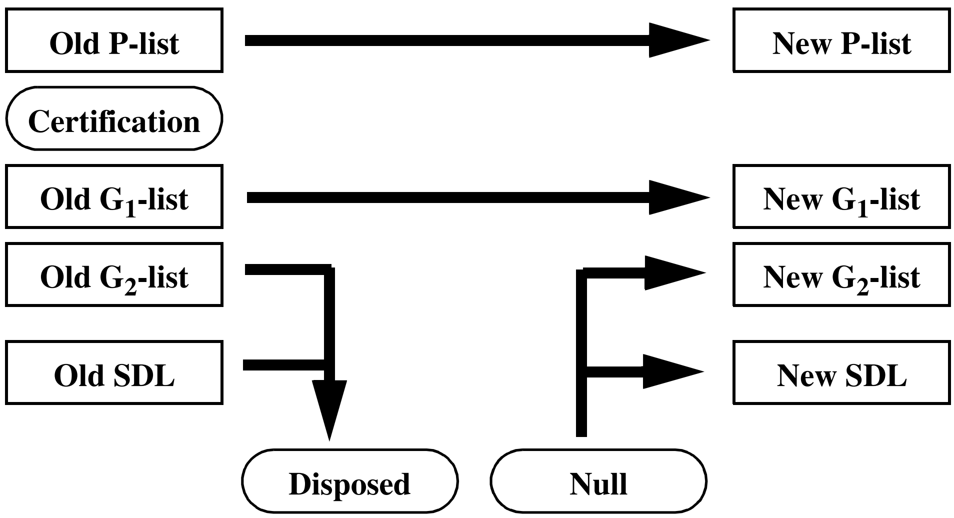


Figure 32 - Formatting Type 4 - Quick Clearing

4.15.11 Interruption of formatting

An interruption of formatting by reset, or power off may cause the media to be unusable without another formatting operation. In any case, all the user data in the formatting extent ***shall*** be assumed to be lost, because correspondence between the LBAs and physical addresses may have been changed.

- An interruption of formatting Type 1 may cause the media to be unusable because of uncompleted change of the ECC boundaries. Any access to the media in this condition other than a proper FORMAT UNIT command ***shall*** be terminated with CHECK CONDITION status, 3/31/00 MEDIUM FORMAT CORRUPTED. The only recovery operation to this case is another formatting by formatting Type 1 only.
- An interruption of formatting Type 2 causes the media to be usable as there is no media certify operation.
- An interruption of formatting Type 4 causes the media to be usable as there is no certification operation.

4.15.12 Zoned formatting (Ver.1.0)

Formatting of DVD-RAM Ver.1.0 media can be performed in units of a Zone. Purposes are:

- To remove reassigned sectors of a Zone and change them for Slipping Replacement. *4.15.10.2, "Formatting Type 2 - Quick Improvement (Ver.1.0 and 2.1)"* on page 116
- To remove reassigned sectors of a Zone and encounter really defective sectors by certification for all the sectors of that Zone. *4.15.10.1, "Formatting Type 1 - Slow Initialization (Ver.1.0 and 2.1)"* on page 116

During the Zoned Formatting, data of that Zone is lost but data of the other Zones is preserved. This enables the host to reformat the media without losing the data by using appropriate save/restore operations.

4.15.13 Cartridge and Disc Type

There are three types of cartridges, Type 1, Type 2 and Type 3. See Table 44. Each cartridge has a sensor hole that indicates whether a media has taken out at least once or not, and has a write-inhibit hole for the usable side. A disc may be used without a cartridge.

Table 44 - Feature of cartridge

	Type 1 cartridge	Type 2 cartridge[a]	Type 3 cartridge[a]
Reversibility	Reversible	Non-reversible	Non-reversible
Removability of a disc from the cartridge	Impossible	Possible	Possible
Original condition of a sensor hole A1	Closed	Closed	Open

a. The difference between Type 2 and Type 3 is the condition of the sensor hole A1. The sensor hole A1 of Type 2 is originally closed. The sensor hole A1 of Type 3 is always open. See Physical specification.

4.15.14 Write protection of a disc

There are two types of write protection conditions, one is the condition set directly by users and the other is the condition for the other reasons such as a vender specific implementation.

There are two factors affecting the write protection conditions in the DVD-RAM version 1.0, Write-inhibit hole and disc type identification. In addition there is one more factor in the DVD-RAM version 2.1, Write-inhibit flag. The explanation of each factor and the possible status of the command execution are described below.

4.15.14.1 Write-inhibit hole (supported by Ver.1.0 and 2.1)

This hole is the mechanical switch/tab for write protection on a cartridge. When this hole is closed, the logical unit may write/modify information according to the other write protection conditions. When this hole on a cartridge is open, the logical unit ***shall not*** write/modify/initialize any information (including user data, defect management information and Write-inhibit flag) on the disc.

Host is able to get the Write-inhibit hole condition as a CWP bit value using READ DISC STRUCTURE command with Format Code code C0h or 09h.

4.15.14.2 Write-inhibit flag (supported by Ver.2.1)

The Write-inhibit flag can be used for a write protection function for a disc without a cartridge. When the disc is initialized logical unit ***shall*** set the flag to zero. Supporting the functionality to change this flag is optional. This flag is recorded on the disc surface. When this flag is set to zero, the logical unit may write/modify information according to the other write protection conditions. When this flag on a disc is set to one, the logical unit ***shall not*** write/modify/initialize any information (including user data and defect management information) on the disc surface. The flag itself is not write protected.

Host is able to get the Write-inhibit flag condition as a PWP[a] bit value using READ DISC STRUCTURE command with Format Code code C0h or 09h, and set/reset PWP bit using SEND DISC STRUCTURE command with Format Code code C0h.

4.15.14.3 Disc Type Identification (supported by Ver.1.0 and 2.1)

Disc Type Identification is defined in the embossed Lead-in Area. Disc Type Identification indicates whether the disc can be written without cartridge or not.

When this field of a disc is set to 00h, the logical unit ***shall not*** write/modify any information (including user data, defect management information and Write-inhibit flag) onto the disc mounted without cartridge. In this case, MSWI bit ***shall*** be set to one. See *11.3, "Error reporting"* on page 354.

When this field is set to 10h and the disc is not in the cartridge, some logical units become the write disabled condition. In this case, MSWI bit ***shall*** be set to one. See *11.3, "Error reporting"* on page 354. On the other hand, some logical units become the write enabled condition. A logical unit may reject certain write operations without verification because verify after write is recommended. In this case, the command ***shall*** be terminated with CHECK CONDITION status, 7/27/06 CONDITIONAL WRITE PROTECT.

Host is able to get the Disc Type Identification value by using READ DISC STRUCTURE command with Format Code code 09h.

4.15.14.4 Sensor hole A1 (supported by Ver.1.0 and 2.1)

The Sensor hole A1 indicates whether the disc had been taken out from a cartridge or not. The Sensor hole A1 is closed when the disc had never been taken out from the cartridge. The Sensor hole A1 is open when once the disc had been taken out from the cartridge. In the case of the Sensor hole A1 open, verify after write is recommended. A logical unit may reject certain write operations without verification. In this case, the command ***shall*** be terminated with CHECK CONDITION status, 7/27/06 CONDITIONAL WRITE PROTECT. These differences depend on the drive implementation for keeping data integrity.

Note: WRITE (12) command with Streaming bit set to one may not be affected by the Sensor hole A1 status. If logical unit does not permit execution of the command when Sensor hole A1 is open, the command is terminated with CHECK CONDITION status, 7/27/06 CONDITIONAL WRITE PROTECT.

Host is able to get the sensor hole A1 condition as a Out bit value using READ DISC STRUCTURE command with Format Code code 09h.

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4.16 Recording for DVD-R Single Layer media

4.16.1 Basics for DVD-R vs. CD-R

Generally the contents on a DVD disc are managed using the OSTA Universal Disk Format (UDF) file system. (UDF Bridge may also be used.) A DVD-ROM disc is similar to a CD-ROM disc in that it has one Mode 1 data track with Lead-in and Lead-out. A DVD disc does not have pre-gap or post-gap.

DVD-R is similar to CD-R. It is a write-once media that in most cases will be readable by a DVD read-only logical unit. There are some capabilities that are defined by this specification and could cause some media to not be readable by legacy DVD read-only logical units. DVD-R provides data appendability using incremental sequential writing.

One major difference between DVD-R and CD-R is the Track. DVD-R does not have an Audio Track and Sub-channel data, thus there is no Table of Contents like on CD. Data written on a DVD-R disc looks like a Mode 1 data track on a CD-R disc. For DVD-R, three appendable points are provided. To control (manage) data appendable points in a data recordable area, the concept of an RZone has been introduced. An RZone contains data elements of Next Writable Address, Last Recorded Address, Start Address and Length, which is similar to a CD Track.

Both DVD-R and CD-R use a Link sector to stop and resume recording. Because of differences between the cross-interleaved ECC of CD and the 32K ECC blocks of DVD, the linking scheme is a little different. CD-R uses Run-out, Link, and Run-in sectors. DVD-R uses Linking Loss Area, padding and Block SYNC Guard Area (BSGA)[1]. These Linking Loss sectors use Logical Block Address (LBA) space.

DVD-R has a Recording Management Area (RMA) to store Recording Management Data (RMD) including the RZone information, Disc Status and other helpful information for file system management. RMA is located out of the user Data Area. RMD block size is 32KB.

4.16.2 Recording model for DVD-R Single Layer media

DVD-R Single Layer media supports two types of recording; disc-at-once (un-interrupted) and incremental. In case of incremental recording, when recording is interrupted, linking ***shall*** be used.

The Write Type field in the *Write Parameters* Mode Page (05h) is used to specify if disc-at-once recording or incremental recording will be used.

4.16.2.1 Sequential recording

DVD-R media makes use of sequential recording. This type of recording does not permit random access for recording purposes. Recording may only occur at predefined recording (appendable) points.

Multiple Appendable points may exist within management areas for sequential recording. The data ***shall*** be written sequentially from each appendable point. Each start/stop of recording occurs in a special structure called a Linking Loss Area.

1. Block SYNC Guard Area (BSGA) was called 'Block Sync Guarantee Linking Loss (BSGLL)' in the old revisions of this specification.

4.16.3 Disc-at-once recording

Disc-at-once recording is recording data including Lead-in and Lead-out sequentially written to the media without interruption. There are no Linking Loss Areas in the recorded data from Lead-in through the end of Lead-out. Disc-at-once recording is used to create fully compatible media which behaves like DVD-VIDEO/ROM media.

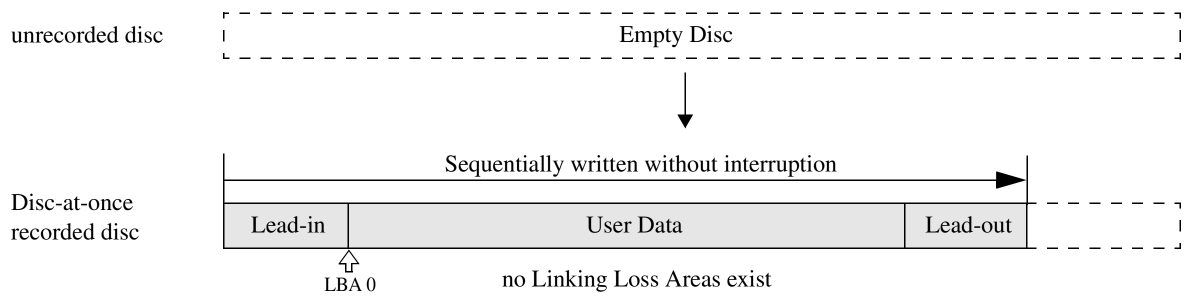

Figure 33 - Disc-at-once Recording

For disc-at-once recording, the Information Area ***shall*** be recorded more than 70 mm in diameter. If the recorded length is less than 70 mm in diameter, the logical unit ***shall*** write Lead-out up to 70 mm in diameter. See the DVD-ROM Book Part 1.

Sample sequence of disc-at-once recording:

1. Set the Write Type field in the *Write Parameters* Mode Page (05h) to “disc-at-once.”
2. Specify transfer user data size by using the RESERVE TRACK/RZONE/RMZ command.
3. Issue WRITE (10) command from logical sector number 0.
   The logical unit ***shall*** perform Optimum Power Calibration (OPC).
   Write and verify RMD in RMA.
   The logical unit starts writing from the Lead-in through Data Recordable Area.
4. Repeat WRITE (10) command for all data.

When all user data has been written on the medium, the logical unit starts writing Lead-out.

If a buffer under-run occurs, the logical unit ***shall*** stop writing immediately and the logical unit ***shall*** start writing of Lead-out.

4.16.4 Incremental recording

In the case of incremental recording, user data is written sequentially from each NWA. A variable amount of user data is written at several distinct times. Each recording begins and ends with a link. Linking Loss and Block SYNC Guard Areas do not contain user data and are used during recording to allow discontinuous recording of data.

For DVD-R media to be readable by DVD read-only logical units, the media ***shall*** contain a Lead-in and a Lead-out or Border-out. The Border-out is similar to the Lead-out. For more information, see DVD-R Book Part 1.

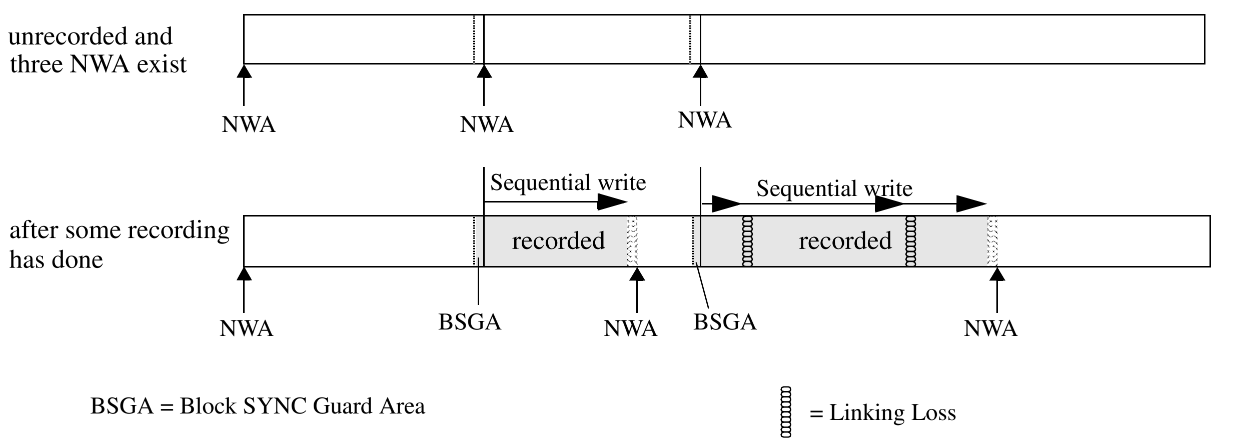

Figure 34 - Example of incremental recording

4.16.4.1 Linking and Data Type bit

When recording is interrupted, e.g., due to SYNCHRONIZE CACHE occurring, the logical unit ***shall*** perform linking. Currently, two Linking Loss Area sizes are defined: 2KB and 32KB. The Link Size field in the *Write Parameters* Mode Page (05h) is used to specify Linking Loss Area size. Mixing the two Linking Loss Area sizes on the same disc is allowed.

LBAs are assigned to Linking Loss Area sectors. Addressing similar to “Method 2” for CD media is not provided for DVD-R media.

The Data Type bit of the Identification Data (first 4 bytes of physical sector) when set to 0, indicates that the next sector is a normal data sector. When the Data Type bit is set to 1, indicates that the next sector belongs to a Linking Loss Area. If the sector contains a linking position, the Data Type bit of the sector ***shall*** be set to 0, even if the next sector will be a Linking Loss sector. This exception is due to the possibility of changing the link size. If a sector is part of a Linking Loss Area and the Link Flag in the previous sector is readable, no ECC related error ***shall*** be returned to the host in response to any command that would require the logical unit read that sector. This would include commands such as READ (10), VERIFY (10), REPORT KEY, and WRITE AND VERIFY (10).

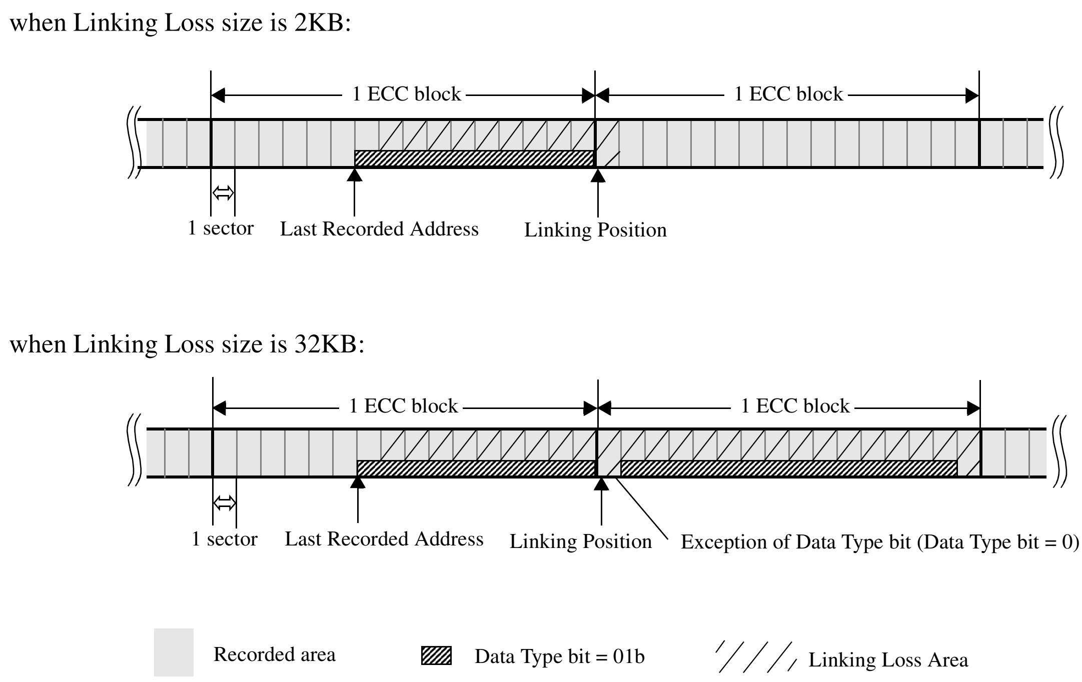

Figure 35 - Relation between Data Type bit and Linking Loss Area

4.16.4.2 Linking with 2 KB or 32 KB Linking Loss

If the Linking Loss Area size is set to 32KB, all of the sectors within a linking ECC block are used as Linking Loss Area. Those ECC blocks can be ignored and no error correction need be provided by the logical unit. A drawback however, is that 16 sectors are exhausted by each link operation.

If the Linking Loss Area size is set to 2KB, the first sector of the linking ECC block is used as Linking Loss Area. The remaining 15 sectors of the ECC block are available for valid user data. As the Parity Bytes used for error correction do not include the correct data from the Link point, the error correction capability may be degraded. If the logical unit uses Erasure Correction techniques and the data contained in the Link Sector has been written with zeros, then the degradation of the error correction capability will be very small.

Table 45 - 2KB linking vs. 32KB linking

2KB linking	32KB linking
less overhead (padding is done up to 2KB)	more overhead (padding is done up to 32KB)
ECC may be degraded	ECC not affected

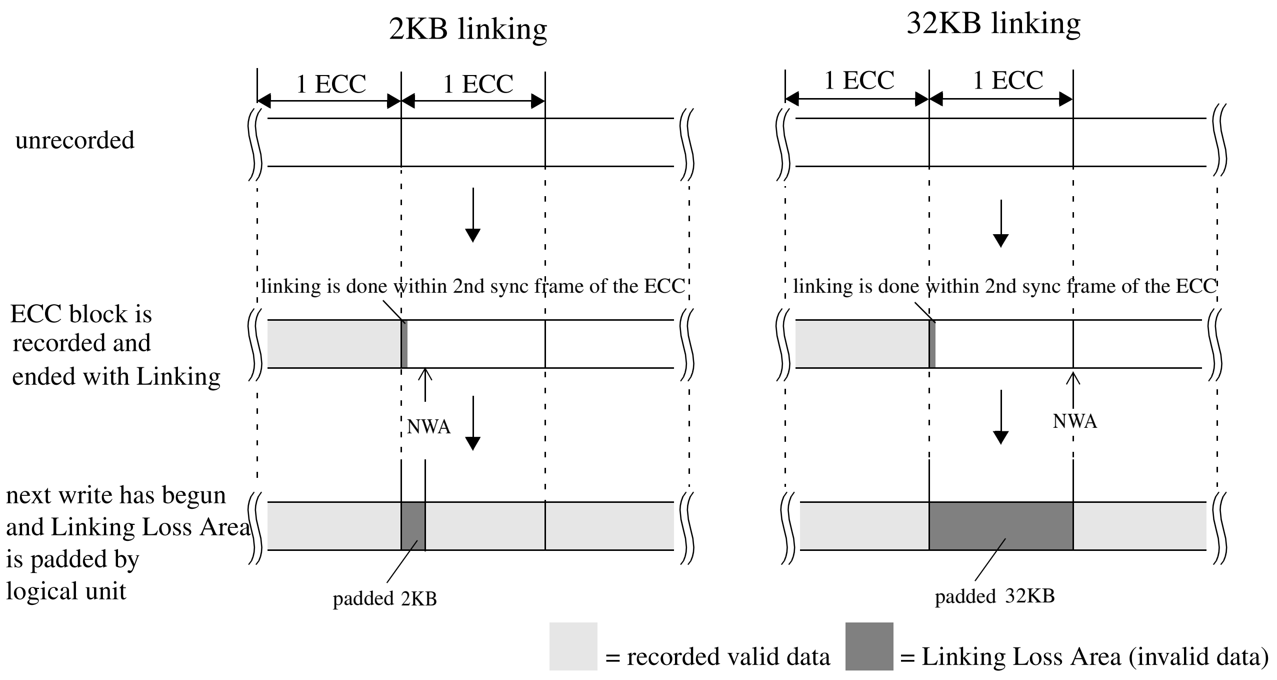

Figure 36 - Difference between 2KB and 32KB linking

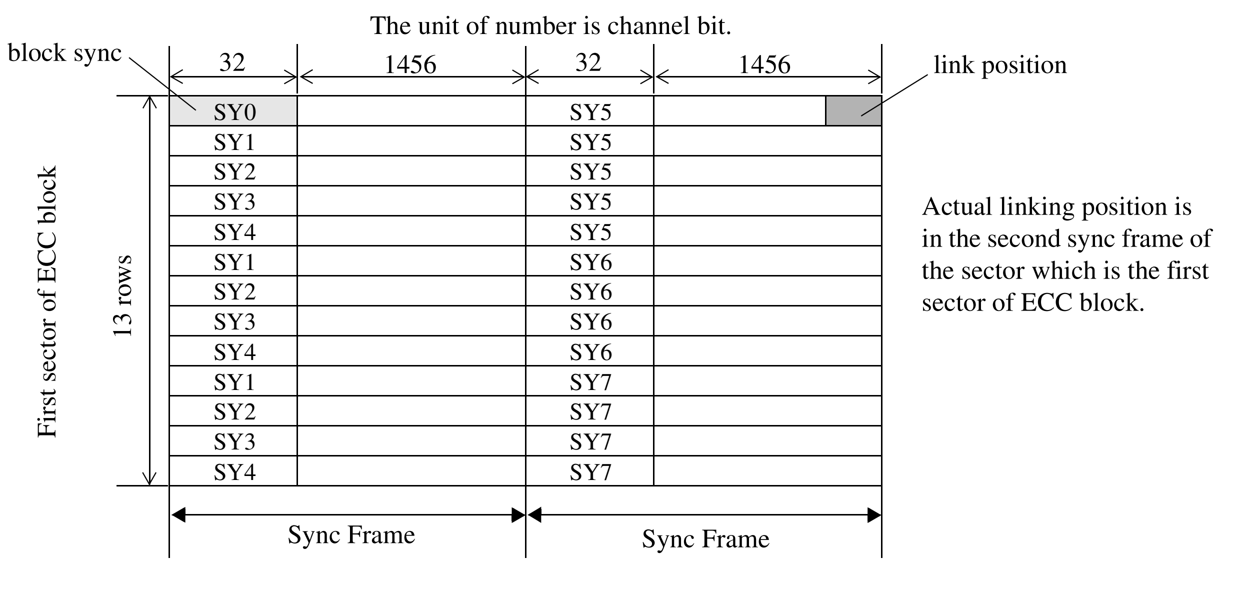

Figure 37 - Linking position in physical sector (DVD-R Ver.1.0/DVD-R for Authoring)

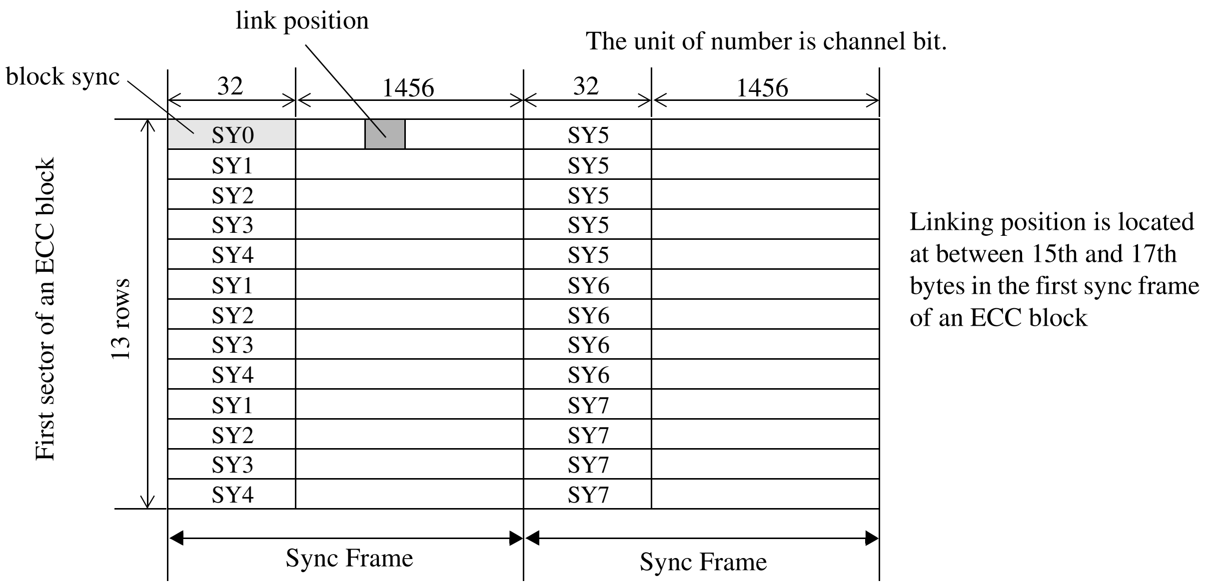

Figure 38 - Link position in physical sector (DVD-R for General)

4.16.4.3 Sample sequence of incremental recording:

1. Set the Write Type field in the *Write Parameters* Mode Page (05h) to “incremental”.
2. Set the Link Size field in the *Write Parameters* Mode Page (05h) to 1 (2KB) or 16 (32KB).
3. If necessary, reserve RZone by using RESERVE TRACK/RZONE/RMZ command.
4. Inquire NWA of the specified RZone by using READ TRACK/RZONE INFORMATION command.
5. Issue WRITE (10) command from NWA.
   The logical unit may perform OPC.
   If an RZone was newly reserved, the logical unit ***shall*** store the RZone information in the RMA prior to writing.
   The logical unit starts writing from NWA.
6. Repeat WRITE (10) command for all data to be transferred.
7. Optionally issue SYNCHRONIZE CACHE command.

When all the user data is written on the medium, the logical unit ***shall*** perform linking.

Once Write Type is selected and a write operation has begun, Write Type is not changeable. If Write Type does not match the disc status, the command ***shall*** be terminated with CHECK CONDITION status, 5/26/00 INVALID FIELD IN PARAMETER LIST.

4.16.4.4 Lossless-Link

The linking that does not set Data Type bit in physical ID of a sector is referred to as Lossless-Link. Linking loss sectors are not generated when Lossless-Link is performed.

The Lossless-Link ***shall not*** be performed at the end of an RZone. The Lossless-Link is able to be performed only during writing. Each RZone ***shall*** be terminated with 2KB or 32KB linking.

4.16.4.5 Buffer under-run free recording

DVD-R logical unit may support buffer under-run free recording for sequential recording. The Buffer Under-run Free Enable (BUFE) bit in Write Parameters Mode Page is used to specify if buffer under-run free recording will be used during sequential recording. During a continuous writing, if BUFE bit is set to 1, the logical unit writes the data to the medium without link generation occurring. When the logical unit detects buffer under-run, the logical unit ***shall*** perform the Lossless-Link to guarantee the first PI line data of ECC block where under-run will occur. Logical unit restarts writing from the Lossless-Link point when following write data is sent by the host without any error. If the writing is forced by a SYNCHRONIZE CACHE command, a link ***shall*** be generated. Commands that are listed in Table 238 - *Commands that shall not interrupt streaming writing* on page 425 ***shall not*** generate a link.

If BUFE bit is set to 0, when buffer becomes empty (under-run occurs), the logical unit ***shall*** perform normal linking with Linking Loss sectors. The following WRITE (10) command may be terminated with CHECK CONDITION status, 5/21/02 INVALID ADDRESS FOR WRITE.

4.16.5 DVD-Video compatibility issues

To record DVD-VIDEO format on DVD-R media, disc-at-once recording is compatible; compatibility is limited in incremental mode (each file ***shall*** be recorded as one "packet"). In the case of incremental recording, to record DVD-Video files correctly, the following limitations ***shall*** be taken into consideration.

All DVD Video Title Sets (VTS) are managed by the Video Manager (VMG). The VMG is recorded as files that are named VIDEO_TS.IFO, VIDEO_TS.VOB (optional), and VIDEO_TS.BUP. The order of the files is specified and it is not possible to change the order.

The VMG ***shall*** be placed before any VTS. The VMG contains the information of the VTS location as offset from VMG start logical sector. Once VMG is recorded, VTS that is not registered in the VMG, cannot be further appended.

Each file ***shall*** be recorded as a single extent. Therefore each file ***shall*** be recorded as one packet.

To guarantee the continuous playback of MPEG 2 data stream, VTS files ***shall*** be recorded contiguously and garbage sectors and Linking Loss sectors are not allowed between Video Object (VOB) files within a VTS. This is because the VOB files consist of a continuous video stream.

See *DVD-ROM Book Part 3* for further information on these limitations.

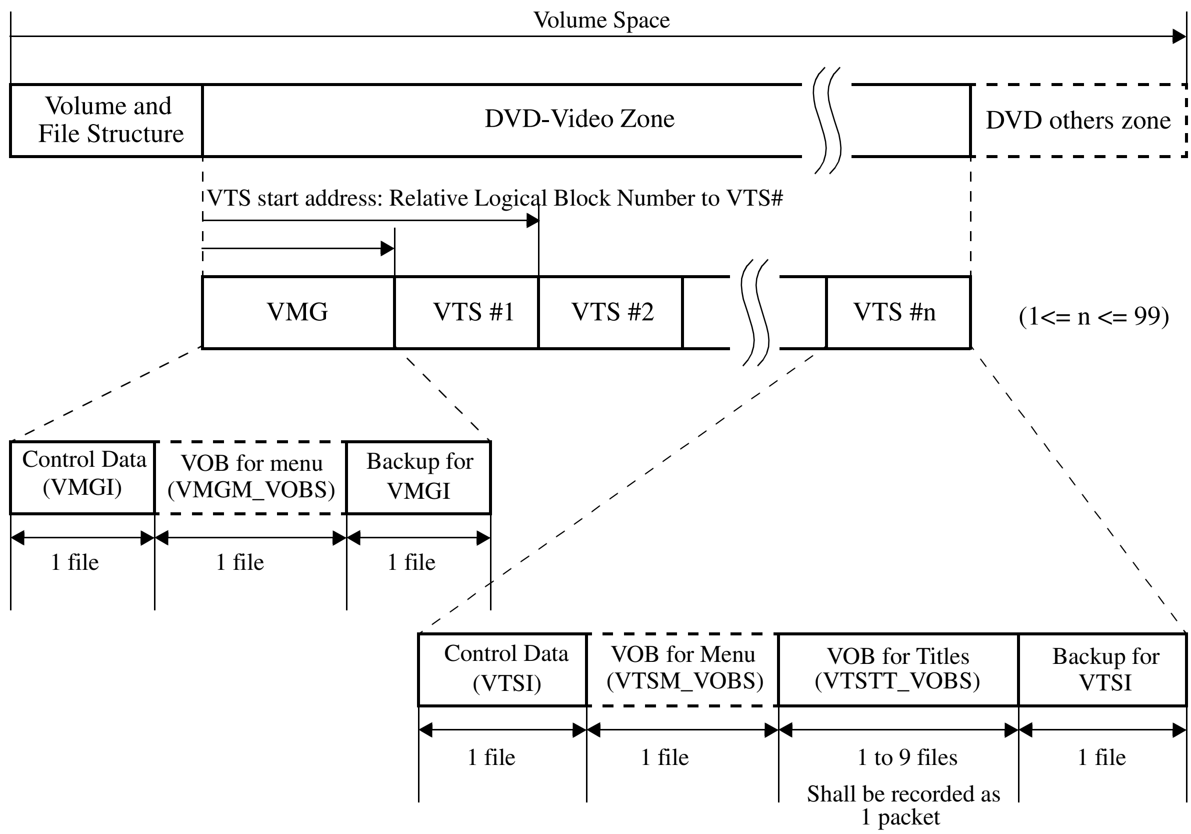

Figure 39 - Example of DVD-Video volume structure

4.16.6 RZone model

The RZone is defined for DVD-R to manage appendable points. The RZone status changes according to its recording stage. These status names are shown in Figure 40 below.

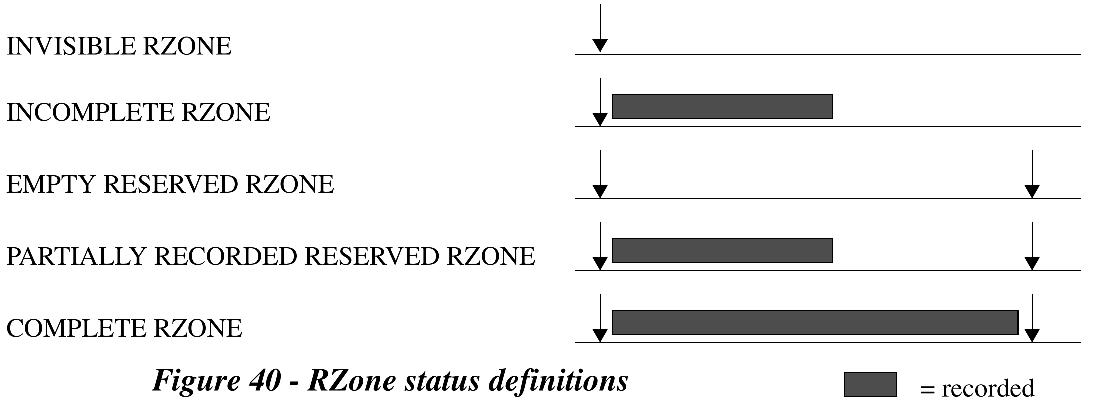

Figure 40 - RZone status definitions

Invisible/Incomplete RZone: The RZone only has a start address. End address is not defined. This kind of RZone is always located on the outermost portion of the media and is data appendable.

Empty Reserved RZone/Partially Recorded Reserved RZone: The RZone has a start address and end address. This kind of RZone is always data appendable.

Complete RZone: The RZone is closed or completely filled with data. This kind of RZone has no NWA and can not append data.

4.16.7 RZone reservation

4.16.7.1 Limitation for number of reserved RZones

A part of the disc space can be reserved for an RZone. For DVD, the maximum number of RZones which can be reserved at the same time is two. In other words, the maximum number of data appendable RZones is three (2 Reserved RZone + 1 Invisible/Incomplete RZone). If two RZones are already reserved, no more RZones can be reserved. To reserve a new RZone, either one or both of the current reserved RZones ***shall*** be closed. Once closed, a new RZone can be reserved.

Figure 41 shows an example sequence for making of a UDF Bridge disc on DVD-R media. In the Figure, two RZones are used for recording. One RZone is reserved for UDF Bridge file system. User data is written by Sequential UDF in the Invisible/Incomplete RZone.

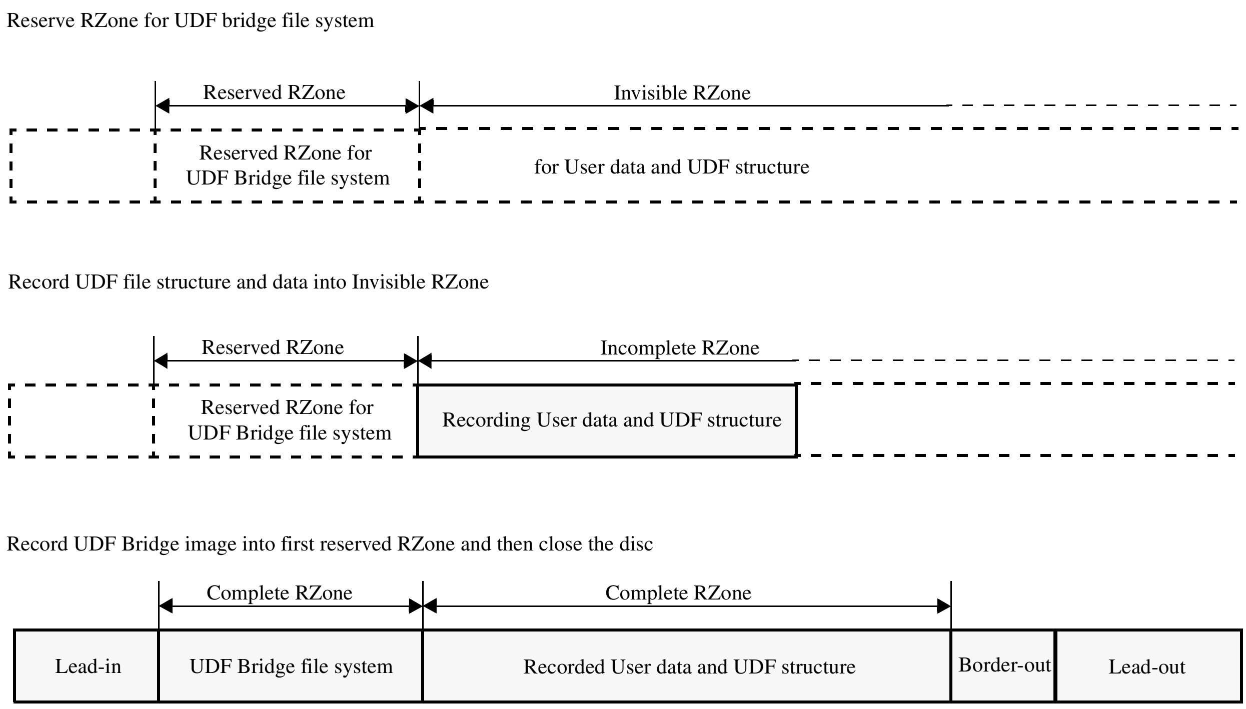

Figure 41 - Typical sequence for making of UDF bridge disc

The RESERVE TRACK/RZONE/RMZ command is used to reserve RZones. If attempting to reserve an RZone when two RZones are already reserved, the command ***shall*** be terminated with CHECK CONDITION status, 5/72/05 NO MORE RZONE RESERVATIONS ARE ALLOWED.

Attempting to reserve an RZone when less than three ECC blocks remain in the RMA, the command ***shall*** be terminated with CHECK CONDITION status, 3/73/05 PROGRAM MEMORY AREA/RMA IS FULL. Three RMD blocks are required for each of reservation, RZone closure or Border closure.

The BSGA (See 4.16.7.3) at the end of each RZone is not writable by the host. If a command attempts to write data beyond reserved RZone length during writing in the RZone, the command ***shall*** be terminated with CHECK CONDITION status, 5/21/02 INVALID ADDRESS FOR WRITE.

4.16.7.2 RZone numbering

The RZone numbers ***shall*** start from 1. The number of the Invisible RZone is increased by one following a reservation. After the reservation is done, the RZone number given to the new reserved RZone is the RZone number of the old Invisible RZone that existed before the reservation.

4.16.7.3 Block SYNC Guard Area (BSGA)

To read an ECC block correctly, block SYNC (first SY0) of the ECC block needs to be recorded.

Regardless of Liking Loss area size, if writing occurs for an ECC block immediately following an unwritten ECC block, the block SYNC (first SY0) is not written due to linking (the linking position is in first or second sync frame). An ECC block ***shall*** be recorded to guarantee readability of the following ECC block(s). An ECC block which is recorded after a written ECC block is readable. The preceding ECC block is referred to as BSGA (Block SYNC Guard Area) and is always 32KB in size. A BSGA is the same as a 32 KB Linking Loss Area. See Figure 42.

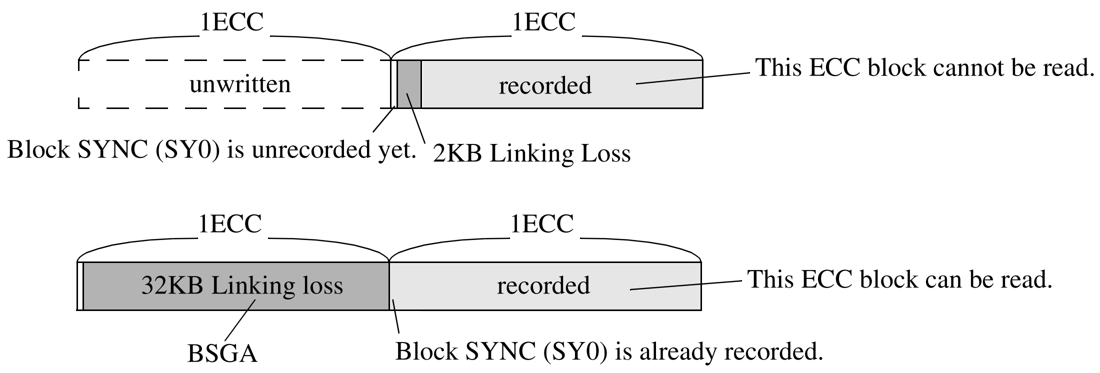

Figure 42 - BSGA (Block SYNC Guard Area)

4.16.7.4 RZone reservation scheme

RZone ***shall*** only be reserved from the NWA of the invisible RZone. If an incomplete RZone exists, the incomplete RZone ***shall*** be closed prior to reserving a new RZone. The start address of the new Invisible RZone is the NWA of the previous incomplete RZone.

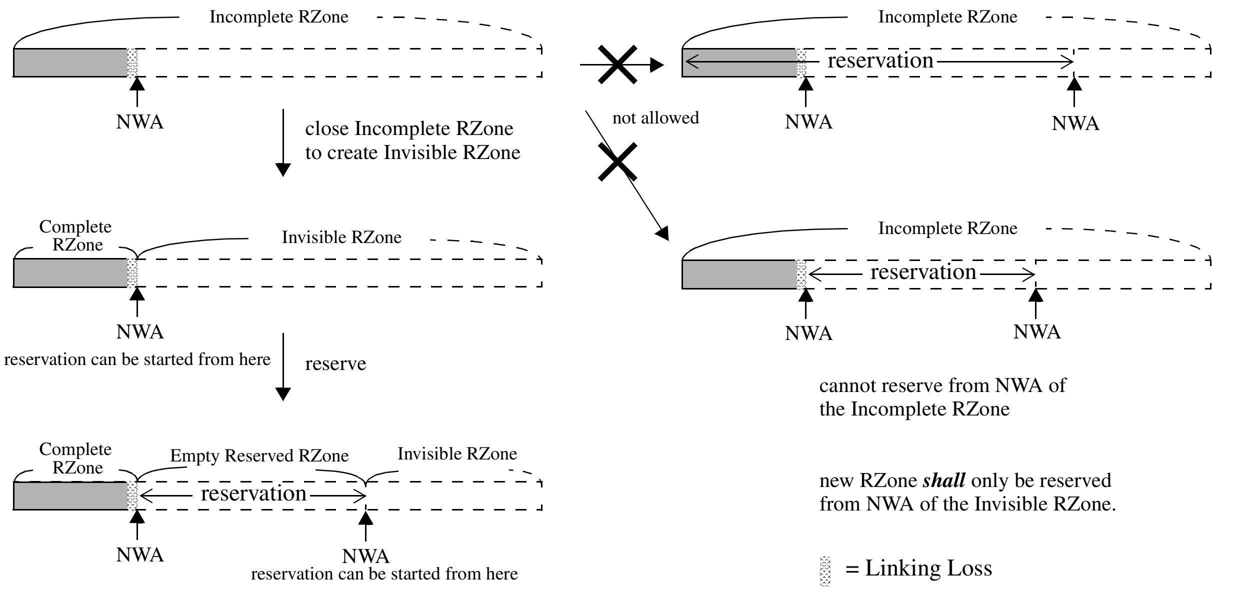

Figure 43 - Start position of RZone reservation

When reservation is required, the logical unit ***shall*** allocate appropriate length for the RZone in the Data Recordable Area.

In the case of Disc-at-Once recording, RZone reservation ***shall*** be done only once to specify user data length to be transferred from host to the logical unit. The allocated reserved length is the same as host required length to keep compatibility with DVD-ROM discs. There is no need to round up the length to ECC block unit and no BSGA ***shall*** be added to the reserved length. For disc-at-once recording, there is only one RZone and Border.

For incremental recording, allocated length ***shall*** take the Linking Loss Area size into consideration. The tail of a reserved RZone is round up to the ECC block unit and one ECC block length is added to the reserved RZone as a BSGA except when the reservation size is the same as the remaining disc capacity. If the reservation size is equal to the remaining disc capacity, the BSGA ***shall not*** be added to the reserved RZone size.

The start address of the RZone following reserved RZone is always on the ECC boundary because of the BSGA.

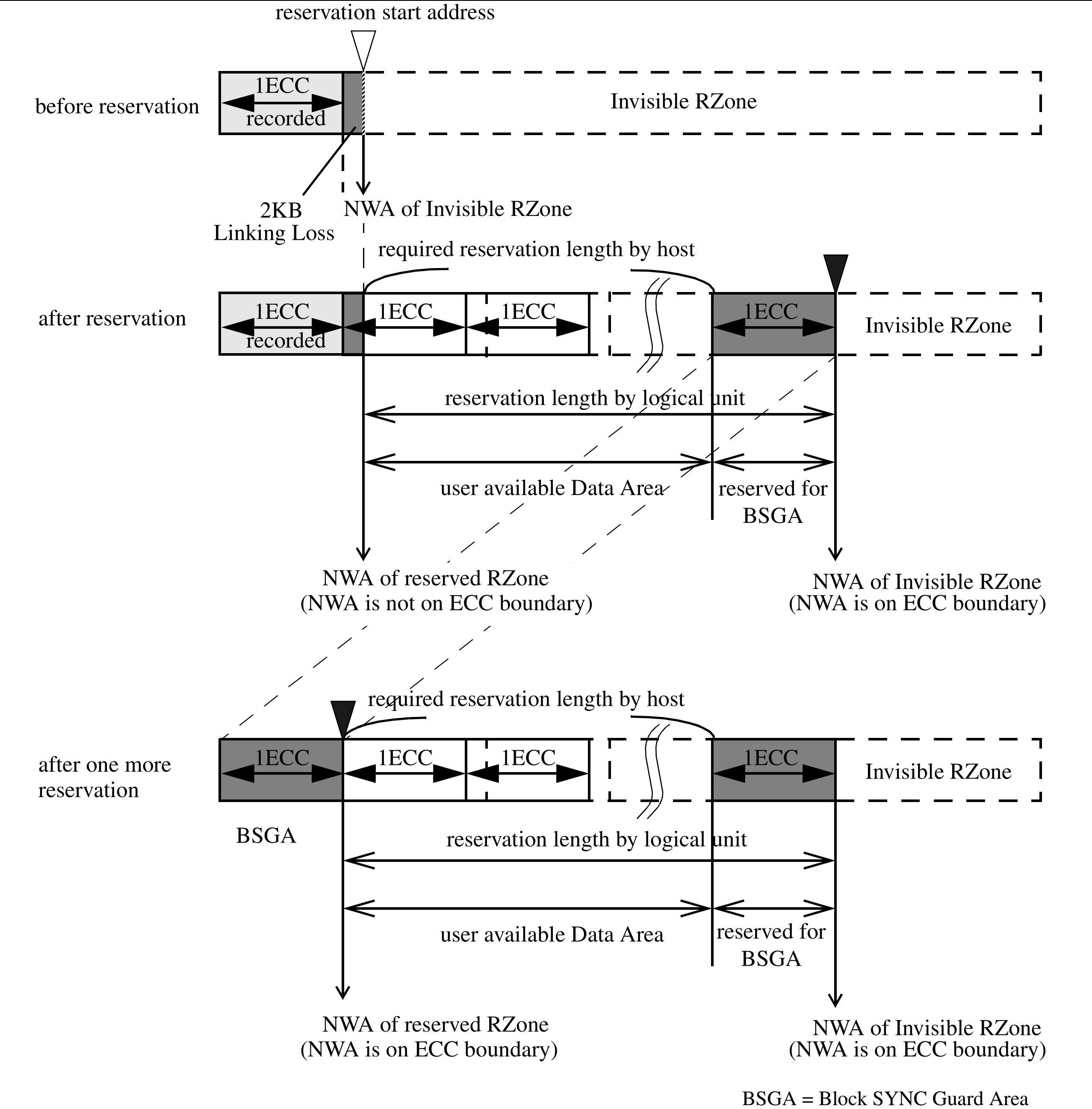

Figure 44 - RZone reservation after 2KB linking loss

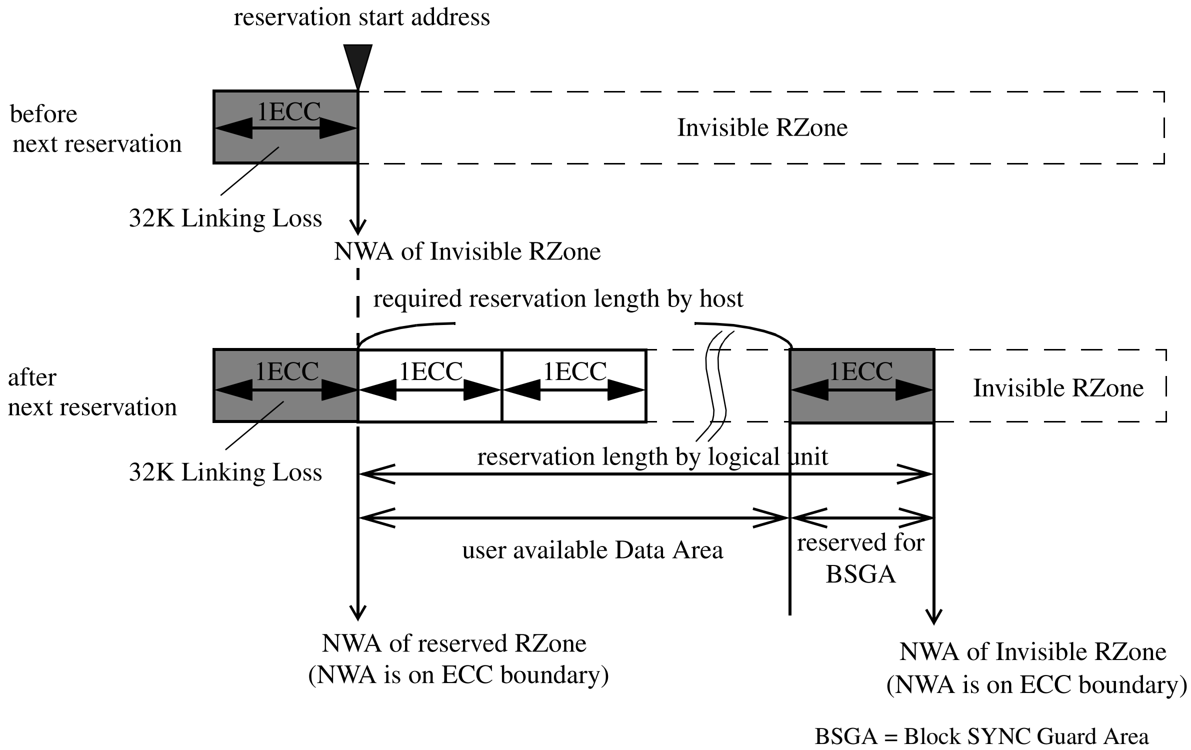

Figure 45 - RZone reservation after BSGA/32KB linking loss

In the case of incremental recording and if Linking Loss Area size is set to 2KB, available reserved RZone size may or may not be multiple of 32KB. The available reserved RZone size is depend on its start address. When reserved RZone start address is on an ECC boundary, the available size is 32 × N (KB). For example, the BSGA of the immediately preceding reserved RZone exists or the RZone starts from the next sector of Lead-in/Border-in. Otherwise, the available data size is 30 + 32 × N (KB). If Linking Loss Area size is set to 32 KB, available reserved RZone size is always 32 × N (KB).

The number of free blocks of the RZone may be different between 2KB Linking Loss size and 32KB Linking Loss size. For example, when Linking Loss size is set to 2KB and last ECC block of the reserved RZone is unwritten, remaining free block size that reported by READ TRACK/RZONE INFORMATION command is 15 blocks. However, if Linking Loss size is changed to 32KB, remaining free blocks that reported by READ TRACK/RZONE INFORMATION command becomes 0 even if there are unrecorded 15 blocks. Such kind of RZone is still Partially Recorded Reserved RZone and ***shall not*** be considered as a Complete RZone. To distinguish this kind of RZone, RT bit of the READ TRACK/RZONE Information is used. The RT bit of one indicates that the RZone is Empty Reserved or Partially Recorded Reserved status. The RT bit of zero indicates that the RZone is Complete, Invisible, or Incomplete status.

4.16.7.5 Sample sequence for RZone reservation

An example of RZone reservation sequence is shown in Figure 46. Initially, a blank medium has only Invisible RZone. NWA is LBA 0 (reference A). When a write operation has begun without reservation, the NWA is proportionally incremented by written data length (reference B).

If reservation is required, the incomplete RZone ***shall*** be closed. Then a new invisible RZone is created. The new reserved RZone is allocated from the NWA of the invisible RZone with required length (reference C).

Sequential writing can be started from each NWA of the RZone (reference D).

When two reserved RZones already exist, no more can be reserved (reference E and F). For reservation of a new RZone, a close RZone operation is required to close one or both of the reserved RZones (reference G). When Close RZone is done, the RZone is complete.

Note: The Linking Loss area except for BSGA is omitted in Figure 46.

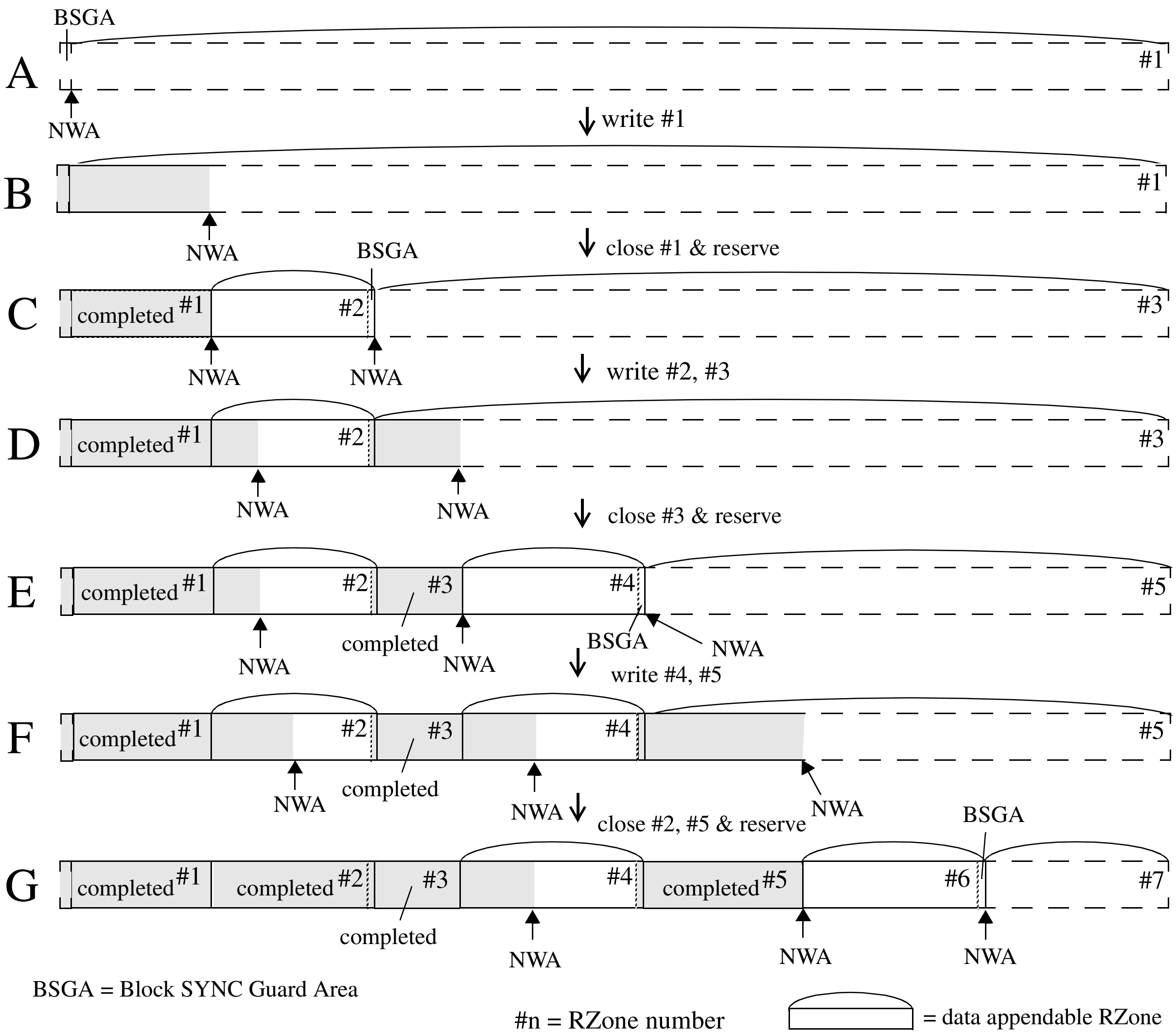

Figure 46 - Example of RZone reservation sequence

4.16.8 RZone closing

This section explains what ***shall*** be done by a logical unit when an RZone is closed.

When a Reserved RZone is closed:

1. Logical unit ***shall*** write RMD in RMA.
2. Then the logical unit ***shall*** pad 00h data until the end of the Reserved RZone with Data Type bit = 0.

When an Incomplete RZone is closed:

1. Logical unit ***shall*** write RMD in RMA.
2. A new invisible RZone which has RZone number N+1 is created from the NWA of the closed incomplete RZone which has RZone number N.

There are three purposes of closing an incomplete RZone:

1. To reserve a new RZone
2. To close Border
3. To make the logical unit write an RMD in RMA for backup against error.

When an Invisible RZone is closed, nothing is done by the logical unit.

4.16.9 Optimum Power Calibration (OPC)

Optimum power calibration (OPC) is required to determine the optimum recording laser power for the mounted DVD-R media. If necessary, OPC operation may be performed automatically when the medium has been first inserted into the logical unit and the first WRITE (10) command is issued. When OPC operation is done, RMA may be updated by the logical unit.

An OPC ***shall*** be performed against current writing speed only.

The PCA (Power Calibration Area) is located from Physical Sector Numbers (PSN) 1E800h to 203AFh[1]. For each OPC, one recording sector (26 sync frames) is assigned. The OPC start address is in descending order within the PCA. As an example, the first power calibration is in PSN 203AFh and the second power calibration is in PSN 203AEh. See Figure 47. Typically, power calibration can be done 7,088 times for each medium. However, actual OPC times and timing are logical unit dependent.

In the case of DVD-R for General media, 256 sectors in the outer PCA is reserved for disc manufacturers use. Therefore a logical unit starts OPC from PSN 202AFh for DVD-R for General media.

If a host requires OPC at desired timing, the SEND OPC INFORMATION command is used.

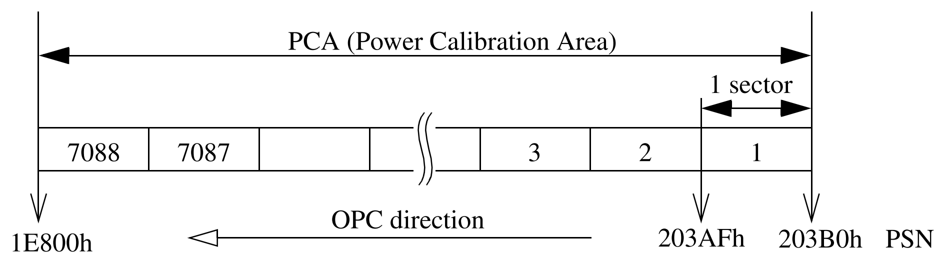

Figure 47 - OPC direction

4.16.10 Required actions during write operation

4.16.10.1 Linking check9 for sequential recording

Random writing within an RZone is not allowed (Sequential recording ***shall*** be used for DVD-R).

It is required that writing is always started from NWA of the RZone.

1. For DVD-R Ver.1.0, the PCA is located from PSN 20800h to 223AFh.

The logical unit ***shall*** check Linking Loss to recognize the LRA and NWA.

When a WRITE (10) command is attempting to write to other than the NWA, the command ***shall*** be terminated with CHECK CONDITION status, 5/21/02 INVALID ADDRESS FOR WRITE.

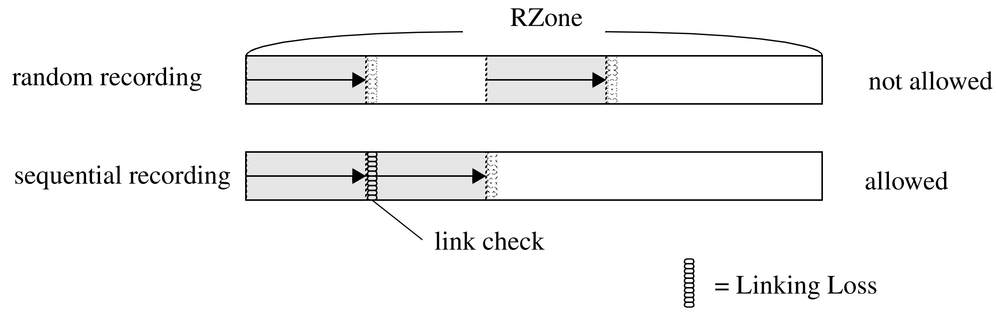

Figure 48 - Sequential recording in an RZone

4.16.10.2 ECC boundary padding and Data Type bit in ID field

The logical unit writes data to the medium only when multiple ECC data blocks are received or the SYNCHRONIZE CACHE command is issued. When the SYNCHRONIZE CACHE operation has been done and the last recorded data address is not an address of the last sector of an ECC block, the logical unit ***shall*** pad to the ECC block boundary with value 00h. This padded area is also called a Linking Loss Area. See Figure 49.

The Last Recorded Address is the address of the last block of user data. The ECC padding ***shall not*** affect the Last Recorded Address.

Note: The READ TRACK/RZONE INFORMATION command is used to get the Last Recorded Address of the RZone.

A SYNCHRONIZE CACHE command may be used to mark the end of the Write data stream.

In the case of buffer under-run, if the WRITE (10) command is completed without error, the data which is less than one ECC block ***shall*** be padded with 00h and the logical unit ***shall*** make a Linking Loss Area. (If the data length to be transferred becomes less than a sector boundary, the host ***shall*** pad to the sector boundary with value 00h.)

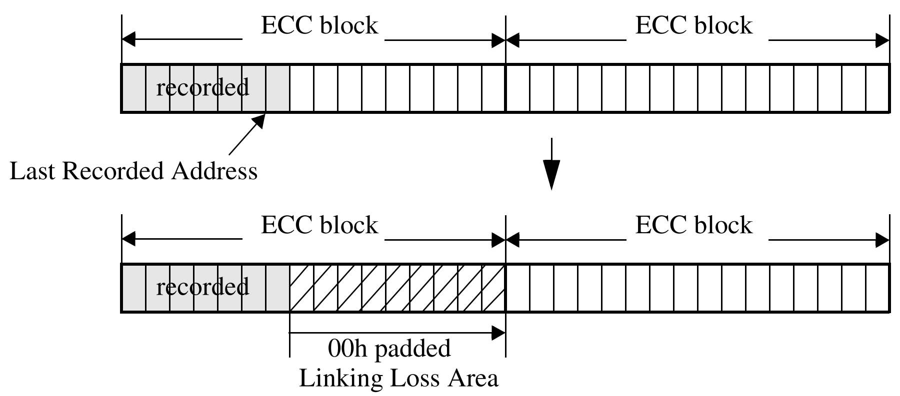

Figure 49 - ECC boundary padding

Data Type bit of Data ID field, when set to 1, indicates that the next sector belongs to the Linking Loss Area except in the following cases.

- If a sector is used for linking and contains linking position, Data Type of the sector ***shall*** be set to 0.
- If a sector is used for error recovery scheme, Data Type bit of the sector is dependent on the error recovery scheme. See Figure 60 - *Repair incomplete linking* on page 156.

4.16.10.3 Overwrite is prohibited

The logical unit ***shall*** avoid overwrites to previously written data. Overwriting may cause data destruction.

When the WRITE (10) command is attempting to write to a previously written sector, the command ***shall*** be terminated with CHECK CONDITION status, 5/21/02 INVALID ADDRESS FOR WRITE.

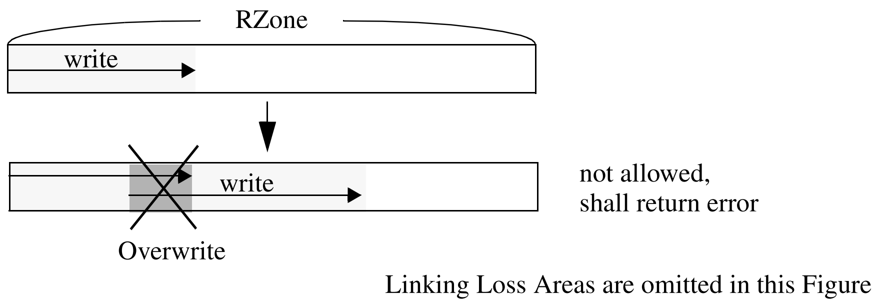

Figure 50 - Forward overwrite

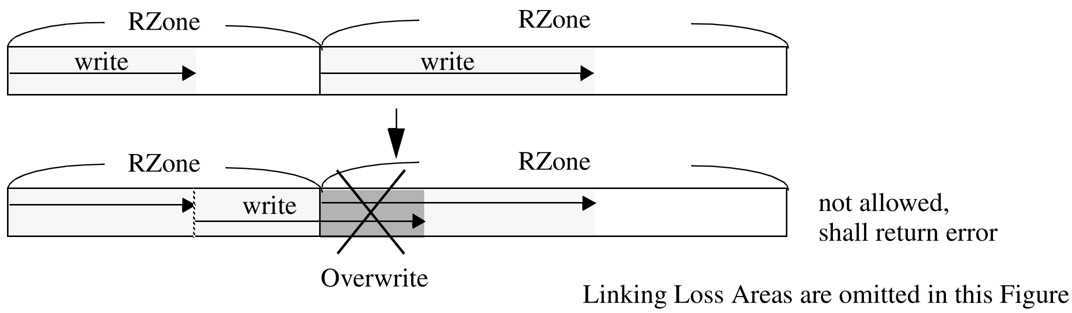

Figure 51 - Backward overwrite

4.16.11 RMD (Recording Management Data) for Single Layer discs

The RMD block size is 32KB. Its physical format is the same as an ECC block. When RMD is written in RMA, 2KB linking is used. Therefore, the valid part of each RMD block is 30KB. The RMA size allows for approximately 700 RMD updates. When the remaining RMA is less than 15 ECC blocks and an RMD update is required by any command, the logical unit ***shall*** terminate the command with CHECK CONDITION status, 1/73/06 PROGRAM MEMORY AREA/ RMA IS (almost) FULL. When the remaining RMA is less than 3 ECC blocks and an RMD update is required by any command, the logical unit ***shall*** terminate the command with CHECK CONDITION status, 3/73/05 PROGRAM MEMORY AREA/RMA IS FULL.

The RMA and RMD block structure are shown in Figure 52 below.

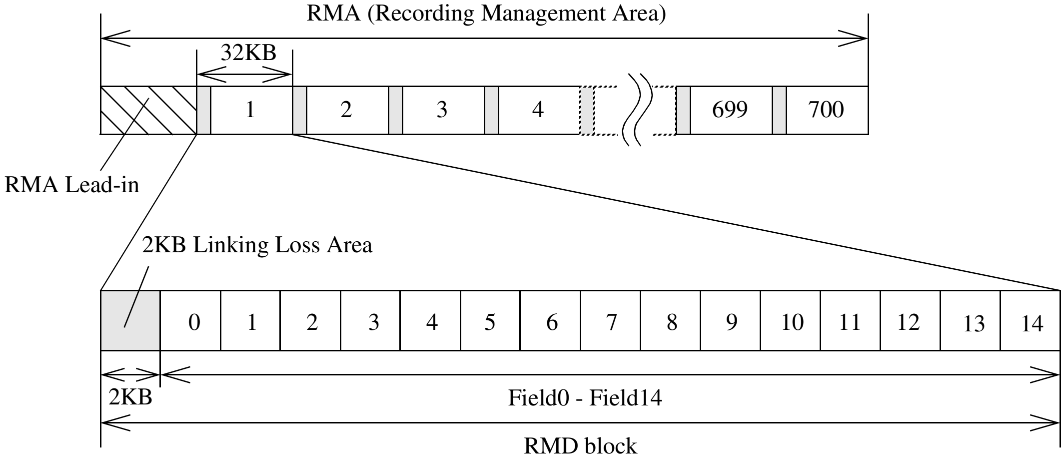

Figure 52 - RMA and RMD block structure

The RMD block consists of 15 fields and a Linking Loss Area. The contents of each Field is defined in the following tables.

Initial value of RMD ***shall*** be 0. The RMD structures describe din this section are defined by DVD-R for General Ver.2.1. For the other versions of DVD-R discs, refer to applicable DVD-R Book for the RMD structures.

4.16.11.1 RMD Field 0 (RMD Header)

RMD Field 0 specifies general information of the disc. Table 46 shows the structure of RMD Field 0.

Table 46 - RMD - Field 0

Bit / Byte	7	6	5	4	3	2	1	0
0-1	(MSB)			RMD Format				(LSB)
2				Disc Status				
3				Reserved				
4-21	(MSB)			Unique Disc ID				(LSB)
22-127				Copy of Pre-pit Information				
128-2047				Reserved				

The RMD Format field specifies the format of the following RMD Field 1-14 which is used on the medium. RMD Format field is defined in Table 47.

Table 47 - RMD Format field definition

Value	Definition
0	Reserved
1	The following RMD Field1-14 are recorded as Format 1 RMD.
2-3	Reserved for DVD-RW media
4	Reserved for DVD-R Dual Layer media
5-65535	Reserved

The Disc Status field indicates the disc status. Disc Status field is defined in Table 48.

Table 48 - Disc Status field definition

Value	Definition
0	The disc has no written data in Data Recordable Area (only RMD is written)
1	The disc is in Disc-at-once recording mode
2	The disc is in Incremental recording mode
3	The disc is completed and not appendable in the case of incremental recording
4-255	Reserved

The Unique Disc ID field ***shall*** be recorded and structured as defined in Table 49. The Unique Disc Identifier contains time stamp fields. The time format should be UTC 24 hour clock[1]. This field ***shall*** be set by the SEND DISC STRUCTURE command. This time stamp data sent by the SEND DISC STRUCTURE command may also be used in the OPC related field in RMD Field 1 and may help the judgement to do OPC. The logical unit ***shall*** update the time stamp during power on. Strict accuracy of time is not required.

Table 49 - Unique Disc ID

Bit / Byte	7	6	5	4	3	2	1	0
0-1	Reserved							
2-3	(MSB)			Random Data				(LSB)
4-7	(MSB)			Year				(LSB)
8-9	(MSB)			Month				(LSB)
10-11	(MSB)			Day				(LSB)
12-13	(MSB)			Hour				(LSB)
14-15	(MSB)			Minute				(LSB)
16-17	(MSB)			Second				(LSB)

The Random Data field is a random number.

The Year field specifies the year coded in ASCII in the range “0001” to “9999”.

The Month field specifies the month of the year coded in ASCII in the range “01” to “12”.

The Day field specifies the day of the month coded in ASCII in the range “01” to “31”.

1. UTC = universal time coordinated

The Hour field specifies the hour of the day coded in ASCII in the range "00" to "23".

The Minute field specifies the minute of the hour coded in ASCII in the range "00" to "59".

The Second field specifies the second of the minute coded in ASCII in the range "00" to "59".

The Copy of Pre-pit Information field contains the copy of Pre-pit Information data which is recorded as LPP (Land Pre-Pit). Copy of Pre-pit Information structure is shown in Table 50. The Pre-pit information data is specified by DVD-R Book Part 1.

Table 50 - Copy of Pre-pit Information

Bit / Byte	7	6	5	4	3	2	1	0
22	Field ID (= 01h)							
23	Application code							
24	Disc Physical code							
25-27	(MSB) Last address of Data Recordable Area (LSB)							
28	LPP Part Version				Extension code			
29	Reserved							
30	Field ID (= 02h)							
31	OPC suggested code (β value)				OPC suggested code (Recording power)			
32	Wavelength code							
33-36	1st field of Write Strategy code							
37	Reserved							
38	Field ID (= 03h)							
39-44	1st field of Manufacturer ID							
45	Reserved							
46	Field ID (=04h)							
47-52	2nd field of Manufacturer ID							
53	Reserved							
54	Field ID (= 05h)							
55-60	2nd field of Write Strategy code							
61	Reserved							
62-77	2x-speed recording parameters							
78-127	4x-speed recording parameters							

4.16.11.2 The contents of Format 1 RMD for Single Layer disc

4.16.11.2.1 Format 1 RMD Field 1

Format 1 RMD Field 1 contains some logical unit and OPC related information. Table 51 shows the structure of Format 1 RMD Field 1.

There are four sets of OPC data blocks. These are prepared for the case of four different DVD-R logical units writing to a disc. The logical unit ***shall*** use an empty set or its own. If there is no owned or empty OPC data block, the logical unit may use the oldest time stamp OPC data block.

Table 51 - Format 1 RMD - Field 1 (logical unit & OPC information)

Bit / Byte	7	6	5	4	3	2	1	0
0-31	Drive manufacturer ID #1							
32-47	Serial Number #1							
48-63	Model Number #1							
64-67	1st field of Write Strategy Code #1							
68-71	Recording Power #1							
72-79	Time stamp #1							
80-83	Power Calibration Address #1							
84-107	Running OPC Information #1							
108-113	2nd field of Write Strategy Code #1							
114-115	DSV #1							
116-127	Reserved							
:	:							
384-415	Drive manufacturer ID #4							
416-431	Serial Number #4							
432-447	Model Number #4							
448-451	1st field of Write Strategy Code #4							
452-455	Recording Power #4							
456-463	Time stamp #4							
464-467	Power Calibration Address #4							
468-491	Running OPC Information #4							
492-497	2nd field of Write Strategy Code #4							
498-499	DSV #4							
500-511	Reserved							
512-2047	Reserved							

The Drive manufacturer ID #n field is recorded in binary and specifies unique drive manufacturer identifier of the logical unit.

The Serial Number #n field is recorded as ASCII code and specifies serial number of the logical unit.

The Model Number #n field is recorded as ASCII code and specifies the recorder model number.

The 1st field of Write Strategy Code #n field specifies the basic write strategy code that is specified by DVD-R Book Part 1.

The Recording Power #n field may be used to store the value of the OPC result. The format of this field is vendor-specific. If this field is set to 0, this field is invalid.

The Time stamp #n field may be used to store date and time when OPC is performed. This field, if used, is recorded in binary. If this field is set to 0, this field is invalid.

The Power Calibration Address #n field may be used to specify the start ECC block address of the PCA where the last OPC was performed. If this field is set to 0, this field is invalid.

The Running OPC Information field may be used to specify values concerning running OPC. The format is vendor-specific. If this field is set to 0, this field is invalid.

The 2nd field of Write Strategy Code #n field specifies the adaptive write strategy code that is specified by DVD-R Book Part 1.

If the disc is incrementally recorded and when RMD is updated, the DSV field ***shall*** be recorded. This field is used to specify the last DSV (Digital Sum Value) in binary notation.

4.16.11.2.2 Format 1 RMD Field 2

Format 1 RMD Field 2 can be used freely and format of this field is user-specific.

Table 52 - Format 1 RMD - Field 2 (User specific data)

Bit / Byte	7	6	5	4	3	2	1	0
0-2047	User Specific Data							

The User Specific Data field is available for user specific data. This field may be used, otherwise this field ***shall*** be set to all 00h.

4.16.11.2.3 Format 1 RMD Field 3

Format 1 RMD Field 3 may contain Border Zone information and ***shall*** be recorded as follows.

Table 53 - Format 1 RMD - Field 3 (Border Zone information)

Bit / Byte	7	6	5	4	3	2	1	0
0-3	(MSB)			Start Sector Number of Border-out #1				(LSB)
4-7	(MSB)			Start Sector Number of Border-out #2				(LSB)
8-11	(MSB)			Start Sector Number of Border-out #3				(LSB)
:				:				
2036-2039	(MSB)			Start Sector Number of Border-out #510				(LSB)
2040-2043	(MSB)			Start Sector Number of Border-out #511				(LSB)
2044-2047	(MSB)			Start Sector Number of Border-out #512				(LSB)

The Start Sector Number of Border-out #n field, if it contains other than 0, indicates that the start sector number of the n^{th} Border-out.

4.16.11.2.4 Format 1 RMD Field 4

Format 1 RMD Field 4 contains RZone related information and ***shall*** be recorded as follows.

Table 54 - Format 1 RMD - Field 4 (RZone Information)

Bit / Byte	7	6	5	4	3	2	1	0
0-1	(MSB)	Invisible/Incomplete RZone number (Last RZone Number)						(LSB)
2-3	(MSB)	First Open RZone number						(LSB)
4-5	(MSB)	Second Open RZone number						(LSB)
6-15	Reserved							
16-19	(MSB)	Start Sector Number of RZone #1						(LSB)
20-23	(MSB)	Last Recorded Address of RZone #1						(LSB)
24-27	(MSB)	Start Sector Number of RZone #2						(LSB)
28-31	(MSB)	Last Recorded Address of RZone #2						(LSB)
:	:							
2032-2035	(MSB)	Start Sector Number of RZone #253						(LSB)
2036-2039	(MSB)	Last Recorded Address of RZone #253						(LSB)
2040-2043	(MSB)	Start Sector Number of RZone #254						(LSB)
2044-2047	(MSB)	Last Recorded Address of RZone #254						(LSB)

The Invisible/Incomplete RZone Number field contains the Invisible/Incomplete RZone number of the medium. If the last RZone state is neither Invisible nor Incomplete due to disc finalization, this field contains the last complete RZone number.

The First Open RZone number field, if recorded with value other than 0, contains the current appendable Reserved RZone number and the value ***shall*** be different from the Second Open RZone number field. If this field is set to 0, there is no Empty Reserved RZone or Partially Recorded Reserved RZone corresponding to this field.

Second Open RZone number field, if recorded with value other than 0, contains the current appendable Reserved RZone number and the value ***shall*** be different from the First Open RZone number field. If this field is set to 0, there is no Empty Reserved RZone or Partially Recorded Reserved RZone corresponding to this field.

When the Incomplete RZone is closed, the Invisible/Incomplete RZone Number field contains the number of the new invisible RZone number (N+1). When Reserved RZone is closed, the corresponding First (Second) Open RZone number field ***shall*** be set to 0.

The Start Sector Number of RZone #n field contains the start sector number of the RZone which has RZone number #n.

The Last Recorded Address of RZone #n field contains the last recorded address of the RZone which has RZone number #n. If this field is set to 0, this field is not valid. If RZone #n is not closed, the value of this field may not be correct and a link point search is required to determine the correct LRA.

Note: The LRA reported by the READ TRACK/RZONE INFORMATION command is always correct.

When the RZone is not closed, even if the Last Recorded Address of RZone #n field contains a value, the logical unit ***shall*** determine the current LRA of the RZone. When RZone is closed, Last Recorded Address of RZone #n field ***shall*** be recorded before RZone padding.

4.16.11.2.5 Format 1 RMD Field 5 - Field 12

Format 1 RMD Field 5 through Field 12 may contain RZone related information continued from Format 1 RMD Field 4.

Table 55 - Format 1 RMD - Field 5 - Field 12 (RZone Information ... continued)

Bit / Byte	7	6	5	4	3	2	1	0
0-3	(MSB)			Start Sector Number of RZone #n				(LSB)
4-7	(MSB)			Last Recorded Address of RZone #n				(LSB)
8-11	(MSB)			Start Sector Number of RZone #(n+1)				(LSB)
12-15	(MSB)			Last Recorded Address of RZone #(n+1)				(LSB)
:				:				
2032-2035	(MSB)			Start Sector Number of RZone #(n+253)				(LSB)
2036-2039	(MSB)			Last Recorded Address of RZone #(n+253)				(LSB)
2040-2043	(MSB)			Start Sector Number of RZone #(n+254)				(LSB)
2044-2047	(MSB)			Last Recorded Address of RZone #(n+255)				(LSB)

The Start Sector Number of RZone #n field contains start sector number of the RZone which has RZone number #n.

The Last Recorded Address of RZone #n field contains the last recorded address of the RZone which has RZone number #n. If this field is set to 0, this field is not valid. If RZone #n is not closed, the value of this field may not be correct and a link point search is required to determine the correct LRA.

Note: The LRA reported by the READ TRACK/RZONE INFORMATION command is always correct.

When the RZone is not closed, even if the Last Recorded Address of RZone #n field contains a value, the logical unit ***shall*** determine the current LRA of the RZone. When RZone is closed, Last Recorded Address of RZone #n field ***shall*** be recorded before RZone padding.

4.16.11.2.6 Format 1 RMD Field 13

Table 56 shows the structure of Format 1 RMD Field 13. This Field contains drive specific information. There are eight sets of drive specific information blocks. These are prepared for the case of up to eight different DVD-R logical units writing to a disc. The unused fields in Format 1 RMD Field 13 ***shall*** be set to zero.

Table 56 - Format 1 RMD - Field 13 (Drive specific information)

Bit / Byte	7	6	5	4	3	2	1	0
0-31	Drive manufacturer ID #1							
32-47	Serial Number #1							
48-63	Model Number #1							
64-66	Recorded RMA address (ECC block address) #1							
67-127	Drive specific data #1							
:	:							
896-927	Drive manufacturer ID #8							
928-943	Serial Number #8							
944-959	Model Number #8							
960-962	Recorded RMA address (ECC block address) #8							
963-1023	Drive specific data #8							
1024-2047	Additional drive specific information for recorder #1							

The Drive Manufacturer ID #n field is recorded in binary and contains unique drive manufacturer identifier.

The Serial Number #n field is recorded in ASCII code and contains the serial number of the logical unit.

The Model Number #n field is recorded in ASCII code and contains the drive model number of the logical unit.

The Recorded RMA address #n field specifies the starting RMA address which is used to record RMD including the information of specific drive. This field is specified in ECC block address.

The Drive specific data #n field may be recorded to store the drive specific data. If this field is set to zero, this field is invalid.

The Additional Drive specific data for recorder #1 field may be recorded to store the additional drive specific data for logical unit #1. If this field is set to zero, this field is invalid.

4.16.11.2.7 Format 1 RMD Field 14

Table 57 shows the structure of Format 1 RMD Field 14.

Table 57 - Format 1 RMD - Field 14 (Versatile information)

Bit / Byte	7	6	5	4	3	2	1	0
0	Outer disc testing area flag							
1-4	Testing address							
5-2047	Reserved							

The Outer disc testing area flag field indicates whether the outer disc testing method is applied to this media. If this field is set to 01h, the outer disc testing method is applied, and if set to 00h the outer disc testing method is not applied. The outer disc testing method is specified by DVD-R Book.

The Testing address field indicates the start ECC block address of Outer disc testing area where the last OPC was performed. This field is set to 00h when the Outer disc testing area flag is set to 00h.

4.16.11.3 When RMD is written in RMA

Usually, RMD may be cached in the logical unit memory. As occasion calls, RMD ***shall*** be written in RMA. By using RMD caching, the logical unit can avoid waste of RMA. The timing when RMD is written in RMA is shown in Table 58.

Table 58 - Mandatory RMD update condition in RMA

condition
1. When a WRITE (10) command is issued following a RESERVE TRACK/RZONE/RMZ command, before the start of writing, RMD ***shall*** be written in RMA.
2. When a CLOSE TRACK/RZONE/SESSION/BORDER command is issued, before the start of the close operation for either RZone or Border, RMD ***shall*** be written in RMA.
3. When a SYNCHRONIZE CACHE command is issued following SEND DISC STRUCTURE command which specifies User Specific Data, RMD ***shall*** be written in RMA.
4. When the difference between the last recorded sector number in fact and "Last Recorded Address of RZone #n" recorded in the latest RMD is larger than 16 MB, RMD ***shall*** be written in RMA. However if the logical unit is busy (e.g., writing is in progress), the update may be done at a later time.

When writing in the same incomplete RZone for an extended period of time, RMD may not recorded for a long time. To force writing of the RMD, the host should close the Incomplete RZone after a certain time has passed. Then the new information is written into the RMA. Although the Invisible RZone number is increased due to the closing of the Incomplete RZone, the NWA of the new Invisible RZone is the same as the NWA of the closed Incomplete RZone.

4.16.11.4 Example of write sequence

This section explains one example of a write sequence. See Table 59 and Table 60.

Table 59 - Example of write sequence (blank disc)

Sequence	user/host	logical unit action
1	Insert blank disc	check RMD
2	Specify Write Type (disc-at-once/incremental) and Unique Disc Identifier (MODE SENSE (10), MODE SELECT (10), and SEND DISC STRUCTURE commands)	cache (RMD Field 0)
3	Specify other Identifier field. (SEND DISC STRUCTURE command)	cache (RMD Field 1)
4	Specify User Specific Data field of RMD if needed. (SEND DISC STRUCTURE command)	cache (RMD Field 2)
5	Reserve RZones if needed. (RESERVE TRACK/RZONE/RMZ command)	cache (RMD Field 4 - Field 12)
6	get NWA (READ TRACK/RZONE INFORMATION command)	calculate and send to host
7	start writing from NWA (WRITE (10) command)	1. do OPC 2. write RMD in RMA if RZone is reserved. 3. start writing 4. if buffer become empty, stop writing with linking.
8	close RZone or Bordered Area (CLOSE TRACK/RZONE/SESSION/BORDER command)	1. write RMD in RMA prior to close RZone or Bordered Area 2. pad RZone or write Border-in/Lead-in and Border-out/Lead-out.

Table 60 - Example of write sequence (non-blank disc)

	user/host	logical unit action
1	Insert non-blank disc	check RMD check Write Type
2	Specify User Specific Data field of RMD if needed. (SEND DISC STRUCTURE command)	cache (RMD Field 2)
3	Reserve RZones if needed. (RESERVE TRACK/RZONE/RMZ command)	cache (RMD Field 4 - Field 12)
4	get NWA (READ TRACK/RZONE INFORMATION command)	search and send to host
5	start writing from NWA (WRITE (10) command)	1. do OPC, if needed 2. write RMD in RMA if RZone is reserved 3. start writing 4. if buffer becomes empty, stop writing with linking
6	close RZone or Bordered Area (CLOSE TRACK/RZONE/SESSION/BORDER command)	1. write RMD in RMA prior to close RZone or Bordered Area 2. pad RZone or write Border-in/Lead-in and Border-out/Lead-out

4.16.11.5 Border Zone

Border Zone is used for Border recording to interchange DVD-R media between DVD-R and DVD read-only logical units.

Border Zone provides a solution for pickup overrun problem of DVD read-only logical unit. Once Border is closed, there are no unrecorded areas between Lead-in/Border-in and Border-out except for Next Border Marker (See *4.16.11.5.5, "Border-out contents"* on page 150).

Disc structure with Border Zone is shown in Figure 53 below.

Note: Linking Loss and BSGA is omitted in this figure.

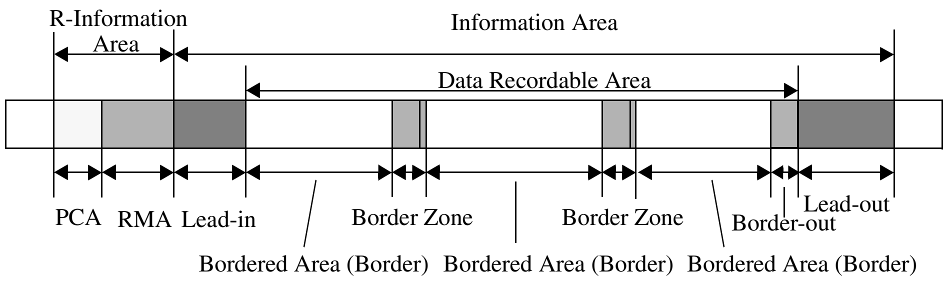

Figure 53 - Border Zone and Bordered Area (Border)

4.16.11.5.1 Border Zone size and length

The Border-out start address ***shall*** be located after PSN 3FF00h[1]. If a CLOSE TRACK/RZONE/SESSION/BORDER command is issued when recorded user data end address is less than PSN 3FF00h, the logical unit ***shall*** pad with 00h data through PSN 3FEFFh[2]. The recorded area width of 3 mm in the radial direction is guaranteed by this padding.

Border Zone size is dependent on its starting address and order. Table 61 shows the relationship between location and Border Zone size for DVD-R media other than Ver. 1.0 media. For DVD-R Ver. 1.0 media, the values of Table 61 are different due to different disc capacity.

- First Border Zone length is approximately 0.5 mm in the radius.
- The other Border Zone length is approximately 0.1 mm in the radius except Final Border Zone.

Note: Final Border Zone means that which is written when the Disc is finally closed with Lead-out. See4.16.11.6, "Disc final closure" on page 152.

Table 61 - Border Zone size for DVD-R media

Physical sector number of beginning Border Zone	**3FF00h-B25FFh**	**B2600h-1656FFh**	**165700h-**
First Border Zone Size	1792 ECC blocks 56 MBytes[a]	2368 ECC blocks 74 MBytes	2944 ECC blocks 92 MBytes
Second and above Border Zone Size	384 ECC blocks 12 MBytes	480 ECC blocks 15 MBytes	608 ECC blocks 19 MBytes

a. MByte = 1024 × 1024 bytes

1. For DVD-R Ver. 1.0 media, this address is 3D700h.
2. For DVD-R Ver. 1.0 media, this address is 3D6FFh.

4.16.11.5.2 Recording for Border Zone

Each logical sector in Border Zone ***shall*** be assigned to a Logical Block Address (LBA). Each logical sector of Data Recordable Area ***shall*** be identified by a unique logical sector number. LBAs ***shall*** be integers assigned in ascending sequence, starting with 0 from the PSN 30000h.

A Border Zone consists of a Border-out, a Data Area, and a Border-in. Border-out/in is written when a CLOSE TRACK/RZONE/SESSION/BORDER command is issued with Close Function=010b.

Border Zone is recorded with following sequence.

1. Close all opened (empty reserved/partially recorded reserved/incomplete) RZones by using a CLOSE TRACK/RZONE/SESSION/BORDER command with the Close Function=001b.
2. Issue CLOSE TRACK/RZONE/SESSION/BORDER command to close Bordered Area (Close Function=010b).
3. Border-out is recorded from NWA of the invisible RZone. Border-in of this Border Zone is still unrecorded at this time. The Border-in will be recorded when next CLOSE TRACK/RZONE/SESSION/BORDER command is issued.
4. If Lead-in is still unwritten, Lead-in is recorded on the medium. If Lead-in is already written, Border-in is recorded after the previously written Border-out.

When a CLOSE TRACK/RZONE/SESSION/BORDER command which specifies the closing of the Border, regardless of Linking Loss size, Border Zone ***shall*** be written from ECC boundary.

When 32KB Linking Loss size is selected, Border Zone is written from NWA of the Invisible RZone. If 32KB Linking Loss size is not selected, logical unit ***shall*** pad 00h from the NWA of the Invisible RZone to the end of the ECC block and then Border Zone is written from the beginning of next ECC block. This padded area is referred to as Border-out Padding. Border-out Padding is used to align the start address of the Border-out on the ECC boundary.

If Border Zone start LBA is less than 0FF00h[1], the logical unit ***shall*** pad with 00h data up to LBA 0FEFFh[2] and then Border Zone is written from LBA 0FF00h[1].

RZone numbers are not assigned to Border Zone. The Invisible RZone number is not incremented due to Border Zone writing.

After Border Zone writing, NWA of the invisible RZone is moved to the following written Border Zone. Figure 54 shows an example of the write sequence and relationship between RZone number and Border Zone.

The Border-in which immediately follows last Border-out ***shall*** remain unrecorded when the Border Zone is written. This unrecorded Border-in will be used for next Bordered Area. The unrecorded Border-in will be recorded when the next Bordered Area is closed.

1. For DVD-R Ver.1.0 media, this address is 0D700h.
2. For DVD-R Ver.1.0 media, this address is 0D6FFh.

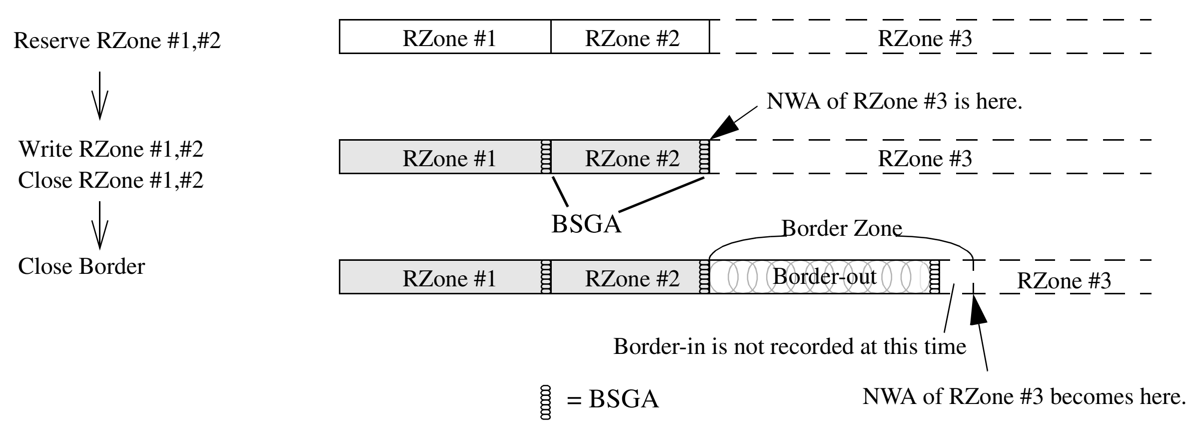

Figure 54 - Relation between RZone number and Border Zone

4.16.11.5.3 Border Zone status

Bordered Area status changes according to its recording stage.

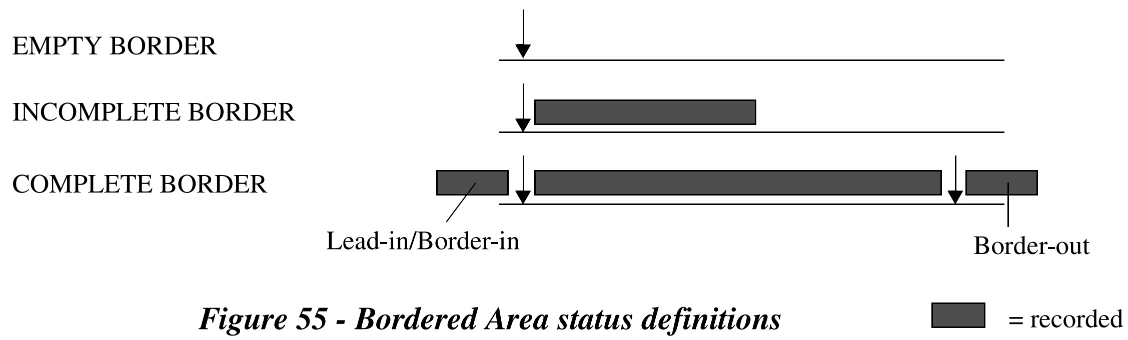

Figure 55 - Bordered Area status definitions

4.16.11.5.4 Border-in contents

Border-in contains five copies of control data structure which has the same structure as the control data that is recorded in the Lead-in.

To provide the information concerning the Border Zone to the DVD read-only logical unit which has no capability of RMA reading, the Physical Format Information field of Lead-in/Border-in contains the pointer to the Border Zone and LRA information for last RZone. See Table 23 - *DVD-R Ver.1.0/R for Authoring Ver.2.0 unique part of Physical format information* on page 86 and Table 21 - *Data Area Allocation field definition* on page 85.

In final closing of a disc, the start PSN of the Next Border-in field in the Physical Format Information ***shall*** be set to 00h.

4.16.11.5.5 Border-out contents

Border-out consists of Border RMD Area, Stop Blocks and Next Border Markers. When a Border-out will be followed by Lead-out Area, Stop Blocks and Next Border Markers may be omitted. Such a Border-out is also called as truncated Border-out.

Border-out has Border RMD Area (5 ECC blocks) which has five copies of latest RMD. Border RMD Area is recorded to provide the information concerning the Bordered Areas to the DVD read-only logical unit which has no capability of RMA reading.

Stop Blocks (2 ECC blocks) are located relatively 38th and 39th ECC blocks from the beginning of the Border-out. The Area type of Stop Block has Lead-out attribute. Stop Block prevents the logical unit which expects Lead-out existence from pick up over-run.

Border-out also contains Next Border Marker (three occurrences of 2 ECC blocks). This specifies whether the next Border exists or not. When next Border does not exist and Lead-out is still unwritten, the Next Border Marker in the last Border-out ***shall*** remain in a mirror state (unwritten). When closing a Border, the previous Next Border Marker ***shall*** be written with 00h or two copies of updated Physical Format information block data of the latest Border-in. In the final closing of a disc, the Next Border Marker in the final Border-out ***shall*** be padded with 00h and have a Lead-out attribute.

The first Next Border Marker in Border-out is located in half of the Border-out. The start address of first Next Border Marker is calculated by following formula:

((Start sector number of the next Border-in) + (Start sector number of the current Border-out)) / 2

The whole structure of Border Zone is shown in Figure 56.

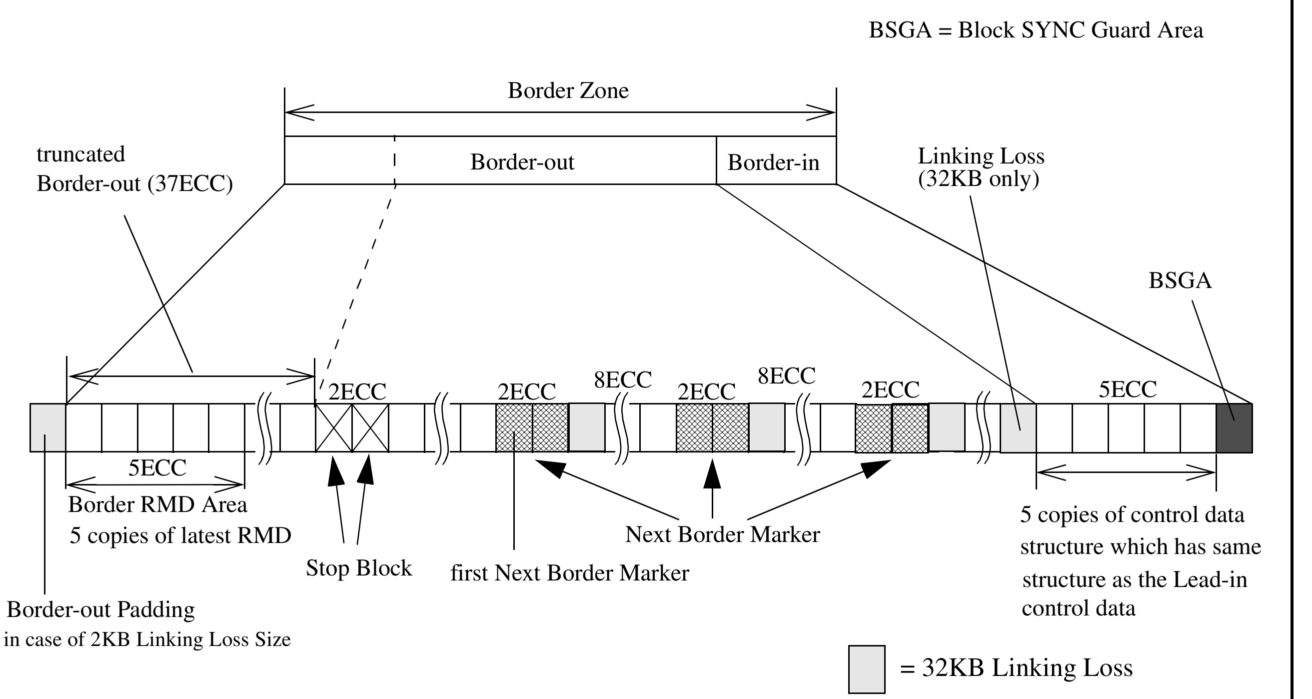

Figure 56 - Border Zone structure

4.16.11.5.6 Example for multi-Border recognition

To explain how to recognize a Border Zone, a sample recognition sequence for a Multi-Border recorded disc is shown below.

Table 62 - Multi-Border example

Sequence	sample sequence
1	insert disc
2	logical unit reads Physical format information field in Lead-in data. - check Start Address of Border-out - check Start Address of Border-in
3	logical unit reads Next Border Marker in Border-out. - check whether next Bordered Area is exist or not and find next Bordered Area
4	logical unit reads Physical format information in Border-in. - check whether Book Type is DVD-R or not - check Start Address of Border-out - check Start Address of Border-in
5	logical unit reads Next Border Marker in Border-out. - check whether next Bordered Area is exist or not and find no next Bordered Area
6	host reads LBA16 by using READ command. - check which kind of file system is used on the media - if UDF and a VAT (See OSTA UDF 1.5 or later) is used, read VAT ICB which recorded at the LRA - get LRA by READ TRACK/RZONE INFORMATION command
7	host reads VAT ICB at Last Recorded Address by using READ command. - get VAT address from VAT ICB - read VAT

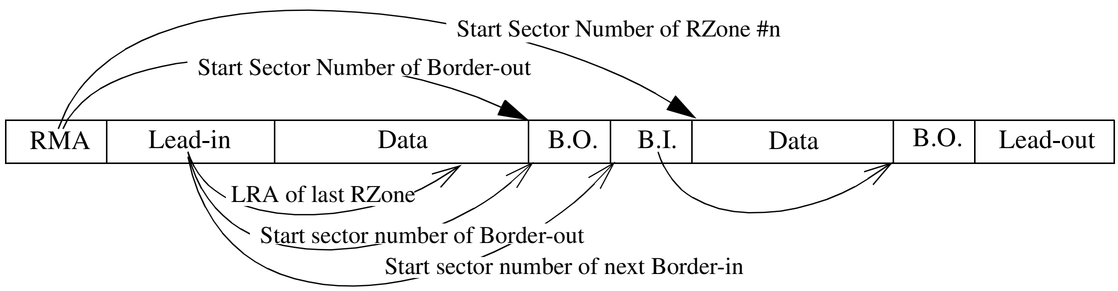

Figure 57 - Pointers for multi-Border recognition

4.16.11.6 Disc final closure

If the Multisession/Border field in the *Write Parameters* Mode Page (05h) is set to 00b, when CLOSE TRACK/RZONE/SESSION/BORDER command which intends to close the Border is issued, the final closure operation ***shall*** be started for the disc. After this operation, Lead-out is appended after the last Border-out and data cannot be appended to the disc any more. The total length of the last Border-out and Lead-out ***shall*** be about 0.5mm in the radial direction. See Table 61 - *Border Zone size for DVD-R media* on page 148.

To recognize whether the disc is finalized or not, the following conditions are checked. If one of the following condition is met, the disc ***shall*** be considered a finalized disc and is not appendable.

- Start PSN of the next Border-in field of Lead-in/Border-in contains 0.
- Next Border Marker is recorded as Lead-out attribute.
- Disc Status field of RMD contains “Complete” status.

Final closure operation (Finalize) is done in the following sequence:

1. Set Multisession/Border field in *Write Parameters* Mode Page (05h) to 00b.
2. Close all opened RZone(s).
3. Issue CLOSE TRACK/RZONE/SESSION/BORDER command with Close Function=010b.
4. Updated RMD is written in RMA with Disc Status field “Complete”.

If the last Bordered Area (Border) is incomplete status and Lead-in is already written:

5. Border-out for current incomplete Border and Lead-out are written with the following conditions:
   Border-out ***shall*** be recorded until Stop Block.
   Lead-out ***shall*** be recorded after the Stop Block.
6. Border-in for current Border is written with following condition.
   The Start Sector Number of Next Border-in field ***shall*** be set to 0.
7. Next Border Marker in previous Border-out is padded with 00h and set to Area Type field of Data ID 00b. (normal data sector)

If the last Bordered Area (Border) is incomplete status and Lead-in is still unwritten:

5. Border-out for current incomplete Border and Lead-out are written with following condition.
   Border-out or truncated Border-out ***shall*** be recorded. If the remaining capacity of Data Recordable Area is not sufficient for Border-out, truncated Border-out ***shall*** be recorded.
   Lead-out ***shall*** be recorded after the Border-out or truncated Border-out.
6. Lead-in is recorded.
   The Start Sector Number of Next Border-in field ***shall*** be set to 0.

If the last Bordered Area (Border) is empty status and Lead-in is already written:

5. Lead-out ***shall*** be recorded immediately following the last Border-out where there is reserved space for the next Bordered Area’s Border-in.
6. Next Border Markers in last Border-out ***shall*** be padded with 00h and set to Area Type field of Data ID 01b. (Lead-out)

The total radial width of last Border-out and Lead-out ***shall*** be about 0.5mm.

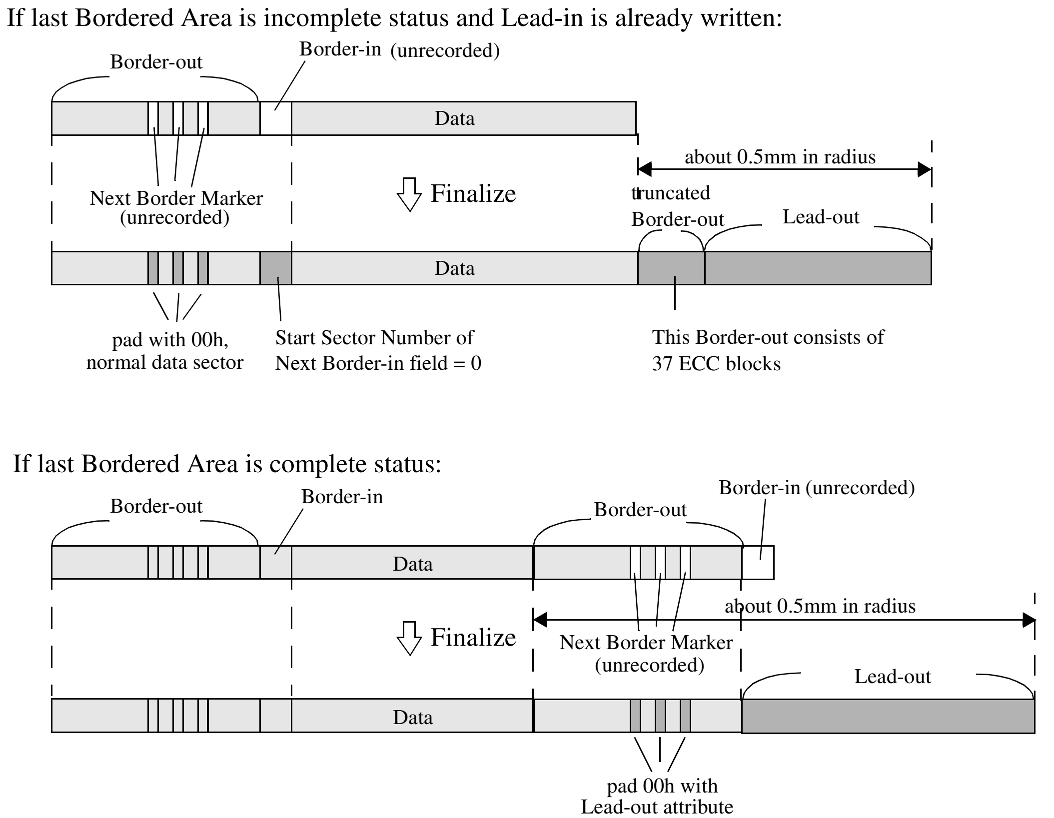

Figure 58 - Finalize

4.16.12 State of disc for interchange

To make recorded user data readable by DVD read-only logical units, a Lead-in/Border-in and Border-out/Lead-out ***shall*** be recorded at each end of recorded user data.

In disc-at-once recording, Lead-in through Lead-out is always written in one recording action. Therefore DVD-R media which is written by disc-at-once recording is ready to be read by any DVD read-only logical unit.

In incremental recording, DVD-R media cannot be read by DVD read-only logical units unless Lead-in/Border-in and Border-out is written at each end of Bordered Areas.

4.16.13 The data which are recordable by DVD-R logical units

The data types which are recordable by a DVD-R logical unit are listed below.

- User data in Data Area
- Copyright Management Information in Data Area
  - CPM
  - CGMS
- Control data in Lead-in Area
  - manufacturing Information field (copied from RMD Field-2)
- RMD in RMA area

Note: The manufacturing Information field of DVD-R media contains user specific data. It may be written by authoring software.

4.16.14 Recovery from a damaged disc

An RZone or RMD may be damaged with incomplete status (no linking) at the end of the written data. This may be caused by a HARD RESET or a power-fail condition during an incremental recording.

A recorded data may not be readable due to EDC error. The disc may be dirty or cracked after recording.

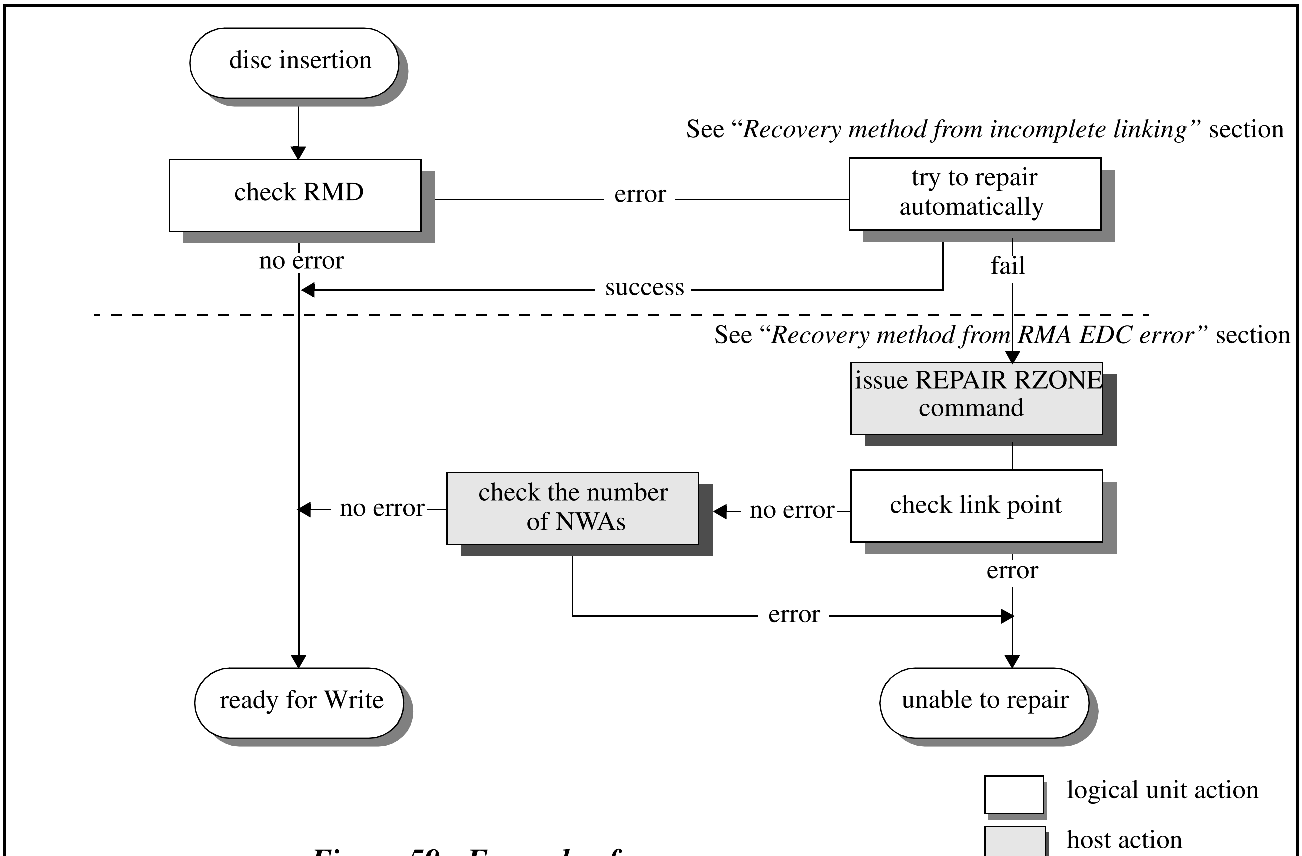

Figure 59 - Example of error recovery sequence

4.16.14.1 Recovery method from incomplete linking

If an ECC block is damaged accidentally, the logical unit overwrites from the damaged sector of the ECC block with Data Type bit 1. If an error occurs in the first through 15th sector of the ECC block, the logical unit writes one more ECC block with Data Type bit 1 immediately following the damaged ECC block. If an error occurs in the 16th sector of the ECC block, the logical unit writes two more ECC blocks with Data Type bit 1 immediately following the damaged ECC block. See Figure 60. In this case, the Last Recorded Address is the last readable sector and does not belong to the Linking Loss sector. Automatically repaired NWA is the first sector of the ECC block which is following padded ECC block(s).

The automatic repair ***shall*** be done by the logical unit. The actual padding to the damaged RZone ***shall*** be done when the next write operation is issued to the RZone. The damaged status of the RZone is kept to notice the RZone has damage even if the disc is newly inserted in another logical unit before the repair operation is performed.

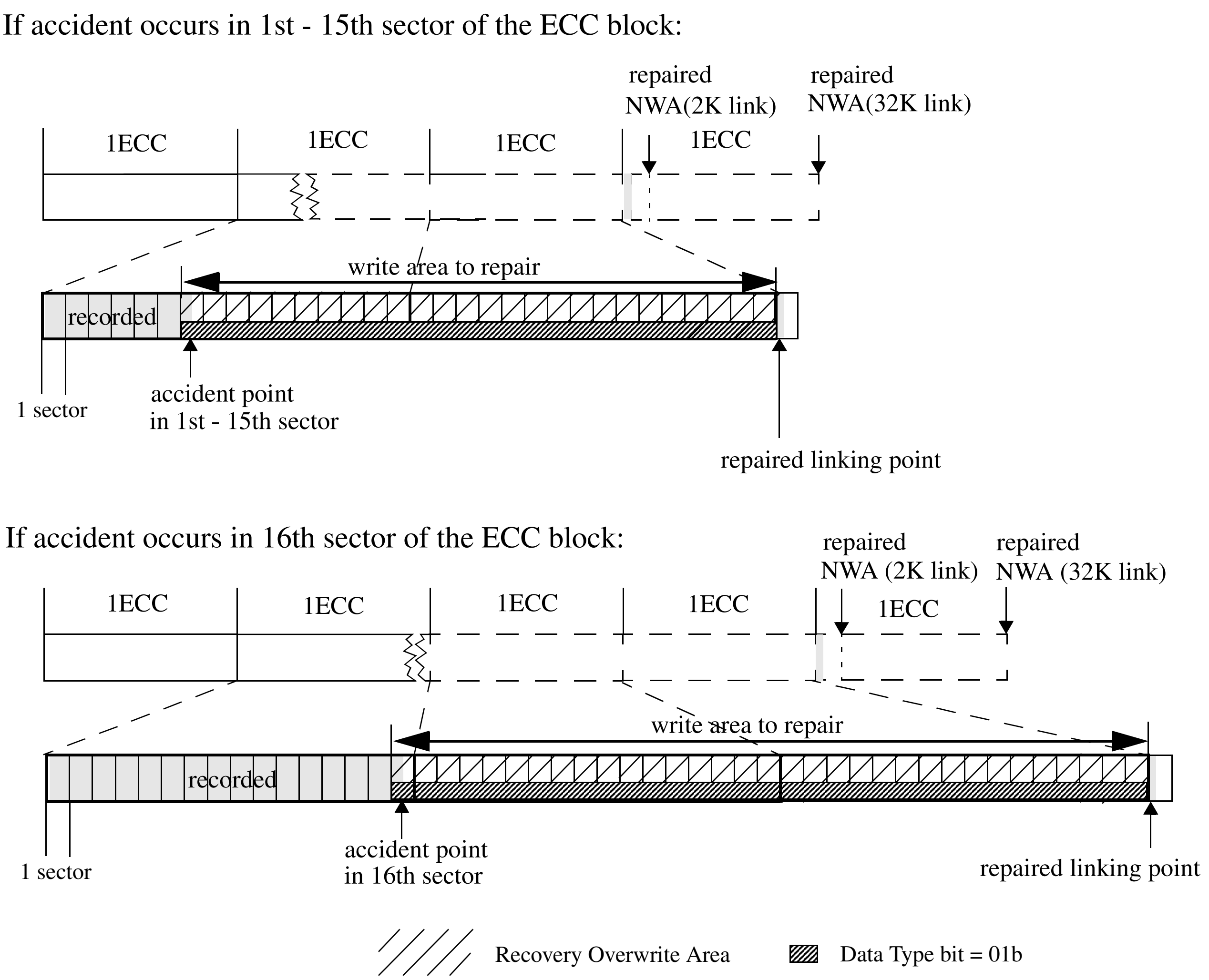

Figure 60 - Repair incomplete linking

4.16.14.2 Recovery method from RMA write error

The recovery method is the same as 4.16.14.1. In this case, there are no modifications in the data recordable area and previously recorded RMD is available as a valid RMD.

4.16.14.3 Recovery method from RMA EDC error

If the logical unit can not read the RMD, the RZone information such as "number of RZones", "start address of RZone", "boundary of RZone" is not recognized by the logical unit.

If the last RMD in the RMA is un-recovered because of an EDC error, the logical unit ***shall*** report the RMA un-recovered error. The logical unit ***shall*** report CHECK CONDITION status, 3/57/00 UNABLE TO RECOVER TABLE-OF-CONTENTS to any command which requires access to the RMA.

When the last RMD in the RMA is un-recovered because of an EDC error, recovery is as follows:

1. When the host receives an error, clean the media. Eject the media and check the surface. If the surface is dirty,

clean the disc.

2. When the error code UNABLE TO RECOVER TABLE-OF-CONTENTS is reported and the media has been cleaned, host ***shall*** send a REPAIR RZONE command with TRACK/RZONE number 0, telling the logical unit to try to recover using the old RMD in the RMA. When the REPAIR RZONE command with RZone number 0 is issued, the logical unit ***shall*** try to read the latest readable RMD and check NWAs on the disc. If all NWAs coincide on the disc in the recovered RMD, the logical unit ***shall*** report GOOD status to the REPAIR RZONE command. The system ***shall*** check the number of NWAs (open RZones) with the READ TRACK/RZONE INFORMATION command. If the number of NWAs on disc and file system are the same, the recovered RMD of RMA is correct. System can recognize the disc status successfully.

When latest RMD is not readable and if some reserved RZones had been completed/closed since last readable RMD was written, the logical unit ***shall*** return CHECK CONDITION status, 3/57/00 UNABLE TO RECOVER TABLE-OF-CONTENTS. In this case, the new Incomplete/Invisible RZone may exist at the outside of the assumed Incomplete RZone. For example, when the last readable RMD reflects the disc status such as case **F** of Figure 46 - *Example of RZone reservation sequence* on page 134 and actual current disc status is the case **G** of Figure 46, logical unit and host might not be aware of the existence of the RZone number 7 of Figure 46.

To make the backup of RMD in RMA, see *4.16.11.3, "When RMD is written in RMA"* on page 146.

4.16.14.4 Recovery for accident during Border-out writing

To close a Border, Border-out ***shall*** be written prior to writing the Border-in.

When an error occurs while writing the information blocks of the Border-out (copies of RMD), the following action may be attempted by the logical unit. If an error occurs while writing data other than information blocks, the logical unit will restart the write at the end of the Border-out.

1. The logical unit attempts to repair the damaged ECC block automatically.
2. If repair is successful, the logical unit updates the RMA with the latest RMD which contains the new Border-out start address (repaired NWA).
3. Rewrites Border-out from repaired NWA.
4. Writes Border-in (or Lead-in) containing the repaired start address of Border-out.

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4.17 Recording for DVD-R Dual Layer media

4.17.1 The basics for DVD-R Dual Layer media

DVD-R Dual Layer disc is developed to provide a write-once DVD recordable media with the same capacity as DVD-ROM Dual Layer disc. There are two recording layers on a single side and they are referred to as Layer 0 (L0) and Layer 1 (L1). The L0 is made up from semi-transparent/semi-reflective material so that the laser beam can pass through to the L1. (The L1 is relatively distant from the disc surface than the L0.)

Up to 8.54 gbytes capacity (= same as DVD-ROM Dual Layer disc capacity) is available for recording while the Single Layer disc can hold up to 4.7 gbytes of data. The mechanical dimensions, sector layout, Control Data Zone structure, and recorded signal characteristics (focus/tracking signal) of DVD-R Dual Layer medium are almost same as that of DVD-ROM Dual Layer medium. When a disc/Border is closed for interchange, it is expected that the disc is readable by DVD players and DVD read-only logical units.

Although DVD-ROM Dual Layer media have two kinds of track path (i.e., Opposite Track Path (OTP) and Parallel Track Path (PTP)), DVD-R Dual Layer Ver. 3.0 disc specification defines only OTP discs to avoid user confusion. The OTP disc is the majority usage in case of DVD-ROM Dual Layer discs and is suitable for recording of video and audio contents due to minimum transition time at the Layer Jump Address.

The lowermost writing speed for DVD-R Dual Layer media is 2× speed (Scan velocity for write = 7.68 m/s).

The maximum number of NWAs is incremented by one in comparison to DVD-R Single Layer media to support real-time DVD-Video format recording at Layer Jump Address. Maximum three RZones can be reserved at a same time. Maximum available number of NWAs and current valid NWAs are reported by the Assigned Track information of READ DISC INFORMATION command.

Table 63 shows the comparison chart of some parameters between different versions of DVD-R media format.

Table 63 - History of DVD-R media format

DVD-R Version / Characteristics	1.0	2.0/2.1 for General	3.0
Capacity per side (12 cm)	3.95 gbytes[a]	4.7 gbytes[a]	8.54 gbytes[a]
Channel bit length (µm)	0.147	0.133	0.147
Track pitch (µm)	0.80	0.74	0.74
Number of Layers per side	1	1	2
Reflectivity	45 to 85%	45 to 85%	16 to 27%
Control Data Zone	recordable	pre-recorded/embossed	pre-recorded/embossed
Maximum Number of NWAs	3	3	4
Standard recording speed	1×	1×/2×	2×

a. gbytes = 1000 × 1000 × 1000 bytes

4.17.1.1 Three Recording Modes for DVD-R Dual Layer disc

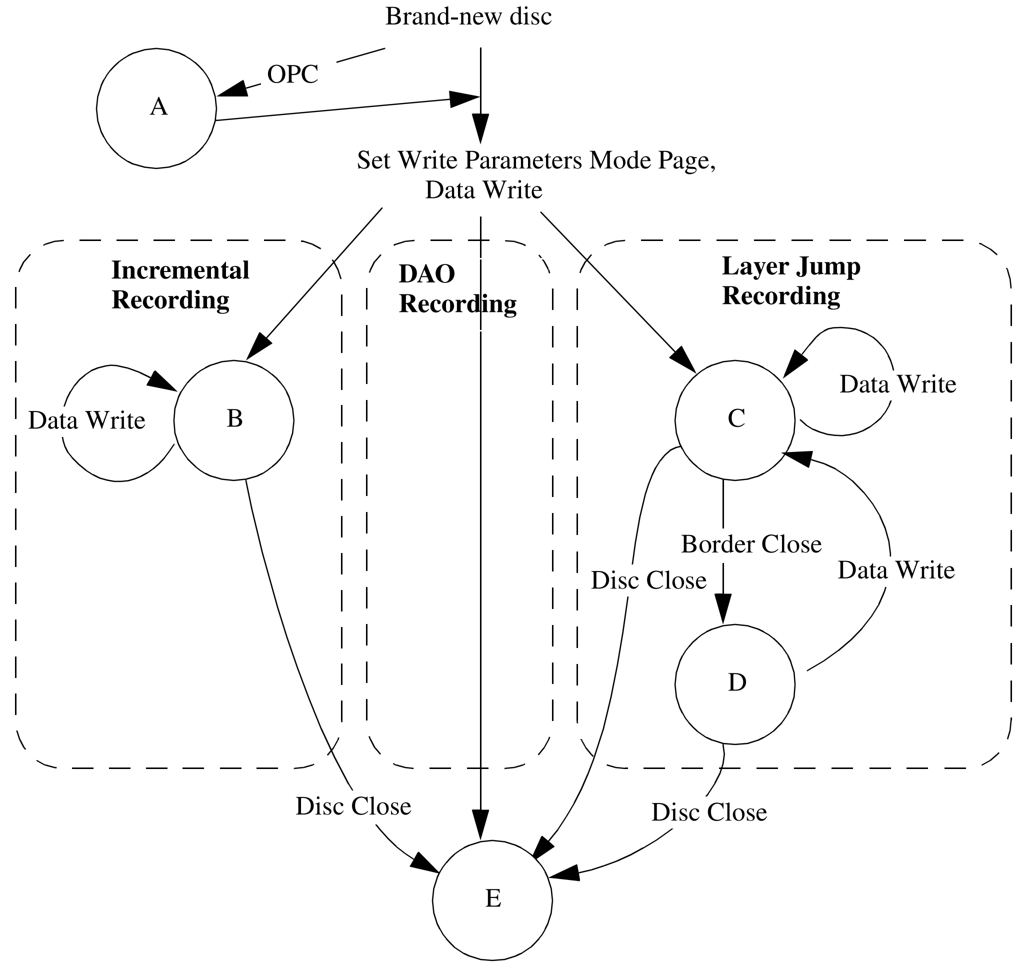
DVD-R Dual Layer disc has three recording modes. They are Disc-at-Once recording, Incremental recording and Layer Jump recording modes. To facilitate the Layer Jump recording, new RMD format (= Format 4) is defined in addition to Format 1 RMD. The Format 1 RMD is defined for conventional recording methods (i.e., Disc-at-once and Incremental recording) that are being used on DVD-R Single Layer media. Some contents of the Format 1 RMD is also expanded.

The multi-Border recording is only supported by the Layer Jump recording mode with Format 4 RMD. Even after the closing of a Border, a user can continue recording until the medium capacity becomes full. If a disc is recorded with multi-Border, the first Bordered Area would be at least readable by legacy DVD read-only logical units and players.

If the Disc Status field of Format 1 RMD is set to blank status (= 00h), none of the recording modes is specified to the disc. When a host specifies the disc as Layer Jump recording mode, the Disc Status field of Format 4 RMD with

Incremental recording status (= 02h) is recorded in RMA after the Format 1 RMD with blank status. To specify Layer Jump recording mode, the Write Type field of Write Parameters Mode Page ***shall*** be set to 04h (= Layer Jump recording).

Figure 61 shows the recording mode and Bordered Area status transition diagram for DVD-R Dual Layer disc.



The last Bordered Area is:

A: Blank (Format 1 RMD) B: Incomplete (Format 1 RMD) C: Incomplete (Format 4 RMD)
D: Empty (Format 4 RMD) E: Complete (Finalized disc, Format 1 or Format 4 RMD)

Figure 61 - DVD-R Dual Layer disc recording mode and Bordered Area state transition

4.17.1.2 Associated Profile and Feature

When a blank DVD-R Dual Layer Ver. 3.0 disc is installed in a logical unit, the logical unit reports the most appropriate Profile code in the Current Profile field of Table 221 - *Feature Header* on page 408. If a logical unit supports both DVD-R Dual Layer Sequential recording Profile and DVD-R Dual Layer Jump recording Profile, the logical unit returns these two Profile Descriptors in the Profile List Feature Descriptor. If default value of the Write Type field in Write Parameters Mode Page is set to 00h or 02h (Incremental or DAO recording), the Current Profile field may be set to Profile 0015h: DVD-R Dual Layer Sequential recording. If default value of the Write Type field is set to 04h (Layer Jump recording), the Current Profile field may be set to Profile 0016h: DVD-R Dual Layer Jump recording. The LJRS field value of READ TRACK/RZONE INFORMATION command depends on the Write Type field value of Write Parameters Mode

Page. When the Write Type field value is invalid for DVD-R Dual Layer disc, the LJRS field may be set to compatible value with default value setting of the Write Type field for the disc.

Once recording mode is fixed, the recording mode is not changed and the logical unit ***shall*** report the assigned recording mode information by the LJRS field of READ TRACK/RZONE INFORMATION command.

The Write Type field of the Write Parameters Mode Page ***shall*** be set to associated value with the specified recording mode on the disc. Otherwise the logical unit ***shall*** terminate disc writing operation with CHECK CONDITION status, 5/64/00 ILLEGAL MODE FOR THIS TRACK.

When the Feature 0033h: Layer Jump recording Feature is current, regardless of the BUFE bit setting, Buffer Under-run Error Free recording ***shall*** be performed. Therefore the host should issue SYNCHRONIZE CACHE command to finish the data recording. Table 64 shows the relationship between recording mode and associated parameters.

Table 64 - Profile, Feature and Write Type value for each recording mode

Specified recording mode on the disc	Associated parameters to be set to the logical unit		
	Profile to be current	**Feature to be current**	**Write Type[a] value to be set**
Disc-at-Once	Profile 0015h: DVD-R Dual Layer Sequential recording	Feature 002Fh: DVD-R/-RW Write Feature	02h (Disc-at-once)
Incremental		Feature 0021h: Incremental Streaming Writable Feature	00h (Incremental)
Layer Jump	Profile 0016h: DVD-R Dual Layer Jump recording	Feature 0033h: Layer Jump recording Feature	04h (Layer Jump)

a. The Write Type field of Write Parameters Mode Page

4.17.1.3 Recording order

There is a strong recommendation that the area on L1 should be recorded through the recorded area on L0. The transmissivity is different between recorded area and unrecorded area on L0. If the recording order is not kept, the recorded signal characteristics on L1 would not have the uniformity due to different transmissivity on L0. This may cause a trouble to Automatic Threshold Control (ATC) of the logical unit when the recorded data on L1 is read.

4.17.1.4 Fixed logical volume space

The End PSN of L0 field value in Control Data Zone is fixed and not changeable because the Control Data Zone is pre-recorded or embossed by disc manufacturer. See Figure 16 - *Data structure of Lead-in Area* on page 81. This means that the logical volume space is fixed and the start address of Middle Area is also fixed to "End PSN of L0 +1" because the LBA in the logical volume space and PSN have one-to-one relationship (i.e., LBA = PSN-30000h . See Figure 7 - *Physical and logical layout of Opposite Track Path DVD-ROM/R Dual Layer media* on page 73.

4.17.2 Remapping on Layer Jump recording

Address remapping mechanism is newly developed to adapt UDF file system and ISO-9660 file system for Layer Jump recording on DVD-R Dual Layer Ver. 3.0 disc. When a writing software uses the remapping mechanism correctly and the logical unit supports the reading of remapping information, the reading environment of a host can treat the multi-Border recorded DVD-R Dual Layer disc as if it is single Border recorded disc.

When the Layer Jump recording is used, the file system such as UDF may not work well without remapping mechanism. A file system starts data reading from some of Anchor Points (APs) of DVD-R Dual Layer disc to recognize the logical volume and file structure. See *Appendix J -, "UDF Key Structure (Informative)"* on page 789. In case of UDF, the Volume Recognition Sequence (VRS) and the Anchor Volume Descriptor Pointers (AVDP) are the kind of APs described in this section. UDF uses at least 2 of 3 APs that are located at the LBA 256, n-256 and n (where the n is LBA of the maximum recorded user data sector in the logical volume space on the disc). Those APs may be recorded in the logical format operation. In case of Layer Jump recording, those APs may be recorded in the early recording period. After the APs are recorded, the recorded data on APs cannot be updated. Figure 62 shows an example of multi-Border recording that contrasts physical disc image with logical volume space image. In Figure 62, the address range in the logical volume space covered by the first Bordered Area involves the address range in the logical volume space covered by the second Bordered Area. Therefore UDF file system cannot see the updated volume structure recorded in the second Bordered Area. To solve this problem, Format 4 RMD provides the address remapping mechanism. Up to four ECC blocks that contain APs can be remapped to alternative ECC blocks. See Figure 91 - *Example sequence of multi-Border recording with remapping* on page 196.

Layer Jump with Border recording also provides physical read compatibility with DVD read-only logical units. The first Bordered Ares recorded by the Layer jump recording is physically same as the Data Area on DVD-ROM OTP Dual Layer disc. Therefore, the playback system using DVD read-only logical unit is able to read at least the first Bordered Area even if the logical unit does not support the multi-Border structure on Dual Layer disc. To provide file system level read compatibility with legacy DVD read-only logical units, a host may need to take care of the position of AP3 and AP4. For example, UDF file system requires the AP4 and/or AP3 at LBA n and LBA n-256, respectively (n is the maximum recorded user data LBA.). Legacy DVD read-only logical units may retrieve LBA n from the pre-recorded CDZ. Thus the AP4 and AP3 locations should match to those information.

See *4.17.8.3, "APs data writing for Layer Jump recording"* on page 188.

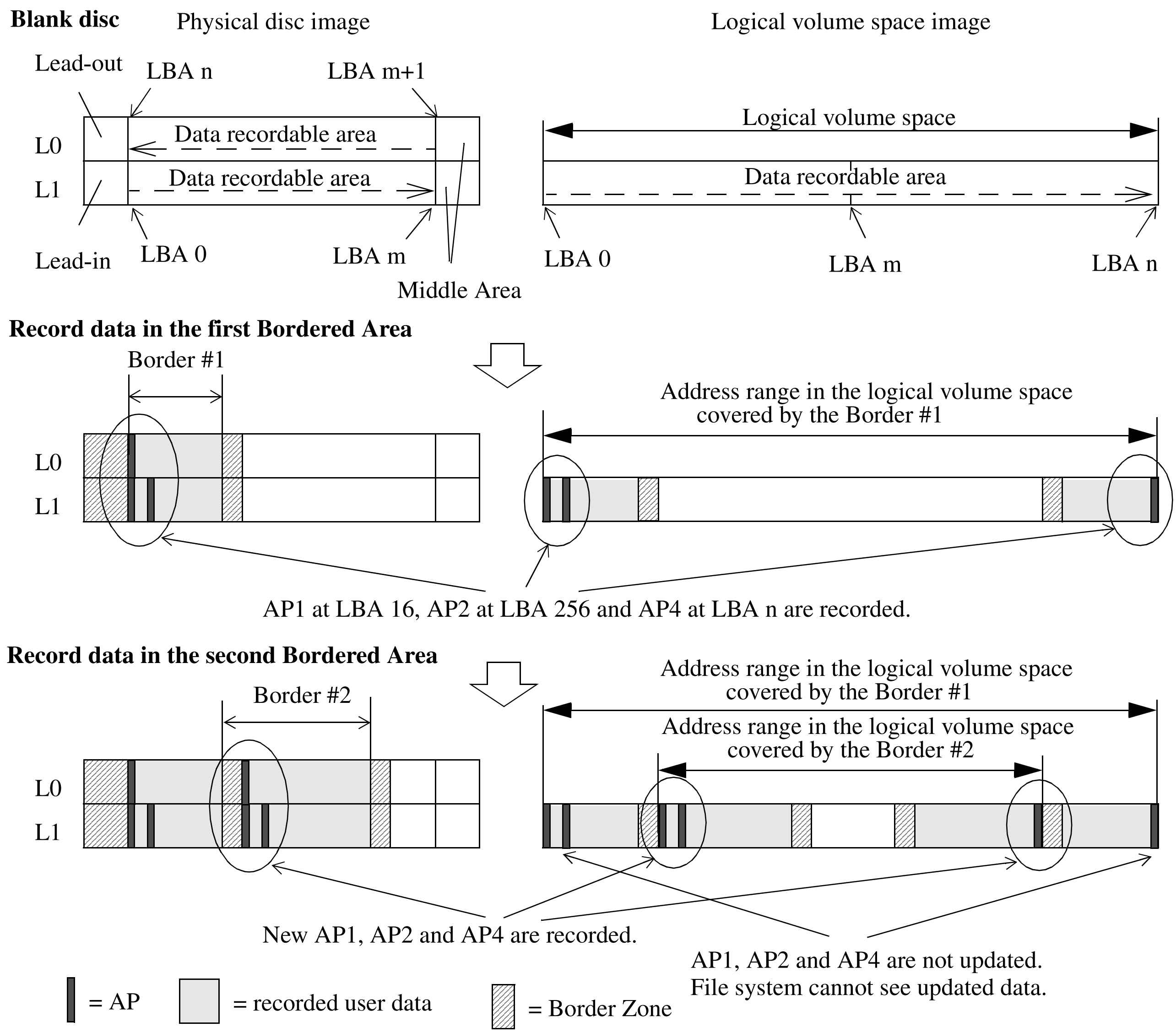


Figure 62 - APs update problem of Multi-Border with Layer Jump recording

4.17.3 State of DVD-R Dual Layer disc for interchange

In general, to make the recorded user data on DVD-R disc physically readable by DVD read-only logical units, at least the following three conditions must be satisfied to prevent the typical DVD read-only logical unit optical pickup from overrunning to the unrecorded area due to the tracking servo mechanism,

- at the inner end of the recorded user Data Area, buffer zone such as Lead-in is located,
- at the outer end of the recorded user Data Area, buffer zone such as Border Zone or Middle Area is located,
- all the sectors from the beginning of the inner buffer zone to the end of the outer buffer zone are recorded.

In addition to the conditions above, in case of DVD-R Dual Layer disc, Lead-out and all the sectors on L1 located at the radius between the inner part of Lead-in and the outer part of Border Zone/Middle Area on L0 must also be recorded. See Figure 63.

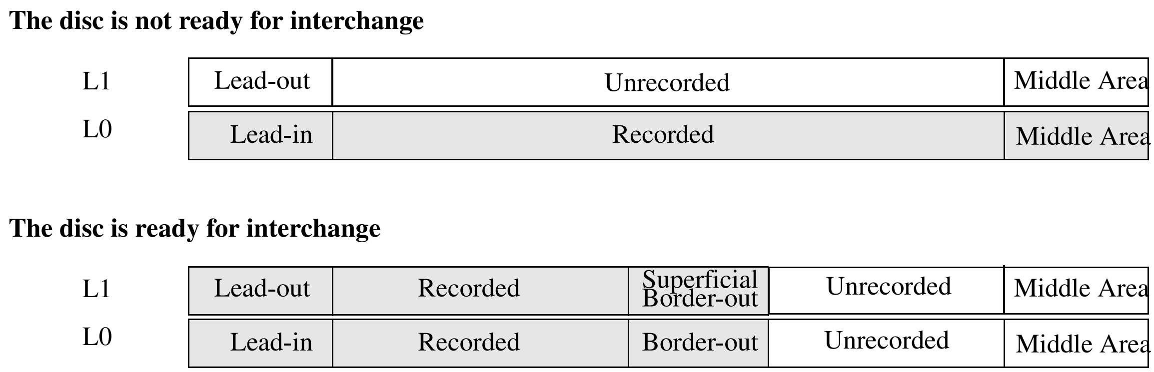


Figure 63 - State for DVD-R Dual Layer disc interchange

4.17.4 Recording mode for DVD-R Dual Layer media

DVD-R Dual Layer media makes use of sequential recording as well as Single Layer discs. DVD-R Dual Layer media supports three kind of recording modes. They are Disc-at-Once (DAO) recording, Incremental recording, and Layer Jump recording. Once a recording mode is determined, the recording mode ***shall*** not be changed afterwards.

4.17.4.1 DAO recording

DAO recording is supported by DVD-R Dual Layer media by using Format 1 RMD. Lead-in through Lead-out is recorded in one recording action. The Middle Area on L0 and L1 may be recorded after Lead-out is written. The Layer Jump Address is fixed location and is not changeable.

When DAO recording is used, all unrecorded user Data Area ***shall*** be recorded. When the amount of user data to be recorded is less than the capacity of L0, the Shifted Middle Area may be used as an exceptional case. See Figure 64.

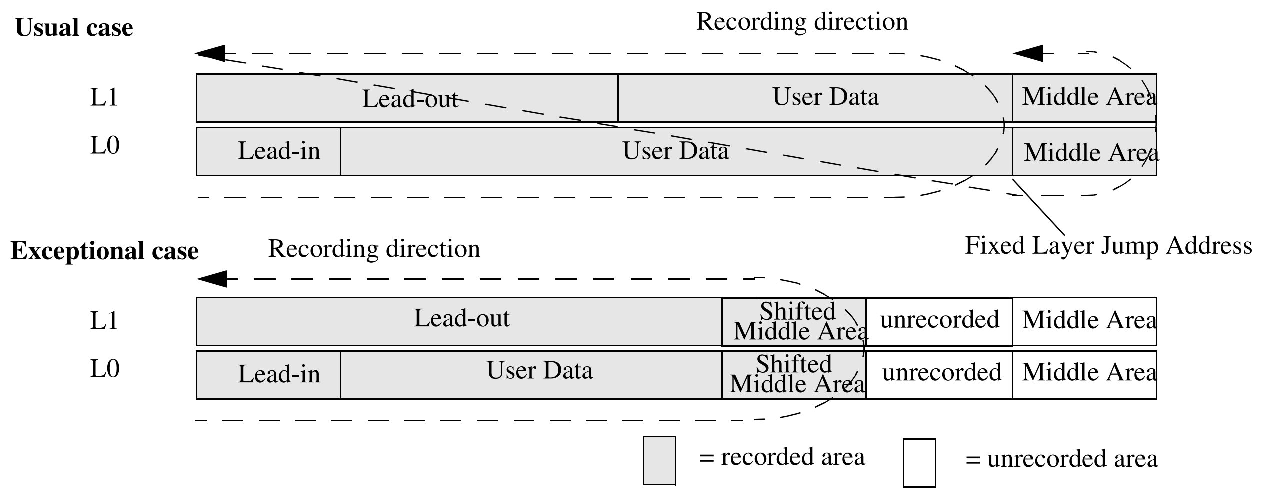


Figure 64 - Example of Disc-at-once recording on DVD-R Dual Layer disc

4.17.4.2 Incremental recording

Incremental recording is supported by DVD-R Dual Layer media by using Format 1 RMD. The RZone reservation scheme is same as the Single Layer disc case. See Figure 65. The multi-Border recording is not defined for incremental recording because Border Zone is meaningless in terms of interchangeability between DVD-R Dual Layer logical units and DVD read-only logical units.

When the disc is finalized, all unrecorded user Data Area ***shall*** be recorded to make the disc readable by DVD read-only logical units. However, if no RZone is reserved in L1 and no user data is recorded in L1, the Shifted Middle Area may be used as an exceptional case at disc final closure. See Figure 95 - *Disc final closure in Incremental recording mode* on page 199.

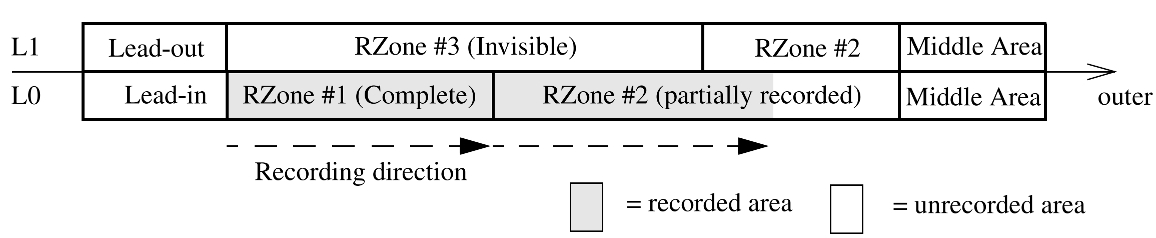


Figure 65 - Example of incremental recording on DVD-R Dual Layer disc

4.17.4.3 Layer Jump recording

Layer Jump recording allows to set several Layer Jump Addresses including Reserved RZone at any position to record both Layers alternately. The symmetrical L1 part can be recorded after the portion of L0 is recorded. This allows quick closing of the disc with Border Zone for DVD read-only logical unit compatibility. Data can be added after closed border. The Layer Jump recording uses Format 4 RMD. The RZone usage is different from the other recording modes.

Layer Jump recording allows to set several Layer Jump Address including Reserved RZone at any position to record both Layers alternately. The symmetrical L1 part can be recorded after the portion of L0 is recorded. This allows quick closing of the disc with Border Zone for DVD read-only logical unit compatibility. Data can be added after closed border. The Layer Jump recording uses Format 4 RMD. The RZone usage is different from the other recording modes.

Note: DVD-R Dual Layer Book has no definition of Layer Jump recording mode explicitly. When the Disc status field of Format 4 RMD Field 0 is set to 02h = "Incremental recording", the disc is regarded as Layer Jump recording mode described in this specification.

An example of Layer Jump recording is illustrated in Figure 66. The detail of Layer Jump recording and related issues are described in the following sections.

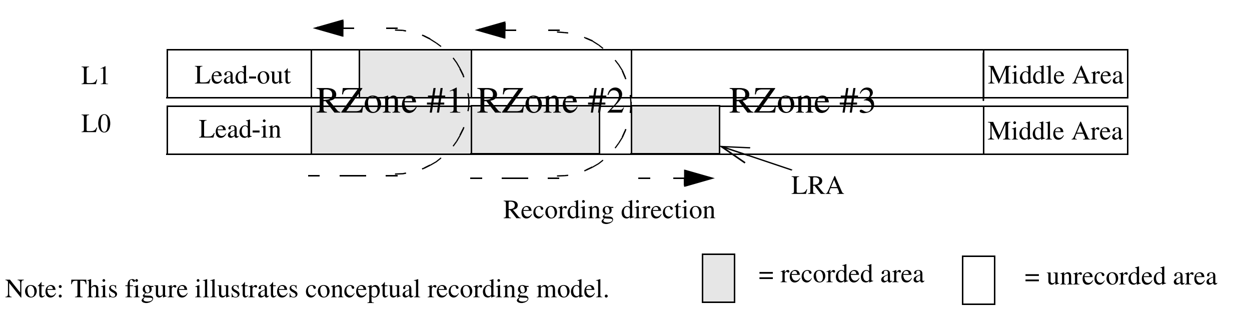


Figure 66 - Example of Layer Jump recording

4.17.4.4 Comparison chart among recording modes

Table 65 is the comparison chart of capability of DVD-R Dual Layer Ver. 3.0 disc.

Table 65 - Comparison of recording mode

Associated capability Recording mode	Recording order management	Recording Area	Quick disc closing[a]	Multi-Border recording[b]
Disc-at-Once (Figure 64)	no need to care	contiguous entire disc (single RZone)	no	no
Incremental (Figure 65)	application responsibility[c]	contiguous in RZone (multiple RZones)	no	no
Layer Jump (Figure 66)	logical unit responsibility	Not contiguous, divided by Layer Jump Address[d]	yes	yes

a. See *4.17.11, "Disc final closure"* on page 198.
b. Data Appendability after disc becomes ROM compatible. See *4.17.9, "Border Zone for DVD-R Dual Layer media"* on page 190.
c. When the application uses multiple of open RZones (NWAs), recording order of Layers should be considered. See *4.17.13.3, "Recommendation for multiple open RZone recording"* on page 215.
d. When the application uses Layer Jump recording, the Layer Jump Address should be considered. See *4.17.5, "Recording unit of Layer Jump recording"* on page 167.

4.17.5 Recording unit of Layer Jump recording

RZone is defined to manage recordable data area and recorded data area on DVD-R disc. This is very similar to Track of CD-R disc. An RZone may have recorded part, recordable part and NWA. In the case of DAO recording or Incremental recording mode on DVD-R Dual Layer Ver. 3.0 disc, the usage of the RZone is same as that of DVD-R Ver. 1.0/2.1 discs (i.e., the RZone is specified by the start LBA, contiguous length and Last Recorded Address). In the case of Layer Jump recording of DVD-R Dual Layer Ver. 3.0 disc, the usage and geometric definition of the RZone are different from the case of DAO recording and Incremental recording mode (i.e., the RZone is specified by the start LBA, end LBA, Last Recorded Address and Layer Jump Address). On Layer Jump recording mode, a Reserved RZone is used to manage the recording sequence of the Layer jump recording. In addition, the Layer Jump Block (LJB) is newly defined to manage the recording sequence of the Layer Jump recording in a subdivision of the Invisible/Incomplete RZone.

4.17.5.1 Blank disc parameters in Layer Jump recording mode

Table 66 shows fields of commands that returns blank disc parameters.

Table 66 - Blank disc parameters and related commands in Layer Jump recording mode

Disc parameter to be returned	READ TRACK/RZONE INFORMATION command[a]	READ DISC STRUCTURE command
Start LBA on L0	Track/RZone Start Address field	Starting Physical Sector Number of Data Area field of Physical Format Information of Control Data Zone in the Lead-in (Format Code = 10h)
End LBA on L0	Next Layer Jump Address field	L0 Data Area Capacity field of Layer Boundary Information (Format Code = 20h)
End LBA on L1	Track/RZone Size / RZone End Address field	End Sector Number in L0 field of Physical Format Information of Control Data Zone in the Lead-in (Format Code = 10h)

a. RZone number is set to 1. The Write Type field of Write Parameters Mode Page is set to 04h (Layer Jump).

4.17.5.2 Reserved RZone structure for Layer Jump recording

An RZone of Layer Jump recording mode may have two separated recording parts on L0 and L1. The RZone can be written sequentially from the beginning of L0 part through the end of L1 part of the RZone via the Layer Jump Address. When an RZone is reserved, a host can recognize the geometric structure of the Reserved RZone as four parameters returned by the READ TRACK/RZONE INFORMATION command. Those are the Track/RZone Start Address field (to indicate the Start LBA of Figure 67), the Next Layer Jump Address field or the Last Layer Jump Address field (LJA), the Last Recorded Address field (LRA) and the Track/RZone Size / RZone End Address field (End LBA). The Last Layer Jump Address field reports the last Layer Jump Address on L0 (from L0 to L1). This field does not report the Layer Jump Address on L1 (from L1 to L0). See Figure 68. In case of Layer Jump recording, the LJRS field of a Reserved RZone is set to 01b and the Track/RZone Size / RZone End Address field reports the end LBA of the RZone. The LJA and End LBA are the LBA of the end sector of an ECC block. See Figure 67. Table 67 explains the relationship between these fields and fields of Format 4 RMD on the disc for logical unit implementation.

Table 67 - Reserved RZone parameters

RZone parameter of Figure 67	READ TRACK/RZONE INFORMATION command	Format 4 RMD - Field 4 (RZone Information)
Start LBA	Track/RZone Start Address	Start sector number of RZone #1
LJA	Next Layer Jump Address or Last Layer Jump Address	Layer Jump Address of RZone #1
LRA	Last Recorded Address	Last recorded address of RZone #1
End LBA	Track/RZone Size / RZone End Address	End sector number of RZone #1

Either one of the Next Layer Jump Address field or the Last Layer Jump Address field specifies the LJA of the Reserved RZone if the RZone has L1 part. Otherwise, both fields are set to zero. In Layer Jump recording mode, when the NWA is located on L1 in an Reserved RZone, the Last Layer Jump Address field reports the Layer Jump Address of the Reserved RZone and the Next Layer Jump Address field reports zero. When the NWA is located on L0 in an Reserved RZone, the Next Layer Jump Address field reports the Layer Jump Address of the Reserved RZone and the Last Layer Jump Address field reports zero.When a Reserved RZone is closed, the Next Layer Jump Address field ***shall*** report zero and the Last Layer Jump Address field ***shall*** report the Layer Jump Address of the Reserved RZone regardless of the location of the LRA to show the geometric structure of the RZone.

The Link Size field of Write Parameters Mode page should be set to 32 KB during Layer Jump recording for easy implementation.

The Linking Loss Areas (LLA) located at the each end of Reserved RZone boundary on L0 and L1 are 32KB in size even if the Link Size is set to 2KB. See Figure 67.

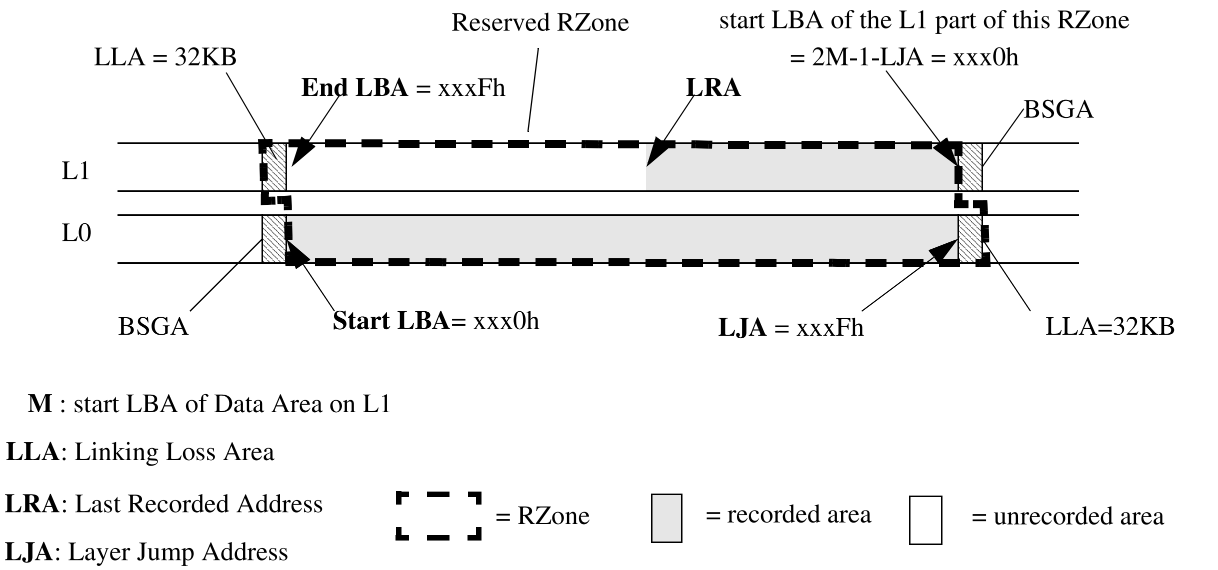


Figure 67 - RZone definition for Layer Jump recording

Feature

4.17.5.3 LJB structure of Invisible/Incomplete RZone

In case of Invisible/Incomplete RZone, the LJB is defined as minimum recording region. Invisible/Incomplete RZone may be recorded as multiple of LJBs. If the RZone does not have L1 part, LJB cannot be assigned to the RZone.

An LJB is defined by the Next Layer Jump Address field, the Last Layer Jump Address field and the Last Recorded Address field of READ TRACK/RZONE INFORMATION command. Only one active LJB that has NWA is reported. In case of Figure 68, parameters of LJB #4 are reported. The Next Layer Jump Address field ***shall*** be actual logical block address of the sector that will cause Layer Jump at write. When the NWA is located on L0, the Last Layer Jump Address field reports the Layer Jump Address on L0 that was used in the previous LJB. If the previous LJB does not exist in the RZone, this field is set to zero. The LLA (Linking Loss Area) of LJB on L0 can be 2KB in size (one sector). BSGA of LJB is 32KB in size (16 sectors).

In case of Regular Interval Layer Jump recording, Invisible/Incomplete RZone is divided into many LJBs. See *4.17.7.3, "Regular Interval Layer Jump"* on page 179.

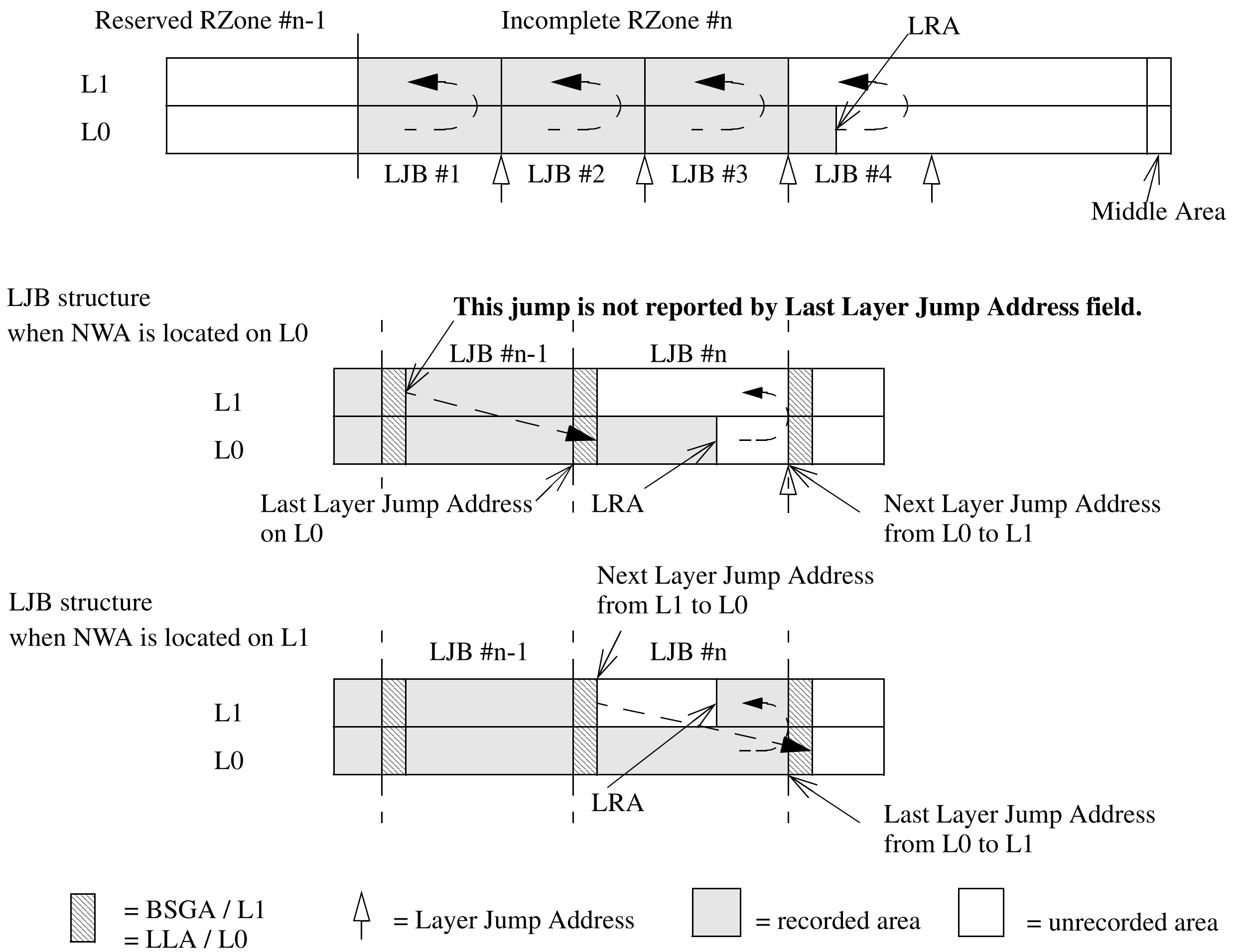


Figure 68 - LJB structure of Invisible/Incomplete RZone

Table 68 explains the relationship of the values in the fields of READ TRACK/RZONE INFORMATION command and the related fields of Format 4 RMD of the disc for logical unit implementation.

Table 68 - Invisible/Incomplete RZone parameters

READ TRACK/RZONE INFORMATION command	Format 4 RMD - Field 4 (RZone Information)
Track/RZone Start Address	Start Sector Number of Invisible RZone
Last Recorded Address	Last recorded address of Invisible RZone
Track/RZone Size / RZone End Address	End sector number of Invisible RZone
LJRS field[a]	Jump interval
When NWA is on L0	
Next Layer Jump Address[b]	Layer Jump Address of Invisible RZone[c]
Last Layer Jump Address	Previous Layer Jump Address of Invisible RZone
When NWA is on L1	
Next Layer Jump Address	Previous Layer Jump Address of Invisible RZone[d]
Last Layer Jump Address[b]	Layer Jump Address of Invisible RZone

a. READ DISC STRUCTURE command with Format Code=22h (Jump Interval) reports this information in case of Regular Interval Layer Jump recording mode (*4.17.7.3,* on page 179).

b. This field reports either one of Layer Jump Addresses that is caused by Shifted Middle Area or Fixed Middle Area if the Layer Jump Address of Invisible RZone is set to zero.

c. READ DISC STRUCTURE command with Format Code=23h (Manual Layer Jump Address) reports this information in case of Manual Layer Jump recording mode (See *4.17.7.2,* on page 177).

d. The value of the Next Layer Jump Address field is calculated from the value of the Previous Layer Jump Address of Invisible RZone field. See "LJB structure when NWA on L1" of Figure 68.

When RMD is written to the disc, these parameters of RMD ***shall*** be updated correctly as shown in Table 68.

4.17.5.4 Consideration of NWA check in logical unit

This subsection describes two typical examples of NWA recovery method in an LJB when RMD is not updated in appropriate timing.

During a recording, RMD may not be updated in appropriate timing by some reason. See Table 92 - *Mandatory RMD update condition in RMA* on page 214. If NWA is not found on the Layer specified by the LRA field of RMD, the logical unit may check another Layer from inverted physical sector address of Layer Jump Address for opposite direction.

In the case of "LJB structure when NWA is located on L0" of Figure 68, when the new RMD that shows LJB#n was not recorded by some reason, the last RMD should have the information of the previous recorded LJB. When the LRA shows the address of L1 in LJB#n-1, the logical unit finds no NWA on L1. The logical unit may check L0 from the Layer Jump Address of Invisible RZone to find correct NWA in LJB#n.

In the case of "LJB structure when NWA is located on L1" of Figure 68, when LRA of LJB#n shows the address of L0, the logical unit finds no NWA on L0 in LJB#n. The logical unit may check L1 from inverted physical address of Layer Jump Address of Invisible RZone to find correct NWA in LJB#n.

4.17.6 RZone reservation for Layer Jump recording

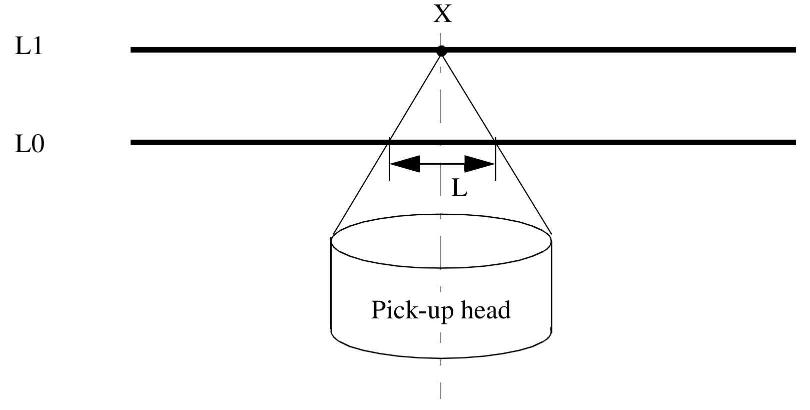
An RZone can be reserved with host specified amount of size. The reserved size on L0 and L1 may not be the same. RZone is reserved with various physical shapes depending on the condition such as its size and recording status of the previous RZone.

4.17.6.1 Restrictions of physical assignment rule of RZone with Format 4 RMD

To keep the recording order of L0 and L1, a gap may be allocated between L1 part of RZones due to several physical factors. Therefore, when Layer Jump recording is used with RZone reservation, full disc capacity may not be available. Disc manufacturer and logical unit control these physical factors and restrictions.

There are several factors for the necessity of gap in between RZones.

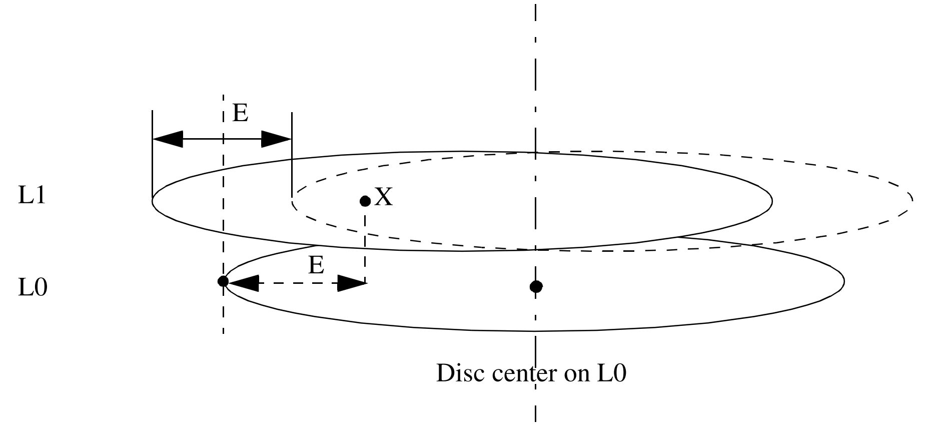
- Laser beam profile
  When the laser is focused on L1, the beam penetrates L0 with some amount of range. This range ***shall*** be recorded prior to recording of the L1.



- To record position X of L1, the range X±(L/2) of L0 needs to be recorded.
  But if the size of an unrecorded area in the above range is very small, it is ignorable.
  For example, Border-in is very small size and it is ignoreable when RZone is reserved.

Figure 69 - Laser beam profile

- Eccentric (Radial run-out) between L0 and L1
  When an RZone is reserved, the eccentric between L0 and L1 is considered to keep the recording order of Layer.

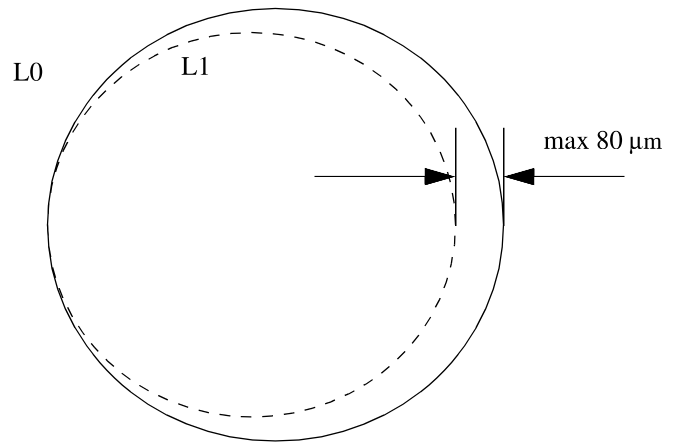


- To guarantee that the position X on L1 is recorded through the recorded area on L0, the X must have relative offset E from the recording start position on L0.

Figure 70 - Eccentric between L0 and L1

DVD-R Dual Layer Book specifies these factors and it is referred to as Physical Clearance in this document. The Physical Clearance is calculated as follows:

- Tolerance of diameter difference between L0 and L1
  When L0 disc and L1 disc are build by injection molding, the diameter size difference between L0 and L1 is maximum 80 µm.



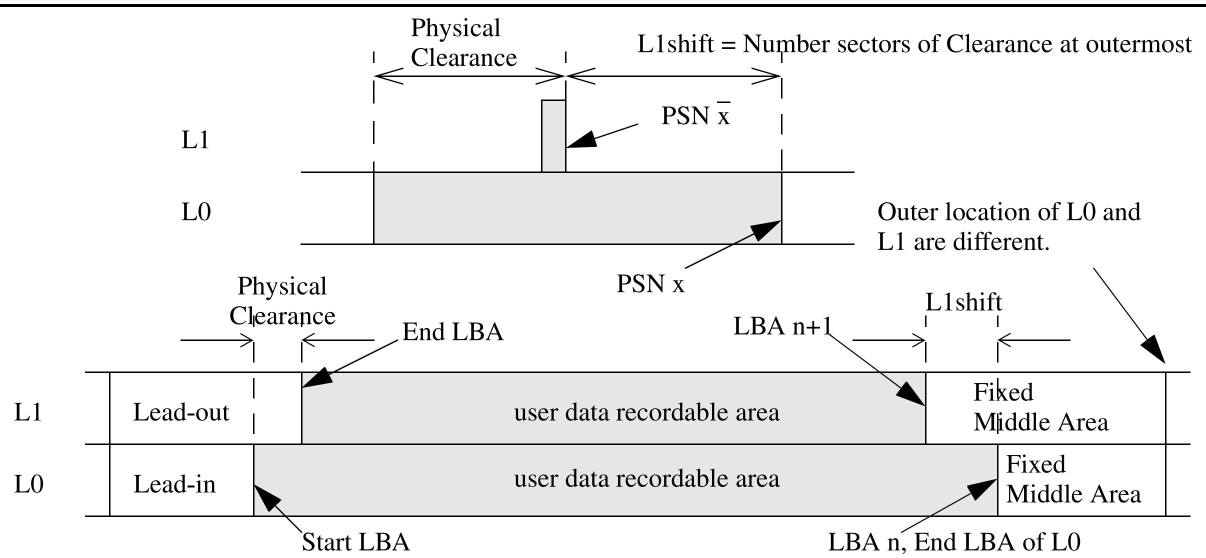
- To guarantee that the L1 is recorded through the recorded area on L0, L1 diameter is smaller than L0.

Figure 71 - Tolerance between L0 and L1

Physical Clearance = Half of laser beam diameter on L0 (2/L) - maximum ignoreable size of unrecorded area on L0 + Eccentric between L0 and L1 (E) + half of tolerance. It is approximately 105 µm width at outermost radius.

To write an ECC block on L1, minimally the Physical Clearance + L1shift size of L0 needs to be recorded as shown in Figure 72. As the result, DVD-R Dual Layer disc is designed and is made to keep L1 smaller than L0. Therefore the capacity of L1 is smaller than L0. The outermost location of Fixed Middle Area are different on L0 and L1. The length of the Fixed Middle Area on L0 is shorter than the length on the L1.

Hereafter, this document uses the term "Clearance" as the number of sectors that consists of Physical Clearance and L1Shift of Figure 72.



The number of sectors of Physical Clearance is variable according to radius position.

Figure 72 - Physical overview of Layers

4.17.6.2 RZone shape and Blank Area

In case of Layer Jump recording, an RZone may have two recording parts on L0 and L1 as shown in Figure 67. If the previous RZone is not closed status, when new Invisible RZone is generated, an unusable area is allocated at the inner side of the Invisible RZone on L1 to keep the recording order between L0 and L1. This unusable area is referred to as Blank Area. The Blank Area will never be usable to record user data even if the previous RZone will become closed status. The length of a Blank Area is calculated by the Clearance.

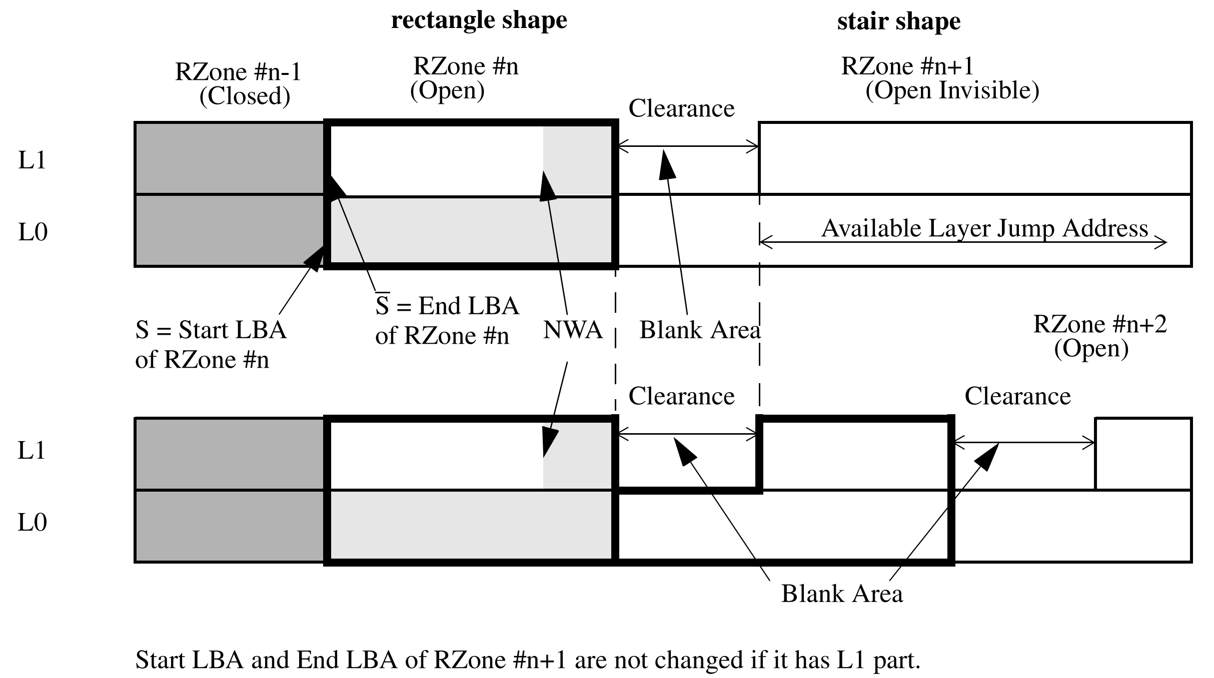


Figure 73 - Blank Areas and RZone shape

As a result, two Blank Areas that are not recordable for user data may be allocated at both sides of the Reserved RZone on L1. These Blank Areas are registered in RMD at RZone reservation and it will be padded by logical unit automatically if all RZones surrounding the Blank Area are closed. Because of the Blank Area, there are two types of Reserved RZone shape. One has a rectangle shape (e.g., RZone #n in Figure 73). The recording capacity of L0 and L1 are the same. Another has a shape like the stairs (e.g., RZone #n+1 in Figure 73). The recording capacity of L0 and L1 are different.

When previous part is Border Zone or when Incomplete RZone is closed then new Invisible RZone is made (e.g., RZone #n-1 in Figure 73), the next RZone (e.g., RZone #n in Figure 73) does not have Blank Area between previous part and the RZone. In this case, the Reserved RZone has even number of ECC blocks for free blocks. The number of free blocks on L0 part and L1 part are same.

Regardless of the recording status (recorded or not) of L0 of the previous RZone (e.g., RZone #n in Figure 73) when the previous RZone is open, the following new Reserved RZone (e.g., RZone #n+1 in Figure 73) ***shall*** have two Blank Areas that the size is Clearance on both sides if the new Reserved RZone has L1 part. In this case, the start LBA and the end LBA of RZone #n+1 ***shall not*** change. On the other hand, even if the previous RZone (e.g., RZone #n or #n+1 in Figure 73) is closed, the size of Blank Areas ***shall not*** change. These Blank Areas ***shall*** be padded by logical unit at least when the Bordered Area is closed. When a Blank Area is padded, the registration entry of the Blank Area in RMD ***shall*** be updated. Maximum eight Blank Areas can be registered in RMD.

When the size of a Reserved RZone is smaller than the Clearance size (e.g., RZone #n+1 and #n+2 in Figure 74), the Reserved RZone does not have recordable part on L1 and it exists on L0 only. This is the exceptional case of the stair-shape Reserved RZone and the Layer Jump Address of RZone #n field of Format 4 RMD Field 4 is set to the same value of the End sector number of RZone #n field. The End PSN of new Invisible RZone (#n+3) ***shall*** move to keep

Clearance from the last reserved RZone (#n+2). In case of Figure 74, Blank Area information registered in RMD starts from RZone number n+3 to RZone number n. The actual address range is from (End LBA of RZone #n+3) +17 to (RZone #n Layer Jump Address point on L1)-1.

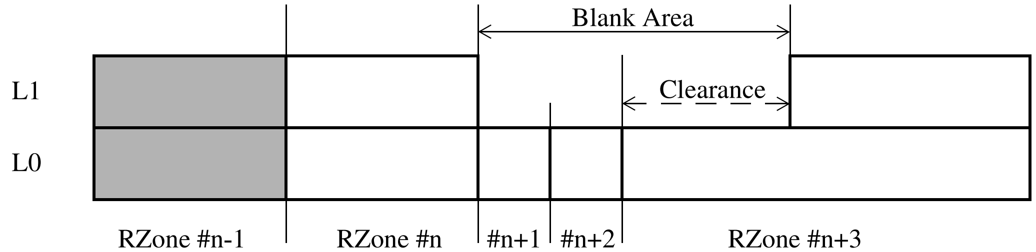
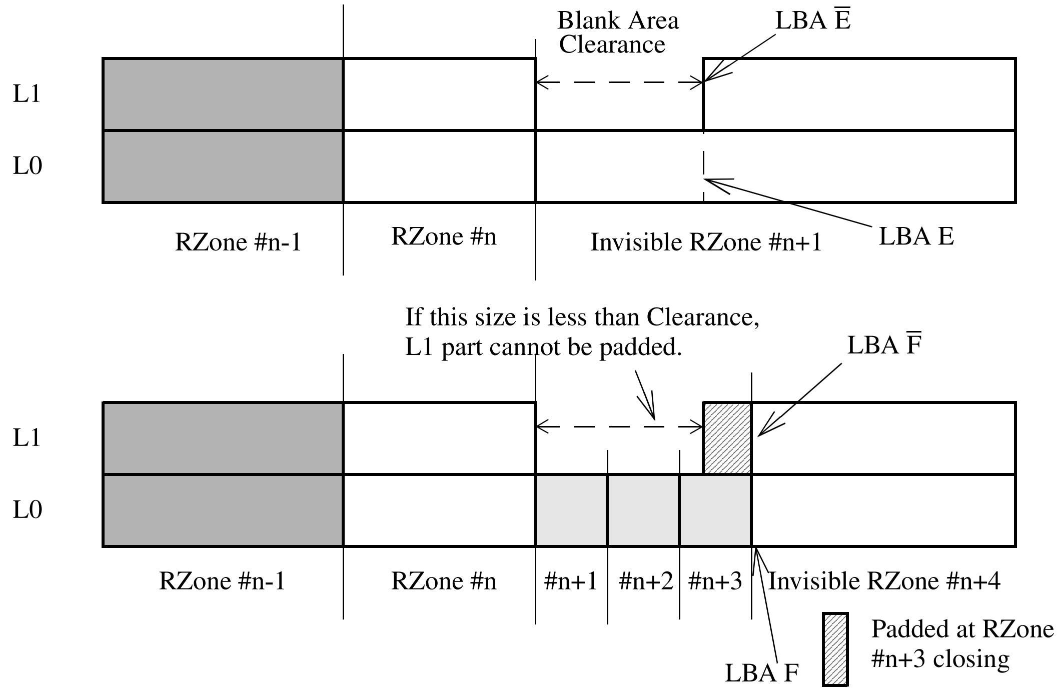


Figure 74 - Small Reserved RZone

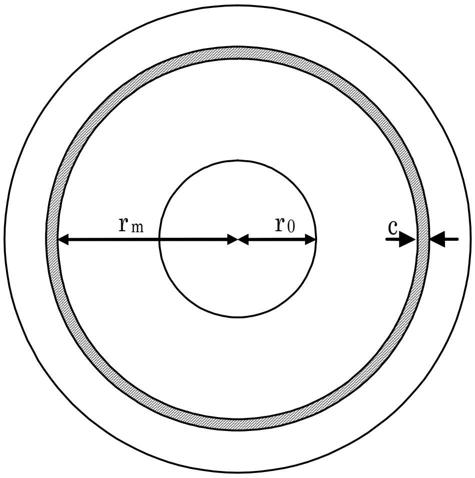
Even if the last RZone that is located just before Middle Area does not have recordable part on L1 due to Clearance, Blank Area is registered by the last RZone number.

When small part of Incomplete RZone is written and closed repeatedly (e.g., RZone #n+1 and #n+2 in Figure 75), the End LBA of new Invisible RZone does not move (e.g., RZone #n+3 in Figure 75). If NWA of the Incomplete RZone is located on L0 and larger than LBA E of Figure 75, when the Incomplete RZone (e.g., RZone #n+4 in Figure 75) is closed, the logical unit ***shall*** pad the area on L1 that is corresponding to the area on L0 between LBA E and NWA (= hatched area in Figure 75). And the End LBA of new Invisible RZone ***shall*** be set to the LBA on L1 (= LBA $\overline{\text{F}}$ in Figure 75) that is corresponding to the Start LBA of new Invisible RZone (= LBA $\overline{\text{F}}$ in Figure 75). See *4.17.8.2, "Closing of Invisible/Incomplete RZone"* on page 186.



Note: The PSN that is corresponding to LBA $\overline{E}$ is inverted address of the PSN that is corresponding to LBA E on L0.
The PSN that is corresponding to LBA $\overline{F}$ is inverted address of the PSN that is corresponding to LBA F on L0.

Figure 75 - Invisible RZone shape



Logical Block Address LBA (r_m) at the radius of r_m is calculated as the number of sectors contained within the area from the radius of r_0, where LBA0 is located, to r_m.

$$LBA(r_m) = \frac{\pi * (r_m{}^2 - r_0{}^2)}{l * p}$$

$$r_m = \sqrt{\frac{LBA(r_m) * l * p}{\pi} + r_0^2}$$

$$where \quad l : \text{sec} tor\ length,\ p : track\ \ pitch$$

Number of sectors N_m contained within the Clearance, shaded area in the right figure, from the radius of r_m to $r_m + c$ is calculated from the following formula.

$$N_m = LBA(r_m + c) - LBA(r_m)$$

$$= \frac{\pi * ((r_m + c)^2 - r_0{}^2)}{l * p} - \frac{\pi * (r_m{}^2 - r_0{}^2)}{l * p}$$

$$= \frac{\pi * c}{l * p}(2 * r_m + c)$$

$$= \frac{\pi * c}{l * p} * \left(2 * \sqrt{\frac{LBA(r_m) * l * p}{\pi} + r_0^2} + c\right)$$

Figure 76 - Formula to get the number of sectors in the Clearance at a given LBA on L0

4.17.7 Layer Jump recording on Invisible/Incomplete RZone

Layer Jump recording allows recording on both Layers alternately. There are three methods to change the recording Layer.

- RZone reservation — RESERVE TRACK/RZONE/RMZ command
- Manual Layer Jump — SEND DISC STRUCTURE command, Manual Layer Jump Address (Format Code = 23h)
- Regular Interval Layer Jump — SEND DISC STRUCTURE command, Jump Interval size (Format Code = 22h)

Only one of above three Layer Jump recording methods can be specified only when the RZone is Invisible state. To change the Layer Jump recording method of the Incomplete RZone, the RZone ***shall*** be closed and new Invisible RZone ***shall*** be created.

Only when DVD-R Dual Layer disc is empty state (Disc Status field in Disc Information Block data of READ DISC INFORMATION command is set to Empty Disc (00b)), the disc can be set to the Layer Jump recording mode by setting the Write Type field of Write Parameters Mode Page to 04h (= Layer Jump recording).

When the last RZone is Invisible RZone and neither the Manual Layer Jump Address nor Jump Interval size for Regular Interval Layer Jump recording is specified (LJRS=01b, RT=0, Blank=1, FP=0 in Track/RZone Information Block of READ TRACK/RZONE INFORMATION command), the Next Layer Jump Address field shows the Layer Jump Address caused by Fixed Middle Area or Shifted Middle Area. In this condition, one of Layer Jump methods can be specified to the RZone. Even if Manual Layer Jump Address (Format Code = 23h) or Jump Interval size (Format Code = 22h) is specified by the SEND DISC STRUCTURE command, the logical unit ***shall not*** register the address in RMD before actual data is written to the Invisible RZone.

When the LJRS is set to 11b (Regular Interval Layer Jump recording), the host should check the Jump Interval size by the READ DISC STRUCTURE command with Format Code = 22h to ensure the write performance of the recording application that requires specific data recording rate. If the Jump Interval size is not appropriate for the recording application, the host may close the Incomplete RZone to specify a new Jump Interval size.

It is recommended that logical unit should update RMD to register Layer Jump Address or Jump Interval size after a write command is issued and before user data of the write command is recorded on the disc. The SYNCHRONIZE CACHE command may cause RMD update at each time. Therefore host should set Layer Jump Address or Jump Interval size at the beginning of data writing.

Note: When the data writing is started, the Jump Interval size cannot be set and changed until the Incomplete RZone is closed.

4.17.7.1 RZone reservation

Reservation of a RZone is valid only for Invisible RZone. When a Reserved RZone is created in Layer Jump recording mode, the Reserved RZone may have one Layer Jump Address point as shown in Figure 67 - *RZone definition for Layer Jump recording* on page 168. After all part of L0 of the Reserved RZone is recorded, NWA moves to L1.

4.17.7.2 Manual Layer Jump

Manual Layer Jump method is valid only for Invisible/Incomplete RZone of Layer Jump recording mode.

The READ DISC STRUCTURE command with Format Code = 23h is used to specify the Layer Jump Address on L0 to create writing address on L1 of Invisible/Incomplete RZone.

Only one Layer Jump Address can exist on Incomplete/Invisible RZone at any given time. After the Layer Jump has happened at the specified Layer Jump Address, a new Layer Jump Address can be specified. If a host try to specify the Layer Jump Address when there is valid Layer Jump Address, the command ***shall*** be terminated with CHECK CONDITION status, 5/24/00 INVALID FIELD IN CDB.

The Layer Jump address ***shall*** be the end sector address of an ECC block (xxxxFh) on L0. The range available for the Layer Jump Address in Incomplete RZone starts from the end LBA of the ECC block that contains NWA-1 on L0 and ends at the start LBA of Middle Area-17.

When the NWA is located on L1, the available address range for the Layer Jump Address starts from the end LBA of the ECC block that contains the previous Layer Jump Address + 32. The range available for the Layer Jump Address in Invisible RZone starts from the end LBA of the ECC block that contains NWA and ends at the start LBA of Middle Area-17. However, when a Layer Jump destination address on L1 is located in a Blank Area, the corresponding address on L0 is not available as a Layer Jump Address. For example in case of Figure 74, the L0 area under the Clearance of RZone #n+3 is not available for the Layer Jump Address. When Layer Jump is not available at the specified Layer Jump Address due to Clearance, the SEND DISC STRUCTURE command with Format Code = 23h ***shall*** be terminated with CHECK CONDITION status, 5/26/00 INVALID FIELD IN PARAMETER LIST.

When the start address of the Shifted Middle Area is specified by the SEND DISC STRUCTURE command with Format Code = 21h at the lower address than the Manual Layer Jump Address specified by the SEND DISC STRUCTURE command with Format Code = 23h, the Manual Layer Jump Address becomes invalid. See *4.17.10.5, "Disc-at-Once like way"* on page 194 about the usage of the Shifted Middle Area.

When NWA reaches to the Layer Jump Address on L0, NWA moves from L0 to L1. When all recordable blocks on L1 are recorded, NWA moves from L1 to L0. NWA is discontinuous at the Layer Jump Address.

The Manual Layer Jump Address specified by a SEND DISC STRUCTURE command with Format Code = 23h is reported by the READ DISC STRUCTURE command with Format Code = 23h until the Layer Jump occurs at the specified address. The Next Layer Jump Address filed of READ TRACK/RZONE INFORMATION command ***shall*** report the same address if the Manual Layer Jump Address is the address where the next Layer Jump occurs. When no Layer Jump Address is specified by the SEND DISC STRUCTURE command with Format Code = 23h and the NWA of Invisible/Incomplete RZone is located on L0, the Next Layer Jump Address field reports Fixed or Shifted Middle Area start address -1 on L0. When Layer Jump from L0 to L1 has happened at Manual Layer Jump Address, the next Manual Layer Jump Address can be specified. And the Next Layer Jump Address field reports Layer Jump Address on L1.

Recording may be completed by repeating this Layer Jump operation. When a Layer Jump Address is specified, RMD is updated to register the Layer Jump Address when the LRA is located on L0.

Note: Too many Layer Jump operations may cause performance problem and RMA exhaustion problem.

Figure 77 is an example of Layer Jump recording.

- Initial state: No jump address is specified. The Next Layer Jump Address field = Fixed or Shifted Middle Area start address-1.
- Step 1: Jump address J1 is specified. The Next Layer Jump Address field = J1.
  The READ DISC STRUCTURE command with Format Code = 23h (Manual Layer Jump Address) reports J1.
- Step 2: Layer Jump has happened at J1. The Next Layer Jump Address field = J0.
  The READ DISC STRUCTURE command with Format Code = 23h reports zero.
  New Layer Jump Address (J2) can be specified. The J2 ***shall not*** be registered in RMD during writing L1. If J2 is specified, the READ DISC STRUCTURE command with Format Code = 23h reports J2.
- Step 3: NWA moves to L0 again after writing J0. The Next Layer Jump Address field = Fixed or Shifted Middle Area start address-1 if J2 is not specified.
- Step 4: Jump address J2 is specified. The Next Layer Jump Address field = J2.
  The READ DISC STRUCTURE command with Format Code = 23h reports J2.
- Future step: After NWA moves to L1, The Next Layer Jump Address field reports J3.
  The READ DISC STRUCTURE command with Format Code = 23h reports zero until new Layer Jump Address is specified.

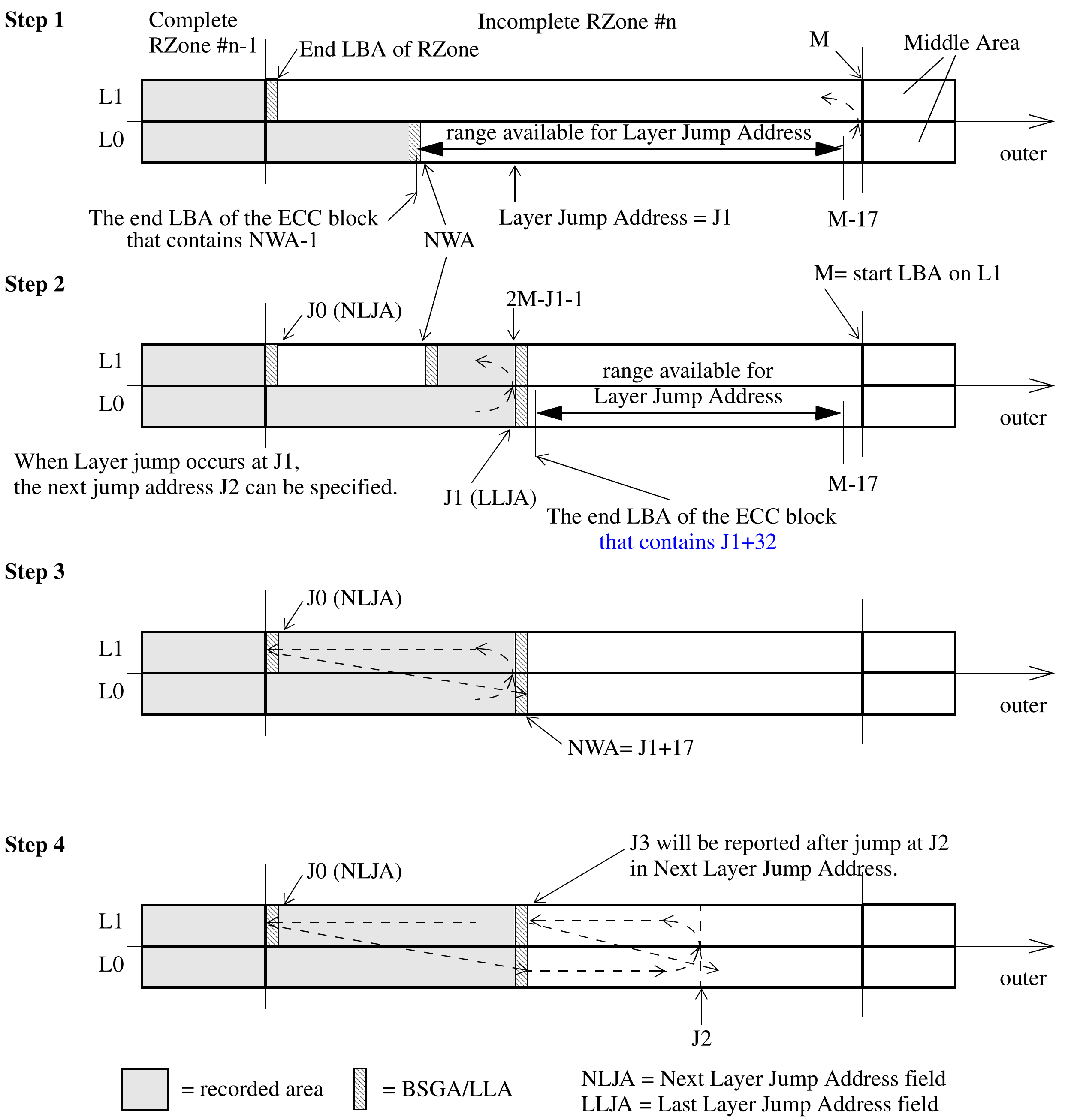


Figure 77 - Manual Layer Jump on Layer Jump recording mode

4.17.7.3 Regular Interval Layer Jump

Regular Interval Layer Jump method can be specified only when the RZone is Invisible state and no Manual Layer Jump Address is specified. When the last RZone is Invisible state, the Jump Interval size on L1 can be specified for the RZone by the SEND DISC STRUCTURE command with Format Code = 22h. The Jump Interval size does not contain Linking blocks such as BSGA. The Invisible RZone may be divided into many LJBs See *4.17.5.3,* on page 168.

When the Invisible RZone is created and if the previous RZone is open Reserved RZone, a Blank Area is allocated on L1 between the Reserved RZone and the Invisible RZone. For such an Invisible RZone, the size of the L0 part of the first LJB is bigger than the size of its L1 part because of the Blank Area as shown in Figure 78.

The Jump Interval size of Incomplete RZone is not changeable. To change the Jump Interval size or to change the Layer Jump mode between Manual Layer Jump and Regular Interval Layer Jump, the Incomplete RZone ***shall*** be closed to create new Invisible RZone. When the Incomplete RZone is closed, the Regular Interval Layer Jump mode is cleared.

In case of DVD-R Dual Layer Ver. 3.0 disc, the Jump Interval size ***shall*** be 512 ECC blocks (16 MB) or greater and 4095 ECC blocks (127.9 MB) or smaller. If non-supported size is specified by the SEND DISC STRUCTURE command with Format Code = 22h, the command ***shall*** be terminated with CHECK CONDITION status, 5/26/00 INVALID FIELD IN PARAMETER LIST. Layer Jump action needs extra time against seek time in the same Layer. Layer Jump from L1 to L0 takes the longest seek time due to OTP. The Jump Interval size should be appropriate size for the recording application if it requires specific data recording rate. Otherwise read operation (e.g., seamless playback) may be broken (e.g., pause of video or sound).

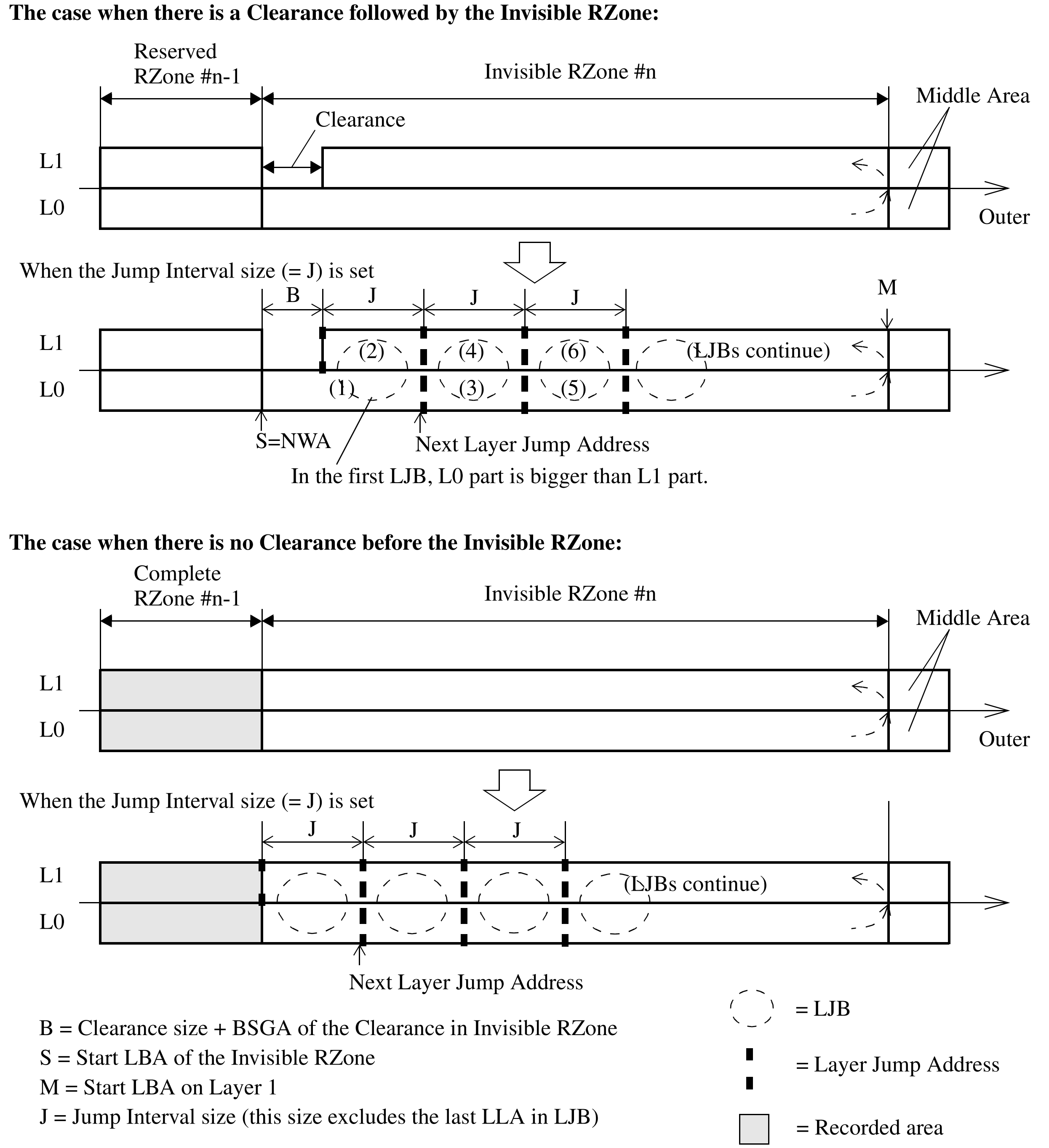


Figure 78 - Regular Interval Layer Jump

Before Jump Interval size is specified, the Next Layer Jump Address field of READ TRACK/RZONE INFORMATION command reports the end LBA of L0. After the Jump Interval size is specified, the Next Layer Jump Address field reports the first Layer Jump Address of the first LJB in the Invisible RZone. When NWA is located on L0, the Next Layer Jump Address field ***shall*** report the Layer Jump Address on L0 of the current LJB (Step 1 of Figure 79). When a Layer Jump has happened and NWA is located on L1, the Next Layer Jump Address field ***shall*** report the Layer Jump Address on L1 of the current LJB in the Incomplete RZone (Step 2 of Figure 79).

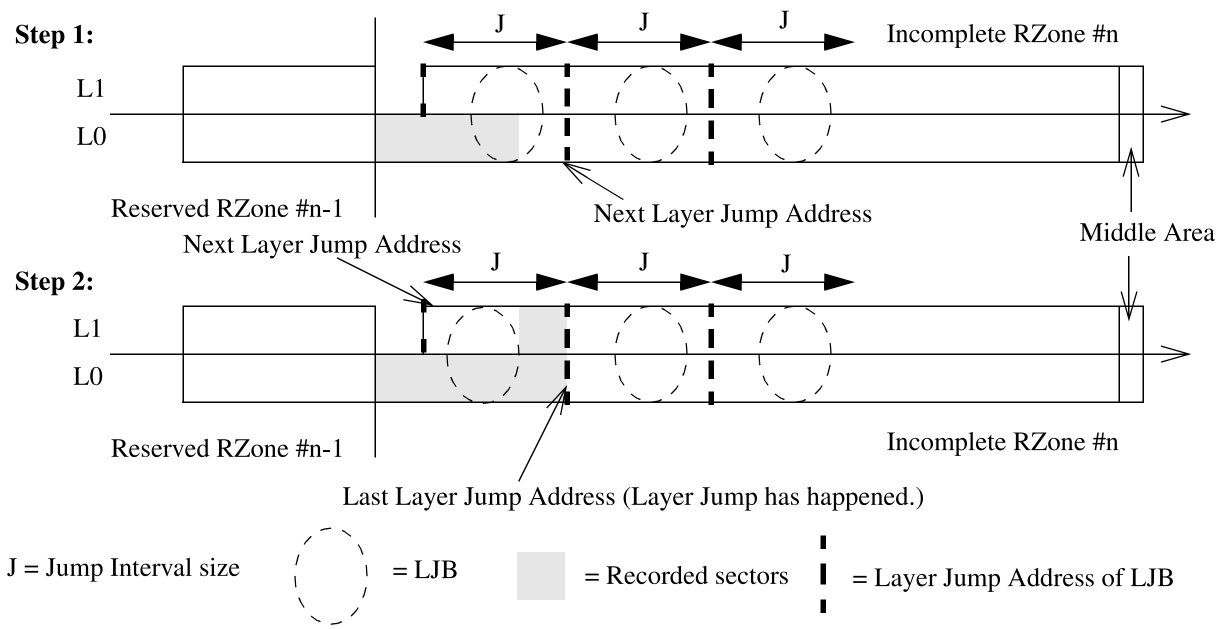


Figure 79 - Layer Jump Address report

4.17.7.4 Recordable area allocation of Regular Interval Layer Jump recording

Table 69 shows the start logical block address and the end logical block address of the each recording areas of LJBs in Figure 78 when 32KB Linking Loss Area is used. This formula may be used to locate recording data to the recordable areas.

Table 69 - LBA range of user data recordable area in each LJB of Figure 78

Recording area	Start LBA	End LBA
(1)	S[a]	S+C+J-1
(2)	M[b]*2-S-C[c]-J	M*2-S-C-1
(3)	S+C+J[d]+16	S+C+J*2+15
(4)	M*2-S-C-J*2-16	M*2-S-C-J-17
(5)	S+C+J*2+32	S+C+J*3+31
(6)	M*2-S-C-J*3-32	M*2-S-C-J*2-33
:	:	:
(odd number area)[e]	S+C+(J+16)*(n[f]-1)	S+C+(J+16)*n-17
(even number area)[g]	M*2-S-C-(J+16)*p[h]+16	M*2-S-C-(J+16)*(p-1)-1

a. S: start logical block address of the Invisible/Incomplete RZone
b. M: start logical block address of the L1
c. B: number of sectors of Clearance + BSGA of the Clearance located in the end of the Invisible RZone on L1. (C=2M-S-1-End LBA of Invisible RZone)
d. J: number of sectors of Jump Interval
e. formula for the recording area with odd number shows the start/end LBA of recordable area in a LJB on L0. The first LJB is not described by this formula.
f. n is integer number larger than or equal to 2. When n=2, the corresponding recording area is (3), and when n=3, the corresponding recording area is (5) and so on.

g. formula for the recording area with even number shows the start/end LBA of recordable area in a LJB on L1.
h. p is integer number larger than or equal to 1.When p=1, the corresponding recording area is (2), and when p=2, the corresponding recording area is (4) and so on.

4.17.7.5 LRA of RZone and Closing of Bordered Area

LRA of Incomplete RZone indicates the latest recorded user data address to identify NWA of the RZone. Therefore the LRA may not be the maximum recorded user data address of the Incomplete RZone during Layer Jump recording is performed in the Incomplete RZone. The Maximum recorded address of the Data Area field of Table 31 - *Data Area Allocation field in R/RW-Physical format information Block* on page 90 ***shall*** contain the maximum recorded address of user data that may not be same as the LRA of the RZone that has the maximum recorded address. Therefore logical unit ***shall*** check the last ECC block of the Bordered Area to distinguish padding sectors in the ECC block (e.g., Figure 86 - *padding by SYNCHRONIZE CACHE command* on page 189).

If there is no user data sector in the last ECC block of the Bordered Area, the RZone that contain the last ECC block of the Bordered Area is closed by the CLOSE TRACK/RZONE/SESSION/BORDER command. To distinguish whether the LRA is the maximum recorded user data address of the RZone, a host should check the Data Type bit of last two ECC blocks. When the Data Type bit is set to one in the ECC blocks, the LRA is not the maximum recorded user data address and if the Data Type bit is set to zero, the LRA is the maximum recorded user data address.

4.17.7.6 NWA motion at Layer Jump

At Layer Jump Address, NWA moves from a Layer to the other Layer. Therefore NWA changes discontinuously except at the end LBA on L0. Host ***shall*** maintain NWA at Layer Jump Address to issue WRITE command. When single WRITE command exceeded Layer Jump Address other than the end LBA on L0, the WRITE command ***shall*** be terminated with CHECK CONDITION status, 5/21/03 INVALID WRITE CROSSING LAYER JUMP.

When logical unit begins recording on the other Layer including Layer change at Middle Area, the logical unit may suspend the following write command by CHECK CONDITION status, 2/04/08 LOGICAL UNIT NOT READY, LONG WRITE IN PROGRESS. It is because that logical unit may perform OPC for the new Layer. Some logical unit may not support multiple of writing address to store in buffer except Layer Jump Address. See Figure 80.

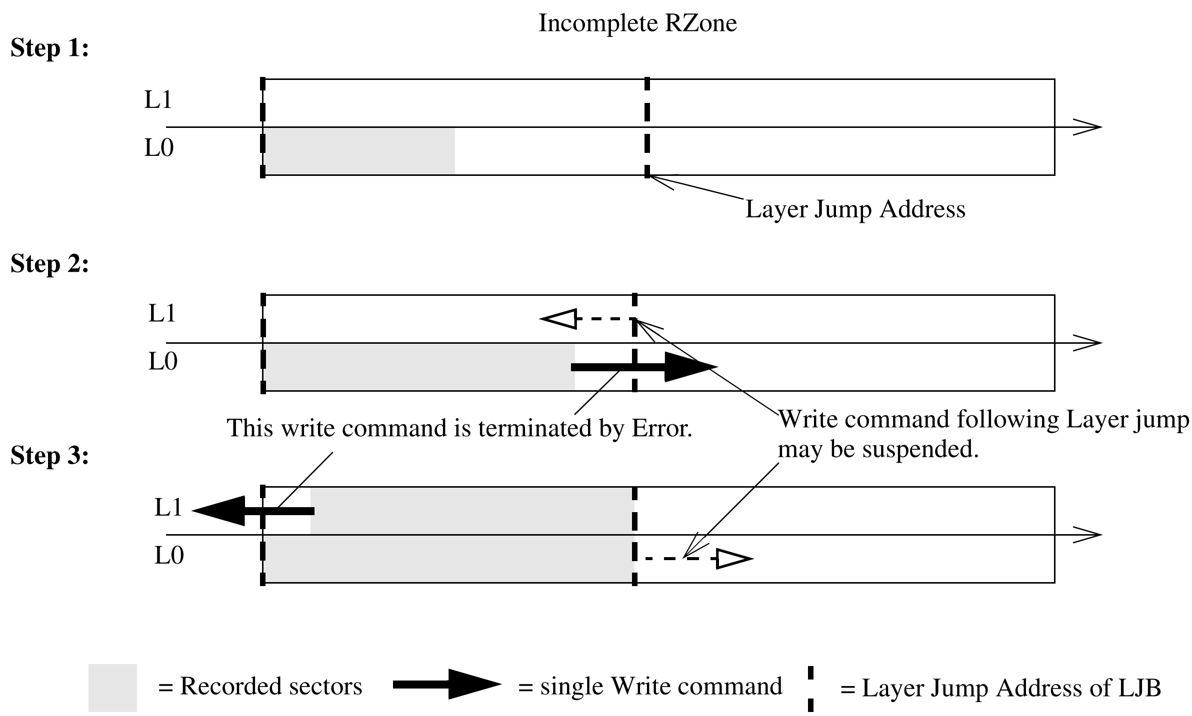


Figure 80 - NWA motion on Layer Jump

4.17.7.7 Layer Jump Address and BSGA/Linking Loss Area

In Incremental recording or DAO recording mode, when recording of L0 is finished, the next recording starts from the outermost data recordable area on L1. In this case, the 32 KB Linking Loss Area is generated at the beginning of Middle Area on L0 and the BSGA ***shall*** be recorded at the end of the Middle Area on L1 prior to start writing the user data on L1.

During performing of Layer Jump recording in incomplete RZone, the BSGA and Linking Loss Area ***shall*** be recorded and generated at the Layer Jump Address with the same manner. See Figure 81.

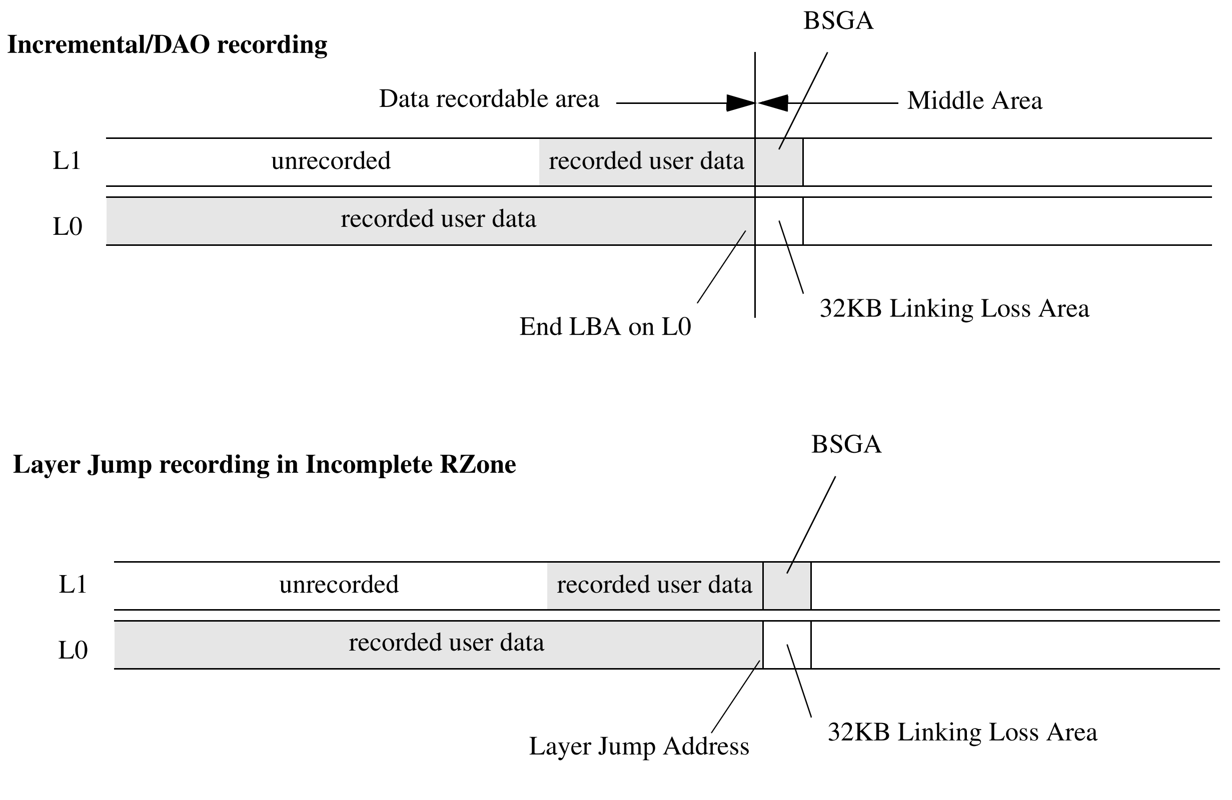


Figure 81 - BSGA and Linking Loss Area at Layer Jump Address

4.17.8 RZone Closing

When RZone is closed in Layer Jump recording mode, the complete RZone is represented by four parameters like an Reserved RZone as shown in Figure 67.

4.17.8.1 Closing of Reserved RZone

Unrecorded blocks of an RZone ***shall*** be padded by the logical unit when the RZone is closed. The Blank Area between Complete RZone and the RZone to be closed may be padded during the RZone closing operation (e.g., Blank Area #1 in Figure 82). The Blank Area that is adjacent to a non-Complete RZone ***shall not*** be padded (e.g., Blank Area #2 in Figure 82).

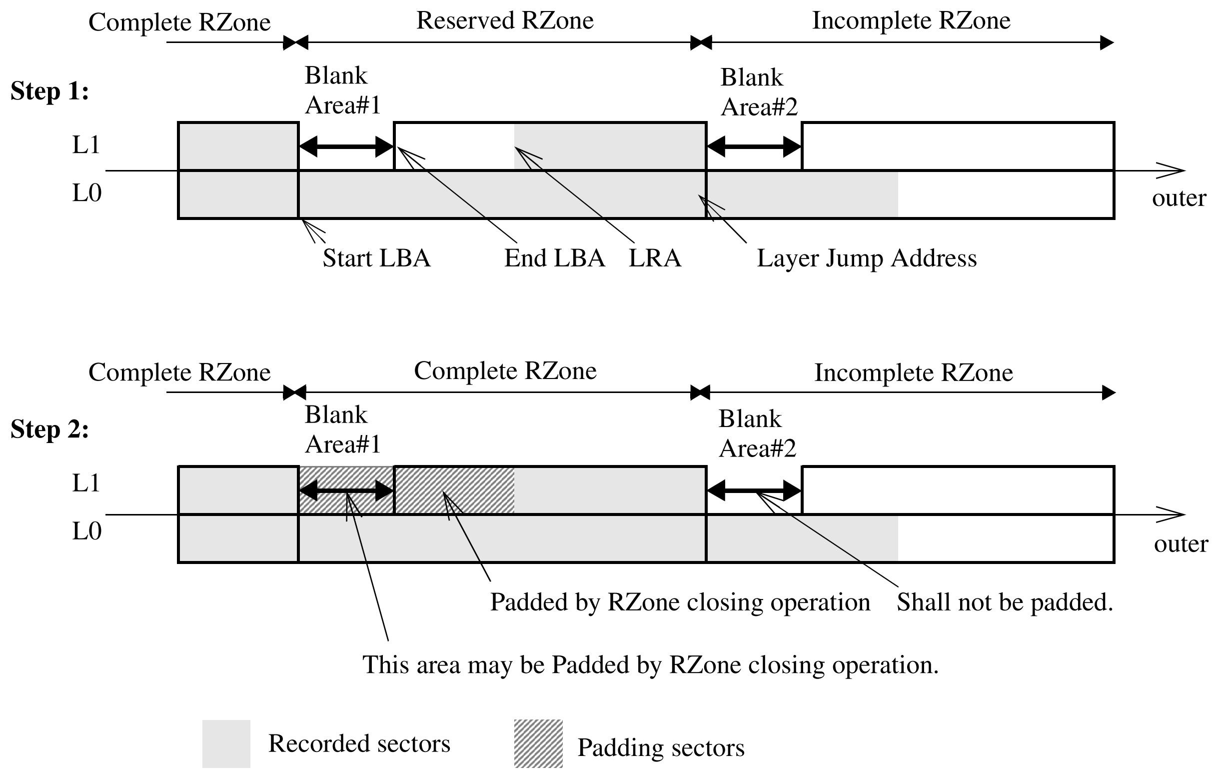


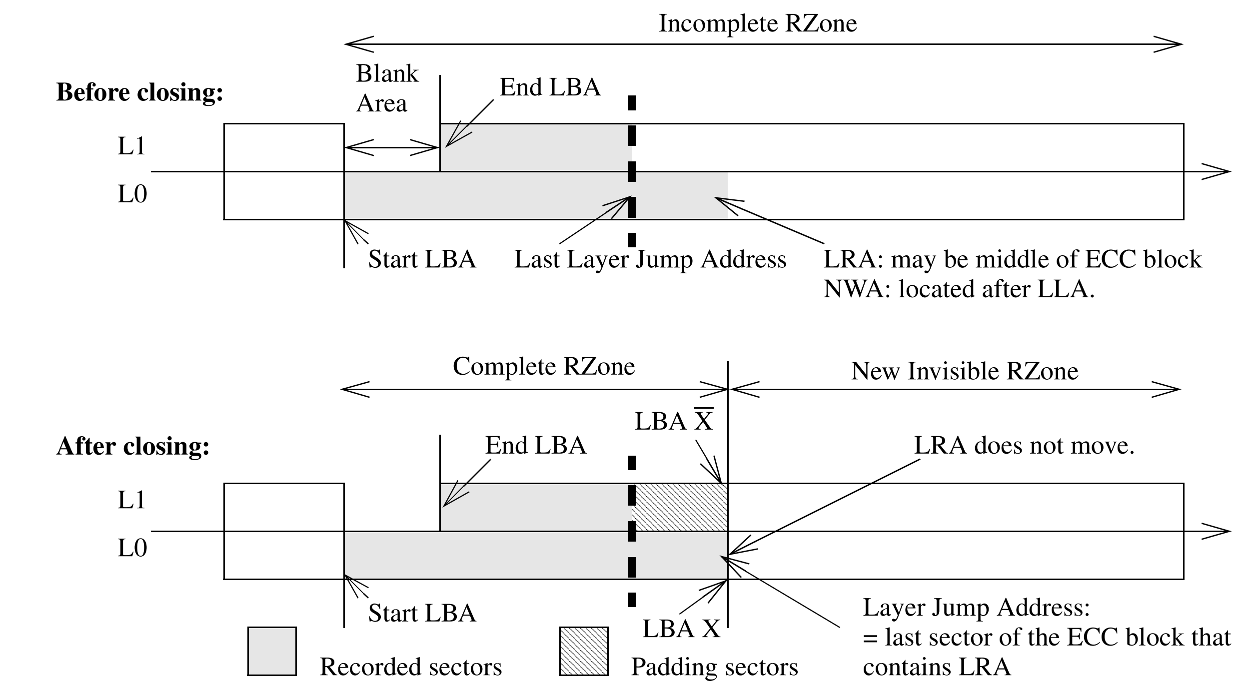
Figure 82 - Reserved RZone closing

4.17.8.2 Closing of Invisible/Incomplete RZone

When an Invisible RZone is closed, actually no action is performed. When the disc or the Border is closed, the Shifted Middle Area or Border-out is recorded from the NWA of the Invisible RZone.

When Incomplete RZone of Manual Layer Jump or Regular Interval Layer Jump is closed, Complete RZone and Invisible RZone are created. The LRA of new Complete RZone is the same address of the LRA of old Incomplete RZone. LRA means logical block address of the latest recorded user data sector.

When NWA of Incomplete RZone is located on L0, new Invisible RZone is created from the NWA. The last sector of the ECC block that contains the last recorded sector on L0 becomes Layer Jump Address of the Complete RZone. The unrecorded part of L1 ***shall*** be padded. If previous RZone is Complete RZone, the Blank Area may be padded.



Note: The PSN that is corresponding to LBA $\overline{X}$ is inverted address of the PSN that is corresponding to LBA X on L0.

Figure 83 - Incomplete RZone closing when NWA is on L0

When NWA is located on L1, new Invisible RZone is created from the last Layer Jump Address + 17 on L0. The last Layer Jump Address of the Incomplete RZone becomes Layer Jump Address of the Complete RZone. The unrecorded part of L1 ***shall*** be padded. If previous RZone is Complete RZone, the Blank Area may be padded.

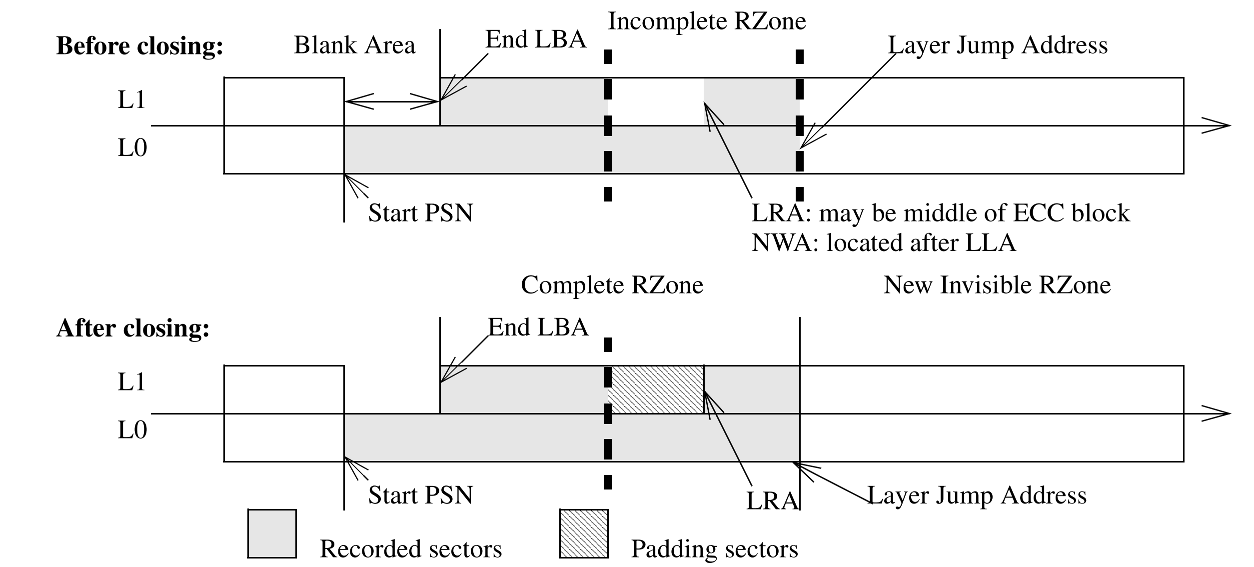


Figure 84 - Incomplete RZone closing when NWA is on L1

4.17.8.3 APs data writing for Layer Jump recording

In case of DVD-R medium, there are two parameters that show the last user data recorded address of the disc in Lead-in. One parameter is Maximum recorded address of the Data Area of Table 29 - *Structure of an R/RW-Physical format information Block* on page 89 that show actual the last user data recorded address of the disc. Another is End PSN of Data Area of Table 21 - *Data Area Allocation field definition* on page 85 that is pre-recorded in CDZ (*4.5.1, "Control Data Zone"* on page 82). A DVD read-only logical unit may read pre-recorded End PSN of Data Area to inquiry the last user data recorded address of the disc. When Maximum recorded address of the Data Area and End PSN of Data Area are different, the DVD read-only logical unit cannot retrieve data on AP4 and AP3 correctly (Figure 85).

It is recommended that host writes all blocks in the RZone that include End PSN of Data Area to write AP data at End PSN of Data Area that is pre-recorded. When End PSN of an RZone is same address of End PSN of Data Area, host should write AP data to the sector of End PSN.

Host should not use CLOSE TRACK/RZONE/SESSION/BORDER command to pad un-recorded area of the first reserved RZone (e.g., Bad disc closing of Figure 85).

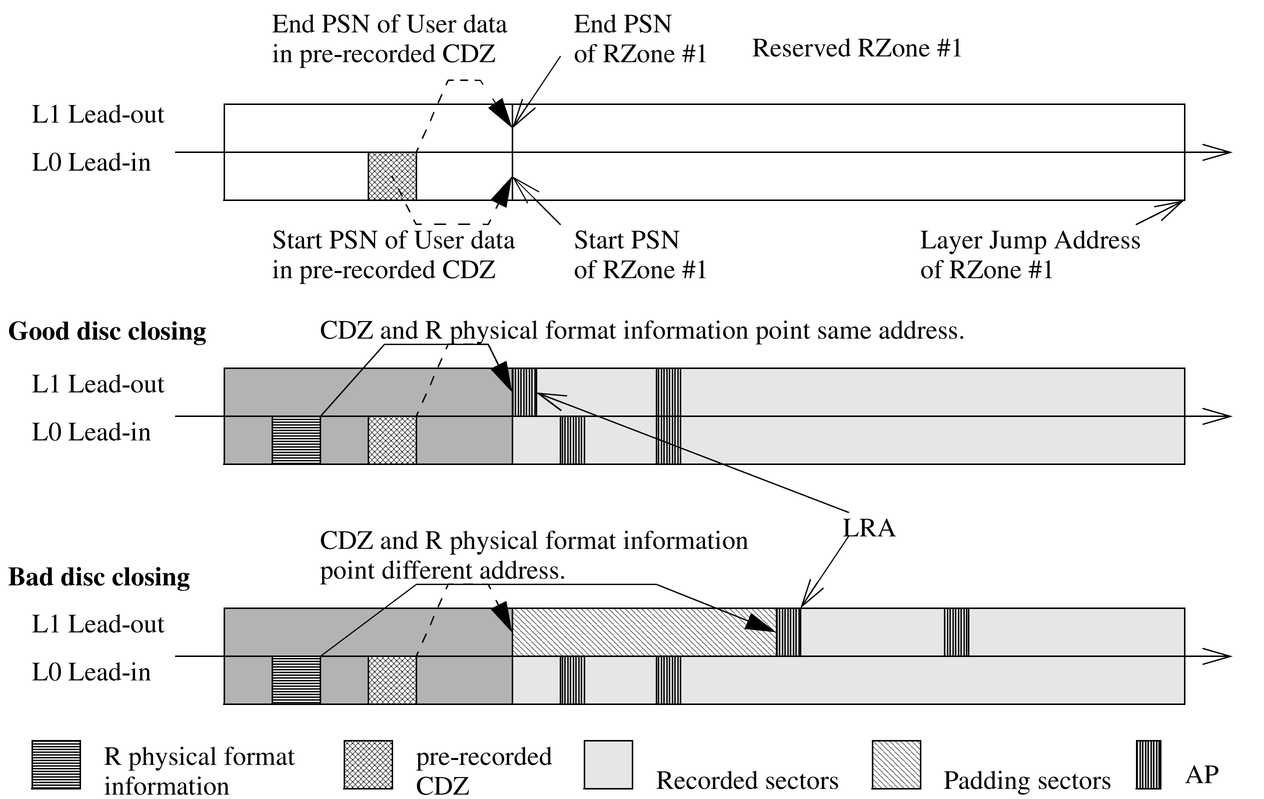


Figure 85 - Last recorded user data sector indication

Host should not pad un-recorded sectors in the last ECC block of the RZone by SYNCHRONIZE CACHE command (e.g., Figure 86).

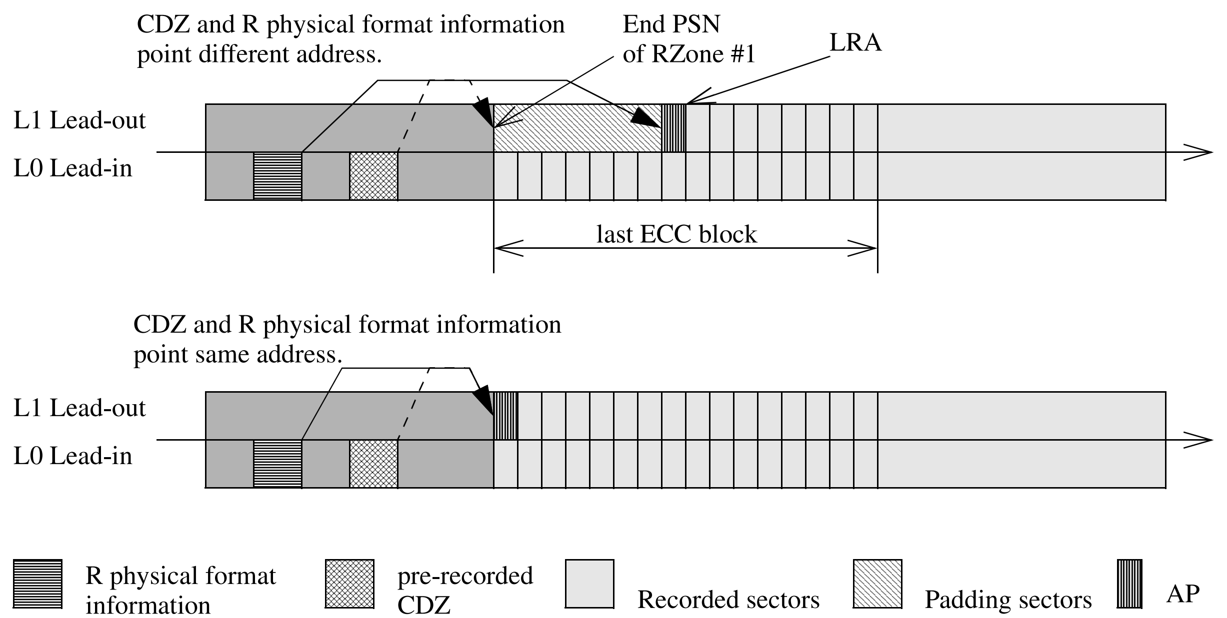


Figure 86 - padding by SYNCHRONIZE CACHE command

4.17.8.4 Maximum Recorded address check at the first Bordered Area closing

In case of Layer Jump recording, LRA of the first RZone may not mean the maximum recorded user data sector of the first Bordered Area. Logical unit ***shall*** check the actual maximum recorded user data sector of the Bordered Area to set Maximum recorded address of the Data Area field. See *4.17.7.5, "LRA of RZone and Closing of Bordered Area"* on page 183.

4.17.9 Border Zone for DVD-R Dual Layer media

For DVD-R Dual Layer media, the Border Zone is defined only for Layer Jump recording with Format 4 RMD. The purpose of the Border Zone is to prevent pick-up overrun of DVD read-only logical unit and is to provide read compatibility as well as Single Layer disc. Data is appendable by multi-Border recording after DVD-R Dual Layer disc becomes readable by DVD read-only logical unit.

The Border Zone structure for DVD-R Dual Layer disc is shown in Figure 87 below.

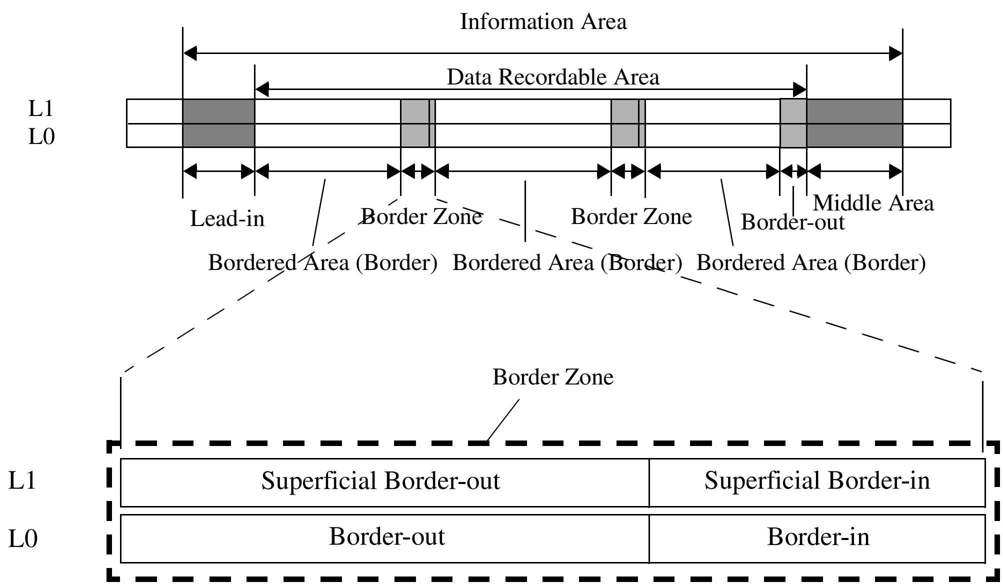


Figure 87 - Border Zone structure for DVD-R Dual Layer media

The Border-out and Border-in structure on L0 is same as that of single Layer disc. For DVD-R Dual Layer disc, there are same amount of buffer zone on L1 called Superficial Border-out and Superficial Border-in. They are used to store the back-up copies of remapped data at Border closing. The detail structure of Border Zone is depicted in Figure 88.

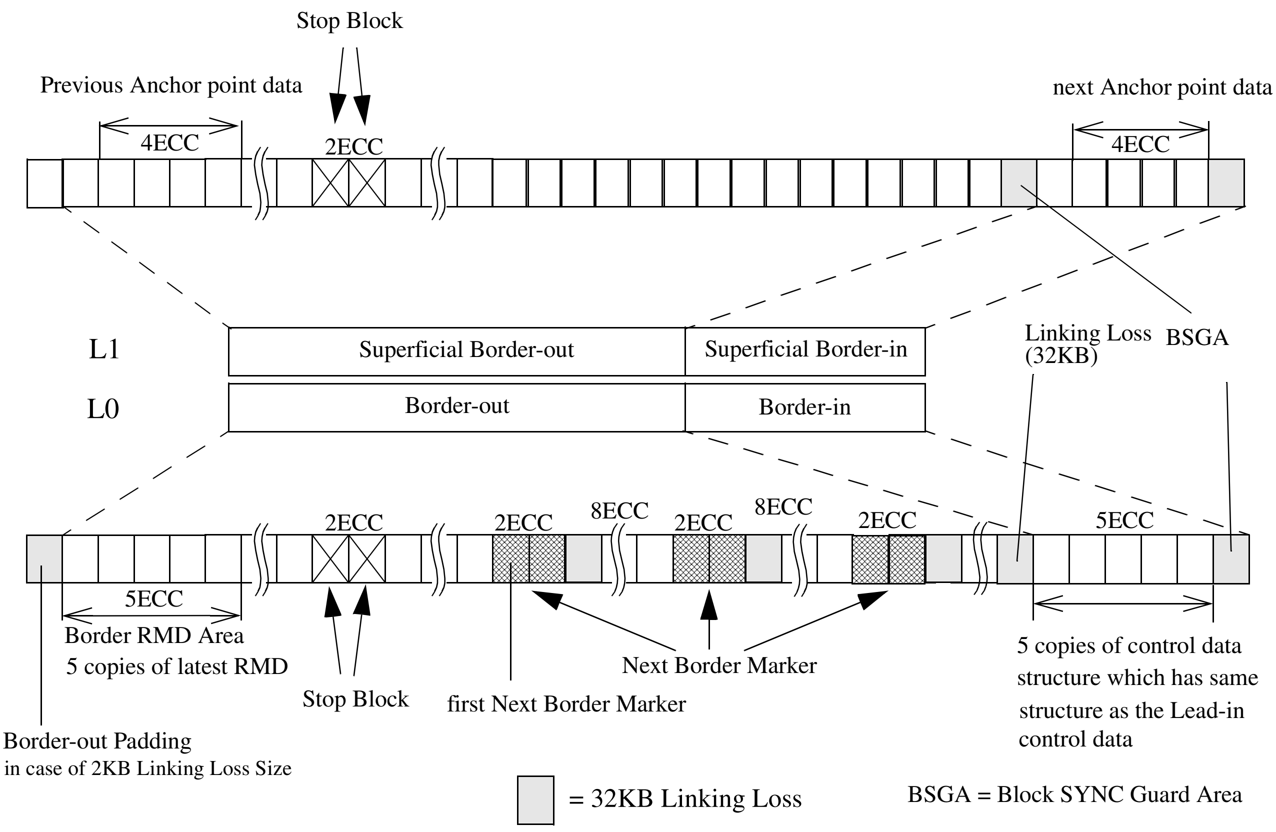


Figure 88 - Detail structure of Border Zone for DVD-R Dual Layer disc

4.17.9.1 Border Zone size and length

Border Zone size is dependent on its starting address. See Table 70. The Border-out start address ***shall*** be located after PSN 3FEFFh. The logical unit ***shall*** pad with 00h data through PSN 3FEFFh when Bordered Area is closed and user data is recorded less than LBA 0FEFFh (Size ***shall*** be 0.554 mm in radial direction).

Table 70 - Border Zone size for DVD-R Dual Layer Ver.3.0 media

Physical sector number of beginning Border Zone	**3FF00h-B25FFh**	**B2600h-1656FFh**	**165700h-**
Border Zone size	1844 ECC blocks 115.3 MBytes[a]	2442 ECC blocks 152.6 MBytes	2972 ECC blocks 185.8 MBytes

a. MByte = 1024 × 1024 bytes

In the case of DVD-R Dual Layer Ver. 3.0, the Border Zone width of the second Border Zone and later are almost same size with the first Border Zone in the radial direction. In future version of DVD-R Dual Layer format, the second and later Border Zone size can be changed to be smaller than the first Border Zone size. It is recommended to design logical unit that can correspond to the size change in the future. The first Next Border Marker address is calculated from Border-out start address and Next Border-in start address. The Next Border-in start address of Empty / Incomplete Bordered Area is calculated from the Start PSN of the first RZone in the Bordered Area.

4.17.9.2 Reduced Border-out

In Layer Jump recording mode, when the remaining user data capacity is not sufficient to record Border-out, the Border-out is recorded with different manner. When the remaining area is less than the Border-out size, the Border-out size is shrank to fit the remaining data recordable area and a part of Border-out (7 ECC blocks) is recorded at innermost Middle Area with Middle Area attribute. This assures the linear logical volume space to the host.

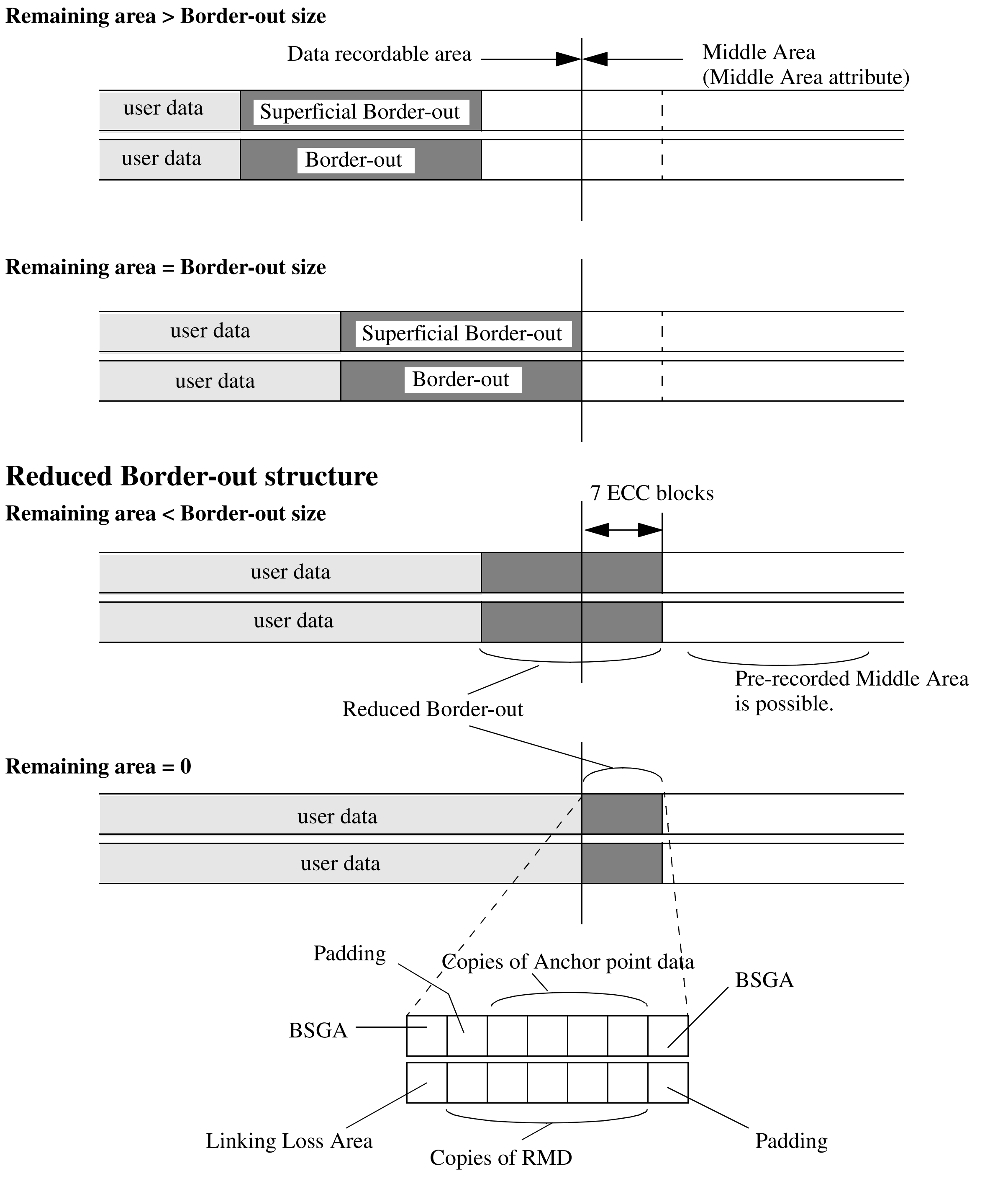


Figure 89 - Reduced Border-out

4.17.10 Remapping recording example

There are two remapping mechanisms defined for DVD-R Dual Layer media. One is the RMD remapping that is referred by DVD-R Dual Layer logical unit. The other is the Border Zone remapping that is referred by DVD read-only logical unit. When the Border is closed, the DVD-R Dual Layer logical unit automatically creates the Border Zone remapping from the RMD remapping information.

A host can remap up to four user data locations called Anchor points. The remappable address is specified by DVD-R Dual Layer Book as shown in Table 71. The remapping is done in ECC block unit. Therefore ECC blocks that contain Anchor points are remapped and the start sector number of these remapped ECC blocks are registered in Format 4 RMD Field 3.

DVD-R Dual Layer logical unit performs remapping data at reading ECC blocks that contain APs according to Format 4 RMD. When the Border is closed, the remapping information is stored in updated Physical format information and replacement data is stored in Superficial Border-in/out. Therefore DVD read-only logical units can also utilize the remapping mechanism to retrieve correct file system information.

The Maximum Last Recorded Address on L1 should be the same address with End PSN of Data Area in pre-recorded CDZ (*4.5.1, "Control Data Zone"* on page 82). Otherwise legacy DVD read-only logical unit cannot retrieve data on AP3 and AP4 in the first Bordered Area. See *4.17.8.3, "APs data writing for Layer Jump recording"* on page 188. See *4.17.5, "Recording unit of Layer Jump recording"* on page 167 for RZone structure.

Table 71 - Anchor points (Remappable locations)

Anchor point	Location
AP1	PSN 30010h (LBA16)
AP2	PSN 30100h (LBA256)
AP3	Maximum Last Recorded Address - 256 on L1
AP4	Maximum Last Recorded Address on L1

Typical operation sequence of remapping is explained as follows.

- Write ECC block of an AP.
- Write alternative ECC block for updated data of the AP.
- Issue SYNCHRONIZE CACHE command to ensure to be written on the disc.
- Remap the AP by Remapping Address (Format Code = 24h) of SEND DISC STRUCTURE command to the alternative ECC block
- Close the Border by CLOSE TRACK/RZONE/SESSION/BORDER command.

4.17.10.1 AP remap operation

To remap an AP, the ECC block of the AP and its alternative ECC block ***shall*** be recorded. The Maximum Last Recorded Address of user data in the disc ***shall*** be the address on L1. The Write Type field of Write Parameters Mode Page ***shall*** be set to Layer Jump recording. See Table 64 - *Profile, Feature and Write Type value for each recording mode* on page 161.

Before closing the first Bordered Area, position of AP3 and AP4 need to be considered. When a RZone is reserved and unrecorded part exists on L1, the Maximum Last Recorded Address may be changed after the previous reserved RZone is recorded. Once the first Border is closed, the position of AP3, AP4 is fixed and is not changeable.

To remap the Anchor points, the SEND DISC STRUCTURE command with Format Code = 24h is used. Host needs to perform read-modify-write because the other sectors in the ECC block of an AP may have its own data. Host reads the original 16 sectors from an ECC block of AP (may be may not be remapped), updates some parts, and then writes the data to an alternative ECC block on an NWA. If multiple of APs need to be updated, host performs this operation up to 4 times. Then host issues SEND DISC STRUCTURE command with Format Code = 24h to remap the ECC block of the AP to the alternative ECC block up to 4 times. Logical unit may not write user data and remapping information on the disc with above operation immediately to reduce RMD consumption. It is recommended that host issues SYNCHRONIZE CACHE command to finish all data recording.

After the remapping operation, when a host requests to read an sector in the ECC block of an AP, updated data from the alternative ECC block is returned to the host automatically. See *4.17.10.8, "Read behavior of logical unit for remapped ECC block"* on page 197. Once a remapping is specified to an AP, the remapping that is done by RMD cannot be cleared. It is because that to change the used AP to the other AP (e.g., AP4 to AP3), old data on the AP that becomes unused ***shall*** be updated correctly. For example AP4 has AVDP. When using AP4 is stopped, and when AP3 is newly used, AP4 ***shall*** be updated to non AVDP data and AP3 ***shall*** have new AVDP by remapping.

4.17.10.2 Canceling of AP3, AP4 remapping by RMD in the first Bordered Area

When the alternative ECC block address of an AP#n remapping (e.g., the Re-mapping block sector number for AP1 field) points to the ECC block of the AP#n itself in the first Bordered Area, the RMD remapping ***shall not*** be succeeded to the superficial Extra Border-in and the first superficial Border-out. The corresponding Re-mapping data Block Valid Flag (RBVF) in Table 32 - *DVD-R for General Ver.2.1 unique part of R-Physical format information* on page 90 ***shall not*** be set to 1.

For example, if RZone#1 is reserved and L1 part is not recorded, then the Maximum Last Recorded Address on L1 is the L1 maximum recorded address of the Incomplete RZone that is RZone#2. During Layer Jump recording in RZone#2, AP4 remapping is performed on the Maximum Last Recorded Address on L1 of RZone#2. To close the Bordered Area, AP4 data are copied to the end address of the RZone#1. Then Maximum Last Recorded Address on L1 moves to the end address of the RZone#1. The alternative address of AP4 is set to the address AP4 itself, then the AP4 remapping is canceled.

4.17.10.3 Termination of remapping recording

To show the termination of some recording that uses remapping, one of the alternative ECC block address should be the ECC block address that contain LRA of the Incomplete RZone or LRA of the last RZone (other than Invisible RZone). This means that the sector on LRA of the last RZone should contain some file system data to be written on an AP. The host can retrieve the alternative ECC block address by READ DISC STRUCTURE command with Format Code = 24h. Otherwise Border should be closed.

4.17.10.4 Multi-Border recording with remapping

When CLOSE TRACK/RZONE/SESSION/BORDER command is issued to close the Border, the replacement data on a ECC block of an AP are copied to both Superficial Border-out and Superficial Border-in. If a ECC block of an AP is remapped, the corresponding RBVF ***shall*** be set to 1 except when the remapping is canceled in the first Bordered Area. See 4.17.10.2. A DVD read-only logical units can utilize these information to return correct replacement data in the ECC block of the AP to the host.

There are three typical recording ways that are Disc-at-Once like way, Session-at-Once like way. and flexible packet recording like way. Session-at-Once like way and flexible packet recording like way use remapping. The Session-at-Once like recording may be used for data writing of DVD recording application. Variable packet like recording may be used for PC data writing.

4.17.10.5 Disc-at-Once like way

When multi-Border recording is not necessary and total data size to be recorded is known, Shifted Middle Area is useful. A host creates a complete data image on the large buffer (e.g., HDD) then writes the image on DVD-R disc. Shifted Middle Area is set to appropriate position for the recording data size by the SEND DISC STRUCTURE command with Format Code = 21h. The address ***shall*** be the start sector address of an ECC block (xxxx0h). The available start address range is from NWA on L0 (for 32K Link size, NWA-2 for 2K Link size) to end address of L0 -15. When NWA is on L1, the available start address range starts from the first writable address of L0 part after Layer Jump happens at Next Layer Jump Address on L1. When Layer Jump is not available at the specified start address due to Clearance, the SEND DISC STRUCTURE command with Format Code = 21h ***shall*** be terminated with CHECK CONDITION status, 5/26/00 INVALID FIELD IN PARAMETER LIST. See Figure 96 - *Padding under Lead-out to create Shifted Middle Area* on page 199. All data is written to the end of the disc through the Layer Jump Address of the Shifted Middle Area. Then disc is closed by CLOSE TRACK/RZONE/SESSION/BORDER command. Even if Multisession/Border field of Write

Parameters Mode Page allows Next Border, the disc ***shall*** be closed. The logical block address is discontinuous on the boundary of Layer Jump Address of Shifted Middle Area. See Figure 90.

Once Shifted Middle Area is specified, data recording is not allowed to the outer area from Shifted Middle Area. The outer area may be used as Disc Test Area (e.g., Power Calibrations) if logical unit supports the function.

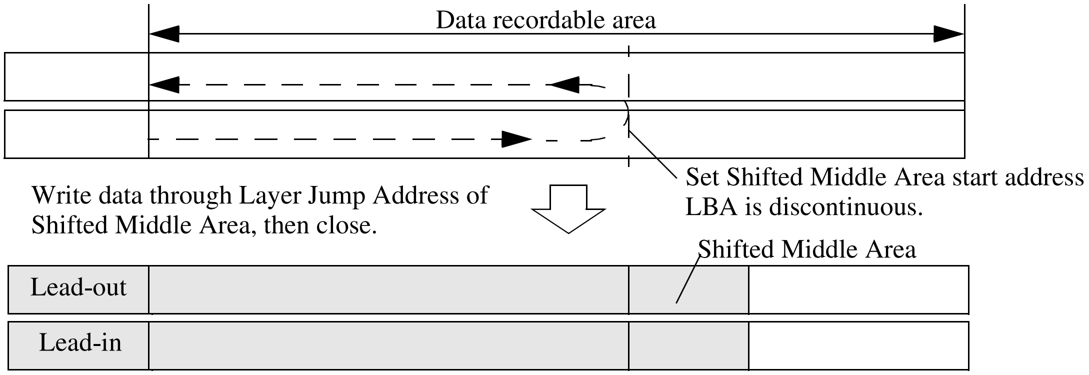
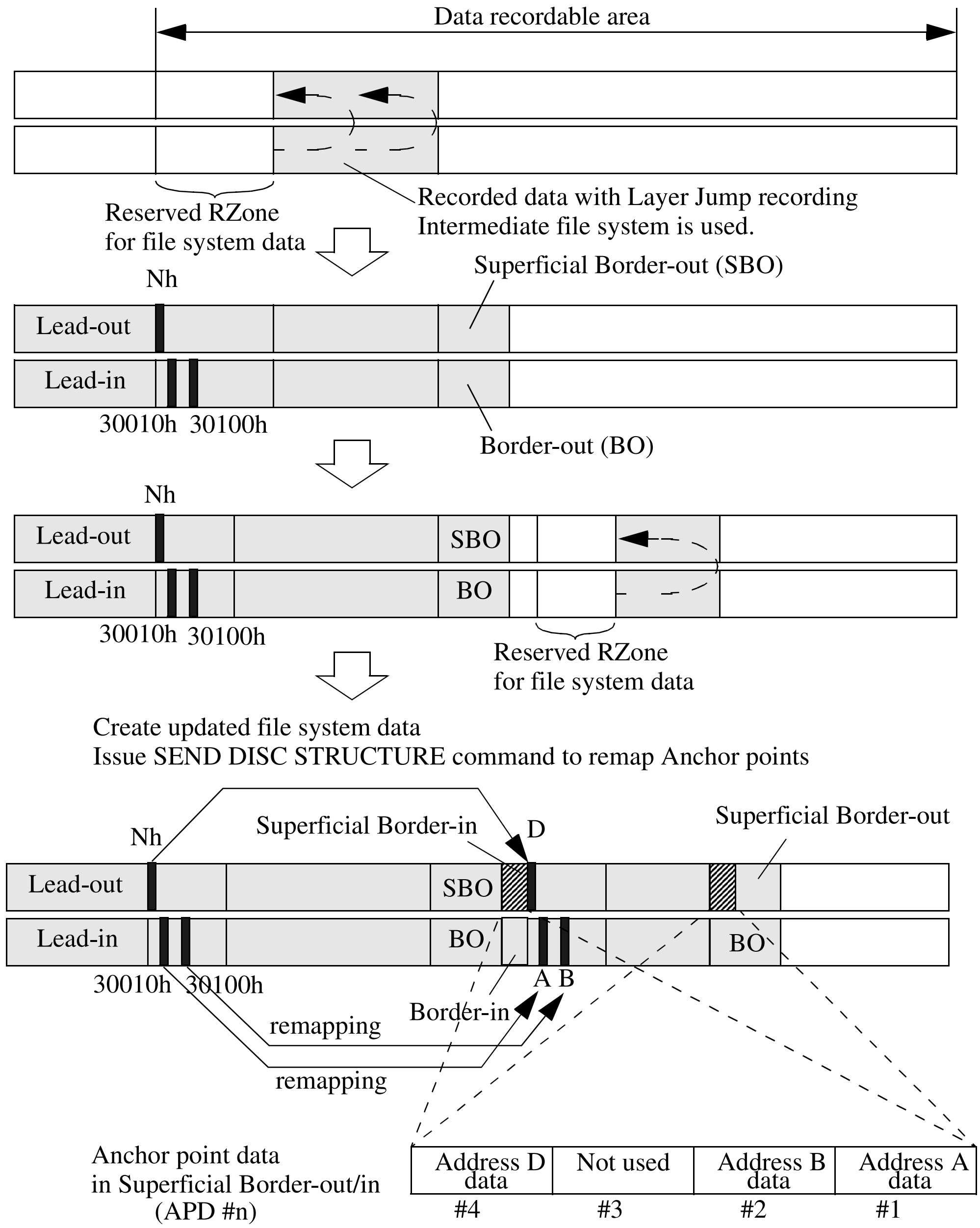


Figure 90 - Example sequence of Disc-at-once like recording

4.17.10.6 Session-at-Once like way

A host creates a complete data image of the Bordered Area on the large buffer (e.g., HDD) then writes the image on DVD-R disc. Other host may use own intermediate file system to write incremental data on Incomplete RZone of the DVD-R disc. Then the host creates interchangeable File System information from intermediate file system and writes it to the Reserved RZone. Host closes the Bordered Area to make the disc readable by DVD read-only logical unit. To record the second and later Bordered Areas, host repeats same manner, but remaps the APs to new places in the new Bordered Area.

In this case, remapping in the first Bordered Area is not necessary. For DVD recording application format (DVD-VR, AR and SR), remapping by the RBVF in the first Bordered Area is prohibited to keep compatibility of the reading data in the first Bordered Area by legacy DVD read-only logical unit that does not support reading multi-border of DVD-R Dual Layer disc. See Figure 91.



Remapping information in RMD

	original PSN	alternative PSN
Anchor point #1	30010h	A
Anchor point #2	30100h	B
Anchor point #3	N-100h	Not used
Anchor point #4	Nh	D

Figure 91 - Example sequence of multi-Border recording with remapping

4.17.10.7 Variable packet recording like way

Host writes user data, interchangeable file system data and updated AP data to Incomplete RZone. Then host remaps the AP to the alternative ECC blocks. In this case, host may not close Border to interchange the data among recordable logical units. Host may use Incomplete disc state for data interchange. In this case, 16th sector and 256th sector from the beginning of the second Bordered Area may not contain VRS and AVDP of file system.

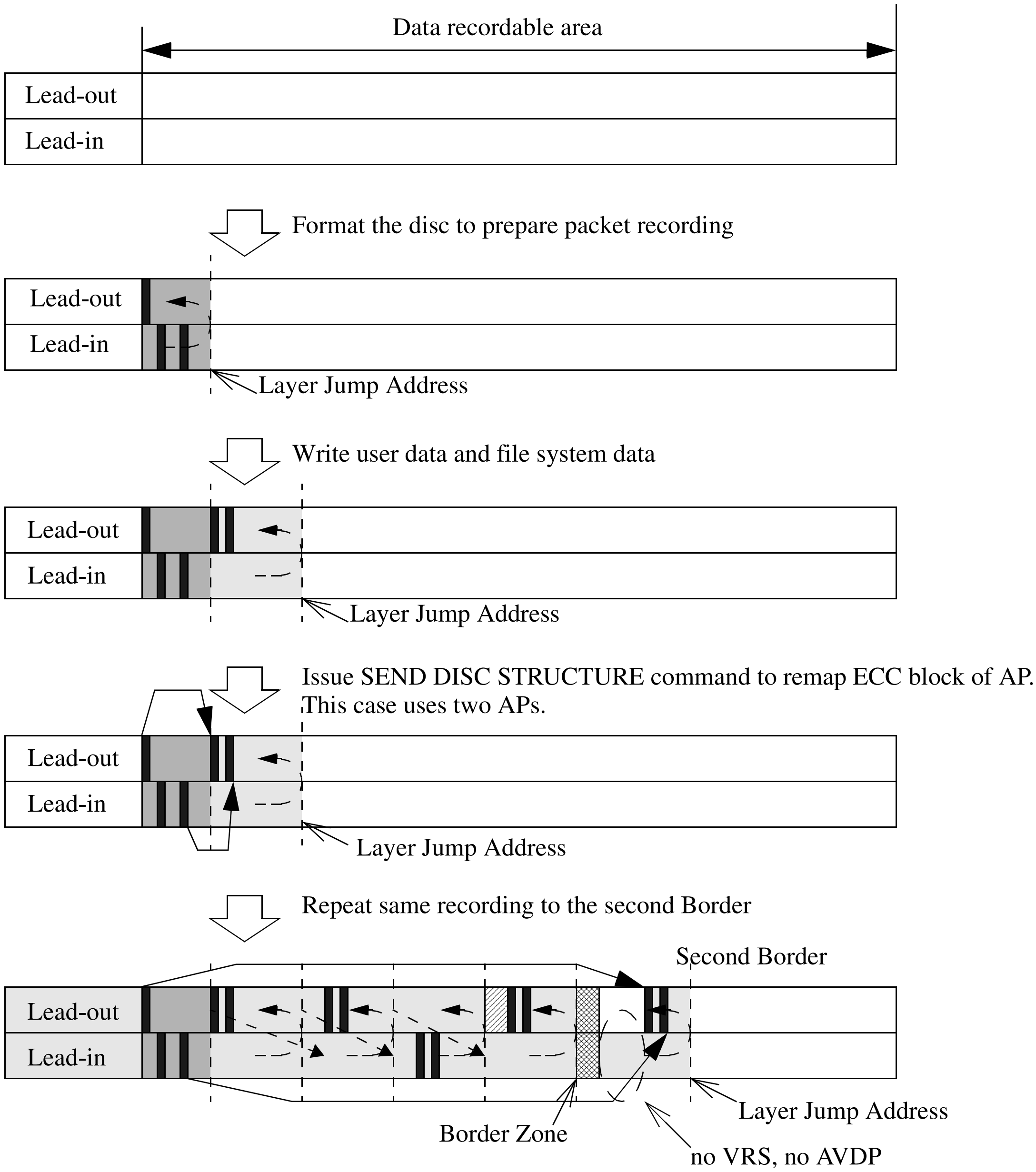


Figure 92 - Example sequence of Packet recording with remapping

4.17.10.8 Read behavior of logical unit for remapped ECC block

When a read request is issued to a sector that is located within the remapped ECC block, the drive will return the updated data in its alternative ECC block to the host. The writer logical unit that reports Feature 0033h: Layer Jump recording Feature ***shall*** return the updated data on the alternative block. Read only logical unit that support multi-border reading also ***shall*** return the updated data correctly. See Figure 93.

But it is recommended that host starts the read operation within the remapped ECC block to read updated data correctly. It is because that when a read operation does not start within the remapped ECC block and the reading has started from previous ECC block through remapped ECC block, some Read only logical unit that have poor implementation may not report the replacement data C:R:E but C:D:E as shown in Figure 93.

When a read request is issued to the alternative ECC block, the contents of the alternative block is returned to the host as it is.

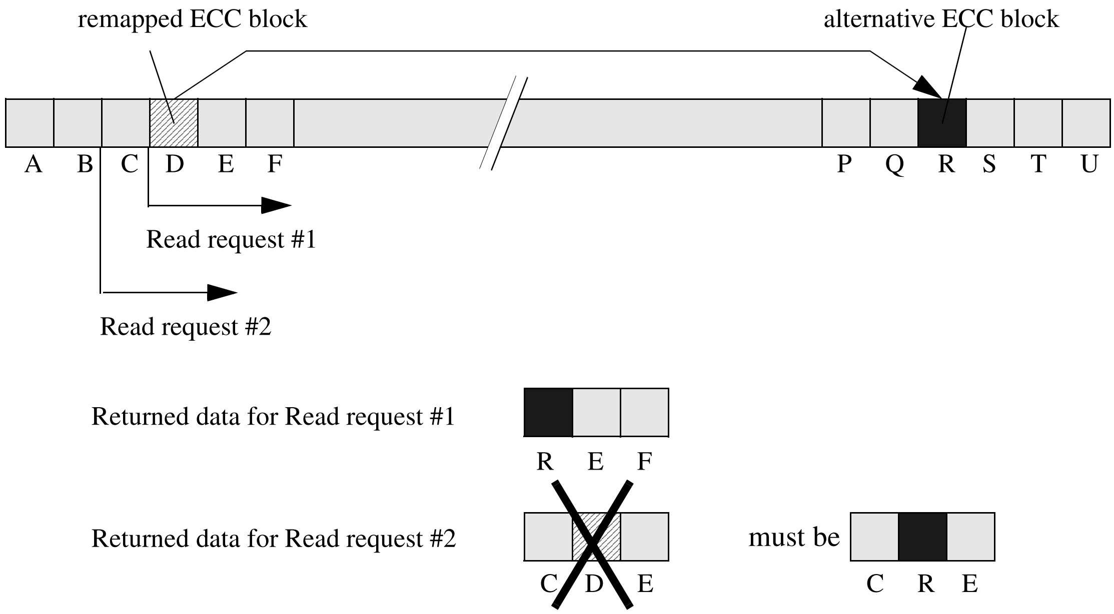


Figure 93 - Example read behavior of remapped ECC block

4.17.11 Disc final closure

In Layer Jump recording mode, when the disc is closed to prohibit further recording (= disc final closure), the Shifted Middle Area or Fixed Middle Area is recorded at the end of the user data. No additional recording is allowed beyond the Shifted Middle Area. When the Shifted Middle Area is recorded, the Information Area ***shall*** be recorded more than 70 mm in diameter. If the recorded length is less than 70mm in diameter, the logical unit ***shall*** write Shifted Middle Area up to 70 mm in diameter. See DVD-R Book Part 1.

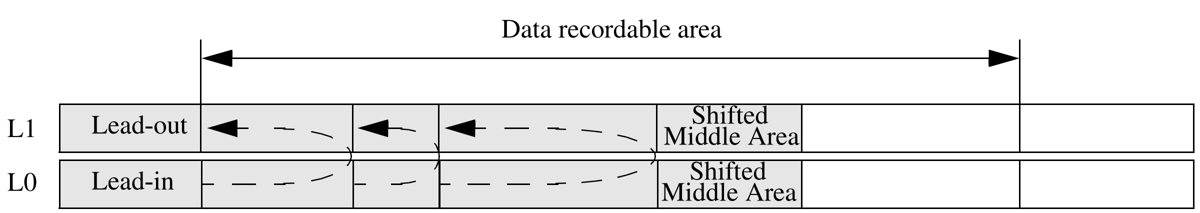


Figure 94 - Disc final closure in Layer Jump recording mode

Shifted Middle Area can be specified by the SEND DISC STRUCTURE command with Format Code = 21h. See 4.17.10.5.

In the case of Incremental recording mode, the Shifted Middle Area can be applied at disc final closure when data is recorded on L0 only. If user data is recorded on both L0 and L1 at disc final closure, the all open RZones ***shall*** be closed first and the logical unit ***shall*** pad the remaining area on L1 with Lead-out.

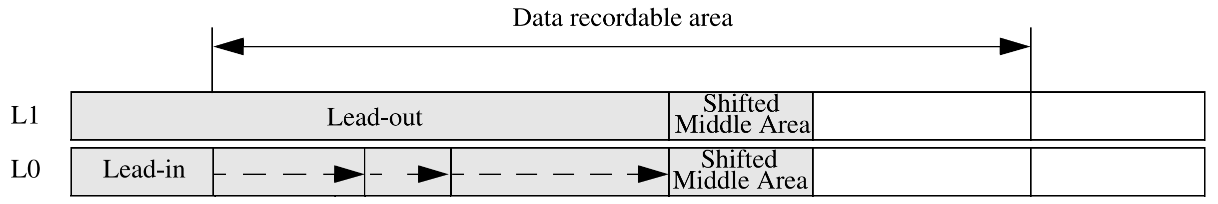


Figure 95 - Disc final closure in Incremental recording mode

4.17.11.1 Padding under Lead-out for Shifted Middle Area

As shown in Figure 72 - *Physical overview of Layers* on page 172, Lead-out is larger than the Lead-in to have the Clearance. The Shifted Middle Area cannot be created under the Lead-out. When user Data Area size is smaller than the Clearance size made by Lead-out, the logical unit ***shall*** pad remaining area to create the Shifted Middle Area. See Figure 96.

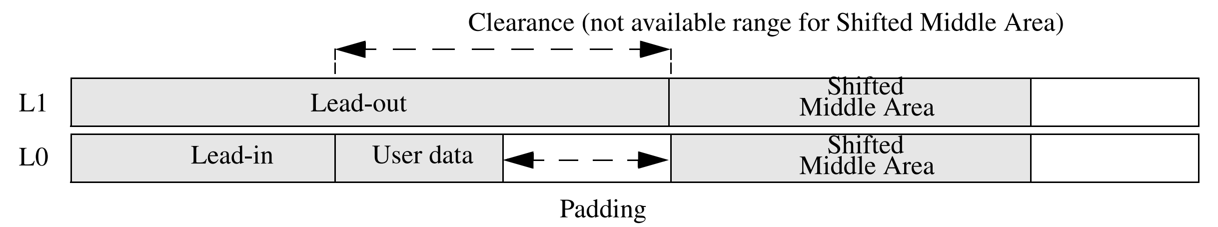


Figure 96 - Padding under Lead-out to create Shifted Middle Area

4.17.12 RMD (Recording Management Data) for DVD-R Dual Layer media

The size of RMA is expanded and RMD can be updated approximately 816 times. The RMD is sequentially recorded from the inner side of L0 and when RMA on L0 is filled up, RMD is recorded from the outer side of RMA on L1.

The RMD structure is same as that of DVD-R Single Layer media. The contents of each Field is defined in the following tables.

4.17.12.1 RMD Field 0 (RMD Header) for DVD-R Dual Layer disc

RMD Field 0 specifies general information of the disc and is structured as follows.

Table 72 - RMD - Field 0

Bit / Byte	7	6	5	4	3	2	1	0
0-1	(MSB)			RMD Format				(LSB)
2				Disc Status				
3				Reserved				
4-21	(MSB)			Unique Disc ID				(LSB)
22-85	(MSB)			Copy of Pre-pit Information				(LSB)
86-89				Start sector number of the Shifted Middle Area				
90				Pre-recorded information code				
91				Reserved				
92-95				End address of pre-recorded Lead-in Area				
96-99				End address of pre-recorded Middle Area on Layer 0				
100-103				End address of pre-recorded Middle Area on Layer 1				
104-107				Start address of pre-recorded Lead-out Area				
108-2047				Reserved				

The RMD Format field specifies the format of the following RMD Field 1 - Field 14 which is used on the medium. RMD Format field is defined in Table 73.

Table 73 - RMD Format field definition

Value	Definition
0000h	Reserved
0001h	The following RMD Field1-14 is recorded as Format 1 RMD defined for DVD-R Dual Layer disc.
0002h-0003h	Reserved for DVD-RW media
0004h	The following RMD Field1-14 is recorded as Format 4 RMD. This format code is defined only for DVD-R Dual Layer disc.
0005h-FFFFh	Reserved

The Disc Status field indicates the disc status. Disc Status field is defined in Table 74.

Table 74 - Disc Status field definition

Value	Definition
00h	The disc has no written data in Data Recordable Area (only RMD is written)
01h	The disc is in Disc-at-once recording mode
02h	The disc is in Incremental recording mode
03h	The disc is completed and not appendable in the case of Incremental recording
04h-FFh	Reserved

The Unique Disc ID field is recorded and structured as defined in Table 75. The Unique Disc Identifier contains time stamp fields. The time format should be UTC 24 hour clock[1]. This field ***shall*** be set by the SEND DISC STRUCTURE command. This time stamp data sent by the SEND DISC STRUCTURE command may also be used in the OPC related field in RMD Field 1 and may help the judgement to do OPC. The logical unit ***shall*** update the time stamp during power on. Strict accuracy of time is not required.

Table 75 - Unique Disc ID

Bit / Byte	7	6	5	4	3	2	1	0
0-1	Reserved							
2-3	(MSB)			Random Data				(LSB)
4-7	(MSB)			Year				(LSB)
8-9	(MSB)			Month				(LSB)
10-11	(MSB)			Day				(LSB)
12-13	(MSB)			Hour				(LSB)
14-15	(MSB)			Minute				(LSB)
16-17	(MSB)			Second				(LSB)

The Random Data field is a random number.

The Year field specifies the year coded in ASCII in the range “0001” to “9999”.

The Month field specifies the month of the year coded in ASCII in the range “01” to “12”.

The Day field specifies the day of the month coded in ASCII in the range “01” to “31”.

The Hour field specifies the hour of the day coded in ASCII in the range “00” to “23”.

The Minute field specifies the minute of the hour coded in ASCII in the range “00” to “59”.

The Second field specifies the second of the minute coded in ASCII in the range “00” to “59”.

1. UTC = universal time coordinated

The Copy of Pre-pit Information field contains the copy of Pre-pit Information data which is recorded as LPP (Land Pre-Pit). Copy of Pre-pit Information structure is shown in Table 76. Pre-pit information data is specified by DVD-R Book Part 1.

Table 76 - Copy of Pre-pit Information for DVD-R Dual Layer disc

Byte \ Bit	7	6	5	4	3	2	1	0
22	Field ID = 01h							
23	Application code							
24	Disc Physical code							
25-27	(MSB) Last address of Data Recordable Area on Layer 0 (LSB)							
28	LPP Part Version				Extension code			
29	Reserved							
30	Field ID = 02h							
31-32	Reserved							
33-35	(MSB) Last address of Data Recordable Area on Layer 1 (LSB)							
36-37	Reserved							
38	Field ID = 03h							
39-44	1st field of Manufacturer ID							
45	Reserved							
46	Field ID = 04h							
47-52	2nd field of Manufacturer ID							
53	Reserved							
54	Field ID = 05h							
55-60	Reserved							
61-85	Reserved							

The Start sector number of the Shifted Middle Area field indicates the start PSN of the Shifted Middle Area on L0 when the Shifted Middle Area is recorded. Otherwise this field is filled with 00h.

The Pre-recorded information code field identifies that whether the pre-recordable area is recorded or not.

Table 77 - Pre-recorded information code field definition

Bit	Definition
0	This bit is set to zero to indicate that the Control Data Zone is pre-recorded
1	When set to one, it indicates that the Lead-in Area is fully pre-recorded except the Extra Border-zone and the R-Physical format information zone. When set to zero, it indicates that the Lead-in Area is not fully pre-recorded.
2	When set to one, it indicates that the Middle Area on L0 and L1 is fully pre-recorded. When set to zero, it indicates that the Middle Area is not fully pre-recorded.
3	When set to one, it indicates that the Lead-out is fully pre-recorded. When set to zero, it indicates that the Lead-out is not fully pre-recorded.
4-7	Reserved

The End address of pre-recorded Lead-in Area field indicates the end address of pre-recorded Lead-in Area. When the bit 1 of Pre-recorded information code field is set to one, this field is set to FFD000h.

The End address of pre-recorded Middle Area on Layer 0 field indicates the end address of pre-recorded Middle Area on L0. When the bit 2 of Pre-recorded information code field is set to one, this field is set to FDCF6Dh.

The End address of pre-recorded Middle Area on Layer 1 field indicates the end address of pre-recorded Middle Area on L1. When the bit 2 of Pre-recorded information code field is set to one, this field is set to 023573h.

The Start address of pre-recorded Lead-out Area field indicates the start address of pre-recorded Lead-out. When the bit 3 of Pre-recorded information code field is set to one, this field is set to 002942h if NBCA exists, or 002F99h if NBCA does not exist.

4.17.12.2 The contents of Format 1 RMD on DVD-R Dual Layer disc

4.17.12.2.1 Format 1 RMD Field 1

Format 1 RMD Field 1 contains some logical unit and OPC related information and ***shall*** be recorded as defined in Table 78. There are four sets of OPC data blocks. These are prepared for the case of four different DVD-R logical units writing to a disc. The logical unit ***shall*** use an empty set or its own. If there is no owned or empty OPC data block, the logical unit may use the oldest time stamp OPC data block.

Table 78 - Format 1 RMD - Field 1 (logical unit & OPC information)

Bit Byte	7	6	5	4	3	2	1	0
0-31	Drive manufacturer ID #1							
32-47	Serial Number #1							
48-63	Model Number #1							
64-79	2x-speed Write Strategy code for Layer 0 #1							
80-83	Recording power #1							
84-91	Timestamp #1							
92-95	Power Calibration Address #1							
96-107	Running OPC Information #1							
108-123	2x-speed Write Strategy code for Layer 1 #1							
124-125	DSV #1							
126-127	Reserved							
:	:							
384-415	Drive manufacturer ID #4							
416-431	Serial Number #4							
432-447	Model Number #4							
448-463	2x-speed Write Strategy code for Layer 0 #4							
464-467	Recording power #4							
468-475	Timestamp #1							
476-479	Power Calibration Address #4							
480-491	Running OPC Information #4							
492-507	2x-speed Write Strategy code for Layer 1 #4							
508-509	DSV #4							
510-511	Reserved							
512-2047	Reserved							

The Drive manufacturer ID #n field is recorded in binary and specifies unique drive manufacturer identifier of the logical unit.

The Serial Number #n field is recorded as ASCII code and specifies serial number of the logical unit.

The Model Number #n field is recorded as ASCII code and specifies the recorder model number.

The 2x-speed Write Strategy Code for Layer 0 #n field is recorded and specifies the 2x-speed write strategy code for L0 that is specified by DVD-R Book Part 1.

The Recording Power #n field may be used to store the value of the OPC result. The format of this field is vendor-specific. If this field is set to 0, this field is invalid.

The Timestamp #n field may be used to store date and time when OPC is performed. This field, if used, is recorded in binary. If this field is set to 0, this field is invalid.

The Power Calibration Address #n field may be used to specify the start ECC block address of the PCA where the last OPC was performed. If this field is set to 0, this field is invalid.

The Running OPC Information field may be used to specify values concerning running OPC. The format is vendor-specific. If this field is set to 0, this field is invalid.

The 2x-speed Write Strategy Code for Layer 1 #n field ***shall*** be recorded and specifies the 2x-speed write strategy code for L1 that is specified by DVD-R Book Part 1.

If the disc is incrementally recorded and when RMD is updated, the DSV field ***shall*** be recorded. This field is used to specify the last DSV (Digital Sum Value) in binary notation.

4.17.12.2.2 Format 1 RMD Field 2

Format 1 RMD Field 2 can be used freely and format of this field is user-specific.

Table 79 - Format 1 RMD - Field 2 (User Specific Data)

Bit / Byte	7	6	5	4	3	2	1	0
0-2047	User Specific Data							

The User Specific Data field is available for recording of user specific data. The use of this field is optional. If not used, this field ***shall*** be set to 0.

4.17.12.2.3 Format 1 RMD Field 3

Format 1 RMD Field 3 is reserved and ***shall*** be set to 0 for DVD-R Dual Layer disc.

Table 80 - Format 1 RMD - Field 3 (Reserved)

Bit / Byte	7	6	5	4	3	2	1	0
0-2047	Reserved							

4.17.12.2.4 Format 1 RMD Field 4

Format 1 RMD Field 4 contains RZone related information and ***shall*** be recorded as follows.

Table 81 - Format 1 RMD - Field 4 (RZone Information)

Bit / Byte	7	6	5	4	3	2	1	0
0-1	(MSB)			Invisible/Incomplete RZone Number (Last RZone Number)				(LSB)
2-3	(MSB)			First Open RZone number				(LSB)
4-5	(MSB)			Second Open RZone number				(LSB)
6-7				Third Open RZone number				
8-15				Reserved				
16-19	(MSB)			Start Sector Number of RZone #1				(LSB)
20-23	(MSB)			Last Recorded Address of RZone #1				(LSB)
24-27	(MSB)			Start Sector Number of RZone #2				(LSB)
28-31	(MSB)			Last Recorded Address of RZone #2				(LSB)
:				:				
2032-2035	(MSB)			Start Sector Number of RZone #253				(LSB)
2036-2039	(MSB)			Last Recorded Address of RZone #253				(LSB)
2040-2043	(MSB)			Start Sector Number of RZone #254				(LSB)
2044-2047	(MSB)			Last Recorded Address of RZone #254				(LSB)

The Invisible/Incomplete RZone Number field contains the invisible/incomplete RZone number of the medium. If the last RZone state is neither Invisible nor Incomplete due to disc finalization, this field contains the last complete RZone number.

The First Open RZone number field, if recorded with value other than 0, contains the current appendable Reserved RZone number. If this field is set to 0, there is no Empty Reserved RZone or Partially Recorded Reserved RZone corresponding to this field.

The Second Open RZone number field, if recorded with value other than 0, contains the current appendable Reserved RZone number. If this field is set to 0, there is no Empty Reserved RZone or Partially Recorded Reserved RZone corresponding to this field.

The Third Open RZone number field, if recorded with value other than 0, contains the current appendable Reserved RZone number. If this field is set to 0, there is no Empty Reserved RZone or Partially Recorded Reserved RZone corresponding to this field.

When the Incomplete RZone is closed, the Invisible/Incomplete RZone Number field contains the number of the new invisible RZone number (N+1). When Reserved RZone is closed, the corresponding First (Second) Open RZone number field ***shall*** be set to 0.

The Start Sector Number of RZone #n field contains the start sector number of the RZone which has RZone number #n.

The Last Recorded Address of RZone #n field contains the last recorded address of the RZone which has RZone number #n. If this field is set to 0, this field is not valid. If RZone #n is not closed, the value of this field may not be correct and a link point search is required to determine the correct LRA.

Note: The LRA reported by the READ TRACK/RZONE INFORMATION command is always correct.

When the RZone is not closed, even if the Last Recorded Address of RZone #n field contains a value, the logical unit ***shall*** determine the current LRA of the RZone. When RZone is closed, Last Recorded Address of RZone #n field ***shall*** be recorded before RZone padding.

4.17.12.2.5 Format 1 RMD Field 5 - Field 12

Format 1 RMD Field 5 through Field 12 may contain RZone related information continued from Format 1 RMD Field 4.

Table 82 - Format 1 RMD - Field 5 - Field 12 (RZone Information... continued)

Bit / Byte	7	6	5	4	3	2	1	0
0-3	(MSB)			Start Sector Number of RZone #n				(LSB)
4-7	(MSB)			Last Recorded Address of RZone #n				(LSB)
8-11	(MSB)			Start Sector Number of RZone #(n+1)				(LSB)
12-15	(MSB)			Last Recorded Address of RZone #(n+1)				(LSB)
:				:				
2032-2035	(MSB)			Start Sector Number of RZone #(n+253)				(LSB)
2036-2039	(MSB)			Last Recorded Address of RZone #(n+253)				(LSB)
2040-2043	(MSB)			Start Sector Number of RZone #(n+254)				(LSB)
2044-2047	(MSB)			Last Recorded Address of RZone #(n+255)				(LSB)

The Start Sector Number of RZone #n field contains start sector number of the RZone which has RZone number #n.

The Last Recorded Address of RZone #n field contains the last recorded address of the RZone which has RZone number #n. If this field is set to 0, this field is not valid. If RZone #n is not closed, the value of this field may not be correct and a link point search is required to determine the correct LRA.

Note: The LRA reported by the READ TRACK/RZONE INFORMATION command is always correct.

When the RZone is not closed, even if the Last Recorded Address of RZone #n field contains a value, the logical unit ***shall*** determine the current LRA of the RZone. When RZone is closed, Last Recorded Address of RZone #n field ***shall*** be recorded before RZone padding.

4.17.12.2.6 Format 1 RMD Field 13

Format 1 RMD Field 13 contains drive specific information and ***shall*** be recorded as defined in Table 83. There are eight sets of logical unit specific information blocks. These are prepared for the case of eight different DVD-R logical units writing to a disc. The unused fields in Format 1 RMD Field 13 ***shall*** be set to zero.

Table 83 - Format 1 RMD - Field 13 (Drive specific information)

Bit / Byte	7	6	5	4	3	2	1	0
0-31	Drive manufacturer ID #1							
32-47	Serial Number #1							
48-63	Model Number #1							
64-66	Recorded RMA address (ECC block address) #1							
67-127	Drive specific data #1							
:	:							
896-927	Drive manufacturer ID #8							
928-943	Serial Number #8							
944-959	Model Number #8							
960-962	Recorded RMA address (ECC block address) #8							
963-1023	Drive specific data #8							
1024-2047	Additional drive specific information for recorder #1							

The Drive Manufacturer ID #n field is recorded in binary and contains unique drive manufacturer identifier.

The Serial Number #n field is recorded in ASCII code and contains the serial number of the logical unit.

The Model Number #n field is recorded in ASCII code and contains the drive model number of the logical unit.

The Recorded RMA address #n field specifies the starting RMA address which is used to record RMD including the information of specific drive. This field ***shall*** be specified in ECC block address.

The Drive specific data #n field may be recorded to store the drive specific data. If this field is set to zero, this field is invalid.

The Additional Drive specific data for recorder #1 field may be recorded to store the additional drive specific data for logical unit #1. If this field is set to zero, this field is invalid.

4.17.12.2.7 Format 1 RMD Field 14

Format 1 RMD Field 14 is defined as follows.

Table 84 - Format 1 RMD - Field 14 (Versatile information)

Bit / Byte	7	6	5	4	3	2	1	0
0	Flexible Outer Disc Testing Area flag							
1-4	Testing address of Flexible Outer Disc Testing Area on Layer 0							
5-8	Testing address of Flexible Outer Disc Testing Area on Layer 1							
9-12	Testing address of Inner Disc Testing Area on Layer 0							
13-16	Testing address of Inner Disc Testing Area on Layer 1							
17-20	Testing address of Outer Disc Testing Area on Layer 0							
21-24	Testing address of Outer Disc Testing Area on Layer 1							
25-28	Testing address of optional Inner Disc Testing Area on Layer 1							
29-2047	Reserved							

When each Disc Testing Area are used, these filed are set. For detail information, see DVD-R Book Ver. 3.0.

4.17.12.3 The contents of Format 4 RMD

4.17.12.3.1 Format 4 RMD Field 1

Format 4 RMD Field 1 contains some logical unit and OPC related information and ***shall*** be recorded as defined in Table 85. There are four sets of OPC data blocks. These are prepared for the case of four different DVD-R logical units writing to a disc. The logical unit ***shall*** use an empty set or its own. If there is no owned or empty OPC data block, the logical unit may use the oldest time stamp OPC data block.

Table 85 - Format 4 RMD - Field 1 (logical unit & OPC information)

Bit / Byte	7	6	5	4	3	2	1	0
0-31	Drive manufacturer ID #1							
32-47	Serial Number #1							
48-63	Model Number #1							
64-79	2x-speed Write Strategy code for Layer 0 #1							
80-83	Recording power #1							
84-91	Timestamp #1							
92-95	Power Calibration Address #1							
96-107	Running OPC Information #1							
108-123	2x-speed Write Strategy code for Layer 1 #1							
124-125	DSV #1							
126-127	Reserved							
:	:							
384-415	(MSB)			Drive manufacturer ID #4				(LSB)
416-431	(MSB)			Serial Number #4				(LSB)
432-447	(MSB)			Model Number #4				(LSB)
448-463	2x-speed Write Strategy code for Layer 0 #4							
464-467	Recording power #4							
468-475	Timestamp #1							
476-479	Power Calibration Address #4							
480-491	Running OPC Information #4							
492-507	2x-speed Write Strategy code for Layer 1 #4							
508-509	DSV #4							
510-511	Reserved							
512-2047	Reserved							

The Drive manufacturer ID #n field is recorded in binary and specifies unique drive manufacturer identifier of the logical unit.

The Serial Number #n field is recorded as ASCII code and specifies serial number of the logical unit.

The Model Number #n field is recorded as ASCII code and specifies the recorder model number.

The 2x-speed Write Strategy Code for Layer 0 #n field ***shall*** be recorded and specifies the write strategy code that is specified by DVD-R Book Part 1.

The Recording Power #n field may be used to store the value of the OPC result. The format of this field is vendor-specific. If this field is set to 0, this field is invalid.

The Timestamp #n field may be used to store date and time when OPC is performed. This field, if used, is recorded in binary. If this field is set to 0, this field is invalid.

The Power Calibration Address #n field may be used to specify the start ECC block address of the PCA where the last OPC was performed. If this field is set to 0, this field is invalid.

The Running OPC Information field may be used to specify values concerning running OPC. The format is vendor-specific. If this field is set to 0, this field is invalid.

The 2x-speed Write Strategy Code for Layer 1 #n field ***shall*** be recorded and specifies the write strategy code that is specified by DVD-R Book Part 1.

If the disc is incrementally recorded and when RMD is updated, the DSV field ***shall*** be recorded. This field is used to specify the last DSV (Digital Sum Value) in binary notation.

4.17.12.3.2 Format 4 RMD Field 2

Format 4 RMD Field 2 can be used freely and format of this field is user-specific.

Table 86 - Format 4 RMD - Field 2 (User Specific Data)

Bit / Byte	7	6	5	4	3	2	1	0
0-2047	(MSB)			User Specific Data				(LSB)

The User Specific Data field is available for user specific data. This field may be used, otherwise this field ***shall*** be set to 0.

4.17.12.3.3 Format 4 RMD Field 3

Format 4 RMD Field 3 may contains Border Zone information and ***shall*** be recorded as follows.

Table 87 - Format 4 RMD - Field 3 (Border Zone Information)

Bit / Byte	7	6	5	4	3	2	1	0
0-3	(MSB)			Re-mapping block sector number for AP1				(LSB)
4-7	(MSB)			Re-mapping block sector number for AP2				(LSB)
8-11	(MSB)			Re-mapping block sector number for AP3				(LSB)
12-15	(MSB)			Re-mapping block sector number for AP4				(LSB)
16-31				Reserved				
32-35	(MSB)			Start Sector Number of Border-out #1				(LSB)
36-39	(MSB)			Start Sector Number of Border-out #2				(LSB)
40-43	(MSB)			Start Sector Number of Border-out #3				(LSB)
:				:				
2036-2039	(MSB)			Start Sector Number of Border-out #502				(LSB)
2040-2043	(MSB)			Start Sector Number of Border-out #503				(LSB)
2044-2047	(MSB)			Start Sector Number of Border-out #504				(LSB)

The Re-mapping block sector number for AP#n field, if it contains other than 0, indicates that the first sector number of the alternative ECC block that contains the AP#n.

The Start Sector Number of Border-out #n field, if it contains other than 0, indicates that the start sector number of the Border-out.

4.17.12.3.4 Format 4 RMD Field 4

Format 4 RMD Field 4 contains RZone related information and ***shall*** be recorded as follows.

Table 88 - Format 4 RMD - Field 4 (RZone Information)

Bit / Byte	7	6	5	4	3	2	1	0
0-1	(MSB)	Invisible/Incomplete RZone Number (Last RZone Number)						(LSB)
2-3	(MSB)	First Open RZone number						(LSB)
4-5	(MSB)	Second Open RZone number						(LSB)
6-7	Third Open RZone number							
8-15	Reserved							
16-19	(MSB)	Start Sector Number of Invisible RZone						(LSB)
20-23	(MSB)	Layer Jump Address of Invisible RZone						(LSB)
24-27	(MSB)	End sector number of Invisible RZone						(LSB)
28-31	(MSB)	Last recorded address of Invisible RZone						(LSB)
32-35	(MSB)	Previous Layer Jump Address of Invisible RZone						(LSB)
36-37	(MSB)	Jump interval						(LSB)
38-47	Reserved							
48-51	(MSB)	Start sector number of RZone #1						(LSB)
52-55	(MSB)	Layer Jump Address of RZone #1						(LSB)
56-59	(MSB)	End sector number of RZone #1						(LSB)
60-63	(MSB)	Last recorded address of RZone #1						(LSB)
:	:							
2032-2035	(MSB)	Start Sector number of RZone #125						(LSB)
2036-2039	(MSB)	Layer Jump Address of RZone #125						(LSB)
2040-2043	(MSB)	End sector number of RZone #125						(LSB)
2044-2047	(MSB)	Last recorded address of RZone #125						(LSB)

The Invisible/Incomplete RZone Number field contains the invisible/incomplete RZone number of the medium. If the last RZone state is neither Invisible nor Incomplete due to disc finalization, this field contains the last complete RZone number.

The First Open RZone number field, if recorded with value other than 0, contains the current appendable Reserved RZone number. If this field is set to 0, there is no Empty Reserved RZone or Partially Recorded Reserved RZone corresponding to this field.

The Second Open RZone number field, if recorded with value other than 0, contains the current appendable Reserved RZone number. If this field is set to 0, there is no Empty Reserved RZone or Partially Recorded Reserved RZone corresponding to this field.

The Third Open RZone number field, if recorded with value other than 0, contains the current appendable Reserved RZone number. If this field is set to 0, there is no Empty Reserved RZone or Partially Recorded Reserved RZone corresponding to this field.

When the Incomplete RZone is closed, the Invisible/Incomplete RZone Number field contains the number of the new invisible RZone number (N+1). When Reserved RZone is closed, the corresponding First (Second) Open RZone number field ***shall*** be set to 0.

The Start Sector Number of RZone #n field contains the start sector number of the RZone which has RZone number #n.

The Layer Jump Address of RZone #n field contains the physical Layer Jump Address of the RZone when Layer Jump recording is applied. When the RZone #n is a Reserved RZone, this field is set to a non-zero value.

The End sector number of RZone #n field contains the End sector number of Invisible RZone When Layer Jump recording is applied.

The Last Recorded Address of RZone #n field contains the last recorded address of the RZone which has RZone number #n. If this field is set to 0, this field is not valid. If RZone #n is not closed, the value of this field may not be correct and a link point search is required to determine the correct LRA.

Note: The LRA reported by the READ TRACK/RZONE INFORMATION command is always correct.

When the RZone is not closed, even if the Last Recorded Address of RZone #n field contains a value, the logical unit ***shall*** determine the current LRA of the RZone. When RZone is closed, Last Recorded Address of RZone #n field ***shall*** be recorded before RZone padding.

4.17.12.3.5 Format 4 RMD Field 5 - Field 12

Format 4 RMD Field 5 through Field 12 may contain RZone related information continued from RMD Field 4.

Table 89 - Format 4 RMD - Field 5-Field 12 (RZone Information ... continued)

Bit / Byte	7	6	5	4	3	2	1	0
0-3	(MSB)			Start Sector Number of RZone #n				(LSB)
4-7	(MSB)			Layer Jump Address of RZone #n				(LSB)
8-11	(MSB)			End Sector Number of RZone #n				(LSB)
12-15	(MSB)			Last Recorded Address of RZone #n				(LSB)
:				:				
2032-2035	(MSB)			Start Sector Number of RZone #(n+127)				(LSB)
2036-2039	(MSB)			Layer Jump Address of RZone #(n+127)				(LSB)
2040-2043	(MSB)			End Sector Number of RZone #(n+127)				(LSB)
2044-2047	(MSB)			Last Recorded address of RZone #(n+127)				(LSB)

The Start Sector Number of RZone #n field contains start sector number of the RZone which has RZone number #n.

The Layer Jump Address of RZone #n field contains the latest Layer Jump Address of the RZone which has RZone number #n.

The End sector number of RZone #n field contains the End sector number of the RZone which has RZone number #n.

The Last Recorded Address of RZone #n field contains the last recorded address of the RZone which has RZone number #n. If this field is set to 0, this field is not valid. If RZone #n is not closed, the value of this field may not be correct and a link point search is required to determine the correct LRA.

Note: The LRA reported by the READ TRACK/RZONE INFORMATION command is always correct.

When the RZone is not closed, even if the Last Recorded Address of RZone #n field contains a value, the logical unit ***shall*** determine the current LRA of the RZone. When RZone is closed, Last Recorded Address of RZone #n field ***shall*** be recorded before RZone padding.

4.17.12.3.6 Format 4 RMD Field 13

Format 4 RMD Field 13 contains drive specific information and ***shall*** be recorded as defined in Table 90. There are eight sets of logical unit specific information blocks. These are prepared for the case of eight different DVD-R logical units writing to a disc. The unused fields in Format 4 RMD Field 13 ***shall*** be set to zero.

Table 90 - Format 4 RMD - Field 13 (Drive specific information)

Bit / Byte	7	6	5	4	3	2	1	0
0-31	Drive manufacturer ID #1							
32-47	Serial Number #1							
48-63	Model Number #1							
64-66	Recorded RMA address (ECC block address) #1							
67-127	Drive specific data #1							
:	:							
896-927	Drive manufacturer ID #8							
928-943	Serial Number #8							
944-959	Model Number #8							
960-962	Recorded RMA address (ECC block address) #8							
963-1023	Drive specific data #8							
1024-2047	Additional drive specific information for recorder #1							

The Drive Manufacturer ID #n field is recorded in binary and contains unique drive manufacturer identifier.

The Serial Number #n field is recorded in ASCII code and contains the serial number of the logical unit.

The Model Number #n field is recorded in ASCII code and contains the drive model number of the logical unit.

The Recorded RMA address #n field specifies the starting RMA address which is used to record RMD including the information of specific drive. This field ***shall*** be specified in ECC block address.

The Drive specific data #n field may be recorded to store the drive specific data. If this field is set to zero, this field is invalid.

The Additional Drive specific data for recorder #1 field may be recorded to store the additional drive specific data for logical unit #1. If this field is set to zero, this field is invalid.

4.17.12.3.7 Format 4 RMD Field 14

Format 4 RMD Field 14 is defined as follows.

Table 91 - Format 4 RMD-Field 14 (Versatile information)

Bit / Byte	7	6	5	4	3	2	1	0
0	Flexible Outer Disc Testing Area flag							
1-4	Testing address of Flexible Outer Disc Testing Area on Layer 0							
5-8	Testing address of Flexible Outer Disc Testing Area on Layer 1							
9-12	Testing address of Inner Disc Testing Area on Layer 0							
13-16	Testing address of Inner Disc Testing Area on Layer 1							
17-20	Testing address of Outer Disc Testing Area on Layer 0							
21-24	Testing address of Outer Disc Testing Area on Layer 1							
25-28	Testing address of optional Inner Disc Testing Area on Layer 1							
29-2015	Reserved							
2016-2017	Start pointer of Blank Area #1							
2018-2019	End pointer of Blank Area #1							
2020-2021	Start pointer of Blank Area #2							
2022-2023	End pointer of Blank Area #2							
2024-2025	Start pointer of Blank Area #3							
2026-2027	End pointer of Blank Area #3							
2028-2029	Start pointer of Blank Area #4							
2030-2031	End pointer of Blank Area #4							
2032-2033	Start pointer of Blank Area #5							
2034-2035	End pointer of Blank Area #5							
2036-2037	Start pointer of Blank Area #6							
2038-2039	End pointer of Blank Area #6							
2040-2041	Start pointer of Blank Area #7							
2042-2043	End pointer of Blank Area #7							
2044-2045	Start pointer of Blank Area #8							
2046-2047	End pointer of Blank Area #8							

When each Disc Testing Area are used, these Disc Testing Area filed are set. For detail information, see DVD-R Book Ver. 3.0.

Start pointer of Blank Area #n field specifies the n^{th} Blank Area start location on L1. This field contains RZone number of RZone that is adjacent to outer side of the n^{th} Blank Area. The start PSN of the n^{th} Blank Area is calculated from the End sector number of the RZone.

End pointer of Blank Area #n field specifies the n^{th} Blank Area end location on L1. This field contains RZone number of RZone that is adjacent to inner side of the n^{th} Blank Area. The end PSN of the n^{th} Blank Area is calculated from the Layer Jump Address of the RZone.

The RZone numbers listed in the Start/End pointer of Blank Area #n fields are sorted in ascending order.

See Figure 74 - *Small Reserved RZone* on page 174.

4.17.12.4 When RMD is written in RMA

Some RMD update conditions are added to DVD-R Dual Layer disc.

Usually, RMD may be cached in the logical unit memory. As occasion calls, RMD ***shall*** be written in RMA. By using RMD caching, the logical unit can avoid waste of RMA. The timing when RMD is written in RMA is shown in Table 92.

Table 92 - Mandatory RMD update condition in RMA

conditions
When a WRITE (10) command is issued following a RESERVE TRACK/RZONE/RMZ command, before the start of writing, RMD ***shall*** be written in RMA.
When a CLOSE TRACK/RZONE/SESSION/BORDER command is issued, before the start of the close operation for either RZone or Border, RMD ***shall*** be written in RMA.
When a SYNCHRONIZE CACHE command is issued following SEND DISC STRUCTURE command which specifies User Specific Data.
Disc status specified in RMD Field 0 is changed (pre-recorded area information is included)
Start sector number of Border-out Area specified in RMD Field 3 is changed
Some Disc Testing Area specified in RMD Field 14 is newly used
Invisible RZone number, First Open RZone number, Second Open RZone number, or Third Open RZone specified in RMD Field4 is changed
The difference between the sector number of the last recorded sector in RZone #i and "Last recorded address of RZone #i" registered in the latest Format 1 RMD becomes lager than 32MB
The number of recorded sector becomes lager than 32MB in the case of Format 4 RMD is used
Layer Jump Address of Invisible/Incomplete RZone is specified by SEND DISC STRUCTURE command when LRA is on L0[a]
Jump Interval in Format 4 RMD Field4 is set
Start sector number of Shifted Middle Area specified in Format 4 RMD Field 0 is changed
Re-mapping block sector number for AP#n (n = 1, 2, 3, 4) specified in Format 4 RMD Field 3 is changed
RZone number of Blank Area specified in Format 4 RMD Field 14 is changed

a. During NWA is located on L1, the LJA specified by the command ***shall not*** be registered in RMD. After Layer Jump from L1 to L0 has happened and when host has sent data to be written on L0 part, the LJA ***shall*** be registered in RMD at appropriate timing.

When writing in the same incomplete RZone for an extended period of time, RMD may not recorded for a long time. To force writing of the RMD, the host should close the Incomplete RZone after a certain time has passed. Then the new information is written into the RMA. Although the Invisible RZone number is increased due to the closing of the Incomplete RZone, the NWA of the new Invisible RZone is the same as the NWA of the closed Incomplete RZone.

Note: Updating RMD is not required as long as the sequence of data recording operation is in process by a disc recorder.

4.17.13 DVD-Video compatibility issues for DVD-R Dual Layer disc

4.17.13.1 Allocation rule of DVD Video format Cell

DVD Video Specification Part 3 specifies that a Cell ***shall not*** be located on different Layers, ***shall*** be terminated in one Layer. The Cells beside Layer jump ***shall*** be non-seamless. DVD-R Dual Layer Ver. 3.0 disc has only OTP. The Layer Jump Address on OTP from L0 to L1 ***shall*** be ECC boundary. It is very difficult to encode such Cells. It is because that usually Cell boundary is not match with ECC block boundary. Usually Cells are encoded as seamless. If a recorded disc does not match with this Cell alignment rule, some DVD players cannot play the disc back from L0 to L1. The players freeze at the end of L0 typically.

4.17.13.2 Typical usage of the third reserved RZone

In case of Incremental-recording method, the Layer Jump Address is fixed at Fixed Middle Area position. In this case, treatment of Cell alignment at the Layer Jump Address is very difficult during real-time encoding/recording. It is necessary that such Cells are encoded and are recorded at later. To allow real-time stream recording without considering the Layer Jump Address alignment, the third reserved RZone may be used. The third reserved RZone that is assigned at the Layer Jump position may be recorded at the termination real-time recording.

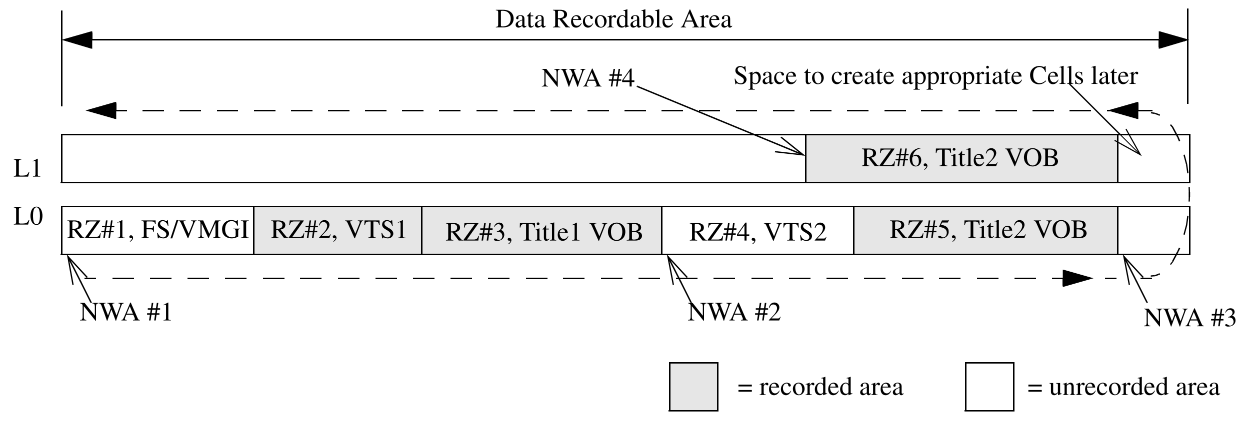


Figure 97 - Usage example of the 3rd NWA on Incremental Recording mode

4.17.13.3 Recommendation for multiple open RZone recording

In case of Incremental recording mode, RESERVE TRACK/RZONE/RMZ command is able to create NWA on L1. It is strongly recommended that when an application uses multiple of open RZones for its specific purpose, before writing from new NWA on L1, unrecorded area of L0 (e.g., RZ#1, RZ#4, and RZ#5 of Figure 97) should be recorded. In case of Figure 97, RZ#6 start address should be bigger than or equal to associated area of L0 (e.g., 2M - NWA #3 - 1). The size of RZ#4 should be smaller than 15 µm radius width. Logical unit does not report any error even if the recording order is not kept.

4.18 Address Mode reservation

To make a new NWA on a sequential recording media, the RESERVE TRACK/RZONE/RMZ command is used. There are two kind of methods to create a new NWA.

1. To specify the Track/RZone reservation size
2. To specify new NWA directly

The latter method is newly defined and is referred to as Address Mode reservation. The Address Mode reservation facilitates a host to specify NWA to the host desired location. In the former method, the host have to calculate Track/RZone gaps such as Run-in, Run-out or Linking Loss Area to allocate new NWA to the specific address. In particular, it is rather complicated when the disc is in Layer Jump recording mode on DVD-R Dual Layer disc due to Clearance or Blank Area. In the case of Address Mode reservation, the specified address ***shall*** be the multiple of blocking factor shown by the Blocking field of Random Readable Feature (0010h). If the specified address is not valid, the command ***shall*** be terminated with CHECK CONDITION status, 5/24/00 INVALID FIELD IN CDB.

In the case of Incremental recording the Address Mode reservation works for Incomplete Track/RZone in addition to Invisible Track/RZone except Fixed Packet mode (Method 2 Addressing) Incomplete Track of CD. The specified address ***shall*** be between NWA and the end of the Invisible/Incomplete Track/RZone. In the case of Layer Jump recording, the Address Mode reservation works for Invisible RZone only. The reservation address ***shall*** be L0 address. A reservation may make two recording parts on L0 and L1.

In the case of DVD-R Incremental Recording mode, when NWA of the Incomplete Track/RZone is specified as reservation address, the recorded part of the Incomplete Track/RZone changes to Complete Track/RZone as shown in Figure 99. Unrecorded part changes to Invisible Track/RZone. When higher address than the NWA is specified for reservation address, a Reserved Track/RZone and new Invisible Track/RZone are made.

In the case of CD-R Incremental Recording mode, the reservation address ***shall*** be bigger than or equal to NWA + pre-gap size + link size as shown in Figure 99. Minimum Track size rule for new Reserved Track ***shall*** be kept. For more information, see RESERVE TRACK/RZONE/RMZ command.

After the Address Mode reservation, the number of free blocks of the Reserved RZone needs to be checked by READ TRACK/RZONE INFORMATION command.

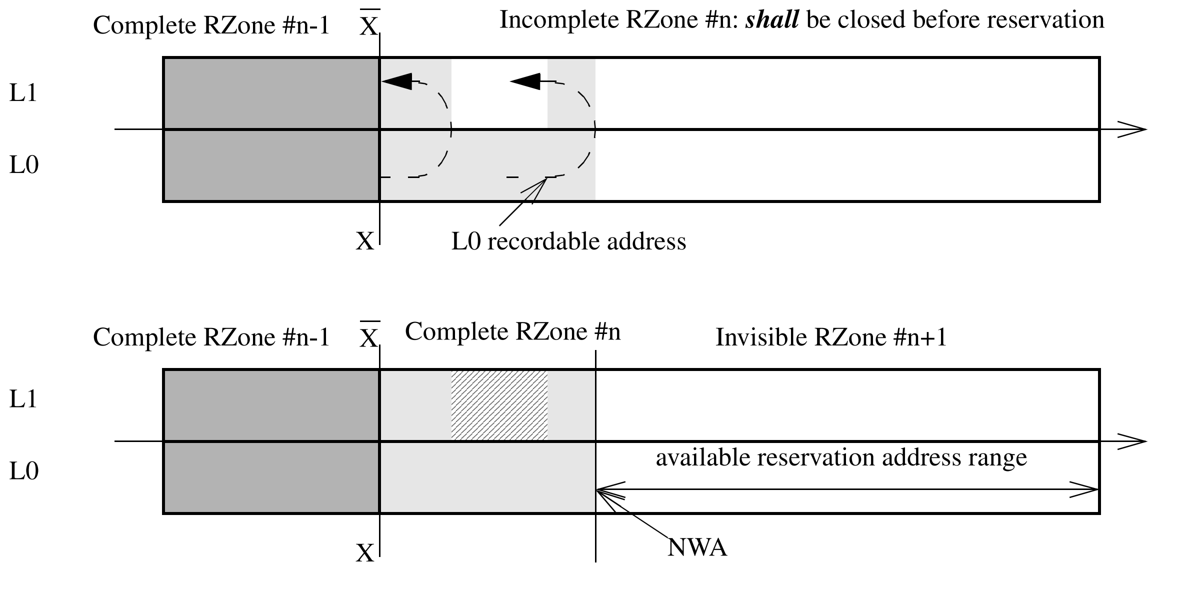


Figure 98 - Address Mode reservation for Layer Jump recording

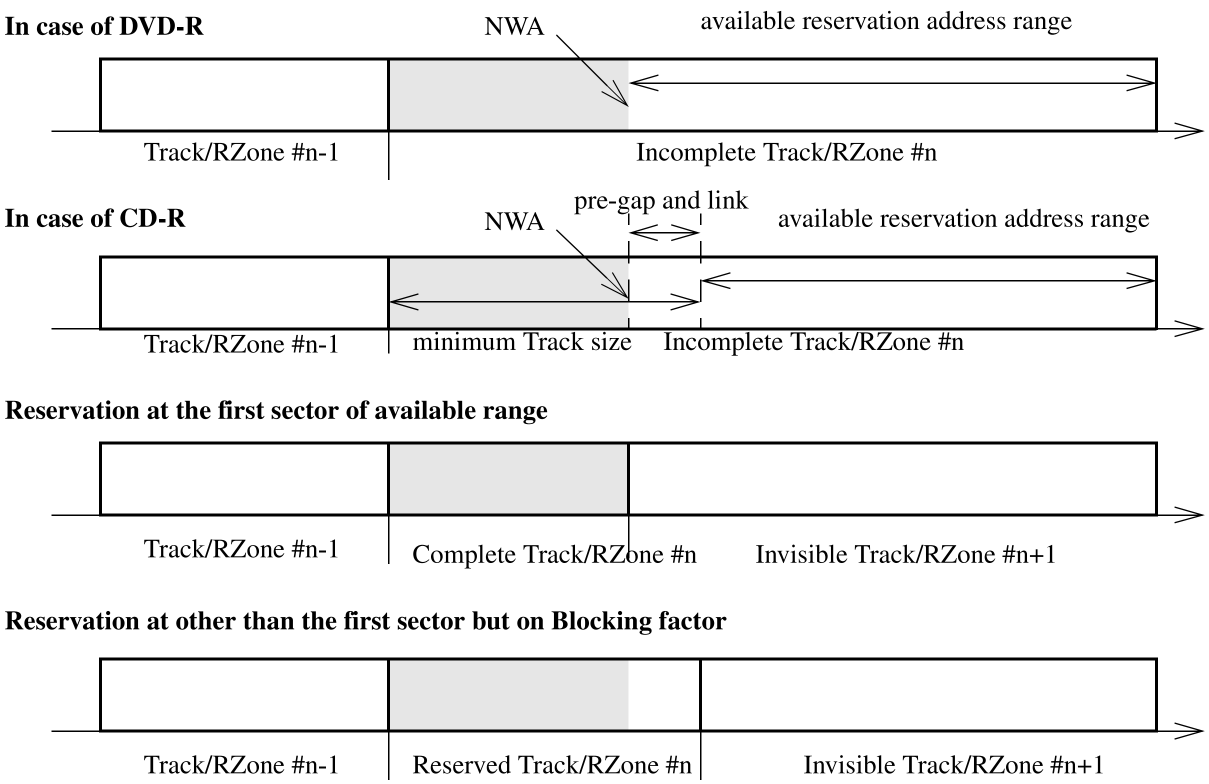


Figure 99 - Address Mode reservation for C/DVD-R Incremental Recording

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4.19 Recording/reading for DVD-RW media

4.19.1 Basics

DVD-RW media has additional properties compared with DVD-R media. These properties are ability to overwrite and ability to erase.

The structure of DVD-RW media is the same as DVD-R media that complies with DVD-R for General Ver.2.1 specification. DVD-RW medium consists of Power Calibration Area (PCA), Recording Management Area (RMA), Lead-in Area, Data Area and Lead-out Area. Data Area may contain Border Zones.

4.19.2 Recording mode

DVD-RW media supports two fundamentally different recording modes that are Sequential recording mode and Restricted overwrite mode. One of them is allowed on a disc surface. These two modes are able to be recognized by different format of Recording Management Data (RMD) that is recorded on the disc. See *4.19.5, "RMA structure"* on page 225.

4.19.2.1 Sequential recording mode

The Sequential recording mode is provided to write data on DVD-RW media with the same manner as DVD-R. See *Section 4.16, "Recording for DVD-R Single Layer media"* on page 121. Overwriting is prohibited during this recording mode even if the mounted media is overwritable. However, the erasable functionality is available.

When a DVD-RW medium is in Sequential recording mode, the logical unit is only able to perform sequential recording (Disc-at-once or Incremental). The Write Type field in Write Parameters Mode Page is used to specify if Disc-at-once recording or incremental recording will be used. If a buffer under-run occurs during sequential recording, Lossless-Link may be performed. See *Section 4.16.4.5, "Buffer under-run free recording"* on page 126.

4.19.2.2 Restricted overwrite mode

The Restricted overwrite mode provides the restricted overwrite method to write user data on a DVD-RW medium. A format operation is required in advance to use the media as available for writing of user data using restricted overwrite method.

When a media is in Restricted overwrite mode, the logical unit is able to overwrite randomly within a formatted area on the media. If the last Bordered Area is intermediate state (See Section 4.19.4.4), the logical unit is able to append data from NWA that appears during intermediate state.

There are some restrictions when overwriting is performed on DVD-RW media. The logical unit is able to record data only by the multiple of ECC block length. Host ***shall*** write data in integral multiple of 16 sectors starting at a logical block address that is an integral multiple of 16. If a WRITE command does not start at the integral multiple of 16 logical block address, the command ***shall*** be terminated with CHECK CONDITION Status, 5/21/02 INVALID ADDRESS FOR WRITE. If Transfer Length field value of WRITE command is not an integral multiple of 16 sectors, the command ***shall*** be terminated with CHECK CONDITION Status, 5/24/00 INVALID FIELD IN CDB. The logical unit writes a series of ECC blocks sequentially without Linking Loss sectors. The logical unit does not perform hardware defect management, Read Modify Write, and Verify after Write. The logical unit does not use method 2 addressing of CD.

Write Parameters Mode Page ***shall not*** be used during Restricted overwrite mode.

Attempting to read an unwritten portion ***shall*** be caused CHECK CONDITION Status, 8/--/-- BLANK CHECK.

4.19.2.2.1 Restricted overwrite method

The logical unit starts writing from a Link position in the first Sync frame of an ECC block and stop writing at a Link position of an ECC block that is next ECC block of the last ECC block sent by the host. This is the basic operation of restricted overwrite.

For Restricted overwrite mode, the Data Type bit in physical ID of sector just before the ECC block by which writing is begun is not written by the logical unit. Any linking becomes Lossless-Link[1] during Restricted overwrite mode.

---

1. See *4.16.4.4, "Lossless-Link"* on page 126.

4.19.2.3 *Recording mode transition*

When a brand-new DVD-RW disc is inserted into the DVD-RW logical unit, the disc is treated as in Sequential recording mode. The FORMAT UNIT command (Format Type = ’Full’ or ’Quick’) is used to format the DVD-RW media. When the medium is formatted, the logical unit and disc enter the Restricted overwrite mode and restricted overwrite method is available on the disc. To the contrary, the BLANK command (Blanking Type = ’Blank the disc’ or ’Minimally blank the disc’) is used to make the disc blank and the recording mode is changed to Sequential recording mode.

4.19.3 *Link position*

Any writing ***shall*** start/stop at a Link position. For DVD-RW media, location of Link position is different from DVD-R Ver.1.0 and DVD-R for Authoring Ver.2.0 media.

On DVD-RW media, Link position is located at between 15th and 17th bytes in the first sync frame of an ECC block as shown in Figure 100. Thus the first PI line of the ECC block by which writing is begun may be degraded. From an error correction point of view, the data in the PI line containing Link position are recovered by outer-code parity (PO) directional error correction.

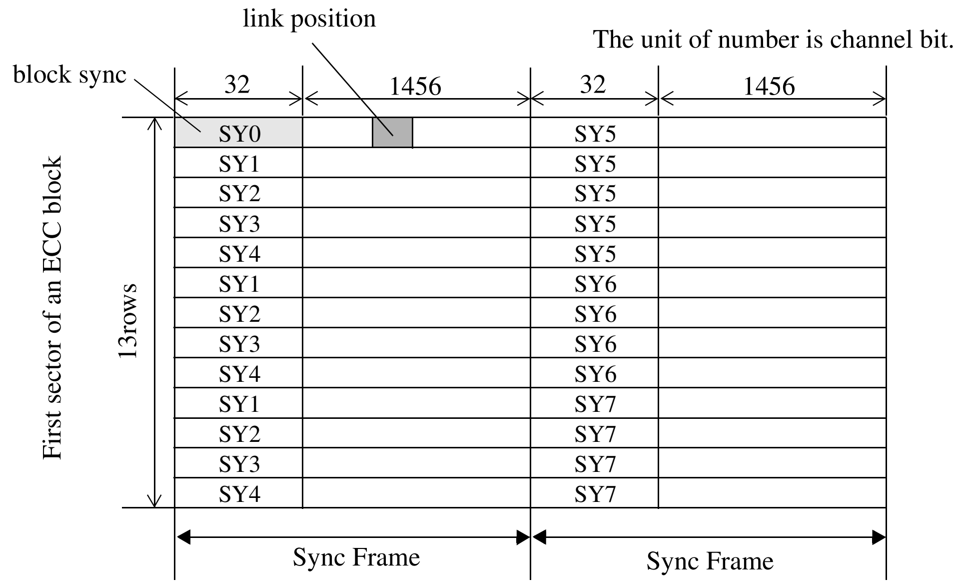


Figure 100 - Link position in physical sector (DVD-RW)

4.19.4 *Bordered Area state*

A Bordered Area on DVD-RW media is classified into four different states according to its recording phase and recording mode. These states are called Empty, Incomplete, Complete, and Intermediate. The Intermediate state is newly defined for DVD-RW. Others are the same as defined in *4.16.11.5.3, "Border Zone status"* on page 150. The relationship between recording mode and Bordered Area states are shown in Figure 102.

4.19.4.1 *Empty state*

When the disc is in Sequential recording mode and if Bordered Area contains no user data and no Lead-in/Border-in and Lead-out/Border-out are written for the Bordered Area, the Bordered Area is Empty state. When a Bordered Area is blanked by BLANK command (Blanking Type = Blank the disc, Minimally blank the disc, Erase the last Border), the Bordered Area is also considered as an Empty state.

When the disc is in Restricted overwrite mode, there is no empty state Bordered Area. Even if the last Bordered Area is complete state, empty state Bordered Area never appears on the disc during Restricted overwrite mode.

4.19.4.2 Incomplete state

When the disc is in Sequential recording mode and if user data is recorded without Lead-in/Border-in and Lead-out/Border-out of the Bordered Area, the Bordered Area is incomplete state. This state only appears during Sequential recording mode.

4.19.4.3 Complete state

When the Lead-in/Border-in and Lead-out/Border-out of the Bordered Area are completely recorded, the Bordered Area is complete state.

4.19.4.4 Intermediate state

When there is only one Bordered Area on a disc, if a part of Lead-in[1] is recorded and 32 ECC blocks with Lead-out attribute are recorded after the end of user data, the Bordered Area is in the intermediate state.

When there are two or more Bordered Areas on a disc, if Border-in is recorded and 32 ECC blocks with Lead-out attribute are recorded after the end of user data, the Bordered Area is in the intermediate state. The intermediate state only appears at the last Bordered Area during Restricted overwrite mode. Figure 101 shows an example of Intermediate state Bordered Area on DVD-RW media.

When the last Bordered Area is in Intermediate state, Starting PSN of Data Area field and Last recorded address of last RZone in the Bordered Area field in Physical Format Information of the last Lead-in/Border-in ***shall*** be set to 30000h. Start PSN of the current Border-out field and Start PSN of the next Border-in field in the DVD-RW unique part of the Physical Format Information of the last Lead-in/Border-in ***shall*** be set to 00h.

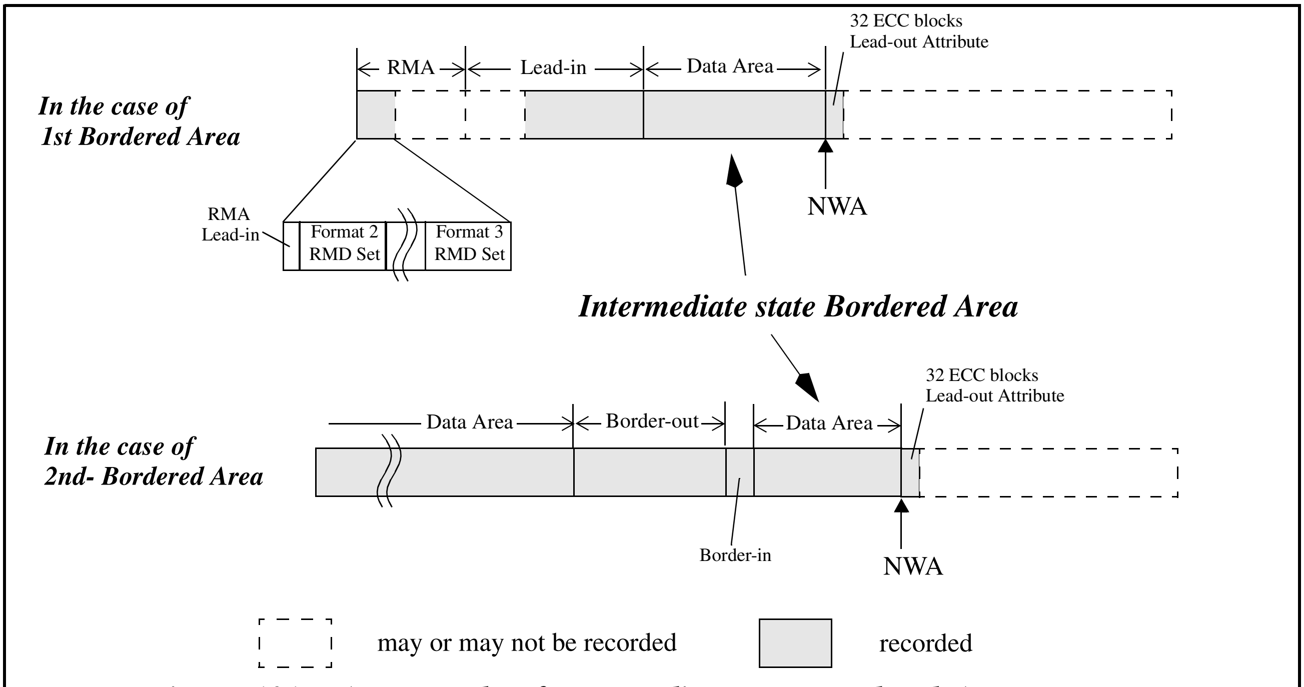


Figure 101 - An example of Intermediate state Bordered Area on DVD-RW

4.19.4.5 Data writing on an intermediate state Bordered Area

When a Bordered Area is in an intermediate state, the logical unit reports the NWA where the last addressable block plus 1 of the intermediate Bordered Area. See Figure 101. The medium can be overwritten within a Bordered Area less than the NWA and data is sequentially appendable from the NWA to the full capacity of a disc. When data is written across

1. At least RW-Physical format information Zone, Reference Code Zone, Buffer Zone 1, and Extra Border Zone ***shall*** be recorded.

the NWA, 32 ECC blocks with Lead-out attribute ***shall*** be recorded at each stop of writing. The NWA is reported by READ TRACK/RZONE INFORMATION command.

When the size of an intermediate state Bordered Area is increased by any value more than 4 Mbytes since the last RMD is written in RMA, and the recording pauses, and the logical unit estimates that there is enough time, the last recorded address ***shall*** be registered in the End Sector Number of RZone #n field of the valid Format 3 RMD. This information is used to search NWA or to recover an incomplete recording on the intermediate Bordered Area.

When the logical unit detects the intermediate state Bordered Area, the logical unit ***shall*** search the ECC blocks with Lead-out attribute from the last recorded address registered in the End Sector Number of RZone #n field to recognize the NWA. If the logical unit cannot detect any ECC blocks with Lead-out attribute within the appropriate area after the last recorded address registered in the End Sector Number of RZone #n field, the RZone is considered as damaged (Damage = 1, NWA_V = 1). The automatic repair ***shall*** be performed. The NWA ***shall*** be set to the next sector of the last recorded address registered in the Format Information 2 field. When a WRITE is applied on the NWA, and the recording pauses, the logical unit ***shall*** record 32 ECC blocks with Lead-out attribute.

To change the intermediate state Bordered Area to complete state, CLOSE TRACK/RZONE/SESSION/BORDER command (Close Function=010b) is used.

4.19.4.6 Multi-border on DVD-RW media

For DVD-RW Restricted Overwritten media, multiple Bordered Areas are allowed up to 16. The structure and method for recognition of Multi-border disc is the same as the case of DVD-R. However, it is different in DVD-RW media that there is no Next Border Marker in Border-out. See Figure 57 - *Pointers for multi-Border recognition* on page 152.

4.19.4.7 Recording mode and Bordered Area state transition

Figure 102 shows the relationship between Recording mode and Bordered Area state transition.

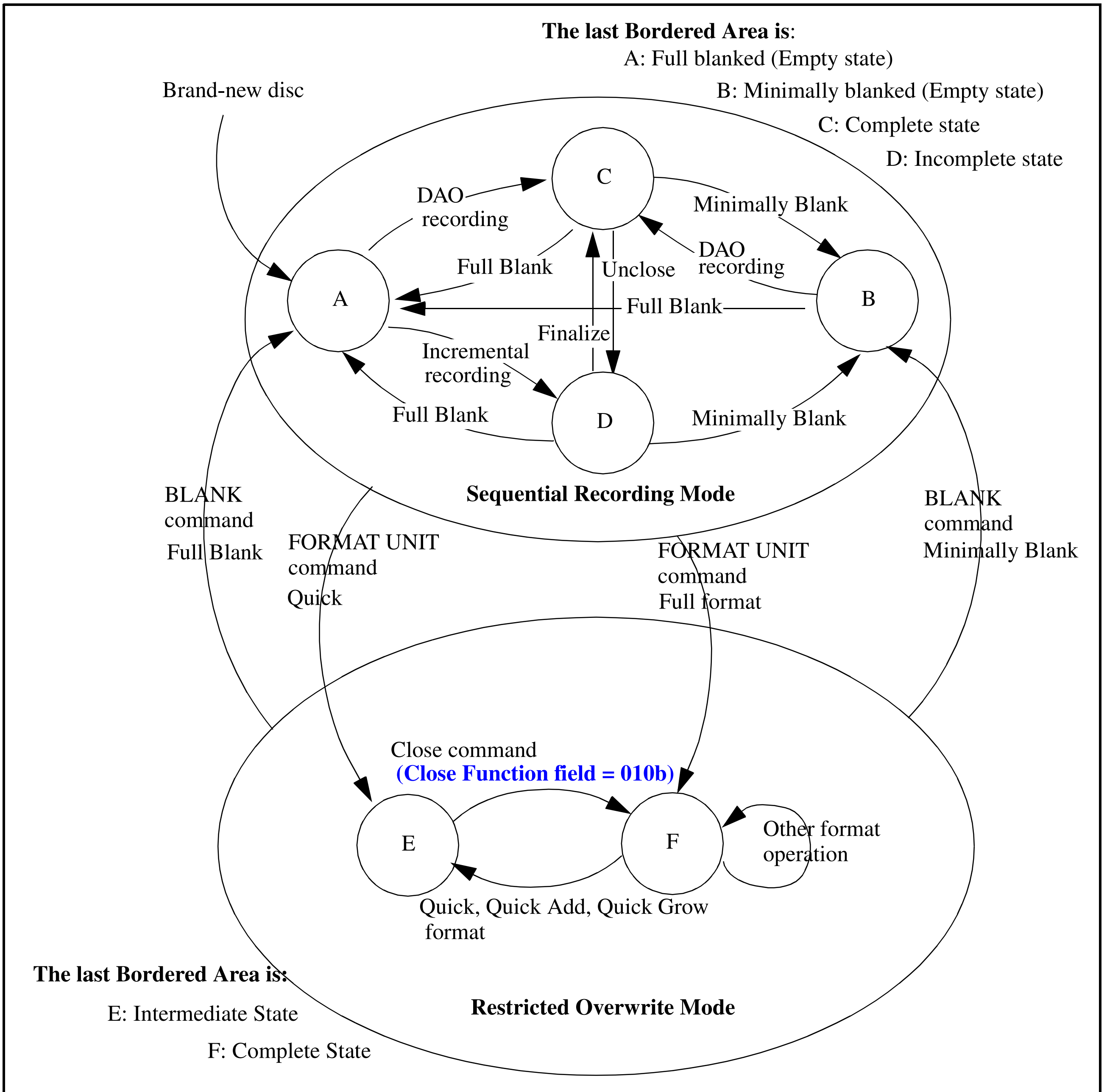


Figure 102 - DVD-RW recording mode and Bordered Area state transition

4.19.5 RMA structure

Three kinds of RMD formats are defined for DVD-RW media. They are Format 1, Format 2, and Format 3 RMDs. The Format 1 RMD is used only for Sequential recording mode. The Format 3 RMD is used only for Restricted overwrite mode. The Format 2 RMD is used for both recording mode. The physical format of an RMD block is the same as an ECC block. The RMD block consists of 15 Fields and a Linking Loss Area. The Linking Loss Area and each Field is 2KB in size.

RMA logical structure and RMD usage are different between Sequential recording mode and Restricted overwrite mode.

4.19.5.1 RMA structure for Sequential recording mode

When a DVD-RW media is in Sequential recording mode, Format 1 RMD and Format 2 RMD are used and the RMA is logically divided into two parts.

The first part is located at the beginning of RMA and consists of an RMA Lead-in and five Format 2 RMD blocks. Each of these five Format 2 RMD blocks ***shall*** contain same data except RBG Information field. These five RMD blocks are referred to as RMD Set. The first part is mainly used for storing the erase status information.

The second part is remaining area of the RMA. The second part is used as same manner with DVD-R recording and contains 695 RMD blocks. The Format 1 RMD ***shall*** be used in the second part.

The RMA logical structure for Sequential recording mode is shown in Figure 103.

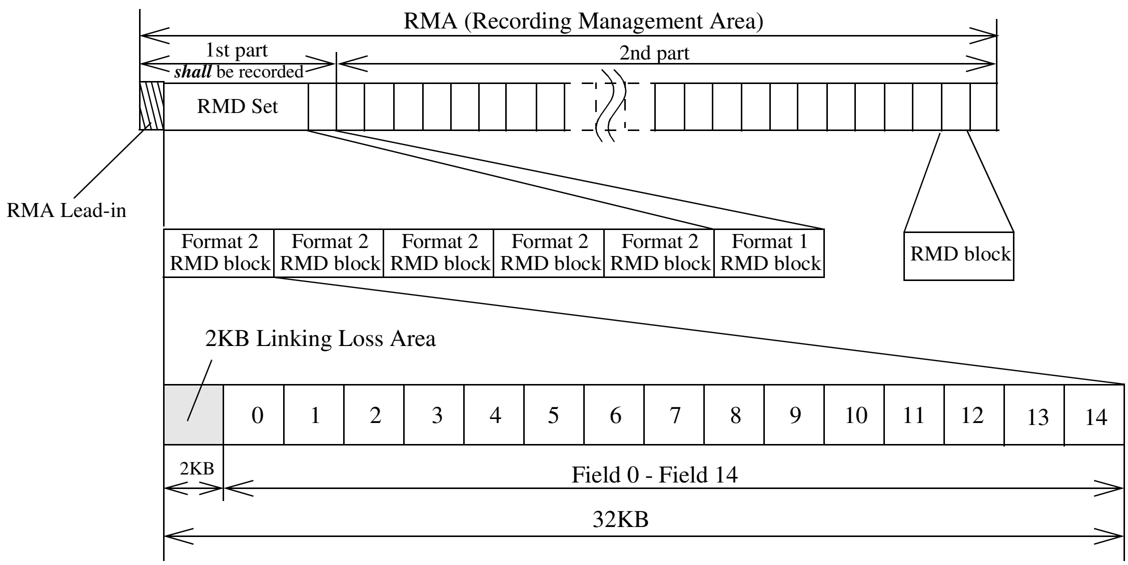


Figure 103 - RMA structure on Blanked disc

4.19.5.2 RMA structure for Restricted overwrite mode

When the DVD-RW media is in Restricted overwrite mode, the RMA is divided into five RMA Segments. Each RMA Segment is constant in length and is divided into 28 RMD Sets. Each RMD Set consists of five RMD blocks. The contents of all five RMD blocks in the RMD Set are equivalent except RBG Information field. This redundancy is only for error tolerance.

The RMA logical structure for Restricted overwrite mode is shown in Figure 104.

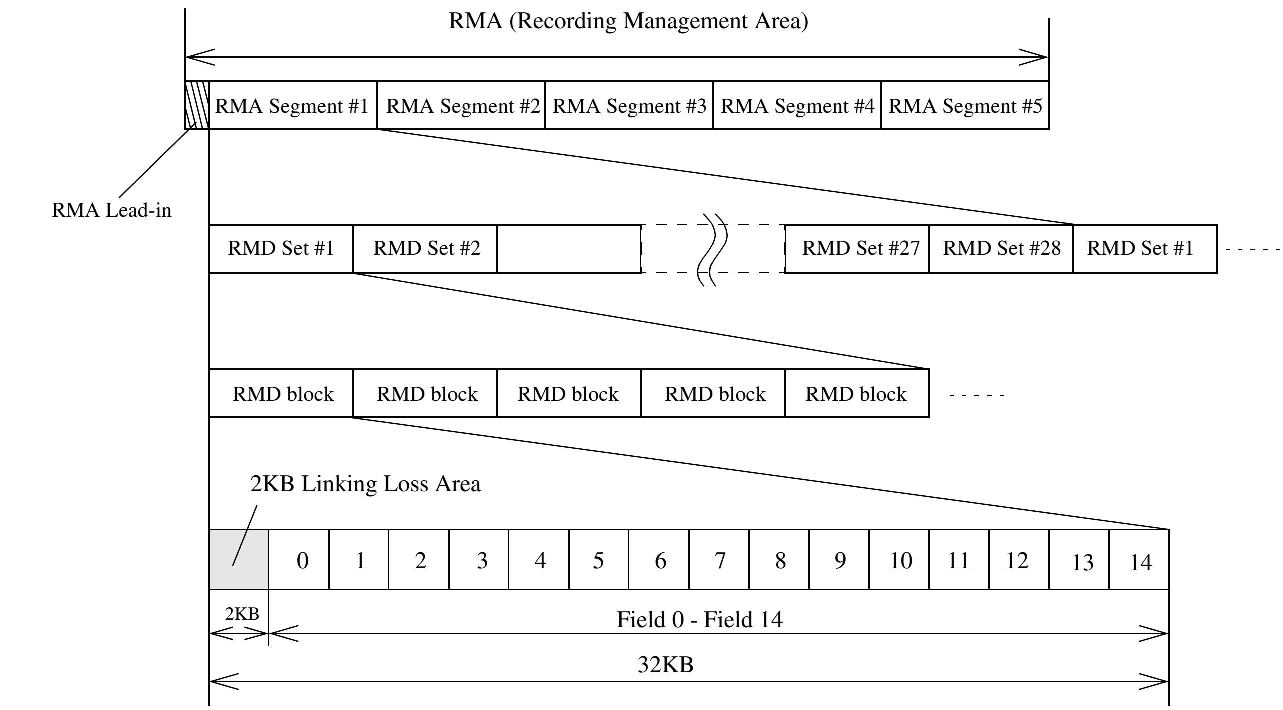


Figure 104 - RMA structure for Restricted overwrite mode

The Format 2 RMD blocks ***shall*** be recorded in the first RMD Set of an RMA Segment. The Format 3 RMD blocks ***shall*** be recorded as an RMD Set and are located other than the first RMD Set of an RMA Segment. There is only one pair of valid Format 2 RMD Set and Format 3 RMD Set in the RMA. The valid Format 2 RMD contains pointer to the current valid Format 3 RMD Set in the same RMA Segment.

4.19.6 RMD contents for DVD-RW media

All the initial value of RMD is 0. The RMD structures described in this section are defined by DVD-RW Ver.1.2. For the other versions of DVD-RW discs, see applicable DVD-RW Book for the RMD structures.

4.19.6.1 RMD Header - Field 0

The RMD Field 0 (RMD Header) is commonly used by every format of RMD and specifies the general information of the disc and ***shall*** be recorded as follows. Table 93 shows the structure of RMD Field 0.

Table 93 - RMD Header - Field 0

Bit / Byte	7	6	5	4	3	2	1	0
0-1	(MSB)			RMD Format				(LSB)
2				Disc Status				
3				Reserved				
4-21	(MSB)			Unique Disc ID				(LSB)
22-85	(MSB)			Copy of Pre-pit Information				(LSB)
86-127				Reserved				
128				RBG Information				
129-2047				Reserved				

The RMD Format field ***shall*** be recorded and specifies the format of the following RMD Field 1- Field 14 which is used on the medium. RMD Format field is defined in Table 94.

Table 94 - RMD Format field definition

Value	Definition
0	Reserved
1	The following RMD Field 1-14 are recorded as Format 1 RMD. Format 1 RMD is specified in Part 1 of DVD-RW Book Ver.1.2.
2	The following RMD Field 1-14 are recorded as Format 2 RMD. Format 2 RMD is specified in Part 1 of DVD-RW Book Ver.1.2.
3	The following RMD Field 1-14 are recorded as Format 3 RMD. Format 3 RMD is specified in Part 1 of DVD-RW Book Ver.1.2.
4	Reserved for DVD-R Dual Layer media
5-65535	Reserved

The Disc Status field indicates the disc status. Disc Status field is defined in Table 95.

The most significant bit of Disc Status field indicates whether the disc is write protected or not. If the most significant bit of Disc Status field is set to 1, the disc is write protected. Otherwise, the disc is not write protected. When the Disc Status is 05h, 10h, or 11h, the most significant bit ***shall not*** be set and not be considered as write protected.

Table 95 - Disc Status field definition

Value	Definition	Available RMD Format
Not Write Protected		
00h	The disc has no written data in Data Recordable Area (only RMDs are written) In the case of Format 2 RMD block, this status indicates that the disc is in Sequential recording mode and its current disc status is specified by the Disc Status field of valid Format 1 RMD block.	All
01h	The disc is in Disc-at-once recording mode	Format 1
02h	The disc is in Incremental recording mode	Format 1
03h	The disc is the finalized disc in the case of Incremental recording	Format 1
04h	The disc is minimally blanked	Format 1
05h	The erase operation is in progress on the disc	Format 1
06h-0Fh	Reserved	-
10h	The disc is in Restricted overwrite mode. Its current disc status is specified by Disc Status field of Format 3 RMD block.	Format 2
11h	The formatting of a border is in progress on the disc	Format 1, 3
12h	The disc is in Restricted overwrite mode	Format 3
13h	The last Bordered Area is in the Intermediate state	Format 3
14h-7Fh	Reserved	-
Write Protected		
80h	The disc has no written data in Data Recordable Area (only RMDs are written) and write protected except R-Information area	Format 1, 3
81h	The disc is in Disc-at-once recording mode and write protected except R-Information area	Format 1
82h	The disc is in Incremental recording mode and write protected except R-Information area	Format 1

Table 95 - Disc Status field definition (Continued)

Value	Definition	Available RMD Format
83h	The disc is the finalized disc in the case of Incremental recording and write protected except R-Information area	Format 1
84h	The disc is minimally blanked and write protected except R-Information area	Format 1
85h-91h	Reserved	-
92h	The disc is in Restricted overwrite mode and write protected except R-Information area	Format 3
93h	The last Bordered Area is in Intermediate state and write protected except R-Information area	Format 3
94h-FFh	Reserved	-

Unique Disc ID field ***shall*** be recorded and structured as specified in Table 49 - *Unique Disc ID* on page 139.

Copy of Pre-pit Information field contains the copy of Pre-pit Information data that is recorded as LPP (Land Pre-Pit) on DVD-RW media. Copy of Pre-pit Information structure is shown in Table 96. Pre-pit information data is specified by DVD-RW Book Part 1.

Table 96 - Copy of Pre-pit Information

Bit / Byte	7	6	5	4	3	2	1	0
22	Field ID (= 01h)							
23	Application code							
24	Disc Physical code							
25-27	(MSB) Last address of Data Recordable Area (LSB)							
28	LPP Part Version				Extension code			
29	Reserved							
30	Field ID (= 02h)							
31	OPC suggested code (Recording power)							
32	OPC suggested code (Erasing power)							
33-36	1st field of Write Strategy code							
37	Reserved							
38	Field ID (= 03h)							
39-44	1st field of Manufacturer ID							
45	Reserved							
46	Field ID (= 04h)							
47-52	2nd field of Manufacturer ID							
53	Reserved							
54	Field ID (= 05h)							
55-60	2nd field of Write Strategy code							
61-85	Reserved							

The RMD Block Group Information (RBG Information) field is structured as Table 97. This field ***shall*** be used when RMD blocks are recorded sequentially with same contents. The RMD blocks that are recorded sequentially with the same contents (except RBG Number field) is referred to as RMD Block Group. The RMD blocks of RMD Block Group have the same RBG Length value. The RBG Number value starts from 1 and is increased by 1 up to RBG Length value in the RMD blocks of RMD Block Group. If only one RMD block is recorded in order to update RMD contents, RBG Length and RBG Number of each RMD block ***shall*** be set to 1. If this field is set to 0, this field is invalid.

Table 97 - RBG Information field definition

Bit / Byte	7	6	5	4	3	2	1	0
128	RBG Number				RBG Length			

4.19.6.2 Format 1 RMD Field 1

Format 1 RMD Field 1 contains some logical unit and OPC related information. Table 98 shows the structure of Format 1 RMD Field 1.

There are four sets of OPC data blocks. These are prepared for the case of four different DVD-RW logical units writing to a disc. The logical unit ***shall*** use an empty set or its own. If there is no owned or empty OPC data block, the logical unit may use the oldest time stamp OPC data block.

Table 98 - Format 1 RMD Field 1 (logical unit & OPC information)

Bit / Byte	7	6	5	4	3	2	1	0
0-31	Drive Manufacturer ID #1							
32-47	Serial Number #1							
48-63	Model Number #1							
64-67	1st field of Write Strategy Code #1							
68-71	Recording Power #1							
72-79	Time stamp #1							
80-83	Power Calibration Address #1							
84-107	Running OPC Information #1							
108-113	2nd field of Write Strategy Code #1							
114-115	Reserved							
116-117	Recording Power by the 8-bit coded power #1							
118-127	Reserved							
:	:							
384-415	Drive Manufacturer ID #4							
416-431	Serial Number #4							
432-447	Model Number #4							
448-451	1st field of Write Strategy Code #4							
452-455	Recording Power #4							
456-463	Time stamp #4							
464-467	Power Calibration Address #4							
468-491	Running OPC Information #4							
492-497	2nd field of Write Strategy Code #4							
498-499	Reserved							
500-501	Recording Power by the 8-bit coded power #4							
502-511	Reserved							
512-2047	Reserved							

Drive Manufacturer ID #n field is recorded in binary and specifies unique drive manufacturer identifier of the DVD-RW logical unit.

Serial Number, Model Number, Recording Power, Timestamp, Power Calibration Address, Running OPC Information fields definitions are the same as specified in *4.16.11.2.1, "Format 1 RMD Field 1"* on page 140.

1st field of Write Strategy Code #n field specifies the write strategy code of the Write Strategy type 1 in the pre-pit data block of Field ID 2. Write strategy code is specified by DVD-RW Book Part 1.

2nd field of Write Strategy Code #n field specifies the write strategy code of the Write Strategy type 2 in the pre-pit data block of Field ID 5. Write strategy code is specified by DVD-RW Book Part 1.

Recording Power by the 8-bit coded power #n field may be used to specify the recording power value of the OPC result by using the 8-bit coded power. This value may be the expected output from the objective lens of the Pickup Head Unit in a logical unit that OPC was performed. The 8-bit coded power indicates the Laser power value as a number n between 1 to 255. See Table 99. If this field is set to 0, this field is invalid.

Table 99 - 8-bit coded power definition

n	Laser Power
1-200	n/10 [mW]
201-255	Reserved

4.19.6.3 Format 1 RMD Field 2 to Field 14

The definitions of Format 1 RMD Field 2 to Field 14 are the same as defined in *4.16.11.2.2, "Format 1 RMD Field 2"* on page 142 through *4.16.11.2.7, "Format 1 RMD Field 14"* on page 146.

4.19.6.4 Format 2 RMD Field 1

The Format 2 RMD Field 1 contains pointer to the start address of the Format 3 RMD Set in the same RMA Segment.

Table 100 - Format 2 RMD Field 1 (Pointer to Format 3 RMD Set)

Bit / Byte	7	6	5	4	3	2	1	0
0-3	(MSB)			Update Counter				(LSB)
4-7	(MSB)			Format 3 RMD Set Pointer				(LSB)
8-11				Reserved				
12-13	(MSB)			Erase Operation Counter				(LSB)
14-15				Reserved				
16	RSDS #8	RSDS #7	RSDS #6	RSDS #5	RSDS #4	RSDS #3	RSDS #2	Reserved
17	RSDS #16	RSDS #15	RSDS #14	RSDS #13	RSDS #12	RSDS #11	RSDS #10	RSDS #9
18	RSDS #24	RSDS #23	RSDS #22	RSDS #21	RSDS #20	RSDS #19	RSDS #18	RSDS #17
19		Reserved			RSDS #28	RSDS #27	RSDS #26	RSDS #25
20-2047				Reserved				

The Update Counter field contains the number of times to which this RMD Set is rewritten. The initial value of this field is 0. The value of this field ***shall*** be incremented by 1 when this field is rewritten. The value is taken over and is also incremented when the RMA Segment that is used to record RMD Set is changed. In the case of Restricted overwrite mode, this value is used to determine which RMA Segment is current.

The Format 3 RMD Set Pointer field contains pointer to start address of the latest Format 3 RMD Set in this RMA Segment. The indicated RMD Set contains Format 3 RMD blocks. In the case of Sequential recording mode, this field ***shall*** be set to 0.

The Erase Operation Counter field contains the number of times that Disc Erase operation is performed. The value of this field ***shall*** be incremented by 1 when the disc is erased. The initial value of this field is 0.

The RMA Segment Defect Status (RSDS #n) bit indicates whether the Format 3 RMD Set in the RMA Segment is defective or not. If set to 1, the RMD Set #n of the RMA Segment is defective (EDC error occur in at least 3 RMD blocks of an RMD Set). Otherwise the RMD Set #n of the RMA Segment is non-defective. In the case of Sequential recording mode, this field ***shall*** be set to 0.

4.19.6.5 Format 2 RMD Field 2

The Format 2 RMD Field 2 contains the information of erase operation. In the case of Restricted overwrite mode, these fields ***shall*** be set to 0.

Table 101 - Format 2 RMD Field 2 (Erase Operation Information)

Byte \ Bit	7	6	5	4	3	2	1	0
0	Erase Operation Code							
1	Reserved							
2-5	(MSB)			Erase Information 1				(LSB)
6-9	(MSB)			Erase Information 2				(LSB)
10-2047	Reserved							

The Erase Operation Code field contains the operation code of the erase operation.

The Erase Information 1, 2 fields contain the information related with Erase Operation Code.

The Erase Operation Code and Erase Information 1, 2 are defined in Table 102.

Table 102 - Erase Operation Code and Erase Information fields definition

Erase Operation Code	Erase Information 1	Erase Information 2	Erase Operation type
0	-	-	No erase operation is in progress.
1	Start PSN of Erasing[a]	Marker PSN[b]	Blank the Disc
2	Start PSN of Erasing	Marker PSN	Minimally blank the Disc
3, 4	-	-	Reserved
5	Start PSN of Erasing	Marker PSN	Blank an RZone Tail[c]
6	Start PSN of the last Border-in[d]	Marker PSN	Unclose the last Border
7	Start PSN of Erasing	Marker PSN	Erase the last Border
8 and above	-	-	Reserved

a. Start PSN of Erasing contains the Physical Sector Number of the first sector of the ECC block where the specified erase operation ***shall*** be started.
b. Marker PSN contains the Physical Sector Number of the last sector of the ECC block where the erase operation ***shall*** be finished.
c. If 'Unreserve an RZone' operation is requested by BLANK command, this Erase operation type is also used. If the last RZone is incomplete state, the entire incomplete RZone is erased. If the last RZone is invisible RZone, the invisible RZone number is decremented by one and the RZone that just before the invisible RZone is erased.
d. This field contains PSN of Linking loss sector just before the Border-in.

4.19.6.6 Format 2 RMD Field 3 to Field 14

Format 2 RMD Field 3 through Field 14 are reserved for future standardization and ***shall*** be set to 00h.

4.19.6.7 Format 3 RMD Field 1

The Format 3 RMD Field 1 contains some logical units and OPC related information as defined in Table 98 - *Format 1 RMD Field 1 (logical unit & OPC information)* on page 230.

4.19.6.8 Format 3 RMD Field 2

The Format 3 RMD Field 2 contains user specific data as defined in Table 52 - *Format 1 RMD - Field 2 (User specific data)* on page 142.

4.19.6.9 Format 3 RMD Field 3

The Format 3 RMD Field 3 contains Border Zone and RZone related information and ***shall*** be recorded as shown in Table 103. The maximum number of Border Zone is 16 and each Bordered Area has only one RZone. This Field also contains the information of the format operation.

Table 103 - Format 3 RMD Field 3 (Border Zone and RZone Information)

Bit / Byte	7	6	5	4	3	2	1	0
0	Format Operation Code							
1	Reserved							
2-5	(MSB)			Format Information 1				(LSB)
6-9	(MSB)			Format Information 2				(LSB)
10-13	Reserved							
14-17	(MSB)			Start PSN of the Border-out #1				(LSB)
18	Reserved						Defect #1	BAM #1
19-21	Reserved							
22-25	(MSB)			Start PSN of the Border-in #2				(LSB)
26-29	(MSB)			Start PSN of the Border-out #2				(LSB)
30	Reserved						Defect #2	BAM #2
31-33	Reserved							
:	:							
190-193	(MSB)			Start PSN of the Border-in #16				(LSB)
194-197	(MSB)			Start PSN of the Border-out #16				(LSB)
198	Reserved						Defect #16	BAM #16
199-201	Reserved							
202-255	Reserved							
256-257	(MSB)			Last RZone Number				(LSB)
258-261	(MSB)			Start Sector Number of RZone #1				(LSB)
262-265	(MSB)			End Sector Number of RZone #1				(LSB)
:	:							
378-381	(MSB)			Start Sector Number of RZone #16				(LSB)
382-385	(MSB)			End Sector Number of RZone #16				(LSB)
386-2047	Reserved							

The Format Operation Code field contains the operation code of the format operation.

The Format Information 1, 2 contain the information related with Format Operation Code.

The meaning of Format Operation Code and Format Information 1, 2 are defined in Table 104.

Table 104 - Format Operation Code and Format Information fields definition

Format Operation Code	Format Information 1 field	Format Information 2 field	Format operation
0	invalid	invalid	No format operation is in progress.
1	Start PSN[a]	Number of ECC blocks[b]	Full Format
2	Start PSN	Number of ECC blocks	Grow the last Border Format
3	Start PSN	Number of ECC blocks	Add Border Format
4	Start PSN	Number of ECC blocks[c]	Quick Grow the last Border Format
5	Start PSN	Number of ECC blocks[c]	Quick Add Border Format[d]
6	Start PSN	Marker PSN[e]	Close the Intermediate Border
7 and above	-	-	Reserved

a. Start PSN contains the start Physical Sector Number of the first sector of the ECC block where the specified format operation ***shall*** be started. The start address should be other than the addresses where the RMD block that is to be updated for the format operation.
b. Number of ECC blocks contains the value that is the number of user data ECC blocks to be formatted by the specified format operation.
c. At completion of the format operation, this field ***shall*** be set to last recorded address of the formatted Bordered Area. See *4.19.4.5, "Data writing on an intermediate state Bordered Area"* on page 223.
d. When 'Quick' format operation is requested by FORMAT UNIT command, this Format Operation Code value is also used. The Start PSN value is set to the beginning of a part of Lead-in that is less than 30000h and only one intermediate state Bordered Area is created on a medium.
e. Marker PSN contains the Physical Sector Number of the last sector of the ECC block where the close operation ***shall*** be finished. (last sector number of Border-out)

The Start Sector Number of Border-out #n field indicates that the start sector number of the Border-out which belongs to Bordered Area #n. If this field contains 0, this field is invalid.

The Defect #n bit of 1, indicates that the critical portion[1] of the Bordered Area is defective[1].

The BAM #n (Bordered Area Modification) bit of 1, indicates that the write operation is done within the Bordered Area #n at least once.

The Start Sector Number of Border-in #n field indicates that the start sector number of the Border-in which belongs to Bordered Area #n. If this field contains 0, this field is invalid.

The Last RZone Number field contains the last RZone number of the medium.

The Start Sector Number of RZone #n field contains the start sector number of the RZone which has RZone number #n.

The End Sector Number of RZone #n field contains the end address of the RZone which has RZone number #n. Start PSN of current Border-out field value of Border-in is the next sector of End Sector Number of RZone #n (where #n is maximum). In the case of Intermediate state Border, these field should be updated at appropriate period. If this field contains 0, this field is invalid.

4.19.6.10 Format 3 RMD Field 4 to Field 12

Format 3 RMD Field 4 through Field 12 contains the Defect Status Bitmap.

1. The definition is an application specific.

Table 105 - Format 3 RMD Field 4 (Defect Status Bitmap)

Bit / Byte	7	6	5	4	3	2	1	0
0-3	(MSB)	PSN of Previous Defect Status Bitmap RMD Set						(LSB)
4-7	(MSB)	Certification Start PSN						(LSB)
8-11	(MSB)	Certification End PSN						(LSB)
12	DS #8	DS #7	DS #6	DS #5	DS #4	DS #3	DS #2	DS #1
13	DS #16	DS #15	DS #14	DS #13	DS #12	DS #11	DS #10	DS #9
14	DS #24	DS #23	DS #22	DS #21	DS #20	DS #19	DS #18	DS #17
:	:	:	:	:	:	:	:	:
2045	DS #16272	DS #16271	DS #16270	DS #16269	DS #16268	DS #16267	DS #16266	DS #16265
2046	DS #16280	DS #16279	DS #16278	DS #16277	DS #16276	DS #16275	DS #16274	DS #16273
2047	DS #16288	DS #16287	DS #16286	DS #16285	DS #16284	DS #16283	DS #16282	DS #16281

PSN of Previous Defect Status Bitmap RMD Set field contains start physical sector number of RMD Set that contains previously generated Defect Status Bitmap. If this field contains 0, this field is invalid.

Certification Start PSN field contains the start sector number of the ECC block where the following Defect Status Bitmap starts. If this field contains 0, this field and subsequent fields (Certification End PSN, DS #n) are invalid.

Certification End PSN field contains the end sector number of the ECC block where the following Defect Status Bitmap ends.

DS #n bit may contain certification result of the ECC block #n. When DS #n bit is set to 0, indicate that the ECC block has no defect and is able to read and write the block safely (no EDC error occurs in the ECC block). When DS #n bit is set to 1, indicates that the ECC block has defect and might not be able to read and write the block safely (an EDC error occurs in the ECC block).

Table 106 - Format 3 RMD Field 5 - Field 12 (Defect Status Bitmap)

Bit / Byte	7	6	5	4	3	2	1	0
0	DS #(n+7)	DS #(n+6)	DS #(n+5)	DS #(n+4)	DS #(n+3)	DS #(n+2)	DS #(n+1)	DS #n
1	DS #(n+15)	DS #(n+14)	DS #(n+13)	DS #(n+12)	DS #(n+11)	DS #(n+10)	DS #(n+9)	DS #(n+8)
:	:	:	:	:	:	:	:	:
2046	DS #(n+16375)	DS #(n+16374)	DS #(n+16373)	DS #(n+16372)	DS #(n+16371)	DS #(n+16370)	DS #(n+16369)	DS #(n+16368)
2047	DS #(n+16383)	DS #(n+16382)	DS #(n+16381)	DS #(n+16380)	DS #(n+16379)	DS #(n+16378)	DS #(n+16377)	DS #(n+16376)

4.19.6.11 Format 3 RMD Field 13

The Format 3 RMD Field 13 contains drive specific information. The definition is the same as defined in *4.16.11.2.6, "Format 1 RMD Field 13"* on page 145.

4.19.6.12 Format 3 RMD Field 14

Format 3 RMD Field 14 specifies versatile information of a disc and logical unit. The definition is the same as defined in *4.16.11.2.7, "Format 1 RMD Field 14"* on page 146.

4.19.7 Reading/recording of RMD

4.19.7.1 RMD recording in Sequential recording mode

If no RMD blocks has been written on a medium and the medium is used as Sequential recording mode, when RMD is written at first time, the Format 2 RMD Set and one or more Format 1 RMD blocks ***shall*** be written at once. After that, the writing manner of RMD is same as the DVD-R sequential recording.

During Sequential recording mode, the Format 2 RMD Set is used to indicate a status of erase operation when the erasing is in progress.

4.19.7.2 RMD recording in Restricted overwrite mode

In the case of Restricted overwrite mode, all RMD blocks ***shall*** be recorded as an RMD Set. Each RMD Set consists of five RMD blocks that are all equivalent except RBG Information field. Two kinds of RMD (Format 2 RMD and Format 3 RMD) are used for this mode. When the RMD information is changed, the updated RMD Set ***shall*** be recorded in the RMA.

For Restricted overwrite mode, RMD is recorded in the current valid RMA Segment. The valid RMA Segment is only one at a certain time. The valid RMA Segment contains one pair of a valid Format 2 RMD and a valid Format 3 RMD. RMD blocks ***shall*** be written sequentially from the beginning of RMA.

The Format 2 RMD ***shall*** be recorded in the first RMD Set of an RMA Segment. The Format 3 RMD ***shall*** be recorded as an RMD Set other than the first RMD Set of the same RMA Segment.

Only the Format 2 RMD that has the largest Update Counter value is valid. The RMA Segment that has the valid Format 2 RMD is currently used and valid.

The valid Format 2 RMD contains pointer to the first ECC block of the current valid Format 3 RMD Set in the same RMA Segment.

The Format 3 RMD Set is written in a same location in the RMA Segment repeatedly until that ECC blocks of the RMD Set becomes defective. See Section 4.19.6.4. When the Format 3 RMD Set becomes defective, the RMD Set is written in non-defective area as a new RMD Set in the same RMA Segment until all RMD Sets of the RMA Segment become defective. Simultaneously, the Format 2 RMD Set is also re-written to indicate the new Format 3 RMD location and Update Counter field and RMA Segment Defect Status (RSDS #n) bit is updated.

When the Defect Status Bitmap (DS #n) field of the Format 3 RMD is updated, new Format 3 RMD Set is written in other non-defective location in the same RMA Segment to preserve history of the Defect Status Bitmap. The preserved RMD Set may be re-used later if the RMD Set is still non-defective.

When there are no non-defective areas to record new RMD Set in an RMA Segment, the RMA Segment ***shall*** be relinquished and other non-defective RMA Segment ***shall*** be used instead.

When ECC blocks of the Format 2 RMD Set become defective, the RMA Segment ***shall*** also be changed to non-defective one. In that case, all unrecorded areas in the unusable RMA Segment ***shall*** be recorded with 00h.

4.19.7.3 RMD read sequence in Restricted overwrite mode

For Restricted overwrite mode, read sequence of RMD blocks is as follows:

1. Logical Unit reads the Update Counter field of Format 2 RMD from each RMA Segment. The RMA Segment that contains the largest Update Counter value is selected as valid RMA Segment.
2. Obtain the start address of the valid Format 3 RMD Set by reading the Format 3 RMD Set Pointer field of Format 2 RMD from the valid RMA Segment.
3. Logical Unit reads the valid Format 3 RMD Set.

4.19.8 Border Zone

Border Zone is defined for DVD-RW media as well as DVD-R media. Border Zone prevents the optical pickup from over running when a DVD-RW disc is played back on a DVD read-only logical unit.

4.19.8.1 Structure

The Border Zone is constructed with the Border-out and Border-in. The structure of the Border Zone is shown in Figure 56 - *Border Zone structure* on page 151. However, the Next Border Marker that is defined for DVD-R media is not defined for DVD-RW media.

4.19.8.2 Border Zone size

The Border-out start address is located after PSN 3FF00h. If a CLOSE TRACK/RZONE/SESSION/BORDER command is issued when recorded user data end address is less than PSN 3FF00h, the logical unit ***shall*** pad with 00h data through PSN 3FEFFh.

Border Zone size is dependent on its starting address and order.
- First Border Zone length is approximately 0.5mm in radial direction.
- The other Border Zone length is approximately 0.1mm in radial direction.

The size of a Border Zone for DVD-RW media is shown in Table 107

Table 107 - Border Zone size for DVD-RW media

Physical sector number of beginning Border Zone	3FF00h-B25FFh	B2600h-1656FFh	165700h-
First Border Zone Size	1792 ECC blocks 56MBytes	2368 ECC blocks 74MBytes	2944 ECC blocks 92MBytes
Second and above Border Zone Size	384 ECC blocks 12MBytes	480 ECC blocks 15MBytes	608 ECC blocks 19MBytes

4.19.9 Erasing

DVD-RW medium is erasable. To erase the written data on a DVD-RW media, the BLANK command is used. The Blanking Type field specifies the blanking type.

For DVD-RW media, following Blanking Types are available. See Table 207 - *Blanking Types for DVD-RW* on page 393. The "Blank the disc" and "Minimally blank the disc" operations are available at any time in any recording mode. The other operations are only permitted during Sequential recording mode.

1. Blank the disc (Blanking Type = 000b)
2. Minimally blank the disc (Blanking Type = 001b)
3. Unreserve an RZone (Blanking Type = 011b)
4. Blank an RZone Tail (Blanking Type = 100b)
5. Unclose the last Border (Blanking Type = 101b)
6. Erase Border (Blanking Type = 110b)

Note: If the disc is blanked by 'Minimally blank the disc' operation, incremental recording is not available for this disc.

4.19.9.1 Registration of erase operation in RMD

When a disc is erased, the status of erase operation is registered in RMD prior to start erasing.

To check if an erase operation is completely finished, the Marker ECC blocks are used. Before start erasing, Marker ECC blocks with all 00h data are recorded (if not recorded) where the erase operation should terminate. At completion of an erase operation, if the Marker ECC blocks are erased, the operation is considered as successfully done.

In the case of 'Blank the disc' or 'Minimally Blank the disc' operation, RMA Lead-in and one Format 2 RMD Set and a Format 1 RMD ***shall*** be recorded at the beginning of RMA.

The Disc Status field of Format 2 RMD is set to 00h and the Disc Status field of the Format 1 RMD is set to 05h to indicate the disc is in Sequential recording mode and an erase operation in progress. The Erase Operation Code and Erase Information fields of Format 2 RMD is set to the corresponded erase operation value prior to begin erasing.

To indicate an erase operation in progress even when a failure of the operation happens:

- when an erase operation is to be done for a Sequential recording mode disc, Format 1 RMD with Disc Status field of 05h ***shall*** be appended after the current valid Format 1 RMD.
- when erase operation is to be done for a Restricted overwrite mode disc, Format 1 RMD with Disc Status field of 05h ***shall*** be written at the end of RMA before erasing.

When the erase operation has been finished, Format 1 RMD with appropriate Disc Status field value is appended. The information fields of Border Zone, RZone ***shall*** be updated.

4.19.10 Formatting

For Restricted overwrite mode, format operation is required in advance to use. To avoid unwritten area remaining in Data Area, all ECC blocks are recorded on the formatted area.

Usually, a format operation takes considerable time to ready for writing user data. To solve this problem, new types of format operations are defined for DVD-RW in addition to the CD-RW format operation. They are called quick format; ’Quick’, ’Quick Add Border’, and ’Quick Grow the last Border’.

To start writing a disc with minimum patience, a quick format operation is used. When a disc is in Restricted overwrite mode, all types of quick format operation are available. When a disc is in Sequential recording mode, only a ’Quick’ type of format operation is available. See Figure 102 - *DVD-RW recording mode and Bordered Area state transition* on page 225.

The state of the last Bordered Area on a medium is changed to the intermediate state by using the quick format operation. In the case of single Border disc, only a part of Lead-in, user data blocks and 32 ECC blocks with Lead-out attribute are formatted. Otherwise, Border-in, user data blocks and 32 ECC blocks with Lead-out attribute are formatted when quick format is performed. See Figure 101 - *An example of Intermediate state Bordered Area on DVD-RW media* on page 223.

To change an intermediate state Bordered Area to a complete state, CLOSE TRACK/RZONE/SESSION/BORDER command (Close Function=010b) is used.

The format length is arbitrary length except for Format Type = 00h (’Full Format’). The format length ***shall*** be multiple of ECC block size. If the format length is not an integral multiple of ECC block size, the logical unit ***shall*** round up the value of Number of Blocks field in the Format Descriptor up to an integral multiple of the ECC block size. The formatted area is expandable up to the full capacity of the disc.

At completion of formatting other than quick format, a Border-out is recorded after formatted user Data Area. When a disc is formatted up to full capacity of a disc, a Lead-out is recorded after Stop Blocks of a Border-out. To force the writing of Lead-out after the last Border-out, CLOSE TRACK/RZONE/SESSION/BORDER command (Close Function=011b) is used.

When a format operation is successfully done, the media is entered to Restricted overwrite mode and restricted overwrite method is available on the formatted ECC block(s). There are no unwritten ECC blocks on the formatted area.

The DVD-RW supports following format operations.

1. Full Format operation (Format Type = 00h, 10h)
2. Grow Session/Border operation (Format Type = 11h)
3. Add Session/Border operation (Format Type = 12h)
4. Quick Grow the last Border operation (Format Type = 13h)
5. Quick Add Border operation (Format Type = 14h)
6. Quick (Format Type = 15h)

4.19.10.1 Registration of format operation in RMD

When a disc is formatted, RMA Lead-in and one combination of valid Format 2 RMD Set and Format 3 RMD Set ***shall*** be recorded and the status of format operation is registered in RMD before start formatting.

When format operation is to be done for a Sequential recording mode disc, the recording mode is changed to Restricted overwrite mode.

The Disc Status field of Format 2 RMD is set to 10h and the Disc Status field of Format 3 RMD is set to 11h to indicate the disc is in Restricted overwrite mode and an format operation in progress. The Format Operation Code and Format Information fields of Format 3 RMD is set to the corresponded format operation value prior to begin formatting. The information fields of Border Zone and RZone ***shall not*** be changed.

From the beginning of RMA to the end of valid Format 3 RMD Set, unrecorded ECC blocks ***shall not*** remain. Therefore, when format operation is attempted to a blank disc, Format 2 RMD Set ***shall*** be recorded before the corresponding Format 3 RMD is recorded on the media.

When the format operation has been finished, the Disc Status field in the Format 3 RMD Set is set to 12h or 13h. The information fields of Border Zone, RZone and Defect Status Bitmap (if necessary) ***shall*** be updated. The Format Operation Code and Format Information fields of Format 3 RMD ***shall not*** be changed until next format operation will be started.

When format operation (Format Type = 'Full Format' or 'Quick') is attempted to Sequential recording mode disc, the Format 1 RMD with Disc Status field value 11h ***shall*** be recorded prior to record Format 2 RMD Set and Format 3 RMD Set. When the format operation completes, this Format 1 RMD becomes invalid.

4.19.11 Recovery from the incomplete Blank/Format operation

4.19.11.1 The theory of the information reporting and read/write action behavior

The theory of the information reporting and read/write action behavior for the incomplete erasing/formatting Bordered Area are as follows.

No automatic repair is necessary on the incomplete erasing/formatting Bordered Area.

In the case of incomplete Erasing, the size of erased RZone is considered to be 0.

In the case of incomplete formatting, the size of the RZone in the damaged Bordered Area other than newly created is considered to be maintained. In the case of incomplete Add/Quick Add Border formatting, a new RZone or a Bordered Area is considered to appear and the size of the RZone is considered to be 0.

The Status of Last Session/Border field of READ DISC INFORMATION command data ***shall*** be set to 10b.

The Damage bit field of READ TRACK/RZONE INFORMATION data ***shall*** be set to 1 for the RZone that is writable and is in the incomplete erasing/formatting Bordered Area and the posterior RZones on the medium. 'Writable' of the RZone means that the Free Blocks field of the damaged RZone is not zero or the RZone is overwritable.

When write action is required to the damaged Bordered Area and the subsequent RZones except to repair, the command ***shall*** be terminated with CHECK CONDISION Status.

When read action is applied to an RZone which is in the damaged Bordered Area and its size is not 0, the action ***shall*** be performed normally. Because of the incomplete erasing/formatting result, when the read action is failed, the command ***shall*** be terminated with CHECK CONDITION status.

If FORMAT UNIT command is failed, CHECK CONDITION Status, 3/31/00 MEDIUM FORMAT CORRUPTED ***shall*** be reported. If CLOSE TRACK/RZONE/SESSION/BORDER command is failed, 3/72/00-02 SESSION FIXATION ERROR ***shall*** be reported. If the BLANK command with Blanking Type = 'Unclose the last Bordered Area' has been failed, CHECK CONDITION Status, 3/51/01 ERASE FAILURE - Incomplete erase operation detected ***shall*** be reported.

To repair the incomplete erasing/formatting Bordered Area, REPAIR RZONE command with the damaged RZone number can be used.

Table 108 - Information reporting in the case of the incomplete Blank operation

Incomplete Operation	Status of last Border	Number of RZone	Number of Borders	RZone number for REPAIR RZONE command
Blank the Disc Minimally Blank the Disc	10b	1	1	Last RZone Number in the last Border
Unreserved an RZone	00b/01b	No change/ Decreased by 1[a]	No change	Last RZone Number in the last Border
Blank an RZone tail	00b/01b	No change	No change	Applied RZone number
Unclose the last Bordered Area	10b	No change	Decreased by 1	Last RZone Number in the last Border
Erase Border	10b	Decreased	No change/ Decreased by 1[b]	Last RZone Number in the last Border

a. If the last RZone is incomplete state, the number of RZone does not change. Otherwise, the number of RZone is decreased by one.

b. If the last Bordered Area is incomplete state, the number of Border does not change. Otherwise, the number of Border is decreased by 1.

Table 109 - Information reporting in the case of the incomplete Format operation

Incomplete Operation	Status of last Border	Number of RZone	Number of Borders	RZone number for REPAIR RZONE command
Full Format Quick	10b	1	1	Last RZone Number in the last Border
Add Border Quick Add Border	10b	Increased by 1	Increased by 1	Last RZone Number in the last Border
Grow Border Quick Grow Border	10b	No change	No change	Last RZone Number in the last Border
Close Intermediate Border	10b	No change	No change	Last RZone Number in the last Border

4.19.11.2 Recovery from incomplete erase operation

It is not possible to return original state after erase operation has been started. When an erase operation is not finished successfully, RZone(s) that are affected by the erase operation are considered as damaged. (Damage = 1, NWA_V = 0) To recover the incomplete erase operation, the un-finished erase operation is performed again from the beginning or the REPAIR RZONE command is used instead. Automatic recovery should not be performed.

4.19.11.3 Recovery from incomplete format operation

In the case of incomplete 'Full'/'Quick' format operation, it is not possible to return original state after these format operations have been started. The repair action is perform the previous requested format operation again.

In the case of incomplete format operation other than 'Full'/'Quick' format, the repair action cancels the previous requested format operation. The disc ***shall*** be return to the original state. Therefore in the case of incomplete 'Add'/ 'Quick Add' formatting, as the result of the repair, the number of RZone/Bordered Area will be decreased by 1.

5.0 HD DVD model

The HD DVD model is the description for the HD DVD media (HD DVD-ROM, HD DVD-R/-Rewritable). See *2.2.74, "HD DVD Standard"* on page 49.

The HD DVD has many advantages over the existing CD and DVD technology. HD DVD Format is based on the current DVD Format.

- HD DVD-ROM is based on DVD-ROM.
- HD DVD-R is based on DVD-R.
- HD DVD-Rewritable is based on DVD-RAM (not DVD-RW).

5.1 HD DVD media description

- HD DVD media can contain information on one side (Single Sided) or on both sides (Double Sided).
- HD DVD-ROM disc has two types of layer structure: Single Layer and Dual Layer.
- Each Layer on either side contains a spiral track. This track contains a Lead-in, Data Area, and a Middle Area or a Lead-out. Layer on HD DVD-Rewritable contains a Double spiral track.
- Dual Layer discs have two types of track path: Parallel Track Path and Opposite Track Path.
- One ECC block, having 75712 bytes, consists of 32 sectors.
- Addressing from the host is LBA (Logical Block Address) only.
- When reading from LBA space, only user data is sent to the host after error correction from the logical unit.
- Some data on HD DVD media is used only inside of the HD DVD logical unit and is not transferred to the host computer. This is due in part because the Physical Addresses (PSN) that the HD DVD uses are not allowed across the Interface.
- The host Read & Write unit (User Data) is 2 Kilobytes (2048 Bytes).

5.1.1 HD DVD specifications

Table 110 specifies some HD DVD parameters.

Table 110 - General Parameters of HD DVD Discs

	Capacity (120 mm disc) [Gbytes]	Wavelength for read [nm]	Wavelength for write [nm]	Data Bit Length [µm]	Channel bit length [µm]	Min Pit/Mark length [µm]	Max Pit/Mark length [µm]	Track Pitch [µm]	User data per sector [bytes]	Error Correction Code	ECC Constraint Length	correctable burst error length [mm]	scan velocity (Ref.) [m/s]	channel bit rate [Mbps]	user data bit rate [Mbps]
HD DVD-ROM Single Layer	15	405	N/A	(A)[a] 0.306 (B)[b] 0.153	(A) 0.204 (B) 0.102	(A) 0.408 (B) 0.204	(A) 2.652 (B) 1.326	(A) 0.68 (B) 0.40	2048	RS (208,192,17) × RS (182,172,11)	32 Physical sectors	7.1	6.61	(A) 32.40 (B) 64.80	(A) 18.28 (B) 36.55
HD DVD-ROM Dual Layer	30														
HD DVD-Rewritable Single Layer	20		405	(A) 0.306 (B) 0.130 ~ 0.140	(A) 0.204 (B) 0.087 ~ 0.093	(A) 0.408 (B) 0.173 ~ 0.187	(A) 2.652 (B) 1.126 ~ 1.213	(A) 0.68 (B) 0.34				(A) 7.1 (B) 6.0	(A) 6.61 (B) 5.64 ~ 6.03		
HD DVD-R Single Layer	15		405	(A) 0.306 (B) 0.153	(A) 0.204 (B) 0.102	(A) 0.408 (B) 0.204	(A) 2.652 (B) 1.326	(A) 0.68 (B) 0.40				7.1	6.61		

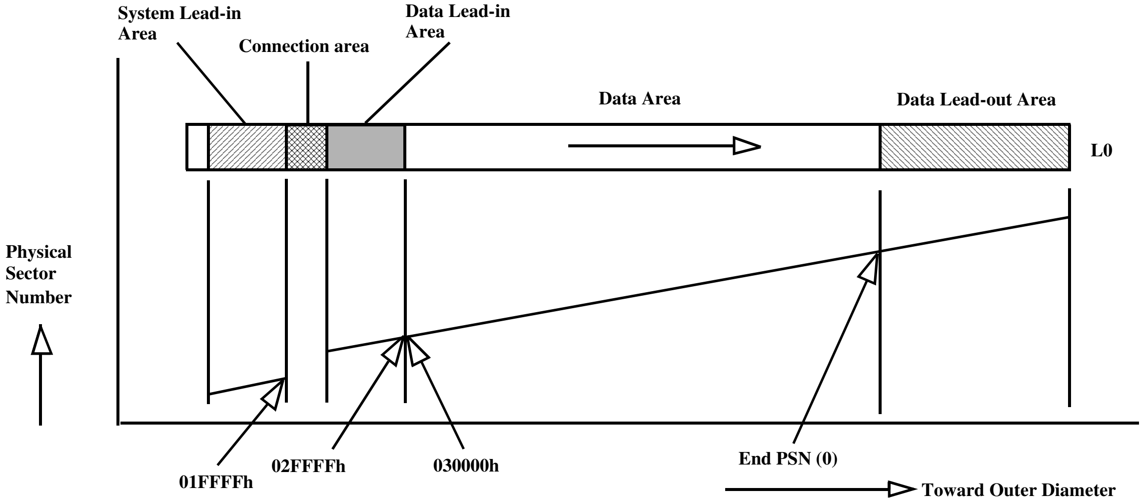
a. (A) : the System Lead-in Area, and the System Lead-out Area in Opposite Track Path (OTP) mode of Dual Layer (DL).
b. (B) : the Data Lead-in Area, Data Area, Data Lead-out Area, and Middle Area in Opposite Track Path (OTP) mode of Dual Layer (DL).

5.2 Track structure

There are two types of track path for Dual Layer discs, either parallel or opposite. When the path is parallel each track has its own Lead-in and Lead-out.

There are two addresses used in the HD DVD system, the Block address contained in the sector headers (Physical Sector Number), and the address used to reference the blocks from the host system (LBA). The address used from the host starts at 0 and progresses up through the end of the recorded information on the disc. LBA 0 shall correspond with the sector address of 030000h on HD DVD-ROM media. Only the Data Area is generally addressable using an LBA.

Figure 105 through Figure 110 show examples of LBA to Physical Sector Number translations for HD DVD media.



End PSN (0): The end Physical sector number of Data Area of L0

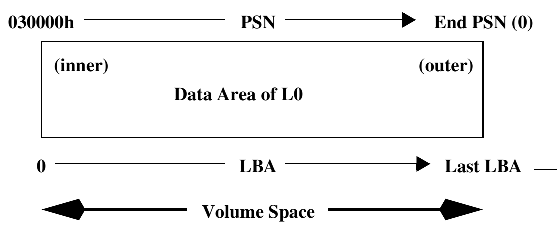
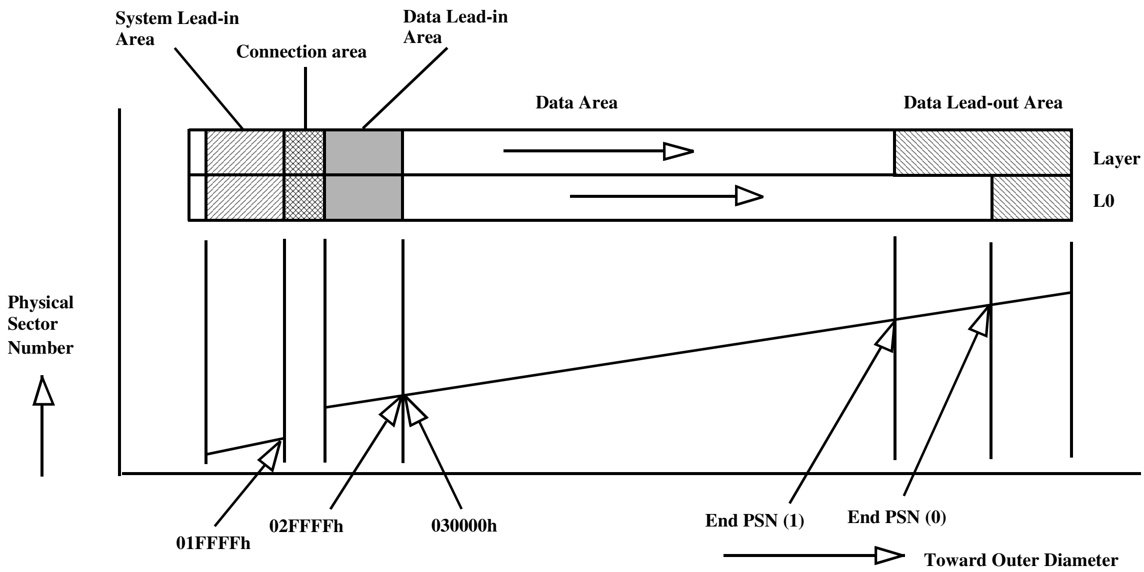


Figure 105 - Physical and logical layout of HD DVD-ROM Single Layer media



End PSN (0): The end Physical sector number of Data Area of L0

End PSN (1): The end Physical sector number of Data Area of Layer 1

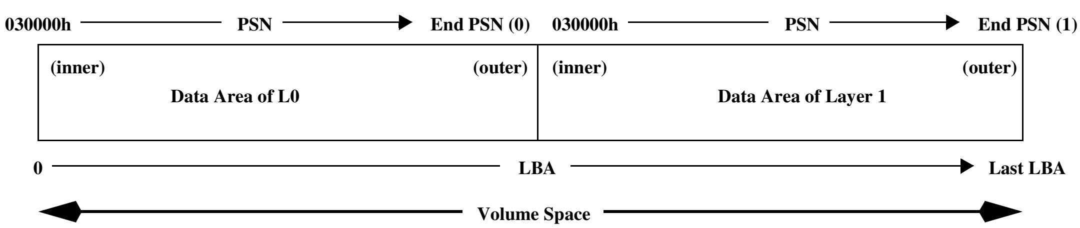
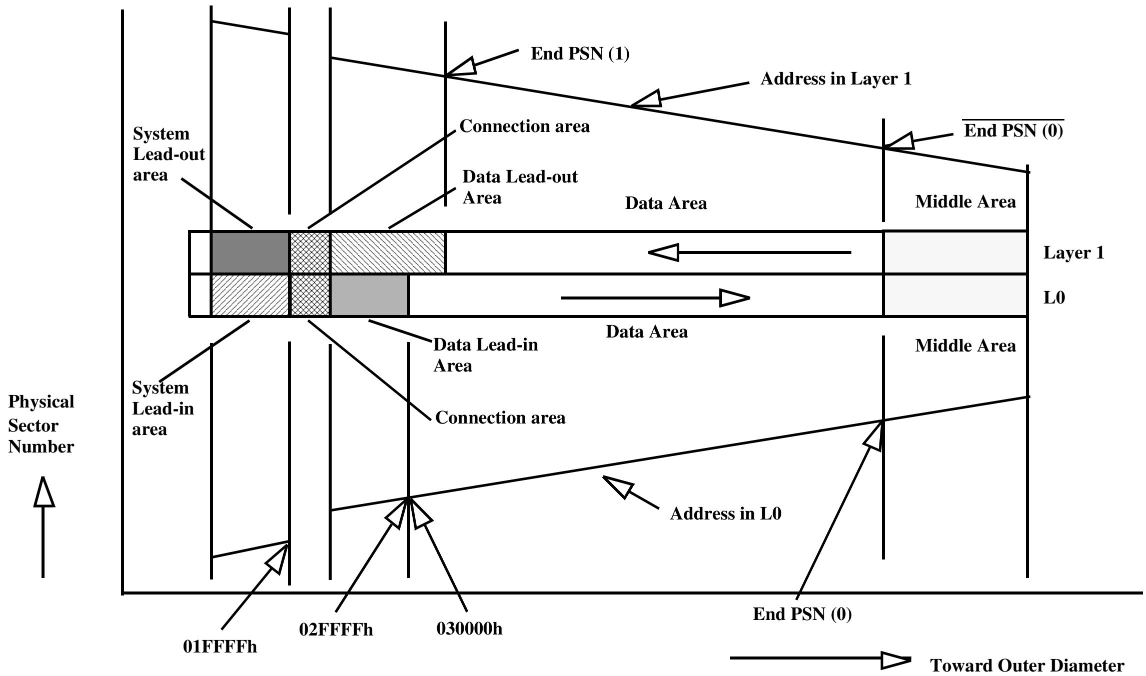


Figure 106 - Physical and logical layout of Parallel Track Path HD DVD-ROM media



End PSN (0): The end Physical sector number of Data Area of L0.

$\overline{\text{End PSN (0)}}$: The number calculated so that each bit of the End PSN (0) is inverted. $\overline{\text{End PSN (0)}}$ shall be a multiple of 32.

End PSN (1): The end Physical sector number of Data Area of Layer 1

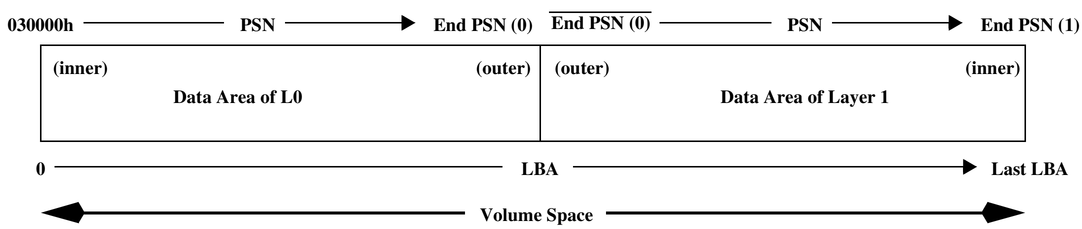
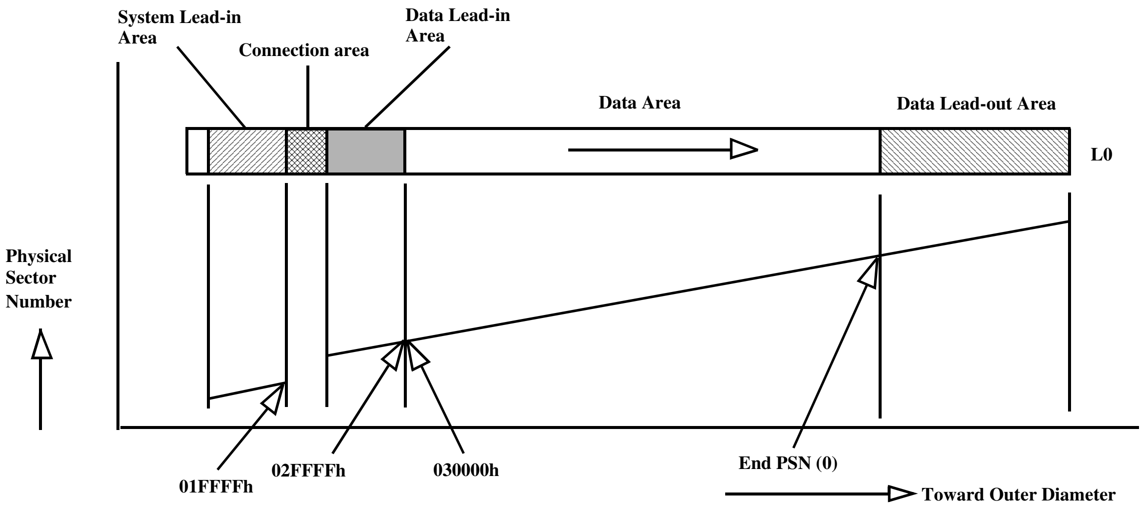


Figure 107 - Physical and logical layout of Opposite Track Path HD DVD-ROM media



End PSN (0): The end Physical sector number of Data Area of L0

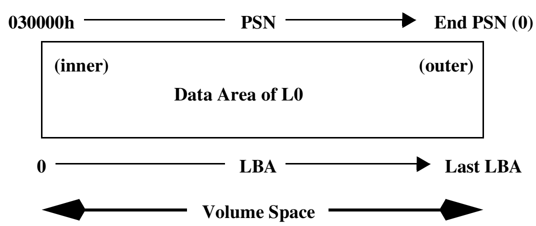
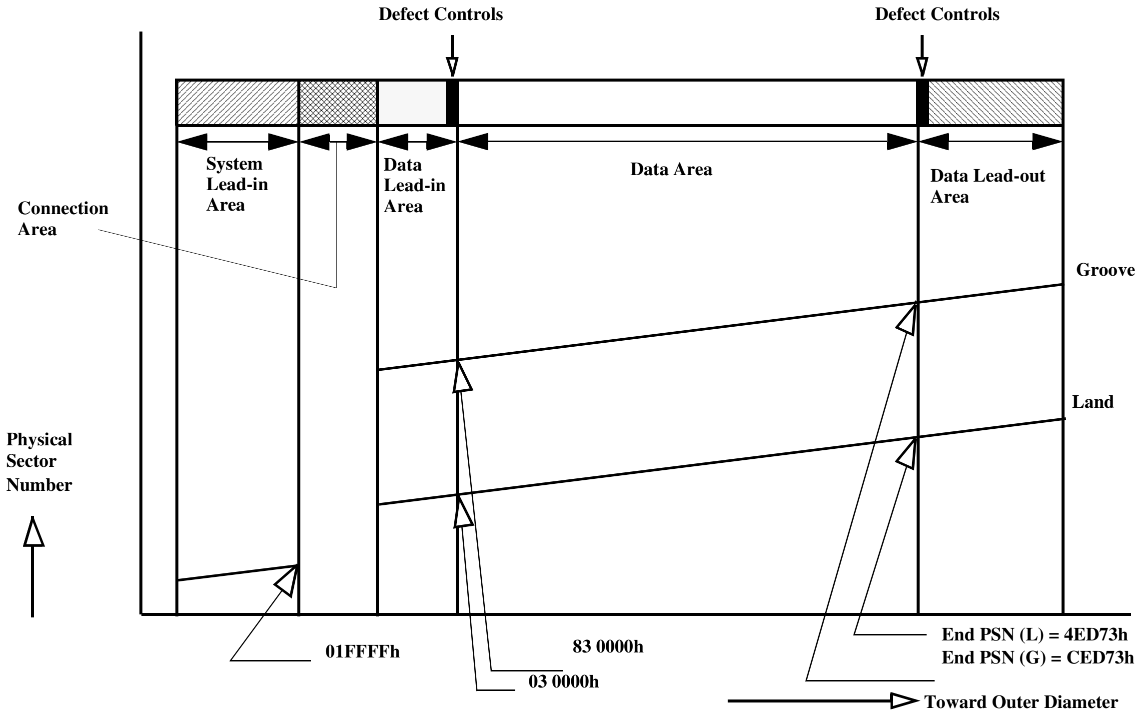


Figure 108 - Physical and logical layout of HD DVD-R media

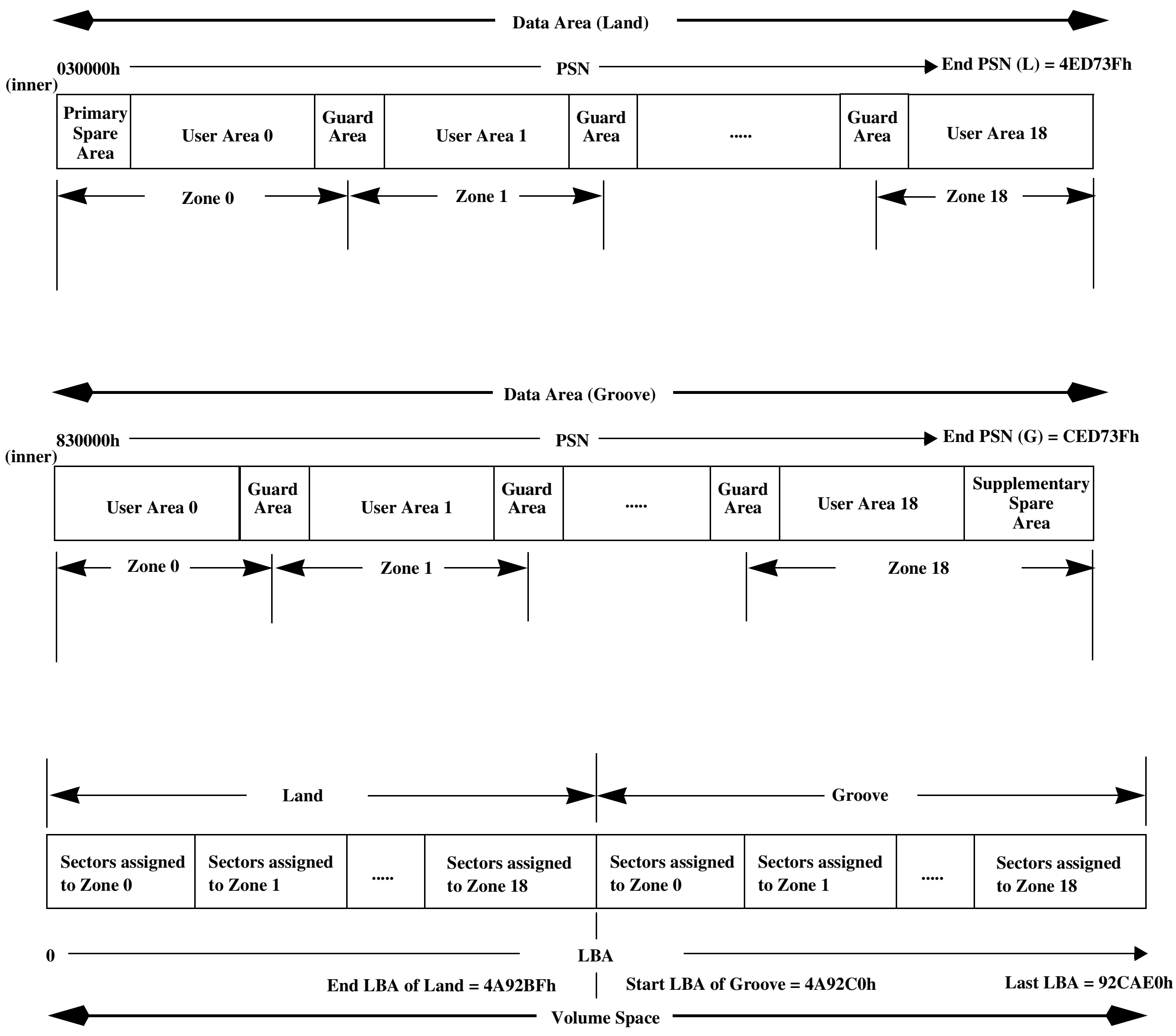


End PSN (L): The end Physical sector number of Data Area of Land

End PSN (G): The end Physical sector number of Data Area of Groove

Defect Controls are non user addressable blocks, used for drive controlled defect management. These blocks contain Defect management Areas (DMAs) and DMA Managers. Defect controls begins 02CE00h on Land, 4ED740h on Groove.

Figure 109 - Physical and logical layout of HD DVD-Rewritable media (1)



- HD DVD-Rewritable media contains 19 zones.

- Each of these zone has nearly equal radial size except Zone 0 and 18, therefore number of ECC blocks per zone increase from at the Inner Diameter to at the Outer Diameter.

- There are two types of Spare Area, Primary Spare Area (PSA) and Supplementary Spare Area (SSA).

- HD DVD-Rewritable media ***shall*** have PSA, and may have SSA. Pre-assigned SSA is selectable and SSA is expandable after Formatting.

- The User Area may contain defective blocks which are replaced by blocks in the Spare Area; therefore, the number of user accessible blocks in each zone is kept at a predetermined number.

Figure 110 - Physical and logical layout of HD DVD-Rewritable media (2)

5.3 Data segment structure

5.3.1 Data segment layout

The Data is physically recorded and read as a Data segment unit on disc by the logical unit. User data included in one ECC is recorded in the Data field of the Data segment. The layout of a Data segment is shown in Figure 111. According to this layout, lossless linking scheme is used especially for the HD DVD-R. The Data field consists of 32 sectors. A sector is created by using a Data frame which consists of Data ID, IED, RSV, User Data and EDC. The Data frame layout is shown in Figure 112.

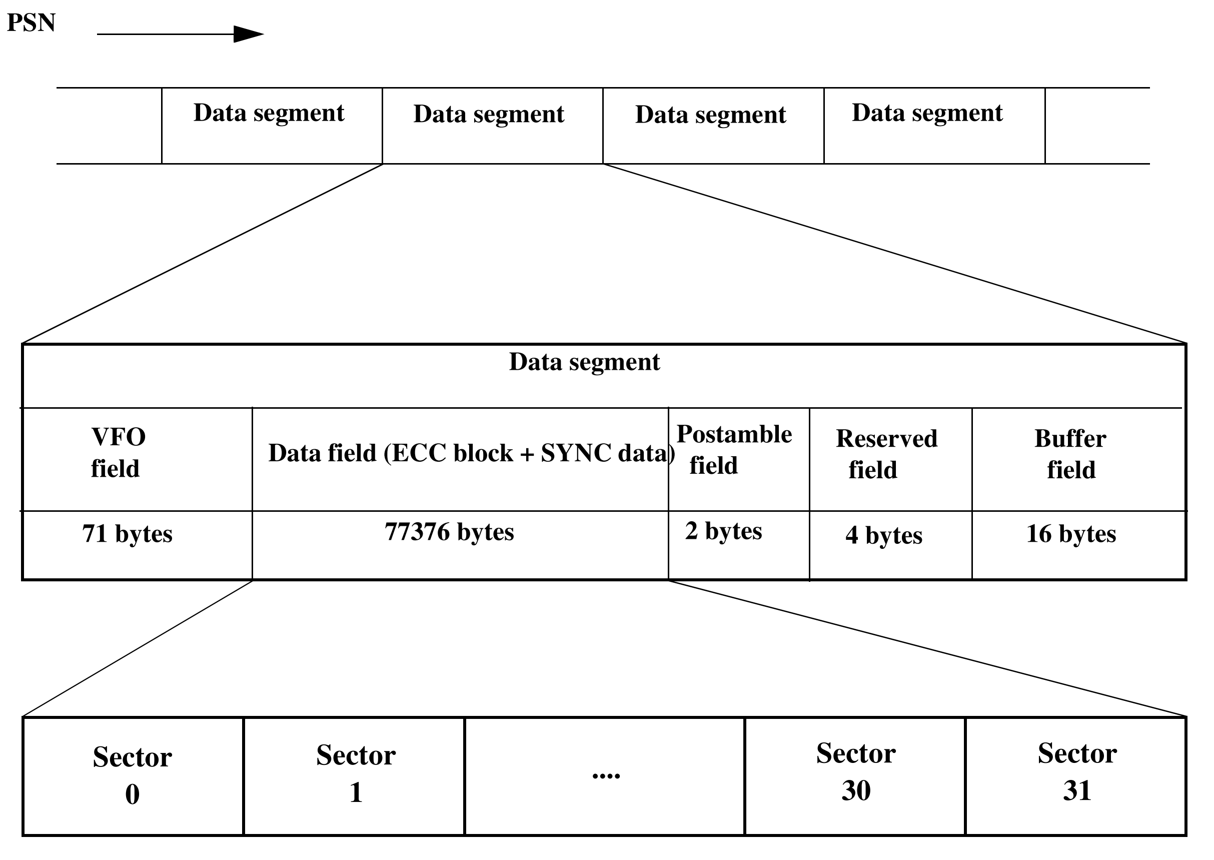


Figure 111 - Layout of a Data segment

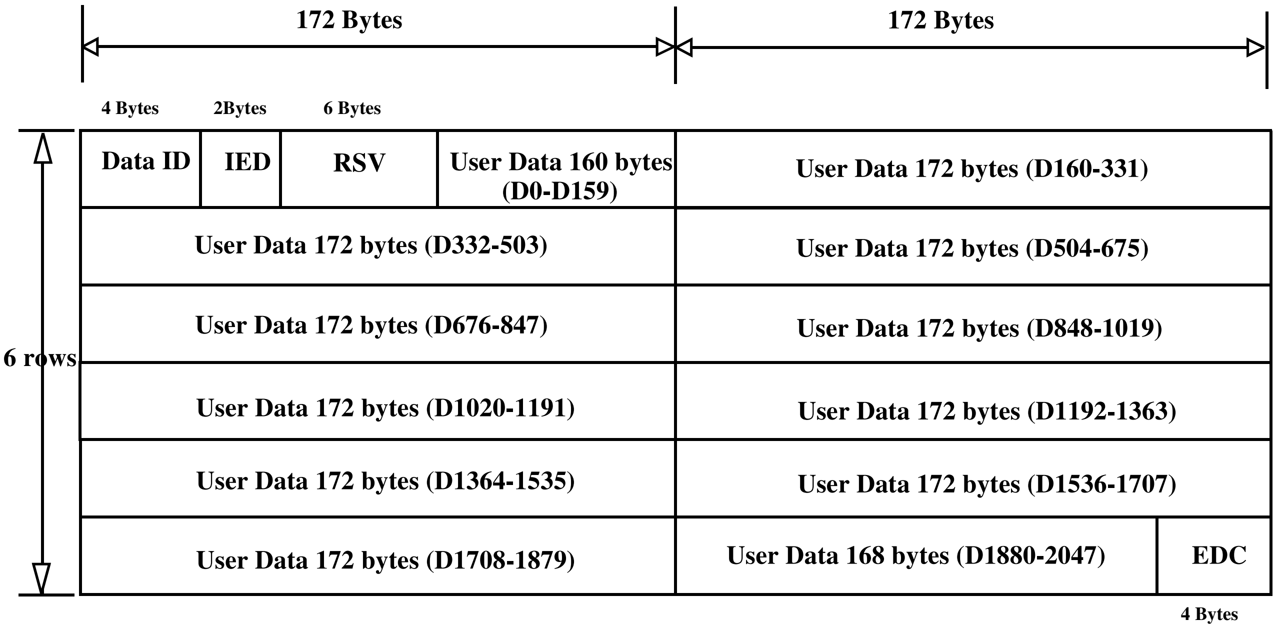


Figure 112 - Data frame layout

5.3.2 Data configuration of Data ID field

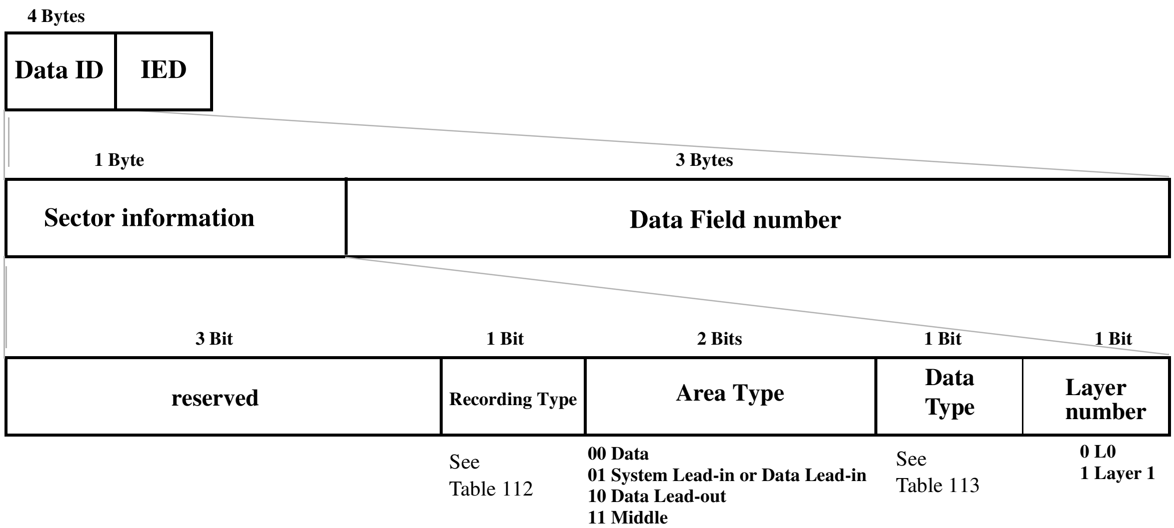


Figure 113 - Data ID field definition

The Data ID is located at the beginning of each sector and consists of 4 bytes. The Data Field number comprises PSN for HD DVD-ROM, and HD DVD-R. In the case of HD DVD-Rewritable, see Table 111.

Table 111 - Data Field Number for HD DVD media

Area	Contents
System Lead-in Area	PSN
Defect Management Area	PSN
Disc identification zones	PSN
Used ECC block[a] in Data Area	LBA + 030000h
Unused ECC block[b] in Data Area	One of the three conditions[c] (1) bit 0 to bit 4 in the first Physical sector : 0 the following Physical sectors : numbers serially increment from the first Physical sector (2) between 000000h to 00001Fh (3) unwritten

a. Used ECC block : ECC block which contains user data.
b. Unused ECC block : ECC block which contains no user data.
c. All the Physical sectors in a ECC block are in the same condition.

Table 112 - Recording Type bit definition for HD DVD-Rewritable media [a]

Area	Definition
System Lead-in Area	0b
Data Lead-in Area, Data Lead-out Area	0b
Data Area	0b: General data[b] 1b: Real-time data[c]

a. The definition of the bit for other than HD DVD-Rewritable media is Reserved.
b. General data: Linear replacement algorithm is applied to an ECC block containing the corresponding sector if the ECC block is defective.
c. Real-time data: Linear replacement algorithm is not applied to an ECC block containing the corresponding sector even if the ECC block is defective.

The Data Type bit specifies the data type of a sector as defined in Table 113.

Table 113 - Data Type bit definition

Media Type	Data Type bit	
	0	1
HD DVD-ROM	Read-only data	N/A
HD DVD-Rewritable	Read-only data	Rewritable data
HD DVD-R	Read-only data	Padding data[a]

a. Padding data is the data which does not include user data which is indicated by the host by using the command for writing, such as WRITE(10) command.

5.4 Data structure of Lead-in Area

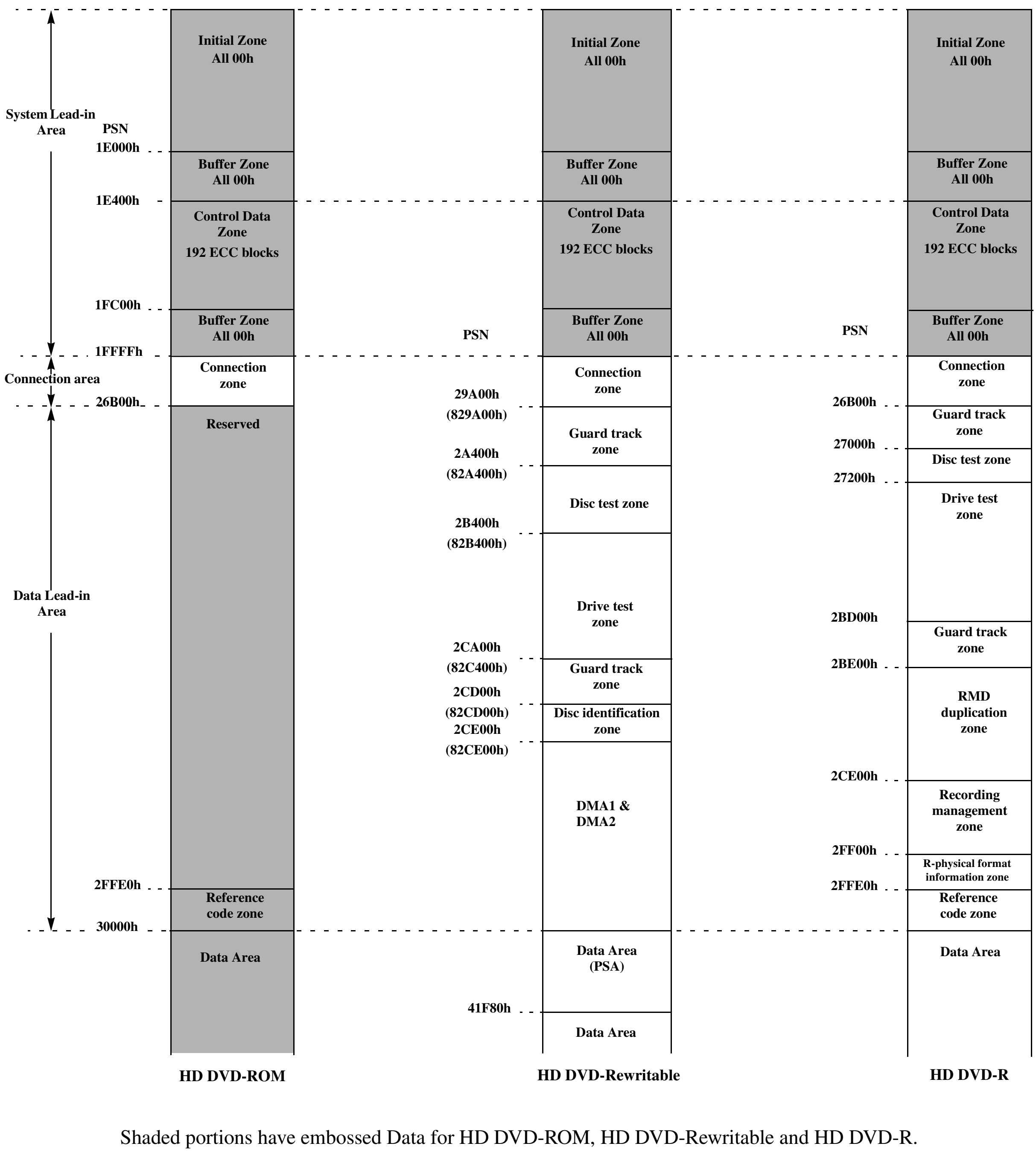


Figure 114 - Data Structure of the Lead-in

5.4.1 Structure of the Lead-in Area

The structure of the Lead-in Area is shown in Figure 114. The Lead-in Area consists of the System Lead-in Area, the Connection area and Data Lead-in Area.

5.4.2 System Lead-in Area

5.4.2.1 Control Data Zone

The Control Data Zone comprise 192 ECC blocks.

Figure 114 shows structure of a Control data zone.

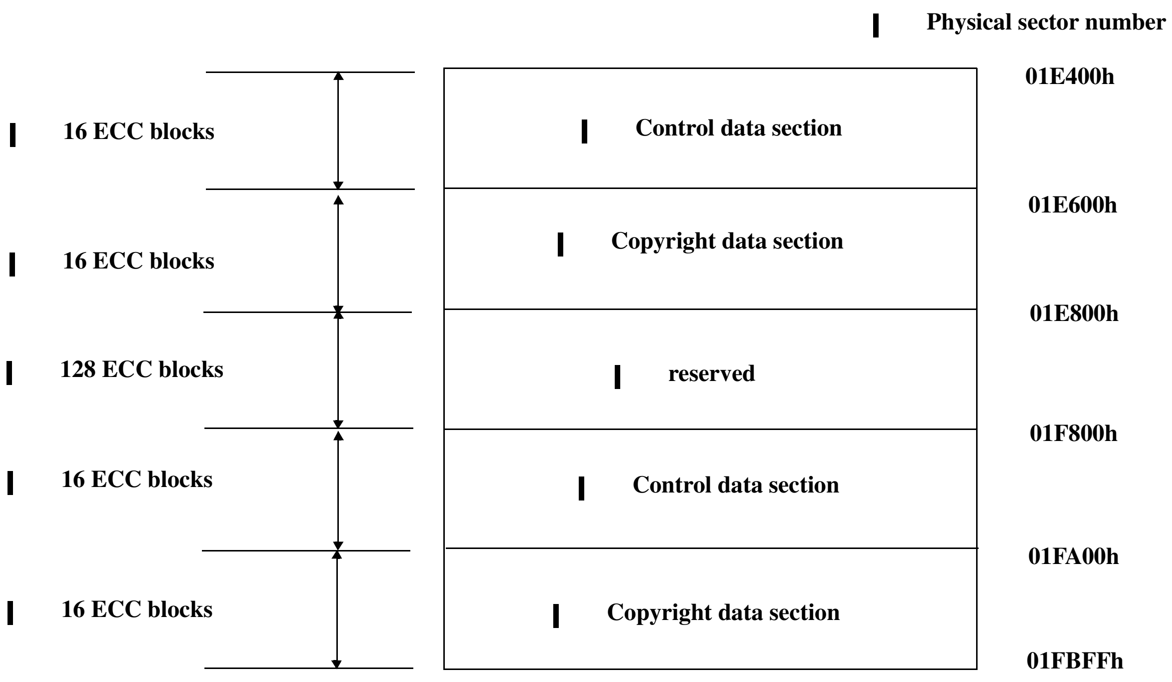


Figure 114 - Structure of a Control data zone

5.4.2.1.1 Control data section

The structure of a Control data section is shown in Table 114.

Table 114 - Structure of a Control data section

Sector Number	Description
0	Physical format information
1	Disc manufacturing information
2	Copyright protection information
3-31	Reserved

5.4.2.1.1.1 Control Data Zone sector descriptions

Table 115 shows the format of the Physical Format descriptor.

Table 115 - Common part of Physical Format Information

Byte \ Bit	7	6	5	4	3	2	1	0
0	Book Type				Part Version			
1	Disc Size				Maximum Transfer Rate			
2	Reserved	Number of Layers		Track Path	Layer Type			
3	Linear Density				Track Density			
4-15	Data Area Allocation							
16	BCA Flag	Reserved						
17	Revision number of maximum recording speed[a]							
18	Revision number of minimum recording speed[a]							
19-25	Revision number table of recording speed[a]							
26	Class[a]							
27	Extended Part Version							
28-31	Reserved							
32-2047	Medium Unique Data							

a. For HD DVD-ROM, these fields are reserved.

The Book Type field is described in Table 116.

Table 116 - Book Type field definition

Book Type Value	Definition
0000b	DVD-ROM
0001b	DVD-RAM
0010b	DVD-R
0011b	DVD-RW
0100b	HD DVD-ROM
0101b	HD DVD-Rewritable
0110b	HD DVD-R
others	Reserved

The Part Version field ***shall*** identify the version number within a Book Type.

Table 117 - Part Version field definition

Part Version Value	Definition
0000b	Version 0.9x for test use only, not for consumer product
0001b	Version 1.0x
0010b	Version 1.1x
0100b	Version 1.9x for test use only, not for consumer product
0101b	Version 2.0x, when byte 27 is 00h. Version 2.0x compatible, when byte 27 is not 00h and specifies actual version.
0110b	Version is higher than 2.0 and specified at byte 27
others	Reserved

The Disc Size field, when set to 0000b, ***shall*** indicate a 120mm disc. When set to 0001b, ***shall*** indicate an 80mm disc. All other values are reserved.

The Maximum Transfer Rate field ***shall*** identify the maximum data transfer rate found in the contents (e.g., video data) on the medium. See Table 118.

Table 118 - Maximum Transfer Rate field definition

Value	Definition
0000b	2.52 Mbps
0001b	5.04 Mbps
0010b	10.08Mbps
0011b	20.16Mbps
0100b	30.24Mbps
1111b	Not specified (Only for the writable medium)
Others	Reserved

The Number of Layers field identifies the number of Layers on the current side. 00b ***shall*** indicate one Layer, 01b ***shall*** indicate two Layers, and other values are reserved.

The Track Path field, when set to 0b, ***shall*** indicate a PTP or Single Layer disc. When set to 1b, ***shall*** indicate an OTP disc.

The Layer Type field ***shall*** identify the Layer according to Table 119.

Table 119 - Layer Type field definition

Bit	Definition
0	When set to one, the Layer contains embossed user Data Area
1	When set to one, the Layer contains recordable user Data Area
2	When set to one, the Layer contains re-writable user Data Area
3	Reserved

The Linear Density field ***shall*** identify the bit density according to Table 120.

Table 120 - Linear Density field definition

Value	Definition
0000b	0.267 µm/bit
0001b	0.293 µm/bit
0010b	0.409-0.435 µm/bit
0100b	0.280-0.291µm/bit
0101b	0.153 µm/bit
0110b	0.130-0.140 µm/bit
1000b	0.353 µm/bit
others	Reserved

The Track Density field ***shall*** identify the track density according to Table 121.

Table 121 - Track Density field definition

Value	Definition
0000b	0.74 µm/track
0001b	0.80 µm/track
0010b	0.615 µm/track
0011b	0.40 µm/track
0100b	0.34 µm/track
others	Reserved

Table 122 describes the contents of the Data Area Allocation field.

Table 122 - Data Area Allocation field definition

<table>
<tr><th>Byte</th><th>Single Layer/ PTP HD DVD-ROM</th><th>OTP HD DVD-ROM</th><th>HD DVD-R</th><th>HD DVD-Rewritable</th></tr>
<tr><td>4</td><td colspan="4">00h</td></tr>
<tr><td>5</td><td colspan="3" rowspan="3">Starting PSN of Data Area (030000h)</td><td rowspan="3">Starting PSN of Data Area in land track (030000h)</td></tr>
<tr><td>6</td></tr>
<tr><td>7</td></tr>
<tr><td>8</td><td colspan="4">00h</td></tr>
<tr><td>9</td><td colspan="2" rowspan="3">End PSN of Data Area</td><td rowspan="3">Outer limit of Data Recordable area</td><td rowspan="3">End PSN of Data Area in land track</td></tr>
<tr><td>10</td></tr>
<tr><td>11</td></tr>
<tr><td>12</td><td colspan="4">00h</td></tr>
<tr><td>13</td><td rowspan="3">000000h</td><td rowspan="3">End PSN in L0</td><td rowspan="3">000000h</td><td rowspan="3">Offset value between start PSN of the Data Area in land track and start PSN of the Data Area in groove track</td></tr>
<tr><td>14</td></tr>
<tr><td>15</td></tr>
</table>

For HD DVD-Rewritable, the end PSN is the PSN for the last spare sector of the last zone. It should not be used for counting user capacity.

The BCA Flag identifies the existence of Burst Cutting Area (BCA) on the medium. 0b ***shall*** indicate non-existence of BCA, 1b ***shall*** indicate existence of BCA on the medium.

The Revision number of maximum recording speed indicates the Revision number of maximum applicable recording speed of this disc.

The Revision number of minimum recording speed indicates the Revision number of minimum applicable recording speed of this disc.

The Revision number table field indicates the supported Revision numbers. These bit assignment rule is same as Byte 17.

The Class field indicates all Basic recording speeds contained in applicable recording speeds that the disc supports.

The Extended Part Version field indicates the major and minor digits of the Book Part version respectively.

Table 123 and Table 124 show the format unique descriptors for each media type.

Table 123 - HD DVD-ROM unique part of Physical Format Information

<table>
<tr><th>Bit / Byte</th><th>7</th><th>6</th><th>5</th><th>4</th><th>3</th><th>2</th><th>1</th><th>0</th></tr>
<tr><td>32-2047</td><td colspan="8">Reserved</td></tr>
</table>

Table 124 - HD DVD-Rewritable/R unique part of Physical Format Information

Bit / Byte	7	6	5	4	3	2	1	0
32-127	Reserved							
128	Mark polarity	Reserved						
129	Velocity							
130	Rim intensity in tangential direction							
131	Rim intensity in radial direction							
132	Read power							
133	Real number of 1st recording speed[a]							
134	Real number of 2nd recording speed[a]							
:	:							
147	Real number of 15th recording speed[a]							
148	Real number of 16th recording speed[a]							
149	Reflectivity of Data Area[a]							
150	Track Shape[a]	Amplitude of Push - Pull signal[a]						
151	On track signal[a]							
152 - 2047	Reserved							

a. For HD DVD-Rewritable, these fields are reserved.

The Mark polarity bit, when set to 0b, indicates that signal from mark is larger than signal from space, Low-to-High disc. When set to 1b, indicates that signal from mark is smaller than signal from space, High-to-Low disc.

The Velocity field defines linear velocity for the disc.

The Rim intensity in tangential direction field specifies the Rim intensity in tangential direction of the reference Optical Head that Read power field is defined.

The Rim intensity in radial direction field specifies the Rim intensity in radial direction of the reference Optical Head that Read power field is defined.

The Read power field specifies the Read power on the read-out surface of the disc for playback.

The Real number of 1st recording speed field specifies the real number of 1st recording speed. The actual 1st recording speed is one tenth of the field value. For example, 0000 1010b indicates 1x.

The Reflectivity of Data Area[a] field specifies the Reflectivity of Data Area. The actual Reflectivity of Data Area is one second of the field value. For example, 0010 1000b indicates 20%.

The Track Shape[a] bit specifies the track shape of the disc. This bit, when set to 0b, indicates that the track is on groove. When set to 1b, indicates that the track is on land. The Amplitude of Push - Pull signal[a] field specifies the Amplitude of Push - Pull signal. The actual Amplitude of Push - Pull signal is one hundredth of the field value. See HD DVD-R book. The On track signal[a] field specifies the amplitude of On track signal. See HD DVD-R book.

5.4.3 Connection area

The Connection area is located between the System Lead-in Area and Data Lead-in Area. This area does not have any embossed pits or grooves.

5.4.4 Data Lead-in Area

The structure of Data Lead-in Area for each media is different.

5.4.4.1 Data Lead-in Area for HD DVD-ROM

5.4.4.1.1 Reference code zone

The Reference Code Zone contains repetition of the Data Symbol "164" with added scrambled data.

5.4.4.2 Data Lead-in Area for HD DVD-Rewritable

5.4.4.2.1 Guard track zone

The ECC blocks of the Guard track zone do not contain data.

5.4.4.2.2 Disc test zone

This zone is intended for quality tests by the disc manufacturer.

5.4.4.2.3 Drive test zone

This zone is intended for tests by a drive.

5.4.4.2.4 Disc identification zone

This zone contains Drive information and a reserved area.

5.4.4.2.5 Defect Management zone

This zone contains DMA (Defect Management Area) manager sets and DMA (Defect Management Area). See *5.14.6 "Defect management for HD DVD-Rewritable media"* on page 308.

5.4.4.3 Data Lead-in Area for HD DVD-R

5.4.4.3.1 Guard track zone

The ECC blocks of the Guard track zone do not contain data.

5.4.4.3.2 Disc Test zone

This zone is intended for quality tests by the disc manufacturer

5.4.4.3.3 Drive Test zone

This zone is intended for tests by a drive.

5.4.4.3.4 Recording Management Data Duplication Zone (RDZ)

The RDZ Recording Management Data (RMD) in each Recording Management Zone (RMZ) that is fully recorded. When the RMZ is extended, the latest RMD is recorded in this zone. For more explanation of RMZ and RMD, see *5.13.2.1 "RMZ (Recording Management Zone)"* on page 269 and *5.13.3 "Recording model for HD DVD-R media"* on page 282.

The size of RDZ is 128 ECC blocks. The first ECC block of the RDZ is used as RDZ Lead-in. The rest of the RDZ is used to store up to 127 RMDs.

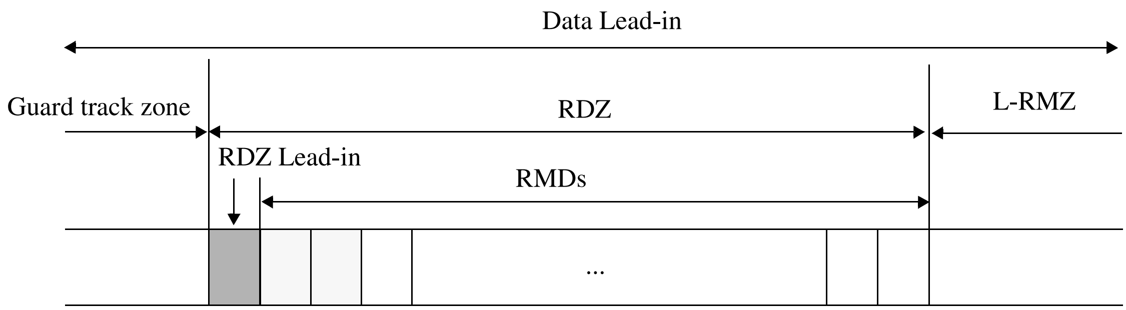


Figure 115 - Layout of the RDZ

5.4.4.3.5 Recording management zone (L-RMZ)

This zone consists of RMD. The size of L-RMZ is 392 ECC blocks. See *5.13.3 "Recording model for HD DVD-R media"* on page 282.

5.4.4.3.6 R-Physical format information

This zone is comprised of 7 ECC blocks. The content of the first ECC block in this zone is repeated 7 times. The structure of R-Physical format information is shown in Table 125. The format of the Physical Format descriptor is same as the format of the Physical Format descriptor in System Lead-in Area (Table 115, Table 124) except the Data Area allocation field and the Start PSN of Border Zone field. The definition of the Data Area allocation field is shown in Table 126, the definition of the Start PSN of Border Zone field is shown in Table 127.

Table 125 - Structure of the R-Physical format information

Sector number	Description
0	Reserved
1	Disc manufacturing information
2	Physical format information
3-31	Reserved

Table 126 - Data Area allocation filed definition

Byte	definition
4	00h
5-7	Start PSN of the Data Area (30000h)
8	00h
9-11	Last recorded PSN of last RZone in the User data zone
12	00h
13-15	000000h

Table 127 - Start PSN of Border Zone field definition

Byte	definition
133-136	Start PSN of the current Border-out
137-140	Start PSN of the next Border-in

5.4.4.3.7 Reference code zone

The Reference Code Zone contains repetition of the Data Symbol "164" with added scrambled data.

5.5 Data structure of Lead-out Area

5.5.1 System Lead-out Area

The System Lead-out Area is located Layer 1 in Opposite Track Path HD DVD-ROM media. See Figure 107. This area is set to 00h.

5.5.2 Data Lead-out Area

The Data Lead-out Area is located in all HD DVD media. The structure of the Data Lead-out Area in each HD DVD media refer to below.

5.5.2.1 Data Lead-out Area for HD DVD-ROM

The Data Lead-out Area for HD DVD-ROM is located in all kind of HD DVD-ROM media. See Figure 105, Figure 106, Figure 107. This area is set to 00h.

5.5.2.2 Data Lead-out Area for HD DVD-R

The Data Lead-out Area for HD DVD-R is located outer area. The structure of the Data Lead-out Area is different between finalized disc and non-finalized disc.

For non-finalized disc, the Data Lead-out Area consists of Guard zone, Drive test zone and Disc test zone. This area size is variable. There are two kinds of the Data Lead-out Area structure, shown in Figure 116. One is the original structure, the other is the structure after extending test zone.

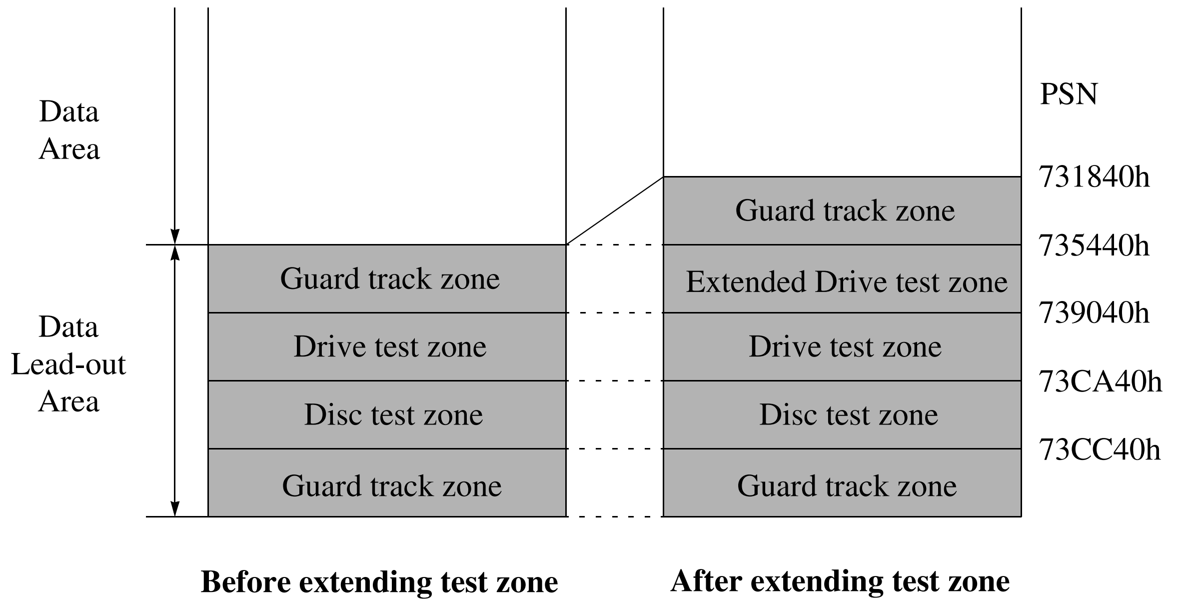


Figure 116 - Structure of Data Lead-out Area for non-finalized HD DVD-R

For finalized disc, the Data Lead-out Area is located from Borer-out (Area type 10h) or Terminator to outer of the disc. See *5.13.10 "Disc Final Closure"* on page 291.

5.5.2.3 Data Lead-out Area for HD DVD-Rewritable

The Data Lead-out Area for HD DVD-Rewritable is located outer area, both land and groove. This area consists of Defect Management zone, Guard track zone, Drive test zone and Disc test zone. Shown in Figure 117.

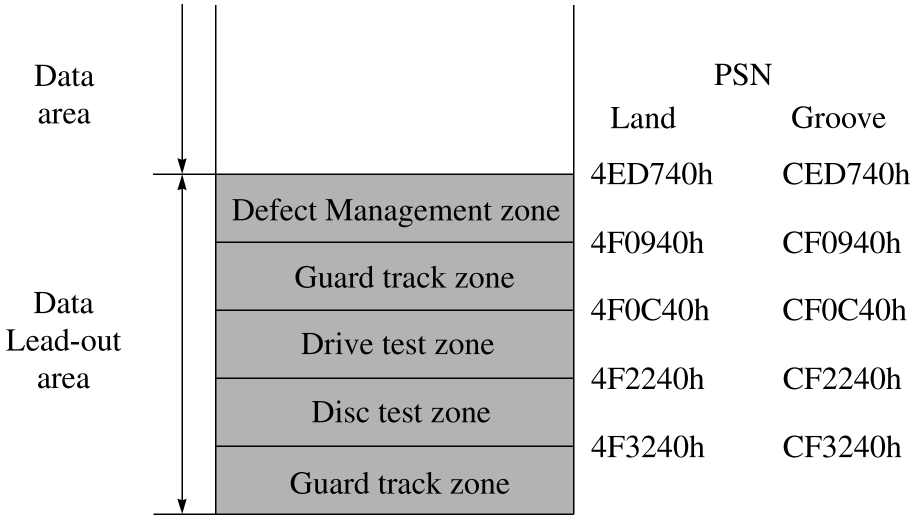


Figure 117 - Structure of Data Lead-out Area for HD DVD-Rewritable

5.6 HD DVD READY condition/NOT READY condition

The READY condition occurs after a disc is inserted and the logical unit has performed its initialization tasks. These may include reading the Lead-in information from the media. This "READY" is different from and should not be confused with the ATA READY status. A CHECK CONDITION status ***shall*** be returned for the NOT READY condition only for commands that require or imply a disc access.

A NOT READY condition may occur for the following reasons:

1. There is no disc mounted, see *5.8, "Removable medium"* on page 265
2. The logical unit is unable to load or unload the disc.
3. The logical unit is performing an extended operation as the result of an Immediate mode command such as FORMAT UNIT. The logical unit ***shall*** attempt to spin up and make the disc ready for media accesses when a new disc is detected.

After the logical unit becomes ready, the logical unit may enter the power state in which the logical unit was when the previous medium was removed.

Any media access that occurs when the logical unit is in the IDLE or STANDBY state ***shall*** spin the media up and not generate an error. Any media access that is requested while a deferred operation is in progress (i.e. writing from a write cache) ***shall not*** generate an error. Any media access that is requested while the logical unit is processing an Immediate command, e.g., FORMAT UNIT with the Immediate bit set, may result in a NOT READY condition.

Note: Accesses to the media can be satisfied from the logical unit's cache and may not require the media to be spinning.

5.7 Error reporting

If any of the following conditions occur during the execution of a command, the logical unit ***shall*** return CHECK CONDITION status. The appropriate Sense Key and additional sense code ***shall*** 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 128 - Error conditions and Sense Keys

Condition	Sense Key
Invalid logical block address	ILLEGAL REQUEST
Unsupported option requested	ILLEGAL REQUEST
Attempt to read a blank block (where illegal)	ILLEGAL REQUEST
Attempt to play a data block as audio	ILLEGAL REQUEST
Logical unit reset or medium change since last command	UNIT ATTENTION
Self diagnostic failed	HARDWARE ERROR
Unrecovered 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.

5.8 Removable medium

HD DVD medium is sometimes contained within a cartridge to prevent damage to the recording surfaces. The combination of medium and optional cartridge is often called a volume.

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 or is able to format it. A mounted disc may not be accessible by a host if it has been reserved by another host. A disc is de-mounted at any other time (e.g., during loading, unloading, or storage).

A host may check whether a disc is mounted by issuing a TEST UNIT READY command. In addition, there now exists the Removable Medium Feature. This Feature allows the host 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 a host to restrict the demounting 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 demounting of the disc. If the host issues a START/STOP UNIT command to eject the disc, and is prevented from demounting by the PREVENT/ALLOW MEDIUM REMOVAL command, the START/STOP UNIT command is rejected by the logical unit.

5.9 Logical blocks

Blocks of data are stored on the medium along with additional information that the controller uses to manage the storage and retrieval. The format of the additional information is unique and is hidden from the host 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 the 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 FORMAT CAPACITIES 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 is terminated with CHECK CONDITION status, 5/21/00 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 length ***shall not*** be different for each logical block on the medium. The block descriptor in the MODE SENSE (10) data describes the block length that is used on the medium. The block descriptor ***shall not*** be present for an ATAPI C/DVD/HD DVD logical unit. In addition, the Block Descriptor has been made Obsolete in this specification.

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].

5.10 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 accessible by the host. 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 host 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 host may wish to have 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 host to control other behavior of the cache memory:

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

5.11 Seek

The SEEK command provides a way for the host to position the logical unit in preparation for access to a particular logical block at some later time. Since this positioning action is implicit in other commands, the SEEK command may not be useful with some logical units.

5.12 Difference between HD DVD and DVD

Table 129 shows Profile for HD DVD.

Table 129 - Profile for HD DVD

Profile
0050h : HD DVD-ROM
0051h : HD DVD-R
0052h : HD DVD-Rewritable

5.12.1 HD DVD-ROM vs. DVD-ROM

- AACS Authentication
- retrieving Copyright data section from the Lead-in Area

Table 130 - Mandatory Features for HD DVD-ROM, DVD-ROM

Feature	HD DVD-ROM	DVD-ROM
0000h Profile List	Mandatory	Mandatory
0001h Core	Mandatory	Mandatory
0002h Morphing	Mandatory	Mandatory
0003h Removable Medium	Mandatory	Mandatory
0010h Random Readable, PP = 1	Mandatory	Mandatory
0050h HD DVD Read	Mandatory	-
001Fh DVD Read	-	Mandatory
0100h Power Management	Mandatory	Mandatory
0105h Time-out	Mandatory	Mandatory
0107h Real-Time Streaming	Mandatory	Mandatory

5.12.2 HD DVD-R vs. DVD-R

- AACS Authentication
- retrieving Copyright data section from the Lead-in Area
- RMZ extension
- Drive Test zone extension
- Finalization method

Table 131 - Mandatory Features for HD DVD-R, DVD-R

Feature	HD DVD-R	DVD-R
0000h Profile List	Mandatory	Mandatory
0001h Core	Mandatory	Mandatory
0002h Morphing	Mandatory	Mandatory
0003h Removable Medium	Mandatory	Mandatory
0010h Random Readable, PP = 1	Mandatory	Mandatory
001Fh DVD Read	-	Mandatory
0021h Incremental Streaming Writable	Mandatory	Mandatory
002Fh DVD-R/-RW Write	-	Mandatory
0050h HD DVD Read	Mandatory	-
0051h HD DVD Write	Mandatory	-
0100h Power Management	Mandatory	Mandatory
0105h Time-out	Mandatory	Mandatory
0107h Real-Time Streaming	Mandatory	Mandatory
0108h Logical unit serial number	Mandatory	Mandatory

5.12.3 HD DVD-Rewritable vs. DVD-RAM

- AACS Authentication
- retrieving Copyright data section from the Lead-in Area

Table 132 - Mandatory Features for HD DVD-Rewritable, DVD-RAM

Feature	HD DVD-Rewritable	DVD-RAM
0000h Profile List	Mandatory	Mandatory
0001h Core	Mandatory	Mandatory
0002h Morphing	Mandatory	Mandatory
0003h Removable Medium	Mandatory	Mandatory
0010h Random Readable, PP = 1	Mandatory	Mandatory
001Fh DVD Read	-	Mandatory
0020h Random Writable	Mandatory	Mandatory
0023h Formattable	Mandatory	Mandatory
0024h Hardware Defect Management	Mandatory	Mandatory
0050h HD DVD Read	Mandatory	-
0051h HD DVD Write	Mandatory	-
0100h Power Management	Mandatory	Mandatory
0105h Time-out	Mandatory	Mandatory
0107h Real-Time Streaming	Mandatory	Mandatory

5.13 Recording for HD DVD-R media

5.13.1 Basics for HD DVD-R vs. DVD-R

HD DVD-R is similar to DVD-R. It is a write-once media that in most cases will be readable by a HD DVD read-only logical unit.

5.13.2 HD DVD-R media Structure

Example of HD DVD-R media structure is shown in Figure 118.

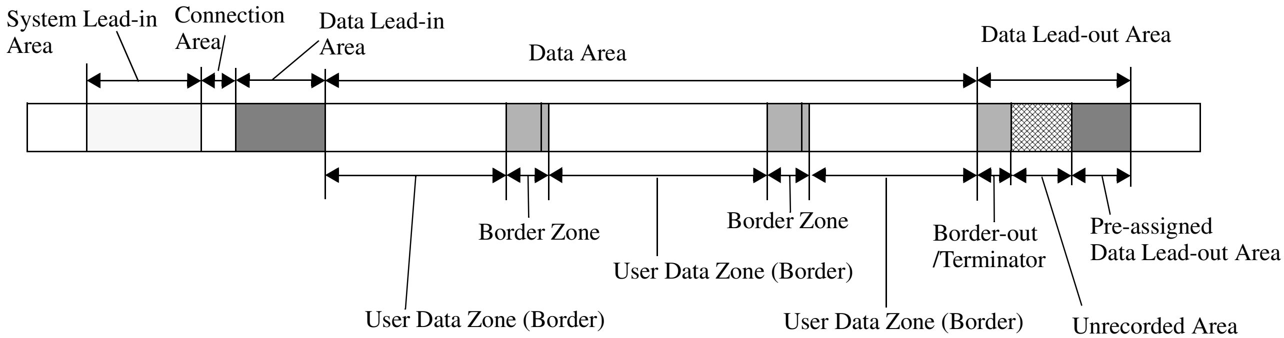


Figure 118 - Example of the finalized disc structure

5.13.2.1 RMZ (Recording Management Zone)

The RMZ consists of RMDs. There are three kinds of RMZs as follows:

1. RMZ in the Lead-in Area (L-RMZ)
   This RMZ is used from the beginning of use of the disc.
2. Extended RMZ in the Border-in (B-RMZ)
   This RMZ is an extension of the RMZ. The B-RMZ is used when an HD DVD-R disc has multi Border structure. The B-RMZ is created by CLOSE TRACK/RZONE/SESSION/BORDER Command.
3. Extended RMZ in the User Data Zone (U-RMZ)
   This RMZ is an extension of the RMZ. The U-RMZ is created without closing Border by RESERVE TRACK/ RZONE/RMZ Command.

5.13.2.1.1 RMD (Recording Management Data)

The RMD is 64 KBytes in length and is recorded as an ECC block. The RMD is recorded in L-RMZ, B-RMZ and U-RMZ. The L-RMZ size allows for 392 RMD updates. The B-RMZ size allows for 200 (inner), 150 (middle) or 100 (outer) RMD updates depending on the radial location of the Border Zone. The B-RMZ size is shown in Table 133. The U-RMZ size allows for 128 RMD updates.

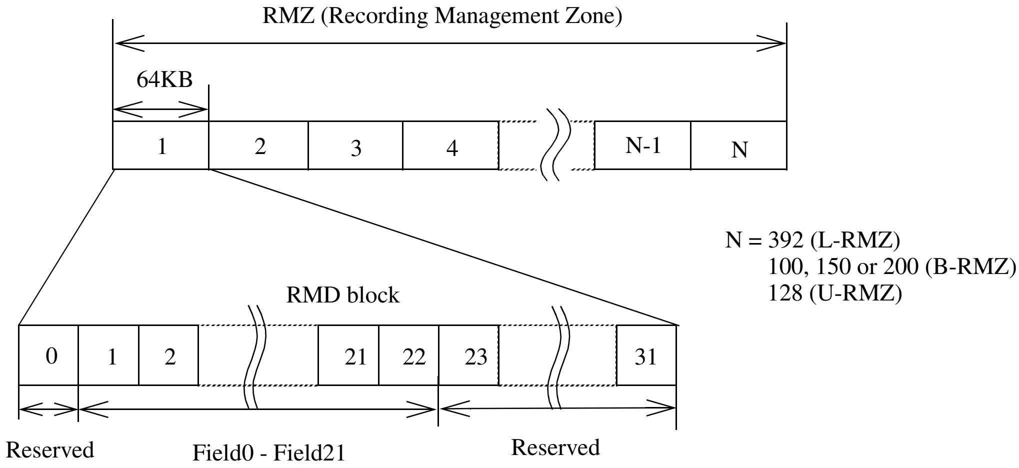


Figure 119 - RMD structure and location in RMZ

Table 133 - B-RMZ size for HD DVD-R media

The first LBA of a Border-zone	01FE00h to 1A0DFFh	1A0E00h to 3E1BFFh	3E1C00h to -
Size (ECC block)	200	150	100

5.13.2.1.1.1 The contents of RMD

RMD contains 22 RMD Fields. The other sectors are reserved. Each RMD Field is 2048 bytes in length.

5.13.2.1.1.2 RMD Field 0 (RMD Header)

RMD Field 0 specifies general information of the disc and is recorded as follows.

Table 134 - RMD - Field 0

Bit / Byte	7	6	5	4	3	2	1	0
0-1	(MSB)			RMD Format				(LSB)
2				Disc Status				
3				Reserved				
4-21	(MSB)			Unique Disc ID				(LSB)
22-33	(MSB)			Data Area allocation				(LSB)
34-45	(MSB)			Renewed Data Area allocation				(LSB)
46-2047				Reserved				

The RMD Format field specifies the RMD Format Code. The RMD Format Code indicates the recording format of the RMD.

These bytes are set to 0001h.

The Disc Status field indicates the disc status. Disc Status field is defined in Table 135.

Table 135 - Disc Status field definition

Value	Interpretation
0	To indicate that the disc has no written data in Data Recordable Area (only RMD is written)
1	Reserved
2	To indicate that the disc is recorded user data and not finalized
3	To indicate that the disc is finalized
4-255	Reserved

The Unique Disc ID field is recorded and structured as defined in Table 136. The Unique Disc Identifier contains time stamp fields. The time format should be UTC 24 hour clock[1]. This field ***shall*** be set by the SEND DISC STRUCTURE command. This time stamp data sent by the SEND DISC STRUCTURE command may also be used in the OPC related field in RMD field 1 and may help the judgement to do OPC. The logical unit ***shall*** update the time stamp during power on. Strict accuracy of time is not required.

Table 136 - Unique Disc ID

Bit / Byte	7	6	5	4	3	2	1	0
0-1	Reserved							
2-3	(MSB)			Random Data				(LSB)
4-7	(MSB)			Year				(LSB)
8-9	(MSB)			Month				(LSB)
10-11	(MSB)			Day				(LSB)
12-13	(MSB)			Hour				(LSB)
14-15	(MSB)			Minute				(LSB)
16-17	(MSB)			Second				(LSB)

The Random Data field is a random number.

The Year field specifies the year coded in ASCII in the range “0001” to “9999”.

The Month field specifies the month of the year coded in ASCII in the range “01” to “12”.

The Day field specifies the day of the month coded in ASCII in the range “01” to “31”.

The Hour field specifies the hour of the day coded in ASCII in the range “00” to “23”.

The Minute field specifies the minute of the hour coded in ASCII in the range “00” to “59”.

The Second field specifies the second of the minute coded in ASCII in the range “00” to “59”.

The Data Area allocation field is recorded and structured as defined in Table 137.

1. UTC = universal time coordinated

Table 137 - Data Area allocation

Bit / Byte	7	6	5	4	3	2	1	0
22	00h							
23 -25	Start PSN of the Data Area (PSN = 30000h)							
26	00h							
27 - 29	Outer limit of Data Recordable area (PSN = 73543Fh)							
30	00h							
31 - 33	000000h							

The Renewed Data Area allocation field is recorded and structured as defined in Table 138.

Table 138 - Renewed Data Area allocation

Bit / Byte	7	6	5	4	3	2	1	0
34	Renewal descriptor							
35-37	Start PSN of the Data Area (PSN = 30000h)							
38	00h							
39-41	Renewed outer limit of Data Recordable area (PSN = 73183Fh)							
42	00h							
43-45	000000h							

Renewal descriptor field specifies the existence of the Extended drive test zone, defined in Table 139.

Table 139 - Renewal descriptor

Value	Interpretation
0	The Extended drive test zone does not exist
1	The Extended drive test zone exists
2-255	Reserved

5.13.2.1.1.3 RMD Field 1

RMD Field 1 contains some logical unit and OPC related information and is recorded as defined in Table 140. There are four sets of OPC data blocks. These are prepared for the case of four different HD DVD-R logical units writing to a disc. The logical unit ***shall*** use an empty set or its own. If there is no owned or empty OPC data block, the logical unit may use the oldest time stamp OPC data block.

Table 140 - RMD - Field 1 (logical unit & OPC information)

Bit / Byte	7	6	5	4	3	2	1	0
0-31	Drive manufacturer ID#1							
32-47	Serial Number #1							
48-63	Model Number #1							
64-71	Time stamp #1							
72-75	Inner test zone address #1							
76-79	Outer test zone address #1							
80-103	Running OPC Information #1							
104-105	DSV #1							
106-255	Reserved #1							
256-287	Drive manufacturer ID #2							
288-303	Serial Number #2							
304-319	Model Number #2							
320-327	Time stamp #2							
328-331	Inner test zone address #2							
332-335	Outer test zone address #2							
336-359	Running OPC Information #2							
360-361	DSV #2							
361-511	Reserved #2							
:	:							
768-799	Drive manufacturer ID#4							
800-815	Serial Number #4							
816-831	Model Number #4							
832-839	Time stamp #4							
840-843	Inner test zone address #4							
844-847	Outer test zone address #4							
848-871	Running OPC Information #4							
872-873	DSV #4							
874-1023	Reserved #4							
1024-2047	Reserved							

The Drive manufacturer ID #n field is recorded in binary and specifies unique drive manufacturer identifier of the logical unit.

The Serial Number #n field is recorded as ASCII code and specifies serial number of the logical unit.

The Model Number #n field is recorded as ASCII code and specifies the recorder model number.

The Timestamp #n field may be used to store date and time when OPC is performed. This field, if used, is recorded in binary. If this field is set to 0, this field is invalid.

The Inner test zone #n field is recorded in binary and specifies the start ECC block address of the Drive test zone in the Data Lead-in Area where the last power calibration is performed. If these fields are set to 00h, then they are invalid.

The Outer test zone #n field is recorded in binary and specifies the start ECC block address of the Drive test zone in the Data Lead-out Area where the last power calibration is performed. If these fields are set to 00h, then they are invalid.

The Running OPC Information field may be used to specify values concerning running OPC. The format is vendor-specific. If this field is set to 0, this field is invalid.

If the disc is incrementally recorded and when RMD is updated, the DSV field is recorded. This field is used to specify the last DSV (Digital Sum Value) in binary notation. If this field is set to 0, this field is invalid.

5.13.2.1.1.4 RMD Field 2

RMD Field 2 can be used freely and format of this field is user-specific.

Table 141 - RMD - Field 2 (User Specific Data)

Bit / Byte	7	6	5	4	3	2	1	0
0-2047	(MSB)			User Specific Data				(LSB)

The User Specific Data field is available for user specific data. This field may be used, otherwise this field is set to 0.

5.13.2.1.1.5 RMD Field 3

RMD Field 3 may contains Border Zone information and is recorded as follows.

Table 142 - RMD - Field 3 (Border Zone Information)

Bit / Byte	7	6	5	4	3	2	1	0
0-3	(MSB)			Start PSN of Border-out #1				(LSB)
4-7	(MSB)			Start PSN of Border-out #2				(LSB)
:				:				
508-511	(MSB)			Start PSN of Border-out #128				(LSB)
512-513	(MSB)			Open RMZ number				(LSB)
514-527				Reserved				
528-531	(MSB)			Start PSN of B/U-RMZ #1				(LSB)
532-535	(MSB)			Size of B/U-RMZ #1				(LSB)
536-539	(MSB)			Start PSN of B/U-RMZ #2				(LSB)
540-543	(MSB)			Size of B/U-RMZ #2				(LSB)
:				:				
1536-1539	(MSB)			Start PSN of B/U-RMZ #127				(LSB)
1540-1543	(MSB)			Size of B/U-RMZ #127				(LSB)
1544-2047	(MSB)			Reserved				(LSB)

The Start PSN of Border-out #n field, if it contains other than 0, indicates that the start PSN of the Border-out.

The Open B/U-RMZ number field indicates B-RMZ number or U-RMZ number where the latest RMD is recorded.

The Start PSN of B/U-RMZ #n field, if it contains other than 0, indicates that the start PSN of the B-RMZ or U-RMZ.

The Size of B/U-RMZ #n field, if it contains other than 0, indicates that the size of the B-RMZ or U-RMZ.

*Note: (1) The maximum number of Border-out is prescribed by the times which RMD is updated in RDZ, because RMD **shall** be updated in RDZ when the Border-out is newly_created. The maximum number which RMD is updated in RDZ is 127. In addition, when the disc is finalized, Border-out is created without updating RMD in RDZ. Therefore, 128 of the total number is the maximum number of Border-out. B-RMZ is also created when Border-out is created without disc finalization. And also RMD **shall** be updated in RDZ when U-RMZ is newly assigned. Therefore, the maximum number of U-RMZ is 127. Because RDZ is commonly used within those updates, each upper limit of RMD updates is changed by the other RMD updates in RDZ. After a new RMZ is created, RMZ which is used till then become not available. The pointer for the RMD update shall be only one in the disc.*

(2) When Border-out is created, the position of the next Border-in is decided without the finalization. Therefore, the available address for B-RMZ in the next Border-in is decided.

5.13.2.1.1.6 RMD Field 4

RMD Field 4 contains RZone related information and is recorded as follows.

Table 143 - RMD - Field 4 (RZone Information)

Bit / Byte	7	6	5	4	3	2	1	0
0-1	(MSB)			Invisible/Incomplete RZone Number (last RZone number)				(LSB)
2-3	(MSB)			First Open RZone number				(LSB)
4-5	(MSB)			Second Open RZone number				(LSB)
6-15				Reserved				
16-19	(MSB)			Start PSN of RZone #1				(LSB)
20-23	(MSB)			Last Recorded PSN of RZone #1				(LSB)
24-27	(MSB)			Start PSN of RZone #2				(LSB)
28-31	(MSB)			Last Recorded PSN of RZone #2				(LSB)
:				:				
2032-2035	(MSB)			Start PSN of RZone #253				(LSB)
2036-2039	(MSB)			Last Recorded PSN of RZone #253				(LSB)
2040-2043	(MSB)			Start PSN of RZone #254				(LSB)
2044-2047	(MSB)			Last Recorded PSN of RZone #254				(LSB)

The Invisible/Incomplete RZone Number field contains the Invisible/Incomplete RZone number of the medium. If the last RZone state is neither Invisible nor Incomplete due to disc finalization, this field contains the last complete RZone number.

The First Open RZone Number field, if recorded with value other than 0, contains the current appendable Reserved RZone number and the value is different from the Second Open RZone Number field. If this field is set to 0, there is no Empty Reserved RZone or Partially Recorded Reserved RZone corresponding to this field.

The Second Open RZone Number field, if recorded with value other than 0, contains the current appendable Reserved RZone number and the value is different from the First Open RZone Number field. If this field is set to 0, there is no Empty Reserved RZone or Partially Recorded Reserved RZone corresponding to this field.

When the Incomplete RZone is closed, the Invisible/Incomplete RZone Number field contains the number of the new Invisible RZone number (N+1). When Reserved RZone is closed, the corresponding First (Second) Open RZone number field ***shall*** be set to 0.

The Start PSN of RZone #n field contains the start PSN of the RZone which has RZone number #n.

The Last Recorded PSN of RZone #n field contains the last recorded PSN of the RZone which has RZone number #n. If this field is set to 0, this field is not valid. If RZone #n is not closed, the value of this field may not be correct and logical unit ***shall*** search the correct LRA by the other method.

When RZone is closed, this field contains the last PSN of the data except the padding data in the RZone.

Note: The LRA information in the latest RMD may not be correct. Host can get the correct LRA by the READ TRACK/ RZONE INFORMATION command. In this case, logical unit reports the correct LRA not by using the latest RMD. See number 7 in Table 145 - Mandatory RMD update condition in RMZ on page 277.

5.13.2.1.1.7 RMD Field 5-Field 21

RMD Field 5 through Field 21 may contain RZone related information continued from RMD Field 4.

Table 144 - RMD - Field 5-Field 21 (RZone Information ... continued)

Bit / Byte	7	6	5	4	3	2	1	0
0-3	(MSB)			Start PSN of RZone #n				(LSB)
4-7	(MSB)			Last Recorded PSN of RZone #n				(LSB)
8-11	(MSB)			Start PSN of RZone #(n+1)				(LSB)
12-15	(MSB)			Last Recorded PSN of RZone #(n+1)				(LSB)
:				:				
2032-2035	(MSB)			Start PSN of RZone #(n+254)				(LSB)
2036-2039	(MSB)			Last Recorded PSN of RZone #(n+254)				(LSB)
2040-2043	(MSB)			Start PSN of RZone #(n+255)				(LSB)
2044-2047	(MSB)			Last Recorded PSN of RZone #(n+255)				(LSB)

The Start PSN of RZone #n field contains start PSN of the RZone which has RZone number #n.

The Last Recorded PSN of RZone #n field contains the last recorded PSN of the RZone which has RZone number #n. If this field is set to 0, this field is not valid. If RZone #n is not closed, the value of this field may not be correct and logical unit ***shall*** search the correct LRA by the other method.

When the RZone is not closed, even if the Last Recorded PSN of RZone #n field contains a value, the logical unit determines the current LRA of the RZone. When RZone is closed, this field contains the last PSN of the data except the padding data in the RZone.

Note: The LRA information in the latest RMD may not be correct. Host can get the correct LRA by the READ TRACK/ RZONE INFORMATION command. In this case, logical unit reports the correct LRA not by using the latest RMD. See number 7 in Table 145 - Mandatory RMD update condition in RMZ on page 277.

5.13.2.1.2 Update timing of RMD in RMZ

To keep the disc interchangeability, information related to RZone, Border Zone, RMZ and Test Zone structures shall be updated in cached RMD. The cached RMD ***shall*** be written on the disc in the conditions described in Table 145.

Table 145 - Mandatory RMD update condition in RMZ

Condition
Condition 1.When a RESERVE TRACK/RZONE/RMZ command with RMZ bit =0 is issued, RMD ***shall*** be written in RMZ.
Condition 2. When a CLOSE TRACK/RZONE/SESSION/BORDER command with Close Function field = 001b or 010b is issued, RMD ***shall*** be written in RMZ. Then when the command indicates to close Border, all unrecorded ECC blocks in RMZ ***shall*** be padded with the latest RMD.
Condition 3. When a CLOSE TRACK/RZONE/SESSION/BORDER command with Close Function field = 110b is issued (except indicating to record Terminator), RMD ***shall*** be written in RMZ. All unrecorded ECC blocks in RMZ ***shall*** be padded with the latest RMD.
Condition 4. When a RESERVE TRACK/RZONE/RMZ command with RMZ bit =1 is issued, RMD ***shall*** be written in RMZ. All unrecorded ECC blocks in RMZ ***shall*** be padded with the latest RMD.
Condition 5. When a FORMAT UNIT command with format type = 16h is issued, RMD ***shall*** be written in RMZ.
Condition 6. When an OPC operation is done, RMD ***shall*** be updated prior to medium ejection or entering the sleep state.
Condition 7. When the difference between the last recorded sector number in fact and "Last Recorded Address of RZone #n" recorded in the latest RMD is larger than 16 MB[a], RMD ***shall*** be written in RMZ. However if the logical unit is busy (e.g., writing is in progress), the update may be done at a later time.

a. To force updating the RMD, the host should close the Incomplete RZone.

By using RMD caching, the logical unit can avoid waste of RMZ. The latest RMD ***shall*** be written in RMZ prior to removing the disc from the logical unit, when the contents of the cached RMD is different from the contents of the latest RMD on the disc. But when the difference between the last recorded sector number in fact and "Last Recorded Address of RZone #n" recorded in the latest RMD is less than 16 MB, there is no need for writing the cached RMD on the disc.

In the case of condition 6 and condition 7 in Table 145, when the number of the unrecorded ECC blocks in Current RMZ is less than or equal to 8, RMD ***shall not*** be written except for the disc removal.

The error reporting for RMZ exhaustion by each command that may change the RMD in each condition of the media is shown in Table 151 through Table 161.

5.13.2.1.3 Update timing of RMD in RDZ

When U-RMZ or B-RMZ is newly created, logical unit ***shall*** write the latest RMD into RDZ. RDZ Lead-in ***shall*** be written before writing the first RMD in L-RMZ.

Table 146 - Mandatory RMD update condition in RDZ

condition
When a CLOSE TRACK/RZONE/SESSION/BORDER command with Close Function field = 010b is issued, RMD ***shall*** be written in RDZ.
When a RESERVE TRACK/RZONE/RMZ command with RMZ bit =1 is issued, RMD ***shall*** be written in RDZ.

5.13.2.1.4 Example of write sequence

This section explains one example of a write sequence. See Table 147 and Table 148.

Table 147 - Example of write sequence (blank disc)

Sequence	user/host	logical unit action
1	Insert blank disc	check RMD
2	Unique Disc Identifier (SEND DISC STRUCTURE commands)	cache (RMD Field 0)
3	Specify other Identifier field. (SEND DISC STRUCTURE command)	cache (RMD Field 1)
4	Specify User Specific Data field of RMD if needed. (SEND DISC STRUCTURE command)	cache (RMD Field 2)
5	Reserve RZones (RESERVE TRACK/RZONE/RMZ command)	1. do OPC. 2. write RDZ Lead-in 3. write RMD in RMZ
6	get NWA (READ TRACK/RZONE INFORMATION command)	calculate and send to host
7	start writing from NWA (WRITE (10) command or WRITE (12) command)	start writing
8	close RZone or Border (CLOSE TRACK/RZONE/SESSION/BORDER command)	in case of closing RZone - write RMD in RMZ - pad RZone in case of closing Border - write RMD in RMZ - pad with latest RMD until the end of RMZ - write RMD in RDZ - write Border-in/Data Lead-in and Border-out

Table 148 - Example of write sequence (non-blank disc)

	user/host	logical unit action
1	Insert non-blank disc	check RMD
2	Specify User Specific Data field of RMD if needed. (SEND DISC STRUCTURE command)	cache (RMD Field 2)
3	Reserve RZones. (RESERVE TRACK/RZONE/RMZ command)	1. do OPC. 2. write RMD in RMZ
4	get NWA (READ TRACK/RZONE INFORMATION command)	search and send to host
5	start writing from NWA (WRITE (10) command or WRITE (12) command)	start writing
6	close RZone or Border (CLOSE TRACK/RZONE/SESSION/BORDER command)	in case of closing RZone - write RMD in RMZ - pad RZone in case of closing Border - write RMD in RMZ - pad with latest RMD until the end of RMZ - write RMD in RDZ - write Border-in/Data Lead-in and Border-out

5.13.2.2 Border zone

A Border zone consists of a Border-out and a Border-in.

The purpose of the Border Zone is for the HD DVD read-only logical unit to be able to read HD DVD-R media by providing Border-in and Border-out to prevent pickup overrun.

Once Border is closed, there are no unrecorded areas between Data Lead-in/Border-in and Border-out.

Border Zone structure is shown in Figure 120

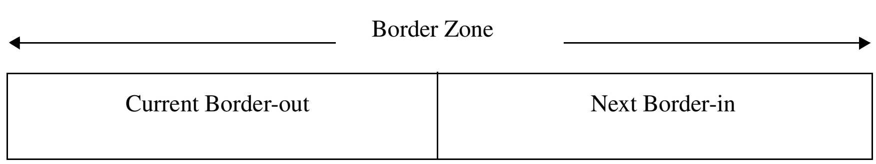


Figure 120 - Border Zone structure

5.13.2.2.1 Border size and length

The first Border-out start address ***shall*** be located after LBA 01FE00h. If a CLOSE TRACK/RZONE/SESSION/BORDER command with Close Function field = 010b, 110b is issued when recorded user data end address is less than LBA 01FE00h, the logical unit ***shall*** pad with 00h data through LBA 01FDFFh.

Border Zone size is dependent on its starting address and order. See Table 149.

Table 149 - Border Zone size for HD DVD-R media

The first LBA of a Border-out	01FE00h to 1A0DFFh	1A0E00h to 3E1BFFh	3E1C00h to -
Border-out size	290 ECC blocks	380 ECC blocks	480 ECC blocks
Border-in size	207 ECC blocks	157 ECC blocks	107 ECC blocks

5.13.2.2.2 Border Zone status

Bordered Area status changes according to its recording stage.

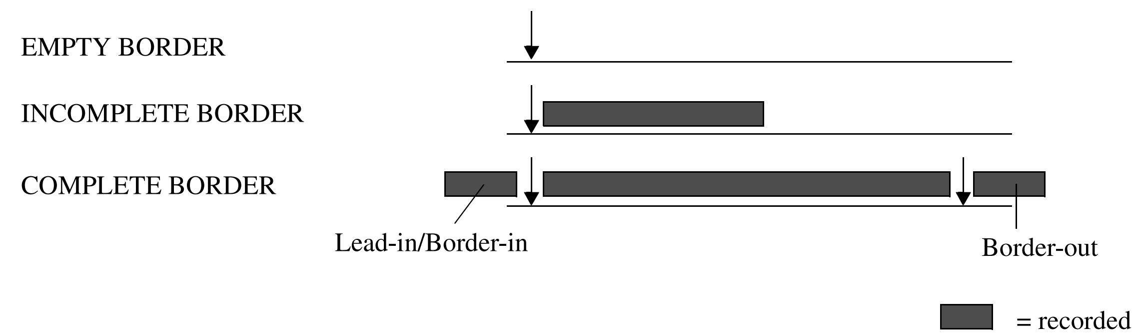


Figure 121 - Bordered Area status definitions

5.13.2.2.3 Border-in contents

Border-in consists of Updated Physical Format Information, B-RMZ and a reserved ECC block. The Updated Physical Format Information is an update of the R-Physical Format Information that contains start address of the next Border at that time and is recorded in six ECC blocks repeatedly. B-RMZ contains ECC blocks for RMDs. The size of B-RMZ depends on its radial location. The last ECC block of Border-in is reserved to separate the B-RMZ from the following RZone.

5.13.2.2.4 Border-out contents

Border-out consists of five copies of the latest RMD, a Stop Block and reserved ECC blocks.The Stop Block is an ECC block to provide means for detection of the Border-out. It is located at the 20th ECC block from the beginning of the Border-out. The reserved ECC blocks are placed to make the Border-out size appropriate to prevent the optical pick up over-run. The whole structure of Border Zone is shown in Figure 122.

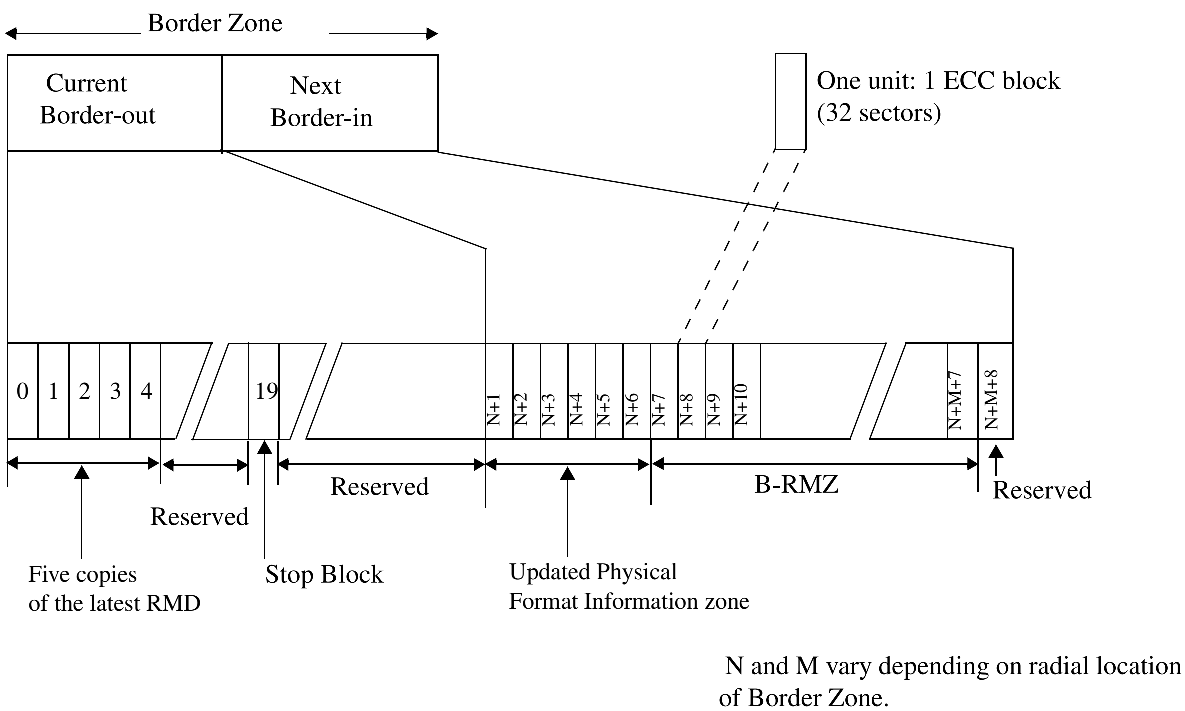


Figure 122 - Border Zone structure

5.13.2.3 User Data Zone

User Data Zone is allocated between Data Lead-in/Border-in and Data Lead-out/Border-out. User Data Zone consists of RZone and U-RMZ, if it exists.

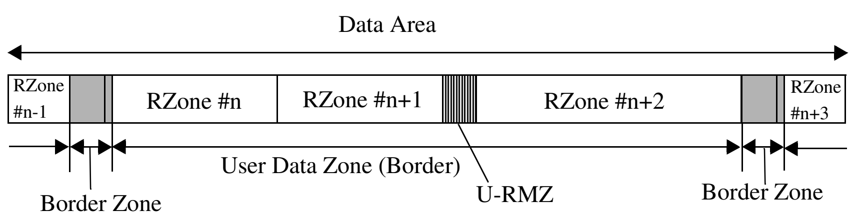


Figure 123 - Example of User data zone structure

5.13.2.3.1 RZone

The RZone is a limited area to record user data. The RZone status is changed according to its recording stage. These status are named as shown in Figure 124 below.

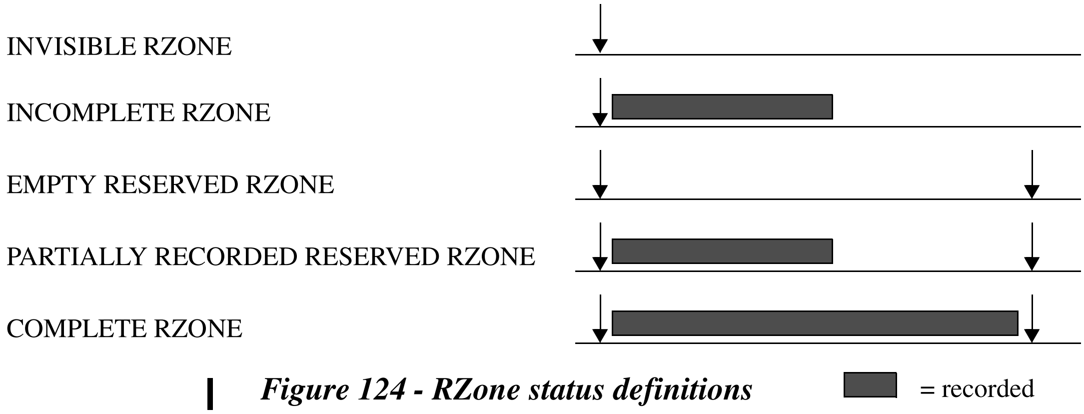


Figure 124 - RZone status definitions

Invisible/Incomplete RZone: These RZones only have a start address. End address is not defined. These kinds of RZones are always located on the outermost portion of the media and are data appendable.

Empty Reserved RZone/Partially Recorded Reserved RZone: These RZones have a start address and end address. These kinds of RZones are always data appendable.

Complete RZone: The RZone is closed or completely filled with data. This kind of RZone has no NWA and is not data appendable.

5.13.2.3.2 U-RMZ

The size of U-RMZ is 128 ECC blocks. The method of creating U-RMZ is described in *5.13.7, "RMZ extension"* on page 287.

5.13.2.4 Additional Zones for the disc finalization

Border-out with Area Type of Data Lead-out or Terminator is recorded just after the Data Area for the disc finalization. By recording either Border-out with Area Type of Data Lead-out or Terminator, Data Lead-out Area begins.

5.13.2.4.1 Border-out with Area Type of Data Lead-out

This Border-out is recorded with an intention of finalizing. The Area type is 10b (Data Lead-out). The size of this Border-out is equivalent to other Border-out and varies depending on its radial location. See *Table 149 - "Border Zone size for HD DVD-R media"* on page 280. The minimum LBA of the Border-out shall be larger than 01FE00h.

5.13.2.4.2 Terminator

Terminator is recorded immediately after Border-out with Area Type of Data Area. The Area type is 10b (Data Lead-out). The size of Terminator is equivalent to Border-out and varies depending on its radial location. See Table 150.

Table 150 - Terminator size for HD DVD-R media

The first LBA of a Terminator	01FE00h to 1A0DFFh	1A0E00h to 3E1BFFh	3E1C00h to -
Size	290 ECC blocks	380 ECC blocks	480 ECC blocks

5.13.3 Recording model for HD DVD-R media

Recording mode for HD DVD-R is only incremental. Disc at once recording mode is not defined in the physical specification. In case of DVD-R, linking sector is necessary. But in case of recording HD DVD-R, linking sector is not necessary (lossless linking).

5.13.3.1 Sequential recording

HD DVD-R media makes use of sequential recording. This type of recording does not permit random access for recording purposes. Recording may only occur at predefined recording (appendable) points.

Multiple Appendable points may exist within management areas for sequential recording. The data shall be written sequentially from each appendable point.

5.13.4 Data recording

In case of Data recording, user data is written sequentially from each NWA. A variable amount of user data is written at several distinct times. An overwriting is inhibited.

For HD DVD-R media to be readable by HD DVD read-only logical units, the media ***shall*** contain a Lead-in and a Lead-out or Border-out.

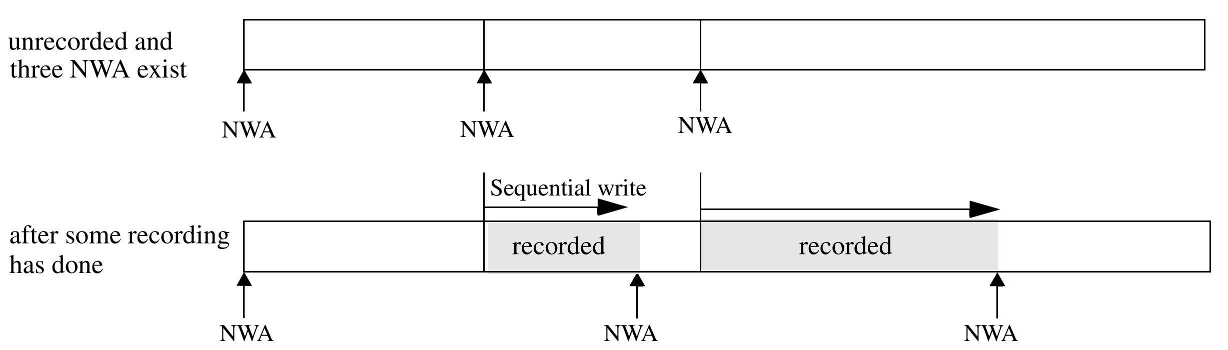


Figure 125 - Example of Data recording

5.13.4.1 ECC boundary padding and Data Type bit in ID field

The logical unit writes data to the medium only when multiple ECC data blocks are received or the SYNCHRONIZE CACHE command is issued. When the SYNCHRONIZE CACHE operation has been done and the last recorded data address is not an address of the last sector of an ECC block, the logical unit ***shall*** pad to the ECC block boundary with value 00h with Data Type bit = 1. See Figure 126.

The Last Recorded Address is the address of the last block of user data. The ECC padding ***shall not*** affect the Last Recorded Address.

Note: The READ TRACK/RZONE INFORMATION command is used to get the Last Recorded Address of the RZone.

A SYNCHRONIZE CACHE command may be used to mark the end of the Write data stream.

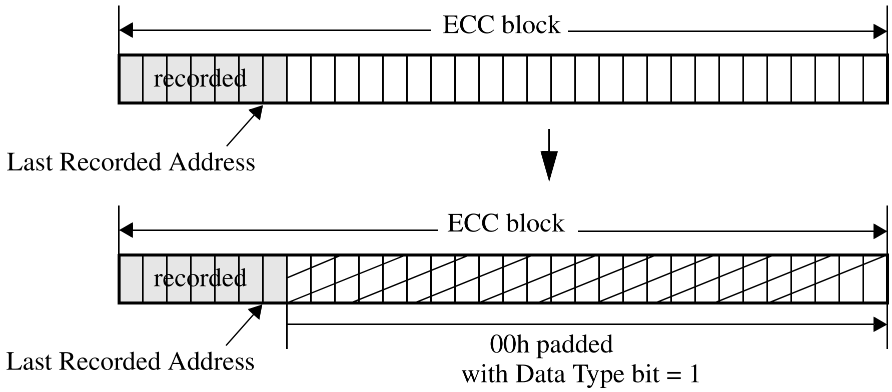


Figure 126 - ECC boundary padding

5.13.5 RZone recording

5.13.5.1 RZone reservation

5.13.5.1.1 Limitation for number of reserved RZones

A part of the disc space can be reserved as an RZone. For HD DVD-R, the maximum number of RZones which can be reserved at the same time is two. In other words, the maximum number of data appendable RZones is three (2 Reserved RZone + 1 Invisible/Incomplete RZone). If two RZones are already reserved, no more RZones can be reserved. To reserve a new RZone, either one or both of the current reserved RZones ***shall*** be closed. Once closed, a new RZone can be reserved.

The RESERVE TRACK/RZONE/RMZ command is used to reserve RZones. If attempting to reserve an RZone when two RZones are already reserved, the command ***shall*** be terminated with CHECK CONDITION status, 5/72/05 NO MORE RZONE RESERVATIONS ARE ALLOWED.

Attempting to reserve an RZone when ECC blocks in the RMZ remain less than certain values, the command may be terminated with several errors depending on how many ECC blocks remain in the current RMZ and RDZ. See *Table 153 - "Error reporting for "RZone reservation" by using RESERVE TRACK/RZONE/RMZ command"* on page 297.

5.13.5.1.2 RZone numbering

The RZone numbers ***shall*** start from 1. The number of the Invisible RZone is increased by one following a reservation. After the reservation is done, the RZone number given to the new reserved RZone is the RZone number of the old Invisible RZone that existed before the reservation.

5.13.5.1.3 RZone reservation scheme

RZone ***shall*** only be reserved from the NWA of the invisible RZone. If an incomplete RZone exists, the incomplete RZone ***shall*** be closed prior to reserving a new RZone. The start address of the new Invisible RZone is the NWA of the previous incomplete RZone.

When reservation is required, the logical unit ***shall*** allocate the RZone in the Data Recordable Area. The allocated reserved length is rounded up the length to ECC block unit.

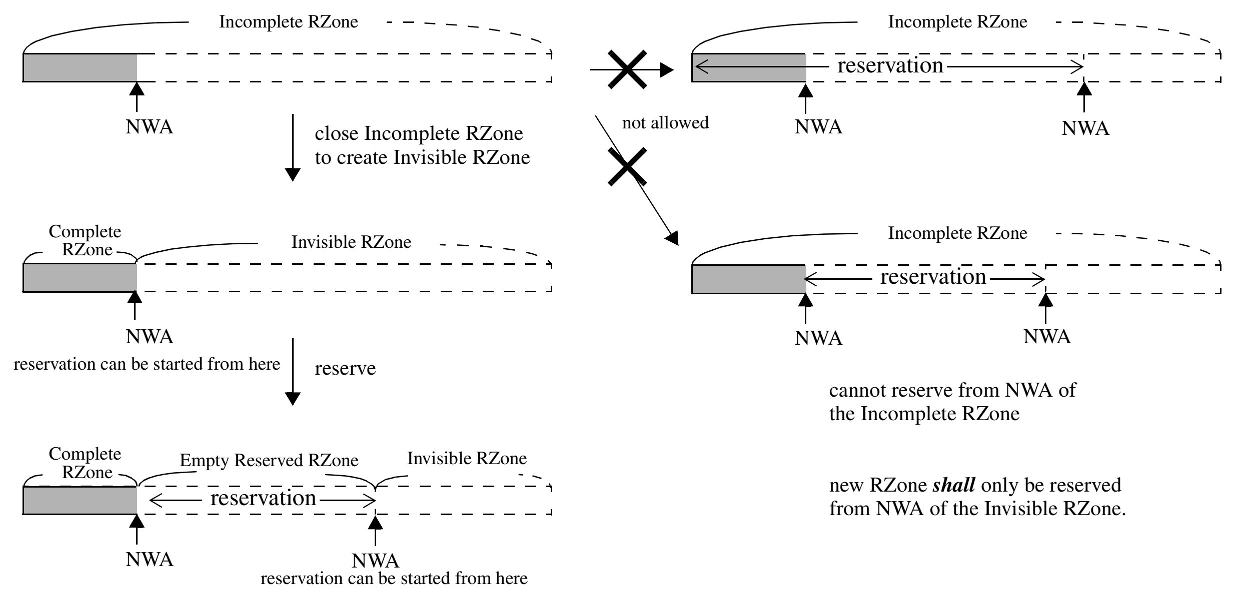


Figure 127 - Start position of RZone reservation

5.13.5.1.4 Sample sequence for RZone reservation

An example of RZone reservation sequence is shown in Figure 128. Initially, a blank medium has only an Invisible RZone. NWA is LBA 0. When a write operation has begun without a reservation, the NWA is proportionally incremented by written data length (reference 0).

If reservation is required, then the incomplete RZone ***shall*** be closed and RMD is updated (reference 1). Then a new invisible RZone is created. The new reserved RZone is allocated from the NWA of the invisible RZone and RMD is updated (reference 2).

Note: RDZ Lead-in ***shall*** *be written before writing the first RMD in L-RMZ.*

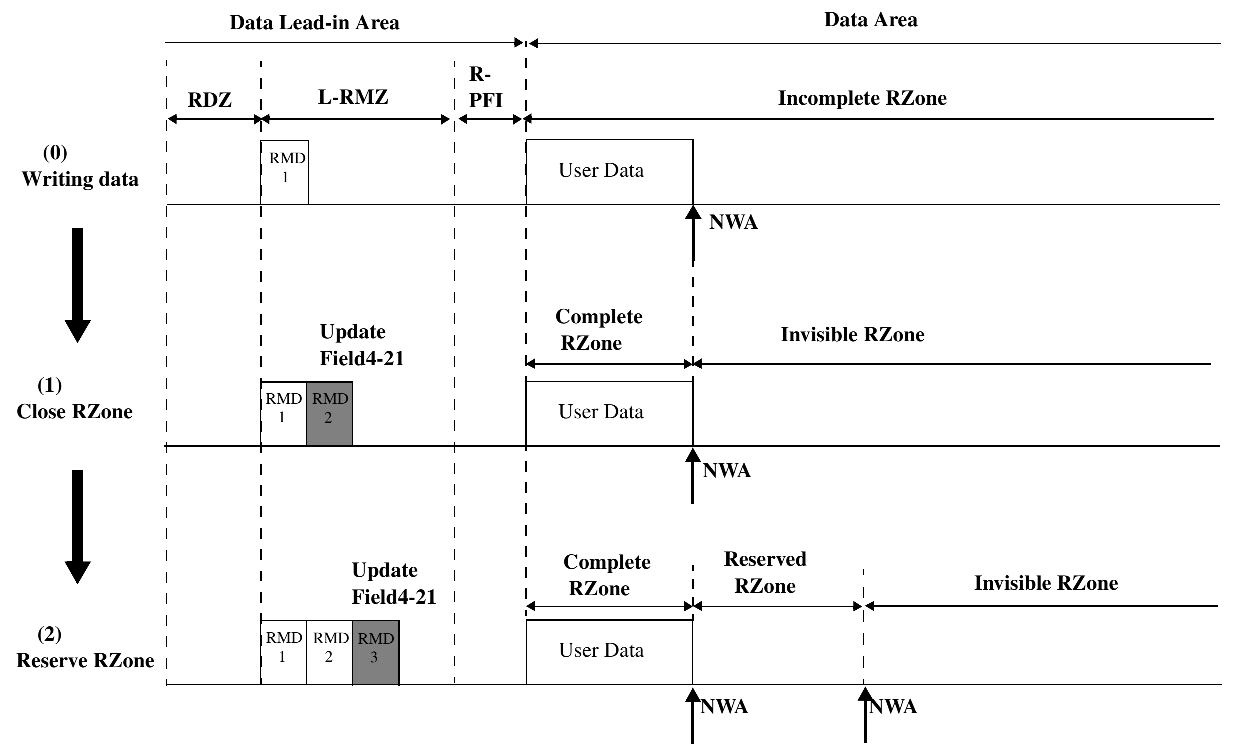


Figure 128 - Example of RZone reservation sequence

5.13.5.2 RZone closing

This section explains what ***shall*** be done by a logical unit when an RZone is closed.

When a Reserved RZone is closed:

- Logical unit ***shall*** write RMD in the current RMZ.
- The logical unit ***shall*** pad 00h data until the end of the Reserved RZone with Data Type bit = 1.

When an Incomplete RZone is closed:

- Logical unit ***shall*** write RMD in the current RMZ.

There are four purposes of closing an incomplete RZone:

- To reserve a new RZone
- To create a new U-RMZ
- To close Border
- To make the logical unit write an RMD in RMZ for backup against error.

When an Invisible RZone is closed, nothing is done by the logical unit.

5.13.6 Border zone recording

After Border zone is recorded, the Bordered Area in the HD DVD-R media can be read by the HD DVD read-only logical unit.

Each logical sector in Border Zone ***shall*** be assigned to a LBA. Each logical sector of Data Recordable Area ***shall*** be identified by a unique logical sector number. LBAs ***shall*** be integers assigned in ascending sequence, starting with 0 from the PSN 30000h.

A Border Zone consists of a Border-out and a Border-in. Border-out/in is written when a CLOSE TRACK/ RZONE/ SESSION/BORDER command is issued with Close Function field = 010b.

Border Zone is recorded with following sequence.

1. Close all opened (empty reserved/partially recorded reserved/incomplete) RZones by using a CLOSE TRACK/ RZONE/SESSION/BORDER command with the Close Function field = 001b.

2. Issue CLOSE TRACK/RZONE/SESSION/BORDER command to close Bordered Area (Close Function = 010b).

3. Border-out is recorded from NWA of the invisible RZone. Border-in of this Border Zone is still unrecorded at this time. The Border-in will be completely recorded when next CLOSE TRACK/RZONE/SESSION/BORDER command is issued.

4. If Data Lead-in is still unwritten, Data Lead-in is recorded on the medium. If Lead-in is already written, Border-in is recorded after the previously written Border-out.

When a CLOSE TRACK/RZONE/SESSION/BORDER command with Close Function field = 010b is issued, Border Zone ***shall*** be written from ECC block boundary.

If Border Zone start LBA is less than 1FE00h, logical unit ***shall*** pad with 00h data up to LBA 1FDFFh. RZone numbers are not assigned to Border Zone. The Invisible RZone number is not incremented due to Border Zone writing.

After Border Zone writing, NWA of the invisible RZone is moved to the following written Border Zone. Figure 129 shows an example of the write sequence and relationship between RZone number and Border Zone.

The Border-in which immediately follows last Border-out ***shall*** remain unrecorded when the Border Zone is written. This unrecorded Border-in will be used for next Border. The unrecorded Border-in will be recorded when the next Border is closed.

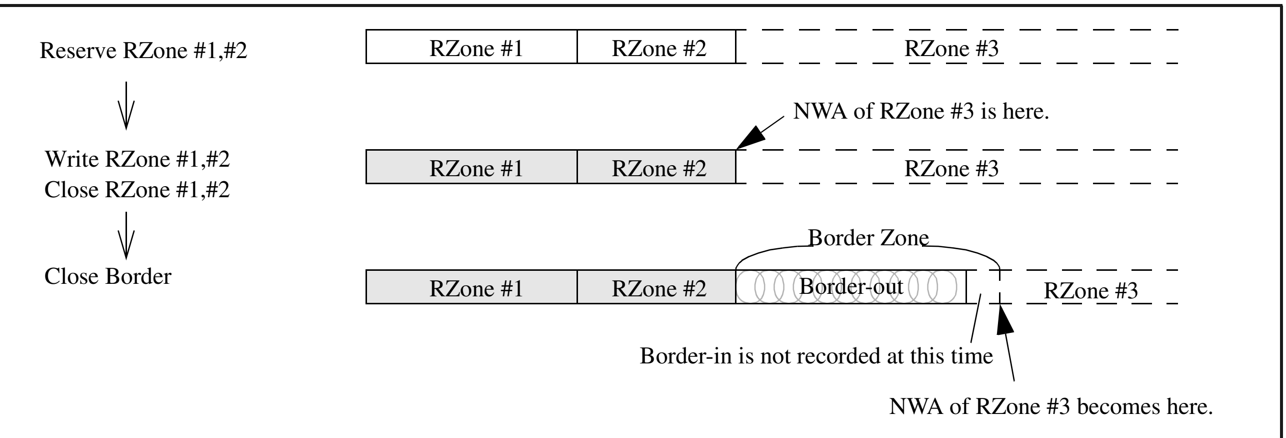


Figure 129 - Relation between RZone number and Border Zone

5.13.7 RMZ extension

5.13.7.1 RMZ Extension scheme

There are three kinds of RMZs. See *5.13.2.1 "RMZ (Recording Management Zone)"* on page 269. Then the RMZ that can be used is always one. This RMZ is called Current RMZ. When a RMZ is newly created, the unrecorded ECC block in the RMZ that is used until the time is padded with the latest RMD and the latest RMD is copied in RDZ. See Figure 130.

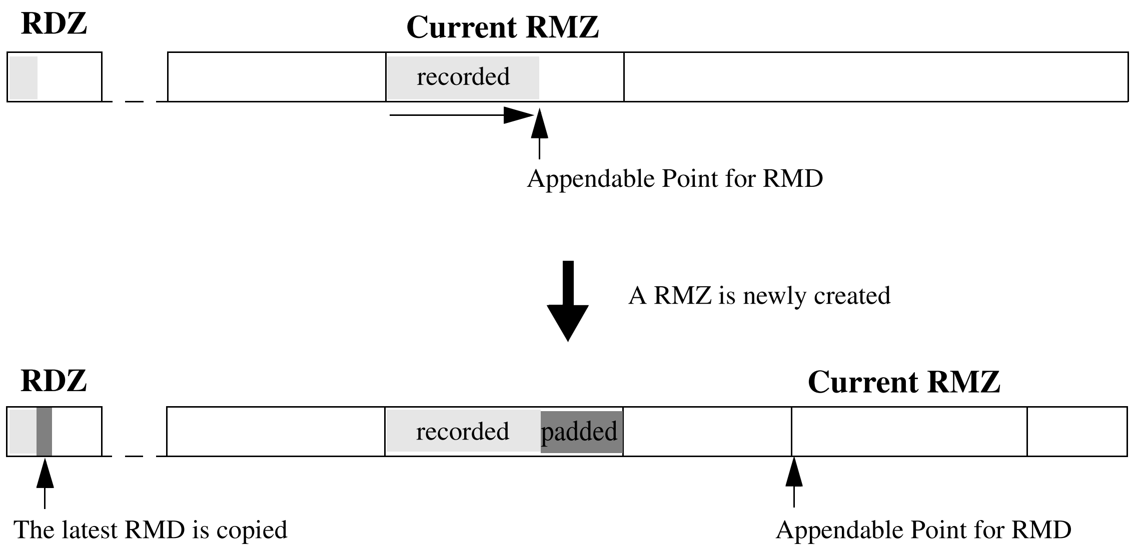


Figure 130 - Current RMZ

There are two kinds of the RMZ extension methods. One is the creation of RMZ in the next Border-in (B-RMZ). The other is the creation of RMZ in the User Data Zone (U-RMZ).

1. B-RMZ ***shall*** be assigned when the Border is closed by using CLOSE TRACK/RZONE/SESSION/BORDER command with Close Function field = 010b.
2. U-RMZ ***shall*** be assigned by using RESERVE TRACK/RZONE/RMZ command with RMZ bit = 1, when the unrecorded part of a Current RMZ become equal to or less than 15 ECC blocks.

The Current RMZ state diagram is shown in Figure 131.

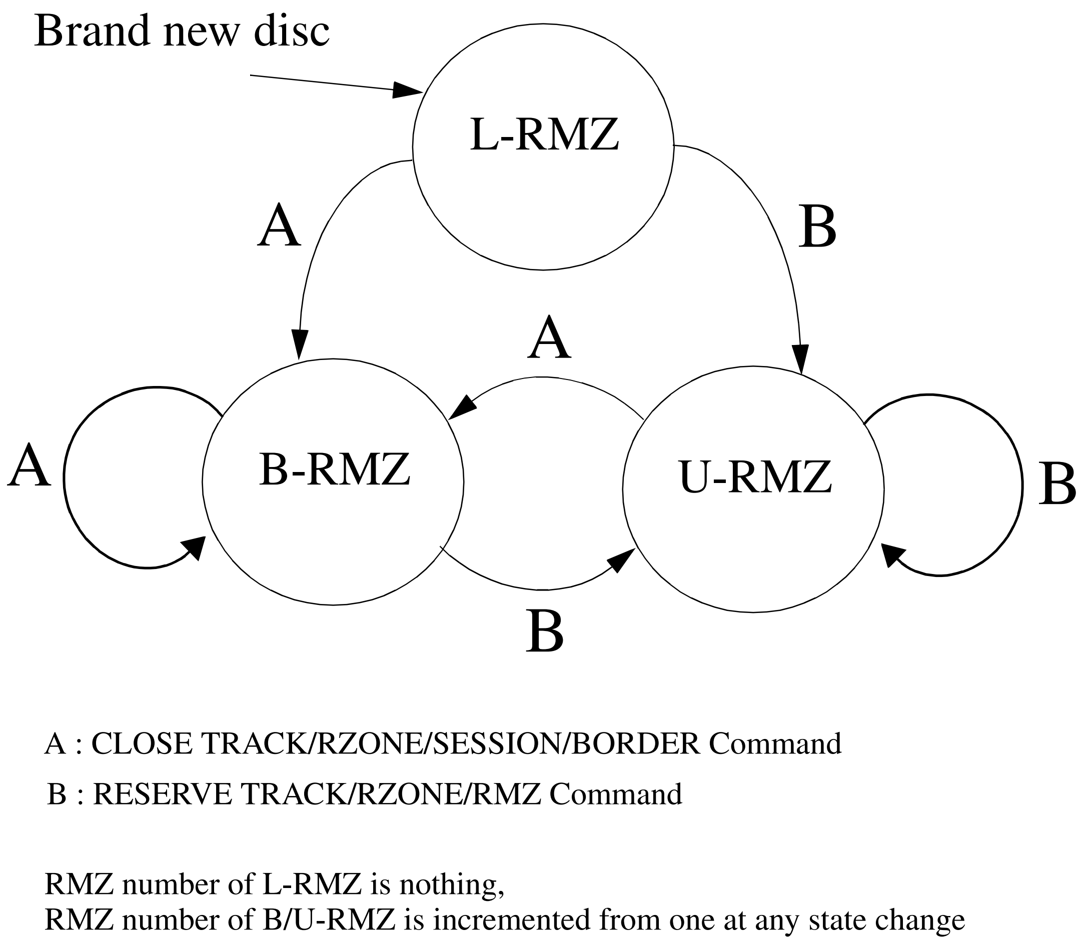


Figure 131 - Current RMZ State Diagram

5.13.7.2 Extended RMZ numbering

The RMZ numbers ***shall*** start from 1 and be increased by one following a RMZ extension. RMZ number ***shall*** be assigned commonly within B-RMZ and U-RMZ. L-RMZ ***shall*** not have a RMZ number.

5.13.7.3 RMZ Extension by B-RMZ

B-RMZ ***shall*** be assigned in the next Border-in when Border is closed. See *5.13.6 "Border zone recording"* on page 286.

5.13.7.4 RMZ Extension by U-RMZ

U-RMZ ***shall*** only be assigned from the NWA of the invisible RZone. If an incomplete RZone exists, the incomplete RZone ***shall*** be closed prior to reserving a new U-RMZ.

U-RMZ can be assigned only under the following conditions;

- The number of the unrecorded ECC Blocks in RDZ is more than or equal to 1 and
- The number of the unrecorded ECC Blocks in the current RMZ is more than or equal to1 and equal to or less than 15.

If the condition is not satisfied, then Error code ***shall*** be reported to the host. See *5.13.12.5 "Error reporting for "RMZ extension by U-RMZ" by using RESERVE TRACK/RZONE/RMZ command"* on page 298.

5.13.7.5 Sample sequence for RMZ extension by U-RMZ

Initially, a blank medium has only Invisible RZone. NWA is LBA 0. When a write operation has begun without or with reservation, the NWA is proportionally incremented by written data length (reference 0).

If a RMZ extension by U-RMZ is required, the incomplete RZone ***shall*** be closed and the RMD is updated. Then a new invisible RZone is created (reference 1).

The new assigned U-RMZ is allocated from the NWA of the invisible RZone with 128 ECC blocks and the RMD is updated. The unrecorded area in the current RMZ is padded with the updated RMD and the copied RMD is located in the RDZ (reference 2).

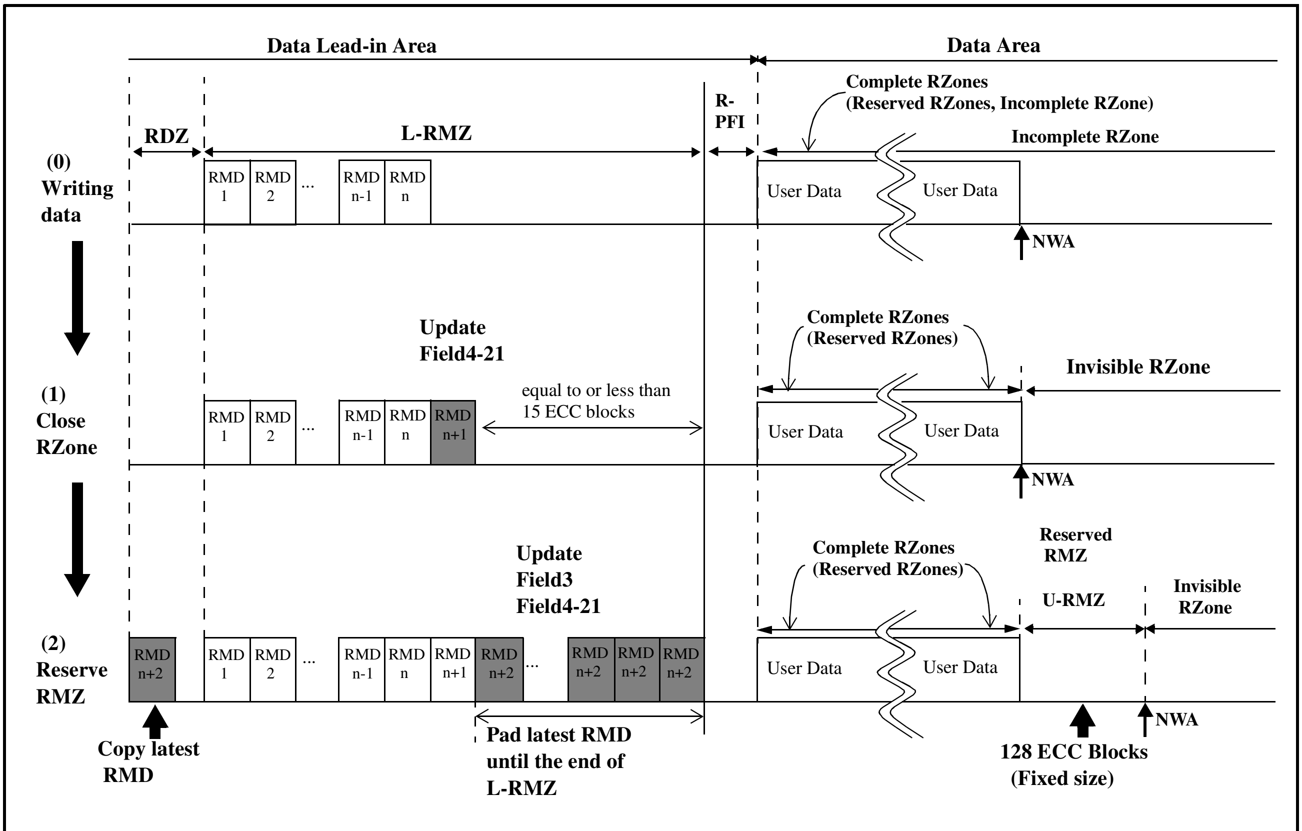


Figure 132 - Sample sequence for RMZ extension by U-RMZ

5.13.8 Test Zone extension

When the host issues FORMAT UNIT Command (Format Type16h), logical unit ***shall*** extend the Test zone and ***shall*** update the RMD. Figure 133 shows an example for extending Test zone.

Initially, a blank medium has no Extended Test Zone (reference 0).

If a extension of the Test zone is required, the inner Guard track zone in the Data Lead-out Area can be used for Extended Test zone and the outermost Data Area is reassigned as the Guard track zone. The RMD is updated (reference 1).

Attempting to extend the Test Zone when the Test Zone is already extended or NWA is larger than 431840h, the command ***shall*** be terminated with CHECK CONDITION status, 5/72/07 NO MORE TEST ZONE EXTENSIONS ARE ALLOWED.

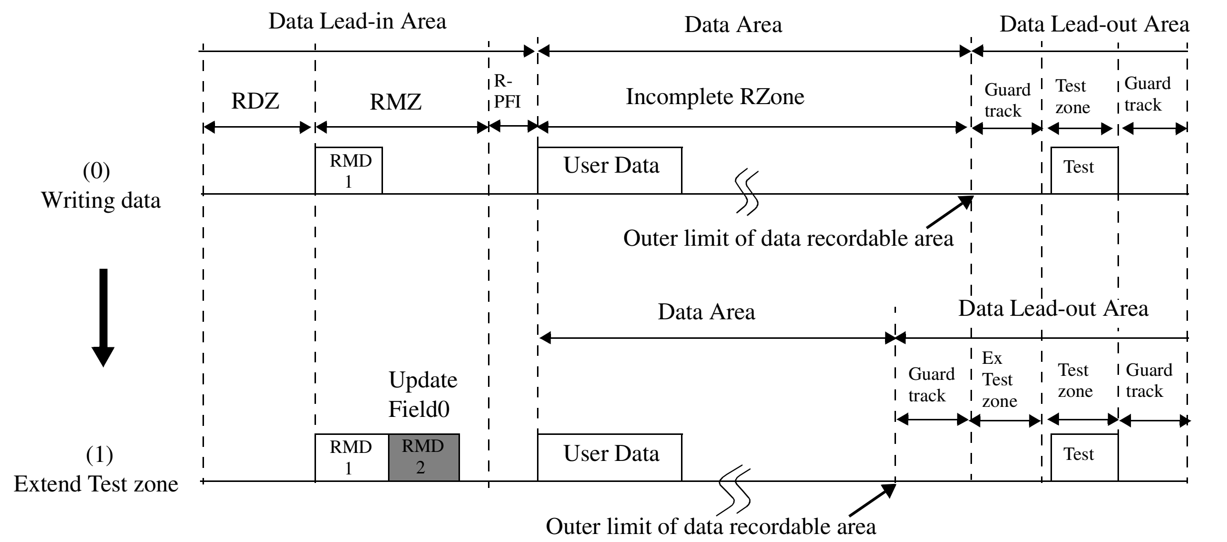


Figure 133 - example for extending Test zone

5.13.9 Optimum Power Calibration (OPC)

Optimum power calibration (OPC) is required to determine the optimum recording laser power for the mounted HD DVD-R media. If necessary, OPC operation may be performed automatically when the medium has been first inserted into the logical unit and the first WRITE (10) command is issued. When OPC operation is done, RMD ***shall*** be cached or written in RMZ by the logical unit. When the unrecorded ECC blocks in Current RMZ are equal to or less than 8 ECC blocks, OPC operation ***shall not*** be performed except for the host request (e.g., WRITE (10) command, RESERVE TRACK/RZONE/RMZ command) for avoiding waste of RMZ.

The Test zone is located from Physical Sector Numbers (PSN) 27200h to 2BCFFh and 739040h to 73CA3Fh. If the Test zone is extended, the Extended Test zone is also located from PSN 735440h to 73903Fh. The OPC start address is in descending order within the Test zone. As an example, the first power calibration is in PSN 2BCFFh and the second power calibration is in PSN 2BCEFh. Power calibration ***shall*** end on a ECC block boundary. If a host requires OPC at desired timing, the SEND OPC INFORMATION command ***shall*** be used.

5.13.10 Disc Final Closure

When CLOSE TRACK/RZONE/SESSION/BORDER command with Close Function field = 110b is issued, the final closure operation ***shall*** be started for the disc. After this operation, data cannot be appended to the disc any more.

Final closure operation is done in the following sequence:

1. If opened RZone(s) exist, close all opened RZone(s).
2. Issue CLOSE TRACK/RZONE/SESSION/BORDER command with Close Function field = 110b.

If current Border is not Empty status (See Figure 134)

3. Border-out which attributes Data Lead-out (Area Type 10b) ***shall*** be recorded.
4. The Start PSN of the next Border-in field in the Data Lead-in or the current Border-in ***shall*** be set to 0.
5. Updated RMD ***shall*** be written in Current RMZ with Disc Status field “Complete (03h)”.
6. The unrecorded ECC blocks in Current RMZ ***shall*** be padded with the Updated RMD.

If current Border is Empty status (See Figure 135)

3. Terminator which attributes Data Lead-out (Area Type 10b) ***shall*** be recorded just behind Border-out zone.

To recognize whether the disc is finalized or not, the following conditions are checked. If one of the following condition is met, the disc ***shall*** be considered a finalized disc and is not appendable.

- Start PSN of the next Border-in field of Lead-in/Border-in contains 0.
- Disc Status field of RMD contains “Complete (03h)” status.
- Terminator or Data Lead-out that has a Data Lead-out attribute exists.

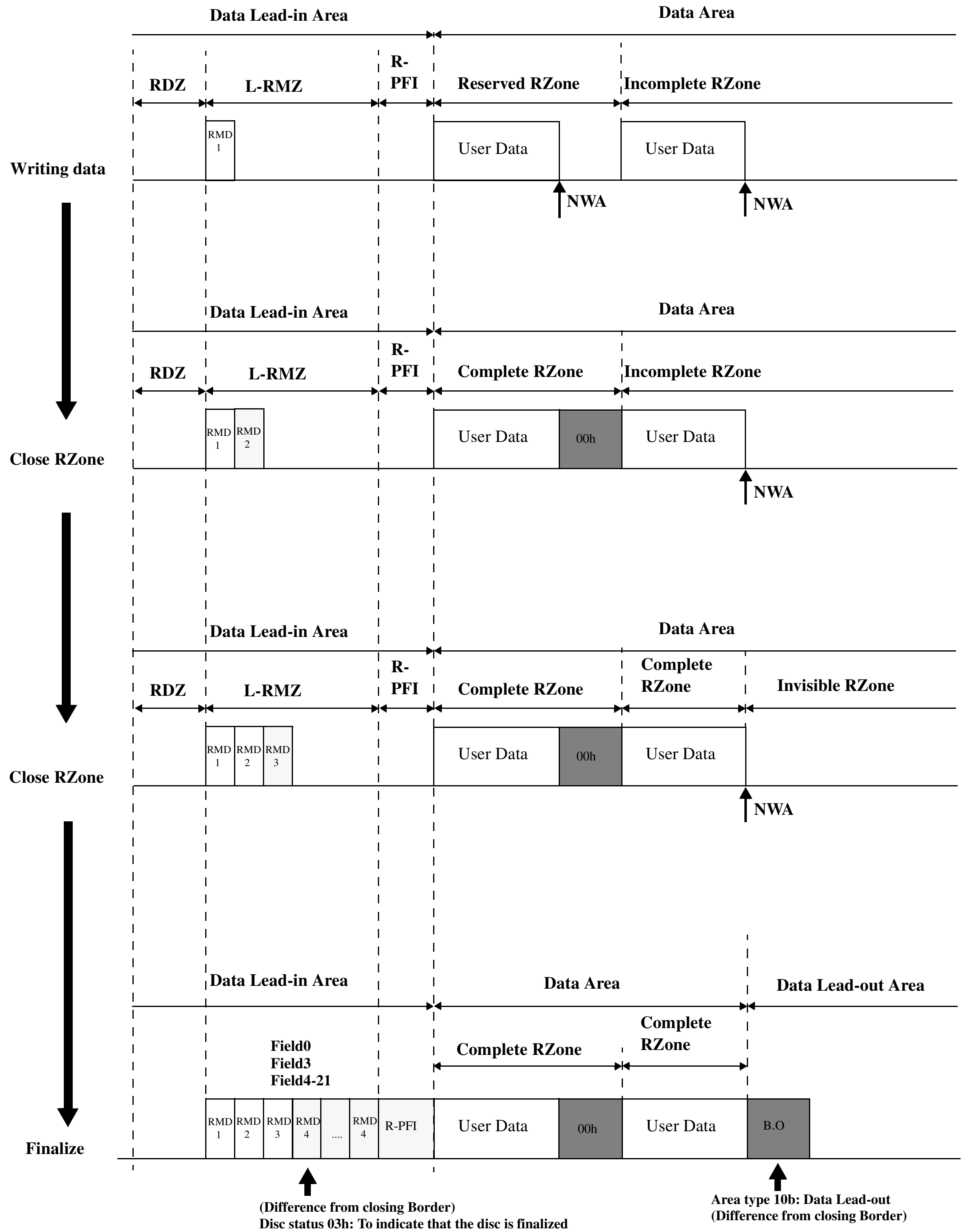


Figure 134 - Disc Final Closure without Terminator

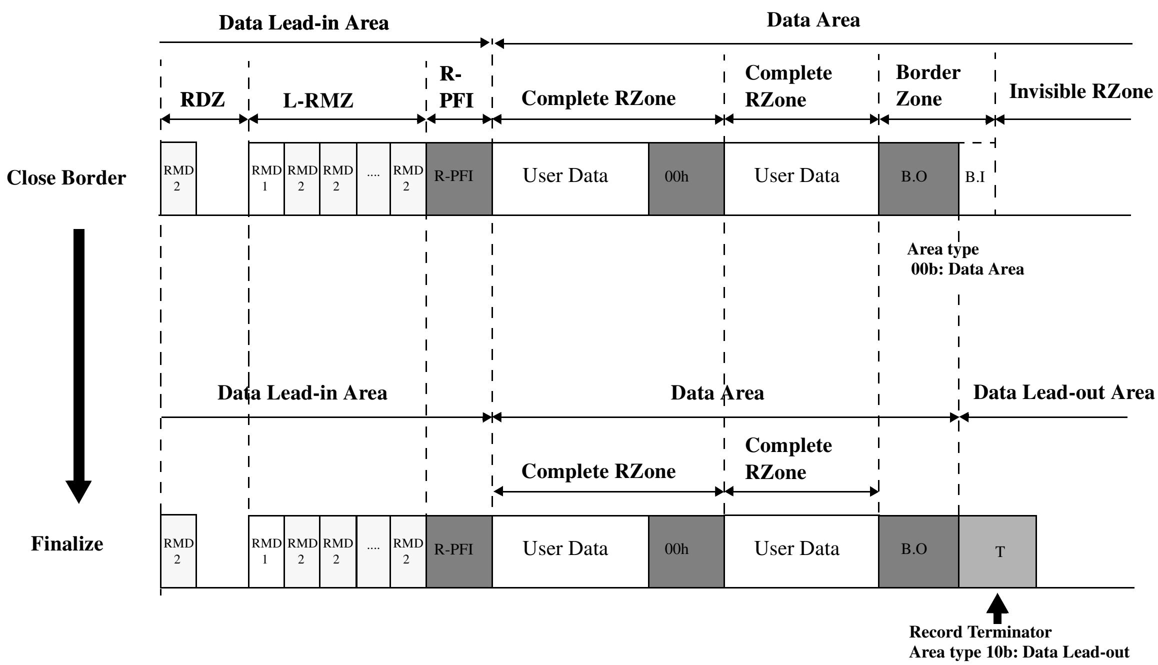


Figure 135 - Disc Final Closure with Terminator

5.13.11 Example for multi-border recognition

When a recorded disc is inserted into an HD DVD-R logical unit, the logical unit searches LRA. An example of searching LRA is shown in Figure 136 and Figure 137.

The HD DVD-R logical unit access to RDZ after reading the information in the System Lead-in Area. The logical unit searches the latest RMD in RDZ. The start LBA of the last Extended RMZ can be gotten from the latest RMD in RDZ. Next, the logical unit accesses to the last Extended RMZ and searches the latest RMD in the last Extended RMZ. The logical unit certifies the value of LRA, then a real LRA is fixed.

When a recorded disc is inserted into an HD DVD read-only logical unit, the logical unit searches LRA. An example of searching LRA is shown in Figure 136 and Figure 137.

The HD DVD ROM logical unit cannot access to the unrecorded part of a disc. In consequence, the logical unit cannot access to RDZ and cannot use the method for searching LRA that the HD DVD-R logical unit uses. In addition, the HD DVD-ROM logical unit can not interpret RMD. The logical unit can interpret Physical Format Information (PFI) in PFI Zone, R-PFI Zone and U-PFI Zone. An example of searching LRA on the logical unit is as follows.

The HD DVD read-only logical unit accesses to the R-PFI Zone after reading the information in the System Lead-in Area. The logical unit can get Start LBA of the second Border Zone from R-PFI. Next, the logical unit accesses to the Border-in of the second Border and can get Start LBA of the third Border Zone from U-PFI. The action is repeated until the logical unit accesses to the last closed Border. The last Border is a Border as follows;

- Start PSN of the next Border-in field of PFI contains 00h.
- Terminator or Data Lead-out that has a Data Lead-out attribute exists.

The HD DVD-ROM logical unit can get the Last Recorded Address of the last closed Border from Last recorded PSN of last RZone in the User data zone field of PFI. When the last Border is not closed, the logical unit may not be able to get a real LRA.

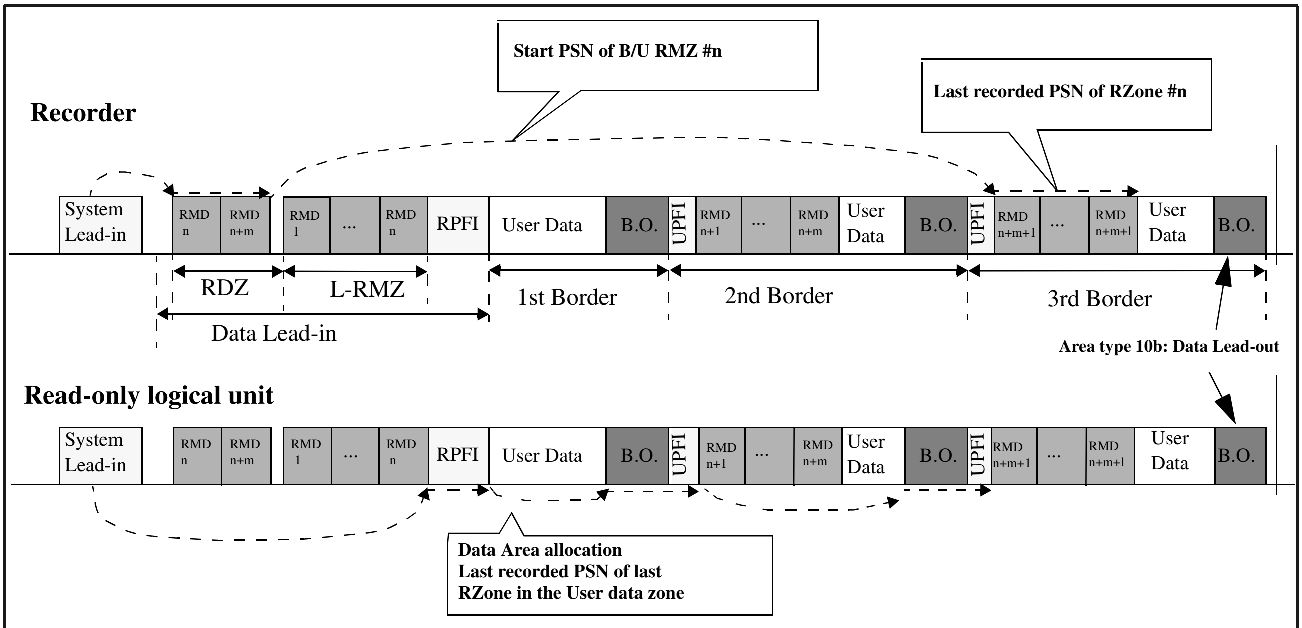


Figure 136 - Example of searching the last recorded PSN of the finalized disc

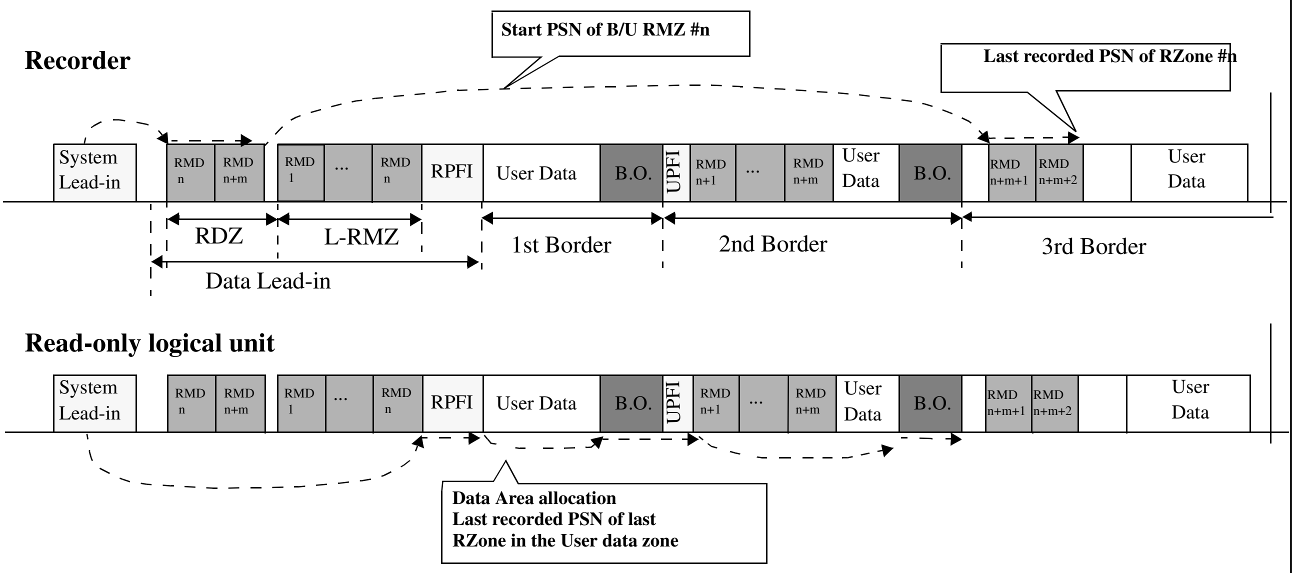


Figure 137 - Example of searching the last recorded PSN of the Incomplete Border disc

5.13.12 Error reporting for RMZ exhaustion

5.13.12.1 Error reporting for WRITE (10) command and WRITE (12) command

The error reporting for the command in each condition of the media is shown in Table 151.

Table 151 - Error reporting for WRITE (10) command and WRITE (12) command

Condition of the RDZ	The number of the unrecorded ECC blocks in the current RMZ	Error code
The unrecorded ECC blocks exists	More than 15	-
	Less than or equal to 15, and more than 4	-
	Less than or equal to 4, and more than 0	5/73/15 CURRENT PROGRAM MEMORY AREA/RMZ IS FULL
	0	3/73/04 PROGRAM MEMORY AREA/RMA UPDATE FAILURE
The unrecorded ECC blocks do not exist	More than 15	-
	Less than or equal to 15, and more than 4	-
	Less than or equal to 4, and more than 0	3/73/05 PROGRAM MEMORY AREA/RMA IS FULL
	0	3/73/05 PROGRAM MEMORY AREA/RMA IS FULL

5.13.12.2 Error reporting for SYNCHRONIZE CACHE command

The error reporting for the command in each condition of the media is shown in Table 152.

Table 152 - Error reporting for SYNCHRONIZE CACHE command

Condition of the RDZ	The number of the unrecorded ECC blocks in the current RMZ	Error code
The unrecorded ECC blocks exists	More than 15	-
	Less than or equal to 15, and more than 4	1/73/16 CURRENT PROGRAM MEMORY AREA/RMZ IS (almost) FULL
	Less than or equal to 4, and more than 0	5/73/15 CURRENT PROGRAM MEMORY AREA/RMZ IS FULL
	0	3/73/04 PROGRAM MEMORY AREA/RMA UPDATE FAILURE
The unrecorded ECC blocks do not exist	More than 15	-
	Less than or equal to 15, and more than 4	1/73/06 PROGRAM MEMORY AREA/RMA IS (almost) FULL
	Less than or equal to 4, and more than 0	3/73/05 PROGRAM MEMORY AREA/RMA IS FULL
	0	3/73/05 PROGRAM MEMORY AREA/RMA IS FULL

5.13.12.3 Error reporting for "RZone reservation" by using RESERVE TRACK/RZONE/RMZ command

The error reporting for the command in each condition of the media is shown in Table 153.

Table 153 - Error reporting for "RZone reservation" by using RESERVE TRACK/RZONE/RMZ command

Condition of the RDZ	The number of the unrecorded ECC blocks in the current RMZ	Error code
The unrecorded ECC blocks exists	More than 15	-
	Less than or equal to 15, and more than 4	1/73/16 CURRENT PROGRAM MEMORY AREA/RMZ IS (almost) FULL
	Less than or equal to 4, and more than 0	5/73/15 CURRENT PROGRAM MEMORY AREA/RMZ IS FULL
	0	3/73/04 PROGRAM MEMORY AREA/RMA UPDATE FAILURE
The unrecorded ECC blocks do not exist	More than 15	-
	Less than or equal to 15, and more than 4	1/73/06 PROGRAM MEMORY AREA/RMA IS (almost) FULL
	Less than or equal to 4, and more than 0	3/73/05 PROGRAM MEMORY AREA/RMA IS FULL
	0	3/73/05 PROGRAM MEMORY AREA/RMA IS FULL

5.13.12.4 Error reporting for "RZone closure" by using CLOSE TRACK/RZONE/SESSION/ BORDER command

The error reporting for the command in each condition of the media is shown in Table 154.

Table 154 - Error reporting for "RZone closure" by using CLOSE TRACK/RZONE/SESSION/ BORDER command

Condition of the RDZ	The number of the unrecorded ECC blocks in the current RMZ	Error code
The unrecorded ECC blocks exists	More than 15	-
	Less than or equal to 15, and more than 4	-
	Less than or equal to 4, and more than 0	-
	0	3/73/04 PROGRAM MEMORY AREA/RMA UPDATE FAILURE
The unrecorded ECC blocks do not exist	More than 15	-
	Less than or equal to 15, and more than 4	-
	Less than or equal to 4, and more than 0	-
	0	3/73/05 PROGRAM MEMORY AREA/RMA IS FULL

5.13.12.5 Error reporting for "RMZ extension by U-RMZ" by using RESERVE TRACK/RZONE/ RMZ command

The error reporting for the command in each condition of the media is shown in Table 155 and Table 156.

Table 155 - Error reporting for "RMZ extension by U-RMZ" by using RESERVE TRACK/ RZONE/RMZ command (1)

Condition of the RDZ	The number of the unrecorded ECC blocks in the current RMZ	Error code
The unrecorded ECC blocks exists	More than 15	5/72/06 RMZ EXTENSION IS NOT ALLOWED
	Less than or equal to 15, and more than 4	-
	Less than or equal to 4, and more than 0	-
	0	3/73/04 PROGRAM MEMORY AREA/RMA UPDATE FAILURE
The unrecorded ECC blocks do not exist	More than 15	5/73/17 RDZ IS FULL
	Less than or equal to 15, and more than 4	5/73/17 RDZ IS FULL
	Less than or equal to 4, and more than 0	5/73/17 RDZ IS FULL
	0	3/73/05 PROGRAM MEMORY AREA/RMA IS FULL

Table 156 - Error reporting for "RMZ extension by U-RMZ" by using RESERVE TRACK/RZONE/RMZ command (2)

Condition of the media	Error code
The number of the free blocks are smaller than 128 ECC blocks	5/72/06 RMZ EXTENSION IS NOT ALLOWED

5.13.12.6 Error reporting for "Border closure" by using CLOSE TRACK/RZONE/SESSION/BORDER command

The error reporting for the command in each condition of the media is shown in Table 157 and Table 158.

Table 157 - Error reporting for "Border closure" by using CLOSE TRACK/RZONE/SESSION/BORDER command

Condition of the RDZ	The number of the unrecorded ECC blocks in the current RMZ	Error code
The unrecorded ECC blocks exists	More than 15	-
	Less than or equal to 15, and more than 4	-
	Less than or equal to 4, and more than 0	-
	0	3/73/04 PROGRAM MEMORY AREA/RMA UPDATE FAILURE
The unrecorded ECC blocks do not exist	More than 15	5/73/17 RDZ IS FULL
	Less than or equal to 15, and more than 4	5/73/17 RDZ IS FULL
	Less than or equal to 4, and more than 0	5/73/17 RDZ IS FULL
	0	3/73/05 PROGRAM MEMORY AREA/RMA IS FULL

Table 158 - Error reporting for "Border closure" by using CLOSE TRACK/RZONE/SESSION/BORDER command (2)

Condition of the media	Error code
The number of the free blocks are smaller than Border-out Area size	5/2C/00 COMMAND SEQUENCE ERROR

5.13.12.7 Error reporting for "finalization" by using CLOSE TRACK/RZONE/SESSION/BORDER command

The error reporting for the command in each condition of the media is shown in Table 159.

Table 159 - Error reporting for "finalization" by using CLOSE TRACK/RZONE/SESSION/ BORDER command

Condition of the RDZ	The number of the unrecorded ECC blocks	Error code
The unrecorded ECC blocks exists	More than 15	-
	Less than or equal to 15, and more than 4	-
	Less than or equal to 4, and more than 0	-
	0	3/73/04 PROGRAM MEMORY AREA/RMA UPDATE FAILURE[a]
The unrecorded ECC blocks do not exist	More than 15	-
	Less than or equal to 15, and more than 4	-
	Less than or equal to 4, and more than 0	-
	0	3/73/05 PROGRAM MEMORY AREA/RMA IS FULL[a]

a. When the disc is finalized with Terminator, no error is returned as an exception.

5.13.12.8 Error reporting for "Test Zone extension" by using FORMAT UNIT command

The error reporting for the command in each condition of the media is shown in Table 160 and Table 161.

Table 160 - Error reporting for "Test Zone extension" by using FORMAT UNIT command (1)

Condition of the RDZ	The number of the unrecorded ECC blocks	Error code
The unrecorded ECC blocks exists	More than 15	-
	Less than or equal to 15, and more than 4	1/73/16 CURRENT PROGRAM MEMORY AREA/RMZ IS (almost) FULL
	Less than or equal to 4, and more than 0	5/73/15 CURRENT PROGRAM MEMORY AREA/RMZ IS FULL
	0	3/73/04 PROGRAM MEMORY AREA/RMA UPDATE FAILURE
The unrecorded ECC blocks do not exist	More than 15	-
	Less than or equal to 15, and more than 4	1/73/06 PROGRAM MEMORY AREA/RMA IS (almost) FULL
	Less than or equal to 4, and more than 0	3/73/05 PROGRAM MEMORY AREA/RMA IS FULL
	0	3/73/05 PROGRAM MEMORY AREA/RMA IS FULL

Table 161 - Error reporting for "Test Zone extension" by using FORMAT UNIT command (2)

Condition of the media	Error code
The extended Test zone already exists	5/72/07 NO MORE TEST ZONE EXTENSIONS ARE ALLOWED
The number of the free blocks are smaller than extended Test zone size	5/72/07 NO MORE TEST ZONE EXTENSIONS ARE ALLOWED

5.13.12.9 Error reporting for SEND OPC INFORMATION command

The error reporting for the command in each condition of the media is shown in Table 162.

Table 162 - Error reporting for SEND OPC INFORMATION command

Condition of the RDZ	The number of the unrecorded ECC blocks in the current RMZ	Error code
The unrecorded ECC blocks exists	More than 15	-
	Less than or equal to 15, and more than 4	1/73/16 CURRENT PROGRAM MEMORY AREA/RMZ IS (almost) FULL
	Less than or equal to 4, and more than 0	5/73/15 CURRENT PROGRAM MEMORY AREA/RMZ IS FULL
	0	3/73/04 PROGRAM MEMORY AREA/RMA UPDATE FAILURE
The unrecorded ECC blocks do not exist	More than 15	-
	Less than or equal to 15, and more than 4	1/73/06 PROGRAM MEMORY AREA/RMA IS (almost) FULL
	Less than or equal to 4, and more than 0	3/73/05 PROGRAM MEMORY AREA/RMA IS FULL
	0	3/73/05 PROGRAM MEMORY AREA/RMA IS FULL

5.14 Recording and reading for HD DVD-Rewritable media

HD DVD-Rewritable media is directly addressable by a logical block address and permits reading and writing from any of the consecutively numbered logical blocks. Though the Logical Block Addresses are consecutive, the actual data may not be stored in a consecutive manner because of defect management and the existence of physical sectors which do not directly correspond to logical blocks. Such physical sectors comprise spare sectors and unused sectors.

5.14.1 Logical layout of HD DVD-Rewritable media

In the case of HD DVD-Rewritable, the LBA numbering increases from the inner land area to the outer land area, then increase from the inner groove area to the outer groove area. The last LBA of land area adjoins the first LBA of groove area. Then LBA continues from 0 to last LBA.

HD DVD-Rewritable media is divided into multiple Zones. The first sector of each revolution in these Zones always align. The data is recorded using a constant angular velocity within each Zone, thus the actual size of the “bits” within a zone increase from the beginning of a zone toward the end of the zone. This keeps the data rate constant for reading and writing within each Zone with constant rotational speed. Each Zone has a fixed radius in width and as such each contains a different number of sectors.

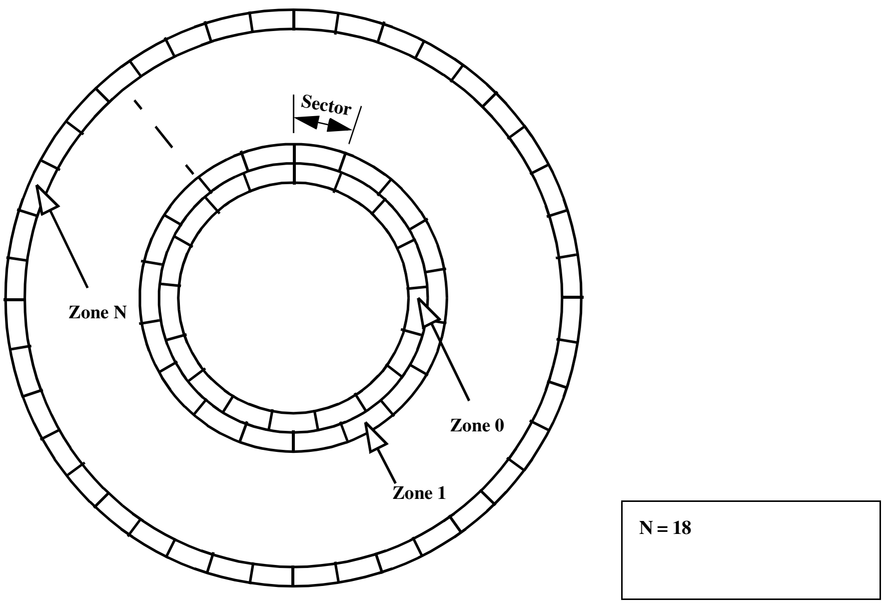


Figure 138 - Zoning of HD DVD-Rewritable media

The Data Area begins at 030000h for HD DVD-Rewritable, like HD DVD-ROM and HD DVD-R, where Data Areas begin at 030000h. This is caused by the existence of Defect Controls. There are two Defect Controls: one is located immediately before the Data Area and starts at 02CE00h, and the other is located immediately after the Data Area. The Defect Controls are non-user addressable areas. These blocks contain Defect Management Areas (DMAs) and DMA managers.

The DMA contains Disc Definition Structure (DDS) for the recording method used for formatting of the disc, a Primary Defect List (PDL) for recording defective sectors identified at formatting of the disc, and a Secondary Defect List (SDL) for recording defective ECC blocks identified during writing/reading user data.

1. HD DVD-Rewritable Ver.1.0
   The Data Area has one or two Spare Areas. There are two types of Spare area, Primary Spare Area (PSA) and Supplementary Spare Area (SSA). Primary Spare Area is always pre-assigned at Initialization/Re-initialization.

Pre-assigned Supplementary Spare Area is selectable at Initialization/Re-initialization. And Supplementary Spare Area is expandable after Initialization/Re-initialization. The User Area and Spare Areas contain user accessible sectors addressed by an LBA. The LBAs increase toward the Outer Diameter within each of land/groove. Defective sectors are replaced by sectors in the Spare Area. In the case of without SSA, the last LBA is 9644FFh. The location of Primary Spare Area is written in the DDS and the location of Supplementary Spare Area is written in the SDL. The total number of sectors in Primary Spare Area is 73600. HD DVD-Rewritable Ver.1.0 has only one group. The total number of sectors in Supplementary Spare Area is from 0 to 227328. The Guard Area is located at the boundary to prevent signal crosstalk between Zones (See Figure 164). LBA of first Sector in the Group in Figure 164 is the case of no defects in the media.

5.14.2 Supplementary Spare Area

As long as a disc is used with a cartridge, PSA has enough size to ensure user data. PSA is allocated in inner area of the Data Area regardless of formatting type. A block in the PSA is used as a replacement block of a defective block in the user Data Area according to Slipping Replacement Algorithm or Linear Replacement Algorithm.

When a disc is used without a cartridge, defective blocks caused by contamination may increase unexpectedly. In order to supplement insufficiency of spare blocks, SSA can be allocated on formatting or after formatting. SSA is allocated in the most outer area of the Data Area and may grow toward inner radius.

On formatting of a disc, the host can allocate SSA with FORMAT UNIT command with Format Type field of 00h in the Format Descriptor. See Figure 139. The number of blocks to be used for user data recording is specified with Number of Blocks field in the Format Descriptor, and the rest of Data Area is assigned for SSA. All allocatable number of blocks ***shall*** be returned in Formattable Descriptors with Format Type field of 00h in response to READ FORMAT CAPACITIES command. On the formatting with Format Type with 00h, defect management information may be changed and user data written before the formatting is not guaranteed.

If the number of available spare blocks decreases because of many replacement operation, SSA is expandable after formatting of a disc. The logical unit ***shall*** report CHECK CONDITION status, 1/5D/03 FAILURE PREDICTION THRESHOLD EXCEEDED - Predicted Spare Area Exhaustion in response to the command after detecting consumption of available spare blocks. If the host receives the Recovered Error for consumption of spare area, the host should issue FORMAT UNIT command with Format Descriptor that contains Format Type field of 01h and the Number of Blocks field. The Format Descriptor, that is sent with FORMAT UNIT command ***shall*** be one of the Formattable Descriptors returned by READ FORMAT CAPACITIES command. All allocatable number of blocks ***shall*** be returned in Formattable Descriptors with Format Type field of 01h in response to READ FORMAT CAPACITIES command, but Formattable Descriptors that contain the Number of Blocks larger than or equal to the current Number of Blocks ***shall not*** be returned. If the area that is newly allocated to the SSA includes user data, the host should move the user data and update file management information. On expansion operation of SSA, user data that is included in the LBA Space after expansion ***shall*** be retained and defect management information ***shall not*** be changed.

SSA ***shall*** be used after PSA exhaustion. See Figure 140. The Spare Area is used in descending Block order in each of Spare Areas, and the defective sectors in the Spare Area and the corresponding replacement sectors, which have been already registered in the PDL or the SDL, ***shall not*** be used as spare sectors.

Generally the proper default size of spare area should be determined by the main purpose. If the main purpose is non Real-Time data recording, then the default spare area size should be maximum. Because the linear replacement algorithm is usually applied to the non Real-Time data by using spare area. If the main purpose is Real-Time data recording, then the default spare area size should be minimum. Because the linear replacement algorithm ***shall*** not be applied to the Real-Time data (object file) recording. See the following matrix.

If the purpose is unclear at the formatting, then maximum SSA may be recommended because of the fail safe. To extend SSA, the special application software for the re-partitioning the physical volume is necessary.

Table 163 - Recommendation default size of Spare Area

	Main purpose	
	Non Real-Time data	Real-Time data
PSA (fixed size)	Fixed	Fixed
SSA (Min - Max)	Max	Min

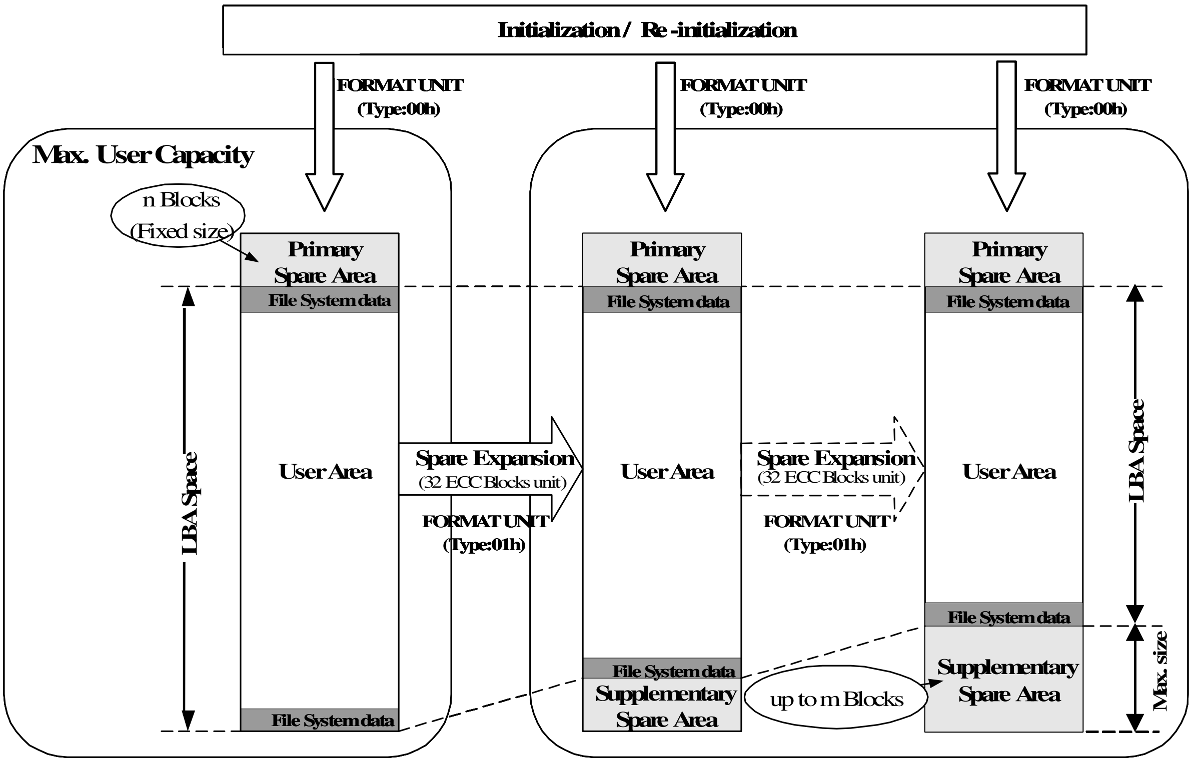


Figure 139 - Supplementary Spare Area example (120 mm, Ver.1.0)

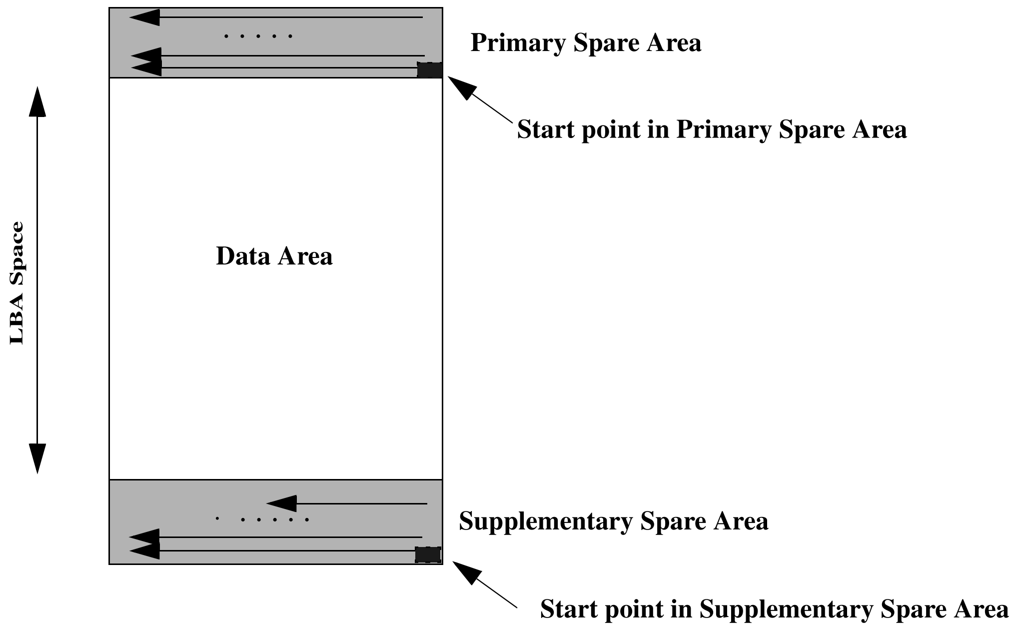


Figure 140 - Usage of Spare Area (Ver.1.0)

Table 164 - Allocation of Data Area of HD DVD-Rewritable Ver.1.0 media

L/G	Zone No.	No. of Physical Sectors				LBA of first Sector in the Group
		Guard Area	User Area	Spare Area	Guard Area	
L[a]	0		60672	73600	192	0
L	1	128	172160	0	192	60672
L	2	160	184416	0	224	232832
L	3	160	196736	0	224	417248
L	4	160	209024	0	256	613984
L	5	192	221312	0	256	823008
L	6	192	233600	0	288	1044320
L	7	192	245920	0	288	1277920
L	8	192	258240	0	288	1523840
L	9	224	270496	0	320	1782080
L	10	224	282816	0	320	2052576
L	11	224	295104	0	352	2335392
L	12	256	307392	0	352	2630496
L	13	256	319680	0	384	2937888
L	14	256	332000	0	384	3257568
L	15	256	344320	0	384	3589568
L	16	288	356576	0	416	3933888
L	17	288	368896	0	416	4290464
L	18	288	227872	0	0	4659360

Table 164 - Allocation of Data Area of HD DVD-Rewritable Ver.1.0 media

L/G	Zone No.	No. of Physical Sectors				LBA of first Sector in the Group
		Guard Area	User Area	Spare Area	Guard Area	
G[b]	0	0	134272	0	192	4887232
G	1	128	172160	0	192	5021504
G	2	160	184416	0	224	5193664
G	3	160	196736	0	224	5378080
G	4	160	209024	0	256	5574816
G	5	192	221312	0	256	5783840
G	6	192	233600	0	288	6005152
G	7	192	245920	0	288	6238752
G	8	192	258240	0	288	6484672
G	9	224	270496	0	320	6742912
G	10	224	282816	0	320	7013408
G	11	224	295104	0	352	7296224
G	12	256	307392	0	352	7591328
G	13	256	319680	0	384	7898720
G	14	256	332000	0	384	8218400
G	15	256	344320	0	384	8550400
G	16	288	356576	0	416	8894720
G	17	288	368896	0	416	9251296
G	18	288	227872-M	M	0	9620192
Total	N/A	7872	9848064-M	73600+M[c]	11072	N/A

a. L : Land
b. G : Groove
c. M is the number of sectors of the Supplementary spare area.

5.14.3 Unrecorded ECC blocks

A HD DVD-Rewritable disc which has not been certified may contain unrecorded ECC blocks to which user data has not been written. The logical unit ***shall*** return all zero data in response to an attempt to read logical blocks from such unrecorded ECC blocks. Further, a logical block may contain an initialization pattern used at certification which can be discriminated by the Data ID of the logical block. The logical unit also returns all zero data in response to an attempt to read such Logical Blocks containing the initialization pattern.

5.14.4 Read Modify Write

Any attempt to write data less than one ECC block causes a read-modify-write operation in the logical unit, which requires more than one rotation to write the data, if data is not cached.

1. Reading an ECC block containing the designated logical blocks (First path)
2. Overlay the data to be written onto the read out ECC block data
3. Writing the modified ECC block data back to the same addresses (Second path)

When an ECC block designated for Read-Modify-Write operation is physically unwritten or contains the initialization pattern used at certification, which can be discriminated by the Data ID of the Logical Block, the logical unit writes all zero data to the logical blocks in the ECC block other than the designated Logical Blocks from the host.

A technique to provide better performance with HD DVD-Rewritable media is to write data in sizes that are a multiple of 65536 bytes starting at a logical block address that is a multiple of 32, which results in a one path direct overwrite operation. These values can be determined from the Random Readable Feature Descriptor (see *16.4.2.6, "Feature 0010h: Random Readable"* on page 420).

5.14.5 Data ID

HD DVD-Rewritable has same Data ID structure that HD DVD-ROM and HD DVD-R have.

5.14.6 Defect management for HD DVD-Rewritable media

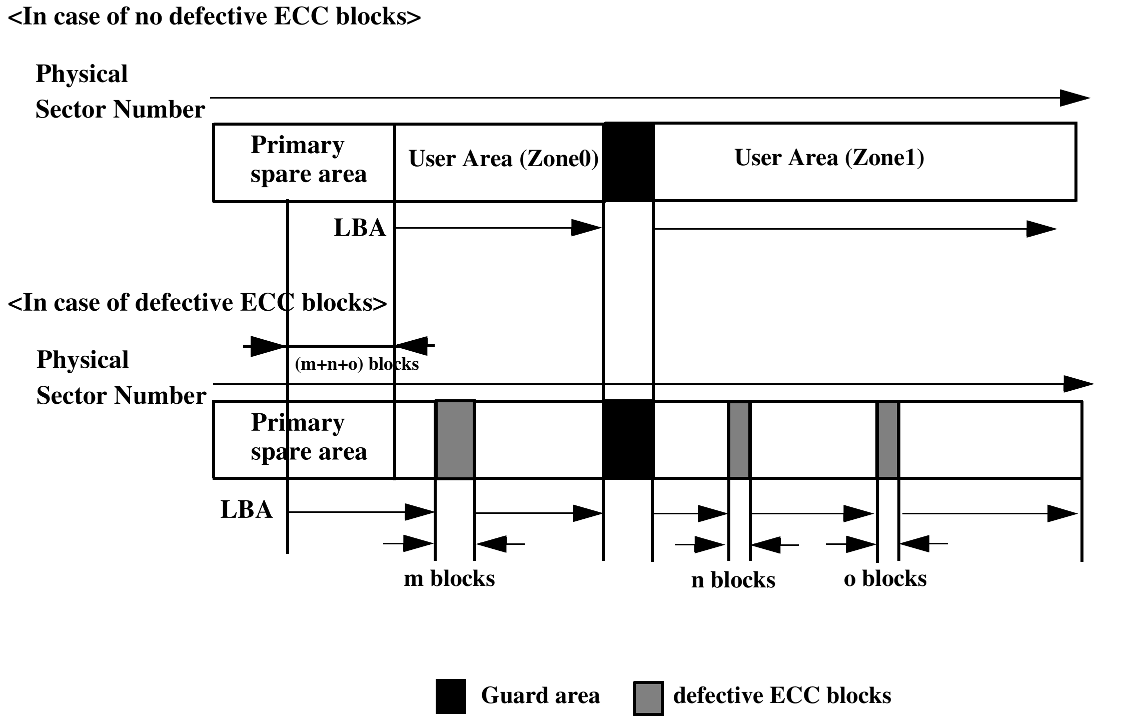
Defective physical sectors in the Data Area of HD DVD-Rewritable media are managed by the logical unit according to the defect management scheme specified in the HD DVD Book for Rewritable Disc, Part 1: Physical Specifications.

Two replacement methods are defined for defective physical sectors:

Slipping replacement is the first method in which a defective ECC block is replaced by the first non-defective ECC block following the defective ECC block. The slipping replacement is performed in units of an ECC block. Defective ECC blocks replaced by the slipping replacement are listed in Primary Defect List (PDL) recorded on the HD DVD-Rewritable media during formatting. Contents of the PDL on HD DVD-Rewritable media can be changed only by formatting. The number of ECC blocks to be listed in the PDL ***shall not*** exceed the number of ECC blocks in the Spare Area. Entries of the PDL consist of three categories: P-list, G_1-list and G_2-list.

- Defective physical ECC blocks encountered by media manufacturer before shipment of the HD DVD-Rewritable media are listed in the P-list. A defect is registered to the P-list in a unit of 1 ECC block. Time to perform the slipping replacement for a defective ECC block listed in the P-list is minimal, because it requires time only to pass the defective ECC block. The P-list ***shall*** be preserved during any formatting and ***shall*** be always used in order to avoid possible change of ECC block framing by formatting.
- Defective ECC blocks encountered by certification after shipment of the HD DVD-Rewritable media are listed in the G_1-list. A defect is registered to the G_1-list in a unit of 1 ECC block. Time to perform the slipping replacement for a defective ECC block listed in the G_1-list is minimal as in the P-list. The G_1-list ***shall*** be always used and ***shall*** only be changed with certification in order to avoid possible change of ECC block framing by formatting.
- Defective ECC blocks transformed from the SDL by formatting are listed in the G2-list. A defect registered to the G2-list consumes 32 entries at once. Time to perform the Slipping Replacement for defective ECC block listed in the G2-list is longer than the time for P-list or G1-list, because it requires time to pass 32 consecutive ECC block. However, it is still much faster than Linear Replacement because it does not require a Seek operation to the Spare Area. The G2-list can be changed without certification, however, the G2-list ***shall*** be disposed at certification in order to avoid possible change of ECC block framing by formatting

Linear Replacement is the second method in which a defective ECC block is replaced by the first available ECC block out of spare sectors. The linear replacement is performed in a unit of an ECC block. An ECC block found to be defective is replaced by the first available good spare ECC block. If there is no spare ECC block left, the first available good spare ECC block is used. Defective ECC blocks replaced by the Linear Replacement are listed in the Secondary Defect List (SDL) recorded on the HD DVD-Rewritable media. Contents of the SDL on HD DVD-Rewritable media are updated whenever an ECC block is found to be defective. When a replacement ECC block is found to be defective, a new replacement ECC block will be substituted and the SDL will be updated on the media. Chaining of replacement will not be performed, direct pointer method will be applied. Time to perform the Linear Replacement is longer than Slipping Replacement because it requires seek operation to the Spare Area and writing/reading the replacement ECC block. However, this is the only method to register a new defect without formatting the media.



Each defective ECC block causes a slip towards the top of the Data Area. Only Primary Spare Area ***shall*** be used for the Slipping Replacement.

Figure 141 - Slipping Replacement Example (Ver.1.0)

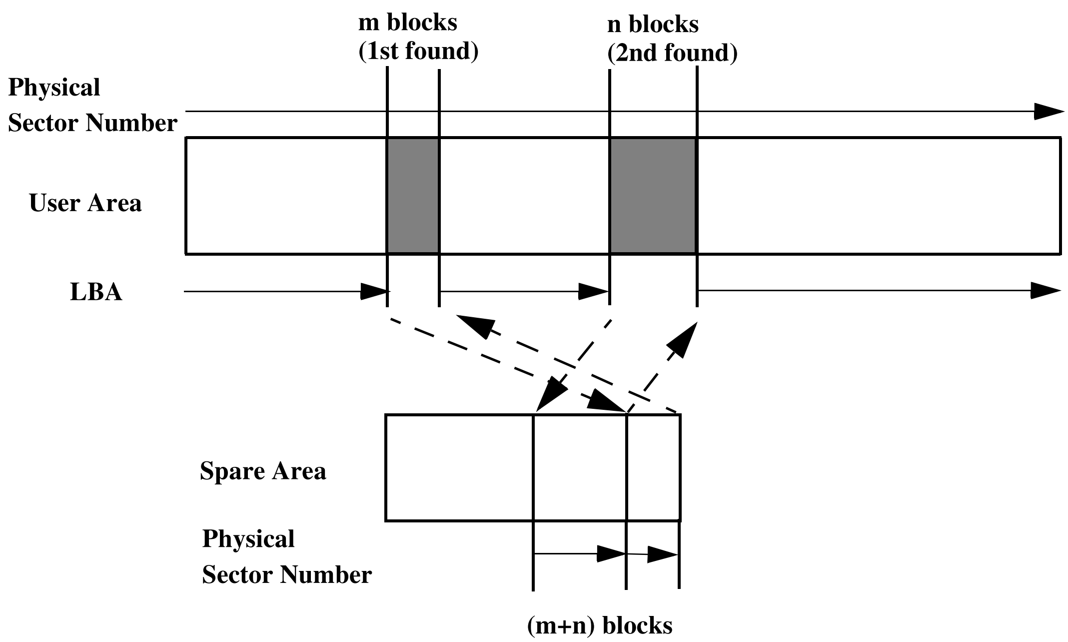


Figure 142 - Linear Replacement Example (Ver.1.0)

5.14.7 DMA information

The Defect Management Area (DMA) consists of two ECC blocks. The first ECC block contains the Disc Definition Structure (DDS) for the recording method used for formatting of the disc, and the Primary Defect List (PDL) for recording defective sectors identified at formatting of the disc. The DDS contains the following information.

- In-progress flag indicating formatting operation is completed or not. This flag enables to recover a suspended formatting operation.
- A flag indicating the media has been certified by media manufacturer or not.
- A flag indicating the media has been certified by the logical unit or not.

The PDL contains information of ECC blocks to be replaced by the slipping replacement. Though the PDL has a capacity to hold defective ECC block information for up to 15871 ECC blocks in the case of 120mm, there is another limitation of the maximum number. See Figure 144 - *Limitation of maximum number of sectors for PDL and SDL* on page 312.

The second ECC block contains the Secondary Defect List (SDL) for recording defective ECC blocks identified during writing/reading user data. Though the SDL has a capacity to hold the defective ECC block information up to 8189 ECC blocks, there is another limitation of the maximum number. See Figure 144 - *Limitation of maximum number of sectors for PDL and SDL* on page 312.

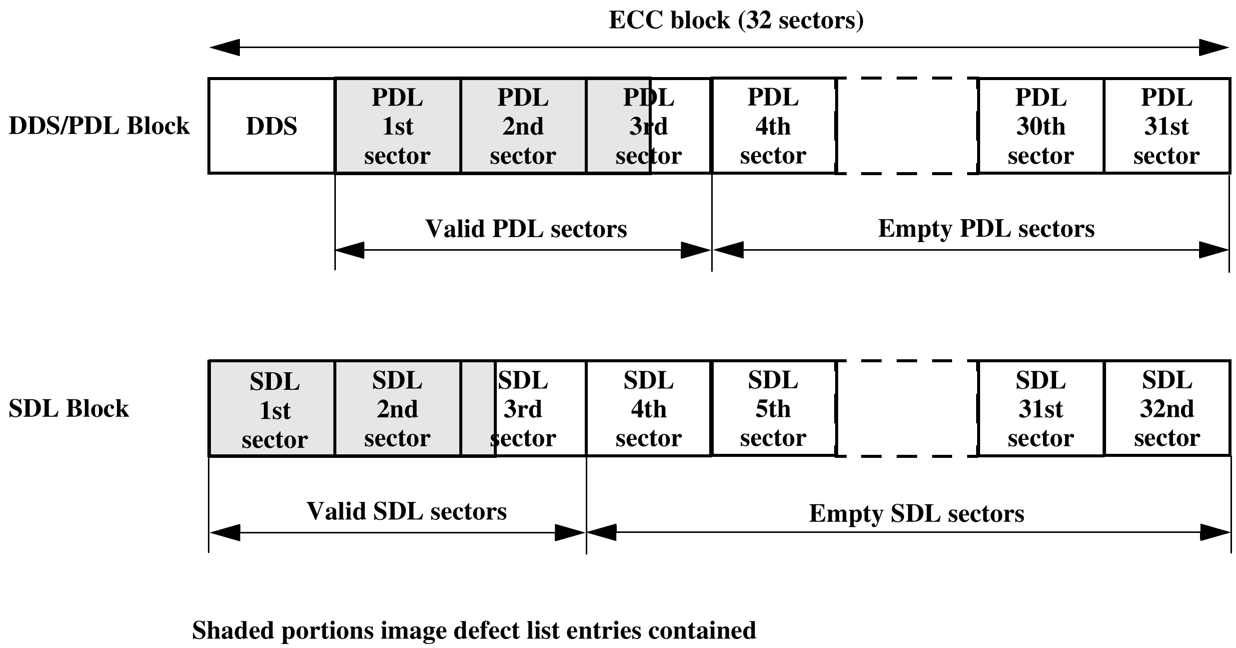


Figure 143 - DDS/PDL Block and SDL Block

Table 165 - DDS information (Ver.1.0)

Bit / Byte	7	6	5	4	3	2	1	0
0 - 1	DDS Identifier (0A0Ah)							
2	Reserved							
3	Disc Certification Flag							
4 - 7	DDS/PDL Update Counter							
8 - 9	Number of Groups (0001H)							
10 - 11	Number of zones							
12 - 79	Reserved							
80 - 87	Location of Primary spare area							
88 - 91	Location of LSN0							
92 - 255	Reserved							
256 - 259	Start LSN for Zone0 in land							
260 - 263	Start LSN for Zone1 in land							
. . .	. . .							
328 - 331	Start LSN for Zone18 in land							
332 - 335	Start LSN for Zone0 in groove							
336 - 339	Start LSN for Zone1 in groove							
. . .	. . .							
404 - 407	Start LSN for Zone18 in groove							
408 - 2047	Reserved							

Table 166 - Disc Certification Flag format (Ver.1.0)

Bit							
7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
Formatting in-progress	Reserved					The whole disc has been certified by user	The disc has been certified by disc manufacturer

The size of the defect lists will be limited by several factors. As the information about all defects in the PDL and the SDL ***shall*** be used to access LBAs, the defect lists would normally be kept in the logical unit's memory.

$$(1 \le S_{PDL} \le 31,\ 1 \le S_{SDL} \le 32)$$

$$S_{PDL} = INT\left[\frac{(E_{PDL} \times 4 + 4) + 2047}{2048}\right]$$

$$S_{SDL} = INT\left[\frac{(E_{SDL} \times 8 + 24) + 2047}{2048}\right]$$

S_{PDL} is the number of sectors used to hold PDL entries
S_{SDL} is the number of sectors used to hold SDL entries
E_{PDL} is the number of PDL entries
E_{SDL} is the number of SDL entries

Figure 144 - Limitation of maximum number of sectors for PDL and SDL

5.14.8 Scheduling of Linear Replacement

The HD DVD-Rewritable format is designed to enable the following Linear Replacement methods, with some consideration for issues of real-time data recording, where for example the reassignments are disabled during some operations.

- When recording data with verification by the WRITE AND VERIFY (10) command, the logical unit has an opportunity to evaluate the written data and if the data is found defective, the logical unit may perform a Linear Replacement.
- For data recorded without verification, the logical unit has an opportunity to evaluate the written data when the host attempts to read the data from that LBA and if the data is found defective but correctable by ECC, the logical unit may perform the Linear Replacement operation, if read reassignment is enabled.

5.14.9 Formatting

Formatting is required at the beginning of use of HD DVD-Rewritable media. During formatting, the logical unit defines correspondence between LBAs and physical addresses and records relevant information in the Defect Management Areas. All the user data in the formatted extent is lost during the formatting. Media certification may be included as a part of the formatting. No defect list ***shall*** be transferred from the host, i.e. there ***shall*** be no D-list for HD DVD-Rewritable media.

The certification process included in the formatting should not be confused with media certification from a media manufacturer. The logical unit controlled "certification" allows the logical unit to write and verify all the sectors on the media. This operation allows some defects to be registered in the G_1-list for the Slipping Replacement. These are not the same as certification defects from the media manufacture which is recorded in the P-list. The result of the "certification" process of the FORMAT UNIT command is to leave every sector with a special ID content called the "Initialization pattern." This type of ECC block ***shall*** be treated as though all zero data has been written. This is the same as an unwritten ECC block.

If the total number of spare sectors are exhausted during a FORMAT UNIT command, the format operation will not stop, but will ignore those defects that cannot be replaced and a RECOVERED ERROR ***shall*** be reported at the completion.

If the size of the PDL & SDL are going to exceed the limit in Figure 144, the logical unit ***shall*** discard defect entries until the size does not exceed that limit.

There can be considered four kinds of formatting depending on how the certification performed and how the old defect list (G_1-list and G_2-list) is treated:

5.14.9.1 Formatting Type 1 - Slow Initialization

The purpose of Formatting Type 1 is to initialize the medium using the media manufacturer's defect list (P-list), assuming that the media has defects not in the P-list. The logical unit performs its own certification. The execution time is long, at least one hour or more. Every physical sector should be written with initialization pattern and verified.

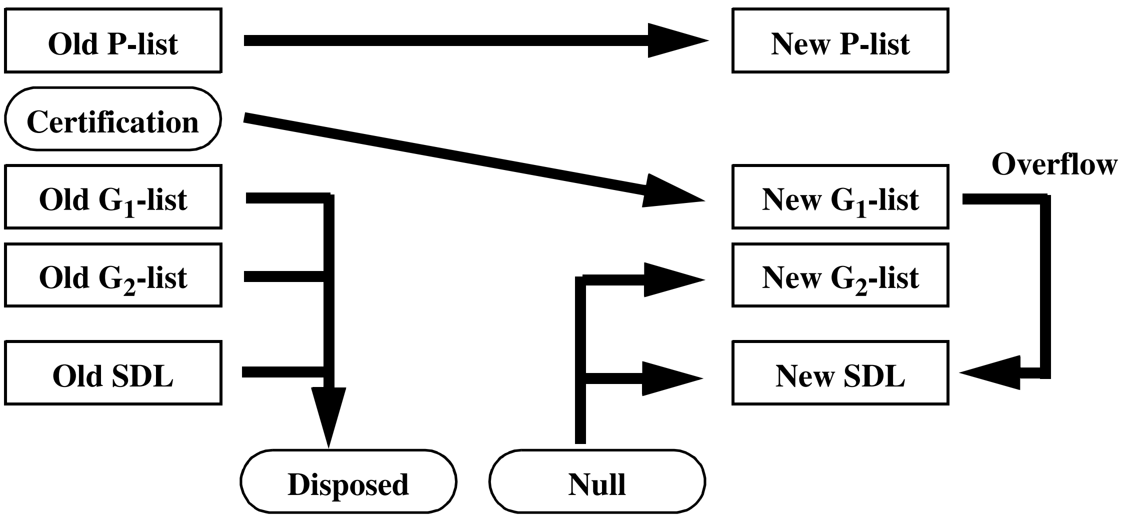


Figure 145 - Formatting Type 1 - Slow Initialization

5.14.9.2 Formatting Type 2 - Quick Improvement

The purpose of Formatting Type 2 is to remove reassigned sectors for Linear Replacement and change them to Slipping Replacement. The total number of Spare sectors available remains the same. The execution time is very little, only several seconds is expected.

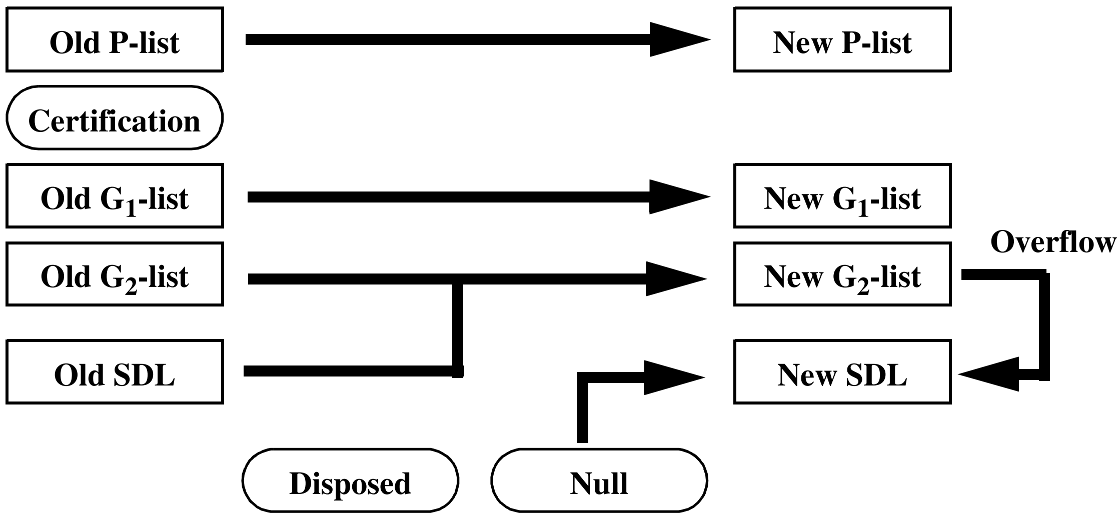


Figure 146 - Formatting Type 2 - Quick Improvement

5.14.9.3 Formatting Type 4 - Quick Clearing

The purpose of Formatting Type 4 is to initialize the media for use, using only media manufacturer defect information. Another purpose is to return the media to the latest certified state by removing reassigned sectors for Linear Replacement and the G_2-list. The execution time is very little; only several seconds is expected.

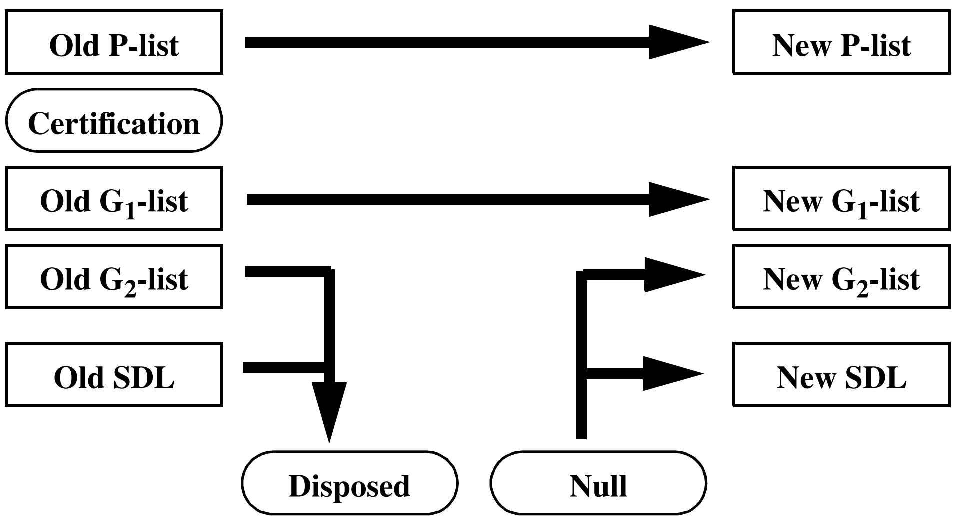


Figure 147 - Formatting Type 4 - Quick Clearing

5.14.10 Interruption of formatting

An interruption of formatting by reset, or power off may cause the media to be unusable without another formatting operation. In any case, all the user data in the formatting extent ***shall*** be assumed to be lost, because correspondence between the LBAs and physical addresses may have been changed.

- An interruption of formatting Type 1 may cause the media to be unusable because of uncompleted change of the assignment for the LBA. Any access to the media in this condition other than a proper FORMAT UNIT command

shall be terminated with CHECK CONDITION status, 3/31/00 MEDIUM FORMAT CORRUPTED. The only recovery operation to this case is another formatting by formatting Type 1 only.

- An interruption of formatting Type 2 causes the media to be usable as there is no media certify operation.
- An interruption of formatting Type 4 causes the media to be usable as there is no certification operation.

5.14.11 Cartridge and Disc Type

The definition of Cartridge and Disc Type for HD DVD is the same definition for DVD. See *4.15.13 "Cartridge and Disc Type"* on page 117.

5.14.12 Write protection of a disc

5.14.12.1 Write-inhibit hole

This hole is the mechanical switch/tab for write protection on a cartridge. When this hole is closed, the logical unit may write/modify information according to the other write protection conditions. When this hole on a cartridge is open, the logical unit ***shall not*** write/modify/initialize any information (including user data, defect management information and Write-inhibit flag) on the disc.

Host is able to get the Write-inhibit hole condition as a CWP bit value using READ DISC STRUCTURE command with Format Code = C0h or 09h.

5.14.12.2 Sensor hole A1

The Sensor hole A1 indicates whether the disc had been taken out from a cartridge or not. The Sensor hole A1 is closed when the disc had never been taken out from the cartridge. The Sensor hole A1 is open when once the disc had been taken out from the cartridge. In the case of the Sensor hole A1 open, verify after write is recommended. A logical unit may reject certain write operations without verification. In this case, the command ***shall*** be terminated with CHECK CONDITION status, 7/27/06 CONDITIONAL WRITE PROTECT. These differences depend on the drive implementation for keeping data integrity.

Note: WRITE (12) command with Streaming *bit set to one may not be affected by the Sensor hole A1 status. If logical unit does not permit execution of the command when Sensor hole A1 is open, the command is terminated with CHECK CONDITION status, 7/27/06 CONDITIONAL WRITE PROTECT.*

Host is able to get the sensor hole A1 condition as a Out bit value using READ DISC STRUCTURE command with Format Code = 09h.

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6.0 AS-MO model

The Advanced Storage MO (AS-MO) is designed to store large amounts of coded and image data. The UDF file system is employed to take advantage of complete data interchangeability for multiple PC platforms. In addition, sophisticated security features are also built into the basic logical unit concept.

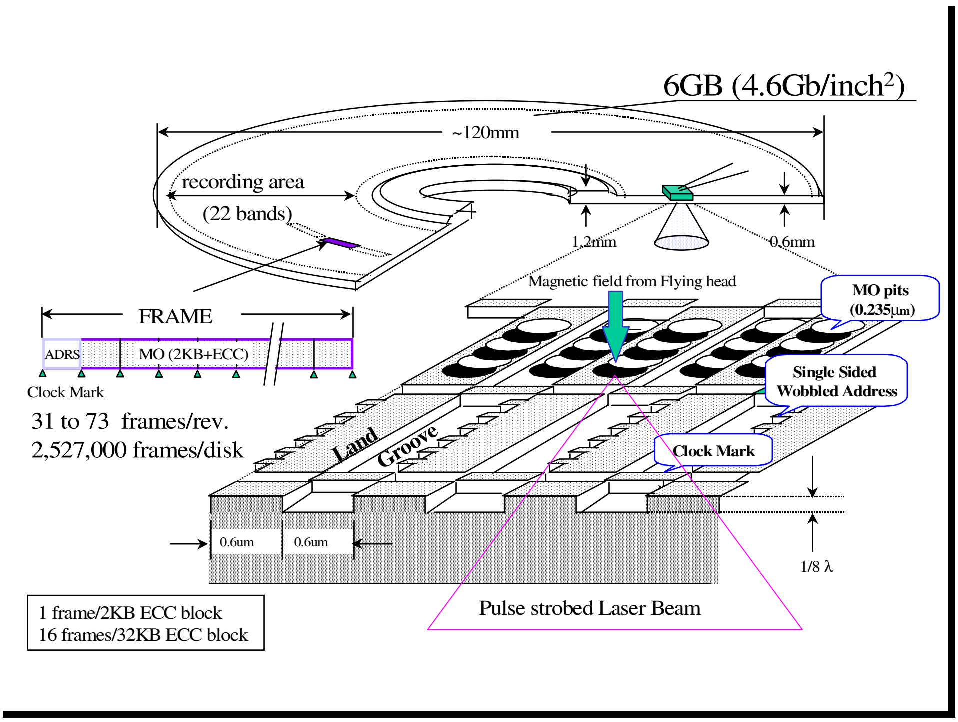

Figure 148 - Disk Structure

An AS-MO disk contains 6 GB of user data on a single sided, 120 mm diameter, 0.6 mm thick substrate. The disk contains land and groove recording in 22 bands. Addressing is done using a single sided wobble groove. Defect management is performed by the drive using standard DMA methods, and has been optimized for real time data capture. The AS-MO disk is contained within a protective cartridge.

6.1 AS-MO media description

The AS-MO media is currently specified by the following book.

ADVANCED STORAGE - MAGNETO OPTICAL DISK (AS-MO) / part 1 - physical specifications - version 1.0 (April 1998) by ASTC.

6.2 AS-MO specifications

General parameters of AS-MO disks are shown in Table 167.

Table 167 - AS-MO parameters

Specification	Contents
User Capacity (Single Layer)	6 GB
Disk Diameter	120 mm
Disk thickness	0.6 mm,1.2 mm (Clamping Area)
Wavelength for W/R	635/650 nm
NA of Objective lens	0.60
Data bit length (=Channel bit length)	0.235µm
Min. Mark length	0.235µm
Data Encoding	NRZI plus
W/R strategy	Write: MFM (Magnetic Field Modulation)
	Read: MSR (Central Aperture Detection)
Track pitch	0.6µm (Land and Groove)
User data per sector	2048 bytes
Error Correction Code	Reed-Solomon product code
ECC block size	32KB/2KB
Physical Address	Staggered Wobbled Groove Address
Linear velocity (CAV)	4.5 to 10.9 m/s
Data transfer rate	15.3 to 35.9 Mbps
Starting Physical Number of Data Area	31000h
End Physical Number of Data Area	2EFD7Fh

6.3 Physical structure (32KB ECC block)

An AS-MO disk has approximately 50,000 tracks grouped into 22 physical zones. Each track contains between 31 and 73 frames (1 frame = 1 logical sector). Data is recorded in 32K ECC blocks. Each ECC block contains 16 frames. Each frame consists of 39 contiguous segments. Each segment contains 532 recorded data bits (user data with ECC). In addition, each segment contains an embossed Fine Clock Mark for read/write clocking. The first segment in each frame is an address segment, which contains the physical address data. See Figure 149.

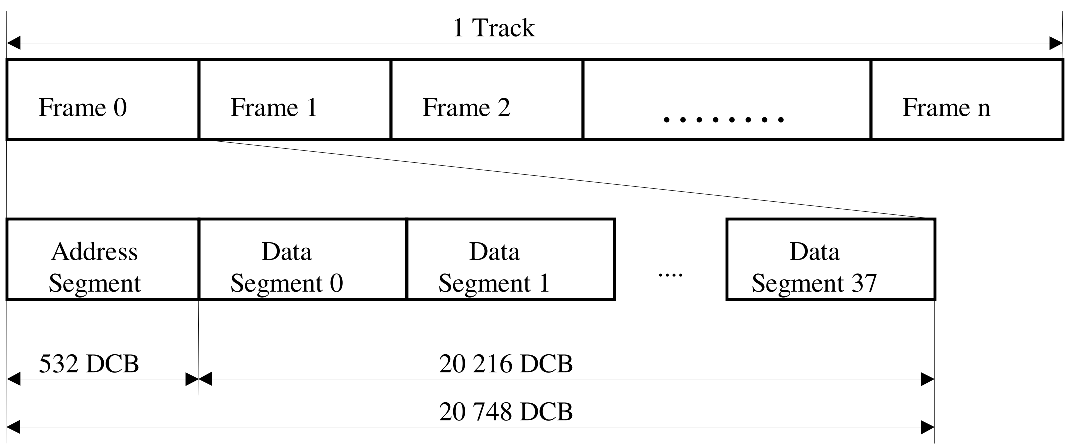

Figure 149 - Physical format

6.3.1 AS-MO physical specification information

See AS-MO Part 1, physical specification for additional information.

Contact address:
Mitsuru Toriyama
Assistant Manager, DVD Business Center, Sony Corporation
Address: 6-7-35, Kitashinagawa Shinagawa-ku, Tokyo, 141-0001 Japan
Fax: +81-3-5448-3458
e-mail: asmo@mift.sony.co.jp

6.4 Logical structure

An AS-MO disk has two continuous land and groove recording tracks. The recording tracks are divided into 714 logical zones, each containing sophisticated defect management areas. Each logical zone consists of 8 Mbytes (252x32 KB) of user data and 128 KBytes (4x32 KB) spare sectors. This structure is defined to optimize optical head movement and buffer capacity in order to make continuous real time data capture and playback possible.

Defect management tables are located in both Outer Area (Band 1) and Inner Area (Band 22) disk areas.

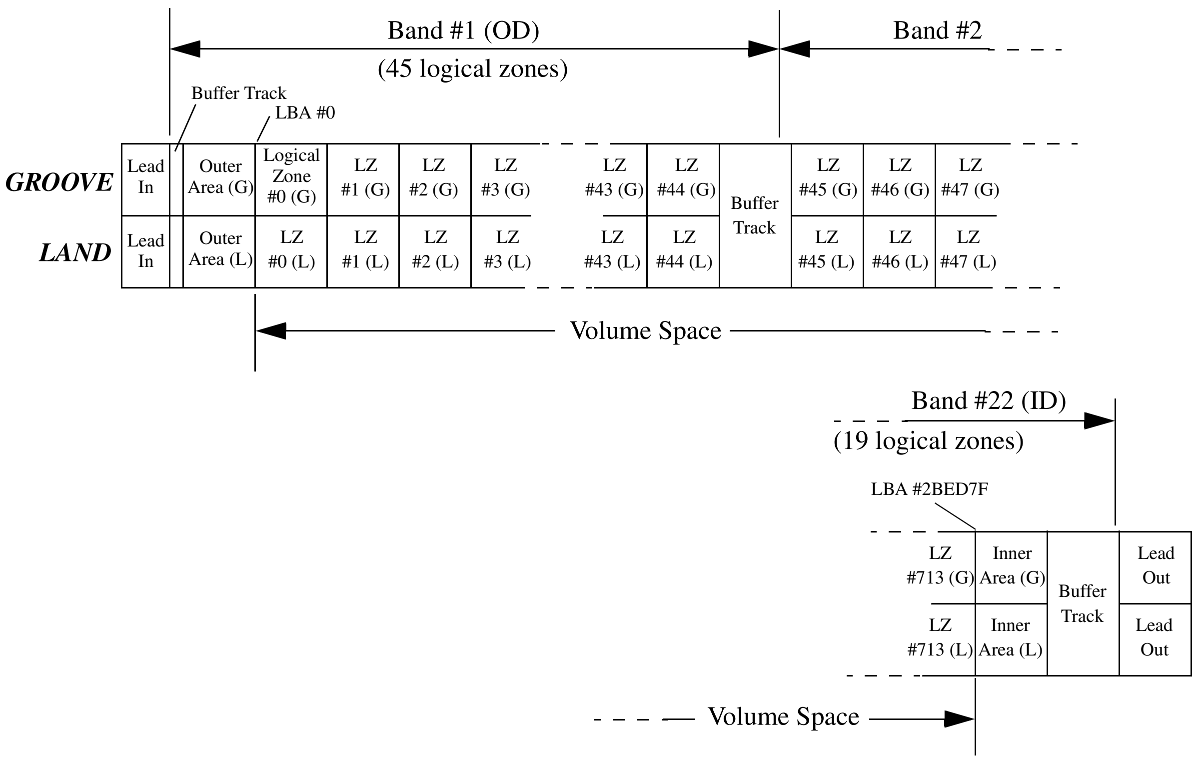

Figure 150 - Physical and logical layout of AS-MO media

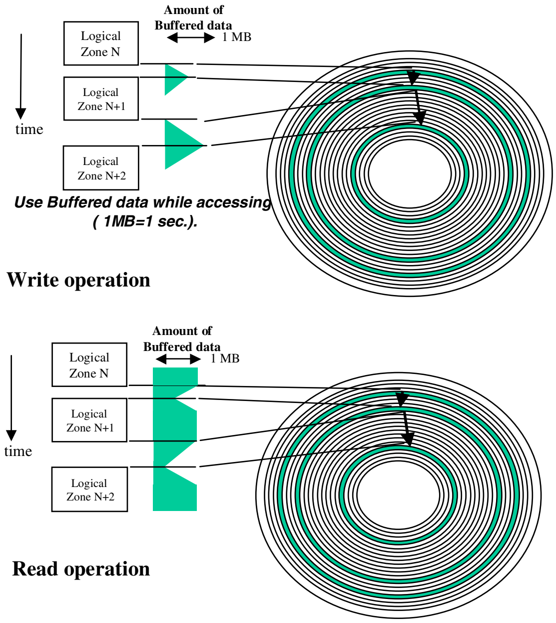

Figure 151 - Concept of seamless linking for AV capture/playback

6.4.1 Concept of seamless linking for AV data

The conceptual model of AS-MO is to maintain consistent data transfer of AV data. The internal buffer is used to guarantee real time capture and playback regardless of the relative location of the data.

6.5 Recording/reading for AS-MO media

6.5.1 AS-MO Features

1. All defect management is handled at the drive level (no OS support is required)
2. Manufacturer certification is not necessary
3. User certification is not necessary
4. Only formatting is required before use for creating the logical file system.
5. Recording in 32K ECC block is preferred (to prevent read-modify-write), but not required.

6.5.2 Defect management for AS-MO media

Each replacement sector area is located within a lens accessible region for the preceding user Data Area.

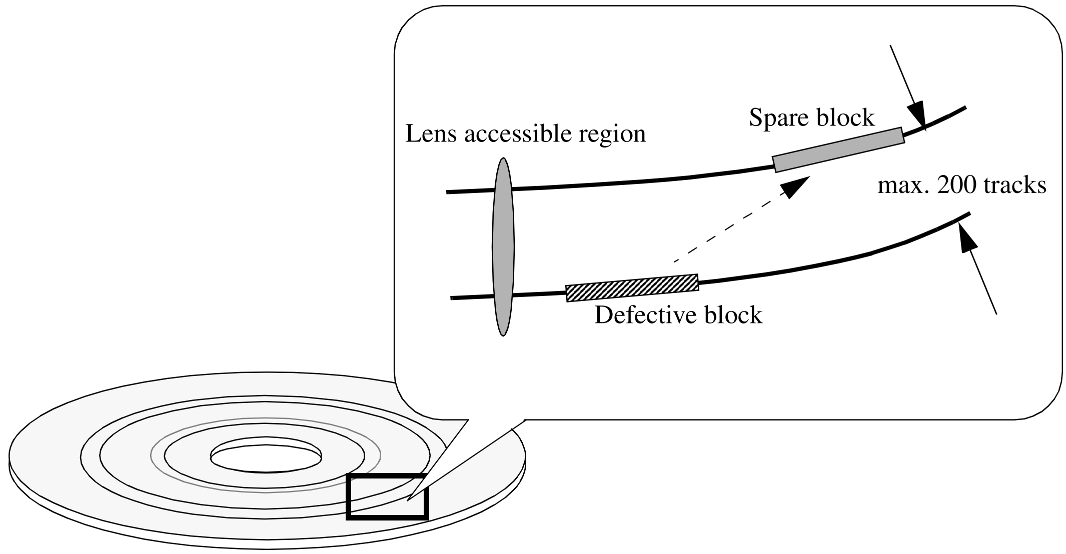

Figure 152 - Spare block allocation in a logical zone

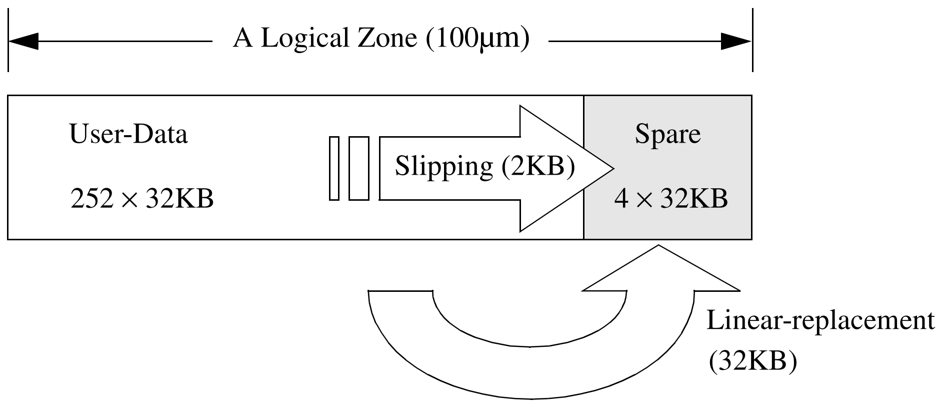

Figure 153 - Defect management in a logical zone

6.5.3 FORMAT UNIT command and READ FORMAT CAPACITIES command use

AS-MO logical units ***shall*** support Format Types 00h, 04h, and 05h.

6.6 Features

The following Features may be supported by the AS-MO logical unit in addition to the AS-MO Profile.

1. MultiRead Feature (001Dh)
2. CD Read Feature (001Eh)
3. DVD Read Feature (001Fh)
4. Microcode Upgrade Feature (0104h)

6.7 Profiles

The following Profiles may be supported by the AS-MO logical unit in addition to the AS-MO Profile.

1. 0002h - Removable disk
2. 0012h - DVD-RAM

7.0 AACS content protection

Advanced Access Content System (AACS) is used to protect audiovisual content on such as HD DVD discs and DVD-ROM 3× discs. AACS Content Protection is made up of two basic concepts. The first is to encrypt the content of the data such that it ***shall*** be decrypted before it can be used. The capability of encrypting and/or decrypting the content is provided only under conditions that require products to be compliant with rules governing the playback, copying, moving and output of the content. The second basic concept is to use an “Authentication” process to verify legitimacy of a logical unit and to ensure the integrity of information transfer from the logical unit to the host. AACS uses its proprietary authentication process (AACS Authentication). The following parameters are transferred from the logical unit to the host by using the AACS Authentication.

- For read-only disc

- AACS uses a “Volume Identifier (Volume ID)” to encrypt content recorded on a set of read-only discs produced by the same glass master. Before decrypting such content the host reads the Volume ID using the READ DISC STRUCTURE command with Format Code = 13h.
- AACS may use a “Pre-recorded Media Serial Number” to identify each piece of read-only disc for an advanced feature. It is read by the host using the READ DISC STRUCTURE command with Format Code = 14h, when necessary.

- For Recordable and Rewritable discs

- AACS uses a “Media Identifier (Media ID)” to bind protected content to the disc on which it is recorded. Before encrypting or decrypting such content the host reads the Media ID using the READ DISC STRUCTURE command with Format Code = 16h.
- AACS uses a “Binding Nonce” to delete the content securely that is moved to another storage medium. Another purpose of the Binding Nonce is to bind keys that are used to encrypt contents to the disc. The Binding Nonce is generated and reported by a logical unit by using the REPORT KEY command with Key Class 02h and KEY Format 100000b. The generated Binding Nonce is memorized by the logical unit with associated LBA Extent provided by the REPORT KEY command and Authentication Grant ID for AACS (AGID for AACS) used for the REPORT KEY command. The stored Binding Nonce is recorded onto the disc together with user data by using the WRITE (10), WRITE (12) or WRITE AND VERIFY (10) command for a LBA that is included in the LBA Extent provided by the REPORT KEY command in such a way that the Binding Nonce is recorded in 4 logical blocks starting from the LBA provided by the REPORT KEY command. The stored Binding Nonce is invalidated by invalidating the AGID for AACS. The host may read the Binding Nonce recorded by using the REPORT KEY command with Key Class 02h and KEY Format 100001b.

AACS also uses "Media Key Block (MKB)". In contrast to CPRM, the MKB for AACS is self-protected and does not require protection by an authentication. The MKB is read by the host using the READ DISC STRUCTURE command with Format Code = 17h, when it is recorded in the Lead-in Area.

Note: AACS does not use the Authentication Success Flag (ASF) or the Region Playback Control (RPC) which are used in the CSS.

7.1 AACS Authentication process

The AACS Authentication is processed in a stateful manner. The process consists of 4 states as shown in Figure 154. This state diagram assumes an appropriate AACS capable disc is loaded. It ***shall*** be possible to perform four processes concurrently.

1. "Initial" state: An AACS Authentication process starts from this state. The logical unit ***shall*** manage that all the 4 processes are in this state after Power-on Reset, Hard Reset and the disc is ejected. When starting a process, the host requests an AGID for AACS by using the REPORT KEY command with Key Class 02h and KEY Format 000000b. The logical unit, when ready to begin an AACS Authentication process, ***shall*** grant the request by returning an AGID for AACS and enters "AGID for AACS granted" state. If there is no available AGID for AACS, the REPORT KEY command ***shall*** be terminated with CHECK CONDITION status, 5/55/00 SYSTEM RESOURCE FAILURE. If the host acknowledges that there is hung AACS Authentication processes initiated by itself, the host ***shall*** reset the hung authentication processes prior to the request by invalidating the corresponding

AGIDs for AACS by using the REPORT KEY command with Key Class 02h and KEY Format 111111b or the SEND KEY command with Key Class 02h and KEY Format 111111b

2. "AGID for AACS granted" state: The host sends a Challenge Key to the logical unit by using the SEND KEY command with Key Class 02h and KEY Format 000001b.

3. "Challenge Key in hold" state: The host performs one of the following operation with an associated command. The logical unit returns the requested value in a protected manner with using the Challenge Key. For the first four operations, the logical unit ***shall*** invalidate the AGID for AACS being used for the process upon completing the command and ***shall*** return to the "Initial" state. For reading existing Binding Nonce, the Binding Nonce ***shall*** be always read from the disc. It is recommended to issue SYNCHRONIZE CACHE command before reading the Binding Nonce. For generating a value of the Binding Nonce, The logical unit ***shall*** store the generated value of the Binding Nonce together with LBA Extent designated by the REPORT KEY command and with the AGID for AACS for later recording and enters the "Binding Nonce generated" state. The length of LBA Extent ***shall*** be no less than 4. If the length of LBA Extent designated by the REPORT KEY command is less than 4, the command ***shall*** be terminated with CHECK CONDITION status, 5/6F/06 INSUFFICIENT BLOCK COUNT FOR BINDING NONCE RECORDING and the logical unit ***shall*** return to the "Initial" state. The logical unit ***shall*** be capable of storing 4 sets of generated Binding Nonce value and its associated LBA Extent and AGID for AACS at a time. If the designated LBA Extent is overlapped with other LBA Extent being stored, the command ***shall*** be terminated with CHECK CONDITION status, 5/6F/07 CONFLICT IN BINDING NONCE RECORDING and the logical unit ***shall*** return to the "Initial" state.
   - Reading the Volume ID using the READ DISC STRUCTURE command with Format code 13h.
   - Reading the Pre-recorded Media Serial Number using the READ DISC STRUCTURE command with Format code 14h.
   - Reading the Media ID using the READ DISC STRUCTURE command with Format code 16h.
   - Reading existing value of the Binding Nonce by using the REPORT KEY command with Key Class 02h and KEY Format 100001b
   - Generating a value of the Binding Nonce to be recorded onto the disc by using the REPORT KEY command with Key Class 02h and KEY Format 100000b

4. "Binding Nonce generated" state: The generated Binding Nonce value is ready to be recorded onto the disc together with user data by using the WRITE (10), WRITE (12) or WRITE AND VERIFY (10) command until the Binding Nonce is invalidated by invalidating the AGID for AACS. The recording of stored Binding Nonce ***shall*** be made for a LBA that is included in the LBA Extent provided by the REPORT KEY command in such a way that the Binding Nonce ***shall*** be recorded in 4 logical blocks starting from the LBA provided by the REPORT KEY command. When the AGID for AACS is invalidated, the logical unit ***shall*** discard the generated Binding Nonce and ***shall*** return to the "Initial" state.

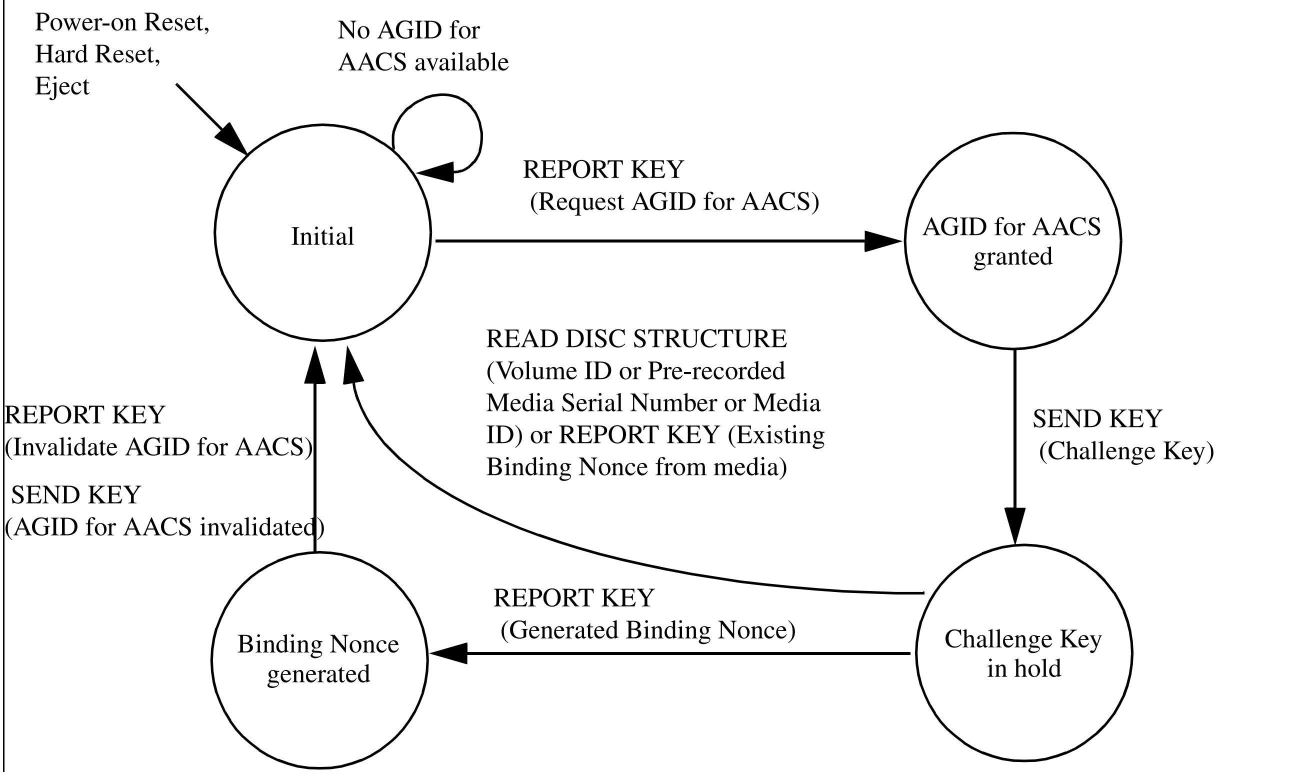

Figure 154 - AACS Authentication State Diagram

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8.0 Real-Time Stream recording/playback model

Real-Time Stream recording/playback is one of the most important applications for recordable optical discs. It is also useful as a bridge between PC peripherals and consumer devices such as DVD players. However, optical disc drives, especially consumer players, have low access performance compared with hard disk drives from the viewpoint of data rate and seek delay. In addition, dispersion of recorded Streaming data on recordable optical discs may further degrade performance leading to the poor quality of data playback. In order to address the issue, Streaming data should be arranged continuously on a disc in order to guarantee the minimum bit rate for Real-Time Stream recording/playback.

Dispersion of Streaming data can be caused by disc defects. After a recordable optical disc has been handled outside a cartridge, for example in order to be inserted in a consumer players, more defects due to contamination may be encountered during subsequent Stream recording than would have been encountered if the disc had been kept in its cartridge. On the other hand, because of Real-Time requirement, a logical unit may not have as much time to handle defects encountered during Stream recording/playback as it has during conventional data recording/reading. The Real-Time Stream recording/playback model specifies new methods to handle defective sectors on a recordable optical disc.

8.1 Stream recording operation

A defect management scheme like Linear Replacement Algorithm is applied when a logical unit encounters defective blocks in a conventional WRITE operation. This is one of the solution to make the disc defect free, and it is applied to many optical discs. Figure 155 shows an example of data allocation when Linear Replacement is used.

But for Stream recording/playback operation, such a defect management may not meet the requirement of Real-Time performance. Because alternative good blocks are located physically remote from replaced defective ones, extra seek time is needed to access a spare good block during either reading or writing. If a defect management like Linear Replacement has to be applied to a Stream recording system, the system ***shall*** have a sufficiently large buffer memory to maintain the recording transfer rate. Otherwise, a recording operation may be interrupted, or playback picture may be jerky, if alternative good blocks in the Spare are have to be read. The problem is that a long distance seek operation is required to access the alternative block in the Spare Area.

To solve this problem, a logical unit commanded to write data using Stream recording ***shall not*** replace a defective block with another block even if the logical unit encounters a defective block during the Stream recording operation. In the case of DVD-VR[1] application, in recording real-time data, the Linear Replacement Algorithm ***shall not*** be applied regardless of software defect management or hardware defect management.

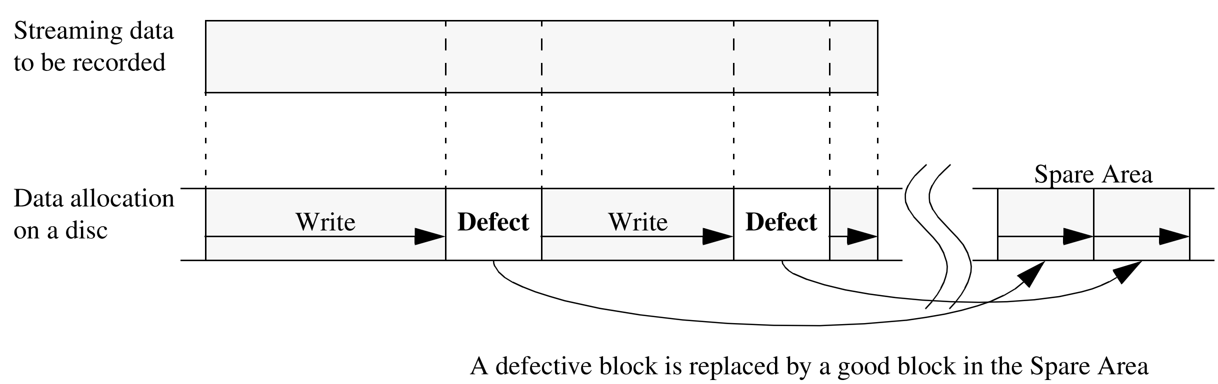


Figure 155 - Example of Data Allocation in the case of Linear Replacement

1. See 2.2.60 DVD Standard.

A logical unit that returns Real-Time Streaming Feature with Version field set to one and SW bit set to one ***shall*** support the following functions.

An example of data allocation on a disc is shown in Figure 156 when the Stream recording operation is performed. The logical unit ***shall*** continue recording without reporting an error, even if a defective block is encountered during a Stream recording operation. The Streaming data recorded to the defective block may not be read correctly.

The host ***shall*** use the WRITE (12) command, with the Streaming bit set to one, to perform the Stream recording operation. The logical unit ***shall not*** perform Linear Replacement operations for defective block. The logical unit's performance ***shall*** be at least 1× speed even if this may prevent the logical unit from retry or verify operations.

The logical unit ***shall not*** report CHECK CONDITION status, except for a fatal error, even if a defective block is encountered during a Stream recording operation. The logical unit ***shall*** return a fatal error when the Stream recording operation can not be continued because of critical errors such as a hardware error.

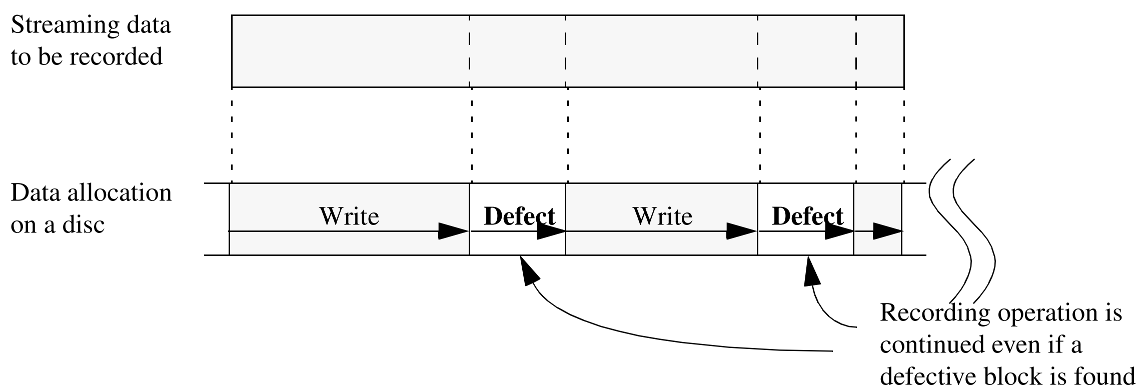


Figure 156 - An example of data allocation on the Stream recording operation

8.2 Stream playback operation

Using Real-Time Stream playback operation may result in erroneous data. If the data is not correctable, some error recovery operations will be performed by the logical unit as in a conventional READ operation. In the case of Stream playback operation, the highest priority should be given to continuity of data.

In order to distinguish between data attributes of Streaming data and normal data, Streaming bit is defined for the READ (12) command. If the logical unit receives the READ (12) command with Streaming bit set to one, the data should be read out continuously without reporting uncorrectable read errors, even if erroneous blocks or erroneous data are detected. When Enhanced Defect Reporting Feature (0029h) is current, reporting of recovered error is managed. See *8.3.3, "Fatal error recovery model with Group 3 time-out"* on page 330.

The logical unit ***shall*** transfer the required size of data on the erroneous block without reporting errors, though the transferred data may contain errors. Read-Ahead operation should be applied on Stream playback operation in order to secure continuity.

*Note: Cached data that contains an erroneous portion **shall not** be returned to the READ (12) command with the Streaming bit cleared. In such a case, cached data in a buffer memory will be thrown away, and an attempt should be made to read with the conventional READ operation.*

8.3 Error handling during Stream recording/playback operation

8.3.1 Error handling with Hardware defect management

An erroneous block encountered on Stream recording/playback operation should be handled following Table 168. A defective block may be registered in the defect list, but the Linear Replacement algorithm ***shall not*** be applied in Stream recording/playback operation. In the case of DVD-RAM media, see *4.15, "Recording and reading for DVD-RAM media"* on page 101.

Table 168 - Error handling on Stream recording/playback operation

Sector Status	Command	Description
Good block	Conventional READ	No Error
	Conventional WRITE	No Error
	READ (12) with Streaming bit is one	No Error
	WRITE (12) with Streaming bit is one	No Error
Defective block registered in defect list and replaced	Conventional READ	No Error
	Conventional WRITE	No Error
	READ (12) with Streaming bit is one	No Error (Defect list is ignored, Null (00h) data ***shall*** be returned for Blocks listed in a defect list[a])
	WRITE (12) with Streaming bit is one	Ignore defect list and keep recording (The data written on the defective block is not guaranteed)
Defective block registered in defect list, but not replaced or Defective block with Recording Type bit set to 1	Conventional READ	No Error[b] (Null (00h) or partially corrected data may be returned)[c]
	Conventional WRITE	No Error (The defective block should be replaced and the data should be written to an alternative block)
	READ (12) with Streaming bit is one	No Error (Erroneous data may be returned)
	WRITE (12) with Streaming bit is one	No Error (The data should be written to the defective block without error reporting, and the defective block should still be registered in defect list)[d]
Defective block which is not registered in defect list	Conventional READ	Report Error[e] (Erroneous data ***shall not*** be returned in the case of TB = 0)
	Conventional WRITE	No Error (The defective block should be replaced and the data should be written to an alternative block)
	READ (12) with Streaming bit is one	No Error (Erroneous data may be returned)
	WRITE (12) with Streaming bit is one	No Error (The data should be written to the defective block without error reporting, and the defective block should be registered in defect list)[d]

a. Legacy logical unit that may not comply with this specification may return erroneous data and continue reading
b. In response to the VERIFY command, the logical unit ***shall*** report an error.
c. This is defined to be able to playback on a legacy system which uses the conventional READ command.
d. The defective block should be registered in defect list, but linear replacement ***shall not*** be applied.
e. Erroneous data may be returned according to the setting of TB bit in *Read/Write Error Recovery Parameters* Mode Page (01h).

8.3.2 Error handling with Logical unit assisted software defect management

When Enhanced Defect Reporting Feature (0029h) is current, error reporting ***shall*** follow the setting of the PER bit and the EMCDR field in *Read/Write Error Recovery Parameters* Mode Page (01h). When the logical unit transfers erroneous data to the host or when the logical unit writes data to defective blocks, and if error reporting is enabled by setting of the PER bit and/or the EMCDR field, the logical unit ***shall*** complete the READ (12) command with Streaming bit set to one/WRITE (12) command with Streaming bit set to one with CHECK CONDITION status, 1/18/05 RECOVERED DATA - RECOMMEND REASSIGNMENT at the command completion. See *Section 9.0, "Logical unit assisted software defect management model"* on page 333.

8.3.3 Fatal error recovery model with Group 3 time-out

Group 3 time-out and commands that are included in Group 3 time-out are used for fatal error recovery at real-time stream recording/playback.

When a fatal error occurs during real-time stream recording/playback operation, the host needs some recovery action to climb over or fix the fatal error. For example, in case of playback, an application user may want to see further story than the suspended scene. In case of recording, application user may want to use the disc for another recording. If the host did not perform any recovery action, the next recording may encounter the same fatal error again.

To recover from fatal error, there are two points to be taken care.

1. Reasonable response time
2. Defend from more damage

If recovery action takes very long time, in case of playback, application user may not wait such long time. In the worst case, user may be confused as system freeze. In case of recording, Streaming data may be lost. Hence the recovery action should be limited to be terminated within a reasonable time length.

A fatal error of Real-Time Stream recording/playback is usually the physical problem of the logical unit (e.g., to hinder the logical unit from positioning the optical pickup to the target track, focusing the laser beam to the disc surface or finding the target sector). Unnecessary overdoing of retry action may cause more physical damage of the logical unit or the medium. Then host needs to select appropriate method and retry times. The logical unit should not perform too much retry action internally.

8.3.4 Recovery from fatal error of streaming

Figure 157 shows a sample recovery sequence from fatal error of real-time stream recording/playback that uses Group 3 time-out.

Streaming fatal error

Seamless recovery

Host allocates buffer for retry action to keep continuous playback or to avoid data loss of recording.

Logical unit terminates READ (12), WRITE (12) command with Streaming=1 within Group 3 time unit. If a host plans to perform certain times of recovery action, the host needs to have buffer to store the data for the time length of the retry.

Assumed empty buffer size for recording recovery and assumed data size in the buffer for playback recovery is shown by formula 1.

Size (KB) = data rate (KB/S) × Group 3 time unit (S) × number of recovery action: formula 1

Non seamless recovery

Some data may be lost during recovery.

READ (12) command with Streaming = 1

In case of streaming playback operation, the host is able to skip certain time length of the content (e.g., video data). The time length is passed till logical unit reported fatal error. When data in the buffer is empty, the host is able to assume the data size to be skipped by formula 1.

WRITE (12) command with Streaming = 1

In case of streaming recording operation, some amount of data may be lost due to buffer overflow. Host is able to assume the data size to be lost by formula 1.

No on track pre-pit address mark media (e.g., C/DVD-RW)

In case of rewritable media that does not have pre-pit address mark on recording track, de-track writing or wrong track writing may not be detected immediately. Spot or scratch may cause de-track/cross-track writing. Sometime this may cause unrecoverable problem on the medium. Therefore using another WRITE (12) command with Streaming=1 for retry is not appropriate. See *8.3.5, "RW media specific matters"* on page 332.
To check the status of newly allocated space, VERIFY (10) command with G3tout=1 should be used.

On track pre-pit address mark media (e.g., DVD-RAM)

In case of rewritable media that has pre-pit address mark on recording track, de-track writing or wrong track writing may not cause unrecoverable problem on the medium. Therefore using WRITE (12) command with Streaming=1 for retry is applicable.

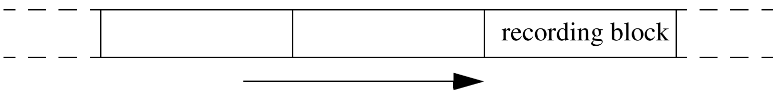
Figure 157 - An example of data allocation on the Stream recording operation

8.3.5 RW media specific matters

Figure 158 shows that RW media (e.g., C/DVD-RW) specific matters that requires attention. Improper recovery by the host may cause unexpected result. When a logical unit encounters a fatal error during WRITE (12) command with Streaming bit=1, host may try to write the streaming data to other location. To check the status of newly allocated space, WRITE (12) command with Streaming bit=1 and READ (12) command with Streaming bit=1 are not appropriate commands. For this purpose, VERIFY (10) command with G3tout bit = 1 should be used. If the G3tout bit of VERIFY (10) command is set to 1, the logical unit ***shall*** certify the specified area within Group 3 time-out duration. If the VERIFY (10) command is terminated with GOOD status, the area should be good for streaming data writing.

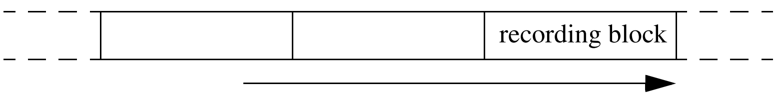
1. Checking the status of newly allocated space

To determine the start position of a recording block on C/DVD-RW media, C/DVD-RW logical unit uses signal that is ATIP Sync of wobble or Land pre-pit Sync in previous block of the recording block. Even if recording block does not have any problem, if previous block has problem and logical unit loses Sync signal, the logical unit may not be able to start recording correctly.



Logical unit traces to find Sync for recording

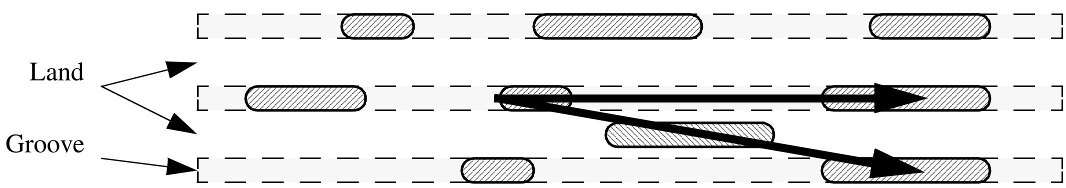
To check the status, certification from previous block of recording block is proper measures.



Verify from previous block of recording block

2. De-track/Cross-track problem

C/DVD-RW media uses Land as guard band and Groove as recording track. The write capable logical unit uses Groove signal for tracking servo. DVD read-only logical unit uses recorded mark signal for tracking servo. If recorded mark is created on Land, DVD read-only logical unit may not be able to follow correct track and may encounter read failure. The write capable logical unit is not able to erase the recorded mark on Land area. So this problem is unrecoverable.



ROM logical unit may not be able to follow track.

Figure 158 - An example of RW media characteristics

9.0 Logical unit assisted software defect management model

There are two types of defect management. The one is host-based defect management (software defect management) and the other is logical unit-based defect management (hardware defect management).

In the case of software defect management, a host retrieves defect information from the logical unit and performs defect management at host's desired timing. For example, the software defect management is being utilized for CD-RW media. In the case of hardware defect management, defect management is automatically performed by the logical unit itself like a DVD-RAM logical unit.

Though the capacity of media is dramatically increased in comparison to CD media, the life of RW media is relatively short. The number of acceptable overwrite cycles on a sector is usually one thousand or several thousand. Therefore some sectors of the Data Area may be worn-out by repeated writing over the life span of the media.

This section defines the Logical unit assisted software defect management method for any type of rewritable media (e.g., CD-RW, DVD-RW) with logical unit that supports Enhanced Defect Reporting Feature. The goal of this model is to provide a defect management mechanism to increase data reliability and media interchangeability after writing the data on a medium by the host and the logical unit. In addition, this model provides a sophisticated real-time defect management with collaboration between the host and the logical unit.

9.1 Basic actions for defect management

The Logical unit assisted software defect management consists of the following basic three actions:

1. Certification
   Certify blocks on a medium
2. Detection
   Detect the use of defective block
3. Management
   Manage data on a defective block or manage data to be written on a defective block.
   Usually, data on a defective block or data to be written on a defective block is relocated to healthy block.

9.2 Defect management modes

The Logical unit assisted software defect management model defines two defect management modes. The one is Persistent defect management (Persistent-DM) mode and the other is Distributed real-time defect management (DRT-DM) mode.

9.2.1 Persistent defect management (Persistent-DM) mode

In the Persistent-DM mode, the "Certification" and the "Detection" actions are taken by verify after write operation of a host. Then "Management" action is taken by the host.

A host ***shall*** verify any written data by enabling Certification and by using one of the following commands.

- READ (10), READ (12) with Streaming bit = 0, VERIFY (10), or WRITE AND VERIFY (10) commands.

The logical unit ***shall*** perform media certification when one of the above commands is issued to the logical unit. The certification result is stored in Defective Block Information (DBI) memory of the logical unit. In the case of Simple DBI memory model (see Section 9.3.4.1), the DBI data is cleared and updated by the above commands. The logical unit may not perform medium certification in response to READ (12) command with Streaming bit = 1.

By using DBI memory, multiple blocks are able to be certified by logical unit at one command.

9.2.2 Distributed real-time defect management (DRT-DM) mode

In addition to the functionality of the Persistent-DM mode, the DRT-DM mode provides functionality that is suitable for real-time streaming applications.

In recording real-time streaming data, recording applications usually suspend or delay the replacement of a defective block to avoid interruption of the real-time recording. In the DRT-DM mode, “Certification” action is taken during a read operation by the host. “Detection” action is taken during a write operation by the host. The host may take “Management” action after the recording operation is complete. Therefore, the DRT-DM mode is able to minimize the performance impact on the real-time operation.

The DRT-DM mode provides for certification before writing. A logical unit performs media certification in response to READ (10), READ (12), or VERIFY (10) command and the logical unit stores the certification result in DBI memory of the logical unit. During writing of a Packet, the logical unit may report a RECOVERED ERROR on WRITE (10) or WRITE (12) command by checking the DBI data that is stored during the certification. To keep compatibility with Persistent-DM mode (verify after write), the logical unit ***shall*** certify the block after the writing of the block and then should check the DBI memory in response to READ (10), READ (12), VERIFY (10) or WRITE AND VERIFY (10) command.

DBI data ***shall*** be cached in DBI memory. Once a block has been certified at a certain defect level, that block ***shall not*** be assigned a lower defect level in DBI memory upon subsequent certification. This ensures that the worst case certification is made available to the host. Regarding the defect level, see Section 9.3.2.

The host may retrieve the stored DBI data at a later time. To keep compatibility with read-only applications that access the disc directly, the host may suspend RECOVERED ERROR reporting on READ (10) or READ (12) command and the host may use RECOVERED ERROR reporting on WRITE (10) or WRITE (12) command instead.

The DRT-DM mode makes use of two types of DBI memory model. One is large DBI buffer model. Another is small DBI cache memory model. See *Section 9.3.4, "DBI memory management"* on page 338.

For the DRT-DM mode, logical unit and media ***shall*** follow the Defect Level Transition model described in Section 9.6.1. When a fatal error occurs during normal overwriting, a Type 1 or Type 2 defect level ***shall*** have been detected by the logical unit before the fatal error happens.

9.3 Enhanced defect reporting

Enhanced defect reporting provides media interchangeability by defect management and improves defect management performance by using DBI memory and provides host/application with appropriate logical unit behavior by DBI memory and various defect reporting control.

9.3.1 Standard playback model for DVD-RW media

To specify the interchangeable defect level between a write capable logical unit and DVD read-only logical unit, a standard playback model and defect level criteria are defined.

For DVD-RW media, ordinary Consumer Electronics DVD players that support playback of DVD-RW media are defined as standard player for the standard playback model. Error correction order of the standard player is assumed as:

1. PI error correction
2. PO erasure error correction
3. EDC error detection.

No additional error correction is performed by the standard player.

Note: Standard playback model for other media is not yet defined.

9.3.2 Four types of defect level

The Logical unit assisted software defect management model defines four types of defect level to handle appropriate operation according to each type of defect. The defect level increases from Type 1 to Type 4. Type 4 is the highest severity level.

- Type 1: Recovered light defect level
  The conceptual criterion is that after 50 - 100 overwrite cycles, the Packet may cause uncorrectable error on standard playback model and the number of retry seek operations is small. For DVD-RW media, the recommended error

threshold is that the number of PI uncorrectable line is 8 through 15. The number of seek retry times should be smaller than the number of seek retry times for Type 2 defect level. A Packet at or below this defect level should be good for data recording/playback with Consumer Electronics products.

- Type 2: Recovered heavy defect level
  The conceptual criterion is that several seek retries are required to read the Packet correctly and reading of the Packet may become a fatal error on standard playback model. And after 50 - 100 overwrite cycles, reading of the Packet may become a fatal error even with the best error correction of the logical unit. For DVD-RW media, the recommended error threshold is that the number of PI uncorrectable line is 16 or higher. To read a Packet correctly many seek retry operations may be required. A Packet that has this defect level may not be good for data recording/playback with Consumer Electronics products.
- Type 3: Unrecovered read error defect level
  An unrecovered read error happens or has happened.
- Type 4: Write error defect level
  Write error has occurred. When RECOVERED ERROR is reported by WRITE (12) command with Streaming bit = 1, some of the specified sectors are not written correctly.

9.3.3 Error reporting control

Reporting of a RECOVERED ERROR is controlled by the PER bit in *Read/Write Error Recovery Parameters* Mode Page (01h). A RECOVERED ERROR only reports the LBA in the Packet that cause the last recovered error during the data transfer in the INFORMATION field of the REQUEST SENSE data. The Logical unit assisted software defect management that uses DBI memory in the logical unit provides multiple Packet defect reporting capability to increase system performance.

A logical unit ***shall*** report a RECOVERED ERROR when

- a Type 1 or Type 2 defect is detected on the medium,
- and Enhanced Defect Reporting Feature is current,
- and RECOVERED ERROR reporting is enabled.

The Enhanced defect reporting capable logical unit uses only one error code for RECOVERED ERROR although there are various other ASC/ASCQs defined for RECOVERED ERRORs. Only the error code of 1/18/05 RECOVERED DATA - RECOMMEND REASSIGNMENT ***shall*** be reported when a Type 1 or Type 2 defect level is detected during media certification. When a some write operations are failed during streaming write operation by WRITE (12) command with Streaming bit = 1, the logical unit ***shall*** report 1/18/05 RECOVERED DATA - RECOMMEND REASSIGNMENT and ***shall*** store Type 4 defect level in the DBI memory.

In the case of DRT-DM mode,

- If a Type 1, Type 2, or Type 3 defect is found in DBI memory upon receiving a WRITE (10), WRITE (12), or WRITE AND VERIFY (10) command and if no write error happens, 1/18/05 RECOVERED DATA - RECOMMEND REASSIGNMENT ***shall*** be reported. The data sent by WRITE (10) or WRITE (12) command ***shall*** be written to the medium.
- If a Type 1, Type 2, or Type 3 defect is found in DBI memory upon receiving a WRITE (10), WRITE (12), or WRITE AND VERIFY (10) command and if write error happens, a deferred write error ***shall*** be reported. In this case RECOVERED ERROR is not returned to the host.
- If a Type 1, Type 2, or Type 3 defect is found in DBI memory upon receiving a VERIFY (10) command, 1/18/05 RECOVERED DATA - RECOMMEND REASSIGNMENT ***shall*** be reported.

Error codes to be reported and DBI update states in each case are defined in Table 169, Table 170, Table 171, Table 172, Table 173, and Table 174.

Note: The ASC/ASCQs for fatal errors are not specified in this model section.

Table 169 - Returned error code for commands under the Persistent-DM mode

Returned error code[a]					
READ			VERIFY / WRITE AND VERIFY		
no error[b]	Type 1/2	fatal error[c]	no error	Type 1/2	fatal error
Good	1/18/05	fatal	Good	1/18/05	fatal

a. the case when RECOVERED ERROR reporting is allowed on the command. Returned error code is not affected by DBI data in DBI memory
b. means that the defect level is lower than Type 1 defect level
c. fatal error happens on this command, does not include a deferred error for previous command

Table 170 - Returned error code for READ and VERIFY commands under the DRT-DM mode

Defect Status in DBI memory	Returned error code[a]					
	READ			VERIFY		
	no error[b]	Type 1/2	fatal error[c]	no error	Type 1/2	fatal error
no defect	Good	1/18/05	fatal	Good	1/18/05	fatal
Type 1/2	Good	1/18/05	fatal	Good	1/18/05	fatal
Type 3	Good	1/18/05	fatal	Good	1/18/05	fatal
Type 4	Good	1/18/05	fatal	Good	1/18/05	fatal

a. the case when RECOVERED ERROR reporting is allowed on the command
b. means that the defect level is lower than Type 1 defect level
c. fatal error happens on this command, does not include a deferred error for previous command

Table 171 - Returned error code for commands under the DRT-DM mode

Defect Status in DBI memory	Returned error code[a]					
	WRITE command			WRITE AND VERIFY command		
	no error[b]	fatal error [c]	fatal error on Streaming bit = 1[d]	no error	Type 1/2	fatal error
no defect	Good	fatal	1/18/05	Good	1/18/05	fatal
Type 1/2	1/18/05	fatal	1/18/05	1/18/05	1/18/05	fatal
Type 3	1/18/05	fatal	1/18/05	1/18/05	1/18/05	fatal
Type 4	1/18/05	fatal	1/18/05	1/18/05	1/18/05	fatal

a. the case when RECOVERED ERROR reporting is allowed on the command
b. means that the defect level is lower than Type 1 defect level
c. fatal error happens on this command, does not include a deferred error for previous command.
d. This is the case when Streaming bit is set to one, and a block is not correctly written. This block is treated as Type 4 defect.

Table 172 - Returned Deferred error code

Defect Status in DBI memory	Returned deferred error code for previous Write command	
	Write command Streaming bit = 0	Write command Streaming bit = 1
no defect	fatal (not specified)	1/18/05
Type 1/2	fatal (not specified)	1/18/05
Type 3	fatal (not specified)	1/18/05
Type 4	fatal (not specified)	1/18/05

Table 173 - DBI update for READ and VERIFY command [a]

Status in DBI memory	Update state of DBI data							
	READ				VERIFY			
	no error	Type 1	Type 2	Type 3	no error	Type 1	Type 2	Type 3
no defect	no defect	Type 1	Type 2	Type 3	no defect	Type 1	Type 2	Type 3
Type 1	Type 1	Type 1	Type 2	Type 3	Type 1	Type 1	Type 2	Type 3
Type 2	Type 2	Type 2	Type 2	Type 3	Type 2	Type 2	Type 2	Type 3
Type 3	Type 3	Type 3	Type 3	Type 3	Type 3	Type 3	Type 3	Type 3
Type 4	Type 4	Type 4	Type 4	Type 4	Type 4	Type 4	Type 4	Type 4

a. Only applicable for small DBI cache memory model and large DBI buffer memory model

Table 174 - DBI update for WRITE and WRITE AND VERIFY command [a]

Status in DBI memory	Update state of DBI data						
	WRITE		WRITE AND VERIFY				
	no error	Type 4	no error	Type 1	Type 2	Type 3	Type 4
no defect	no defect	Type 4	no defect	Type 1	Type 2	Type 3	Type 4
Type 1	Type 1	Type 4	Type 1	Type 1	Type 2	Type 3	Type 4
Type 2	Type 2	Type 4	Type 2	Type 2	Type 2	Type 3	Type 4
Type 3	Type 3	Type 4	Type 3	Type 3	Type 3	Type 3	Type 4
Type 4	Type 4	Type 4	Type 4	Type 4	Type 4	Type 4	Type 4

a. Only applicable for small DBI cache memory model and large DBI buffer memory model

If the logical unit finds defective blocks during the verify operation of VERIFY (10) or WRITE AND VERIFY (10) command, the command ***shall*** be terminated with CHECK CONDITION status when all blocks specified by the command are certified or when DBI memory overflow occurs. If DBI memory overflow occurs, the DBI Full (DBIF) bit of DBI descriptor in GET PERFORMANCE command for the Packet that caused DBI buffer full ***shall*** be set to 1.

In the case of DRT-DM mode, fatal errors are registered in the DBI memory during the certification process. When the logical unit receives a WRITE command to be written to the fatal error Packet, the logical unit ***shall*** terminate the WRITE command with CHECK CONDITION status, 1/18/05 RECOVERED DATA - RECOMMEND REASSIGNMENT after completion of data transfer. The transferred data ***shall*** be written on the media normally.

When an error of 1/18/05 RECOVERED DATA - RECOMMEND REASSIGNMENT is reported the host should check the DBI data.

To keep compatibility with read-only applications (e.g., DVD-Video playback software), reporting of a RECOVERED ERROR on READ (10) or READ (12) command may be suspended by the EMCDR field setting in *Read/Write Error Recovery Parameters* Mode Page (01h). DBI memory allows for polling of defective Packet information without using RECOVERED ERROR reporting. The EMCDR field controls media certification and error reporting on particular commands as shown in Table 176 - *Definition of PER bit and EMCDR field of Persistent-DM mode* on page 341 and Table 177 - *Definition of PER bit and EMCDR field of DRT-DM mode* on page 345.

When a medium is certified, the rotation speed of the logical unit may need to be adjusted to appropriate certification speed[1]. If the certification speed is slower than the maximum reading speed of the logical unit, the host may disable media certification by setting the PER bit and the EMCDR field to 0 to use highest speed of the logical unit for reading operation.

At Power-on reset and hard reset, if the logical unit does not support saving of Read/Write Error Recovery Parameters Mode Page, the PER bit and the EMCDR field ***shall*** be set to 0.

The default values of the PER bit and the EMCDR field are 0.

9.3.4 DBI memory management

To avoid or minimize DBI data overflow with a small amount of logical unit's hardware resources, there are different memory models defined to store DBI data in a logical unit. They are simple DBI memory model, large DBI buffer memory model and small DBI cache memory model.

The DBI data may be cleared when the logical unit is reset by Hard reset.

The DBI data ***shall*** be cleared when the medium is ejected or logical unit is reset by Power on reset.

The DBI data ***shall not*** be cleared even if the PER bit and the EMCDR field are both set to 0.

9.3.4.1 Simple DBI memory model

The simple DBI memory model is permitted only for the Persistent-DM mode. All stored data in DBI memory is updated at the beginning of medium certification. To ensure that a simple DBI implementation gives a minimum level of usefulness and efficiency to the host, the DBI memory ***shall*** be capable of storing at least 10 DBI entries. This allows for the DBI entries to cover a minimum of 256 + 64 KB of defective data (in the case of DVD media) before overflow would occur. This implies that if this minimum is used, the host should not issue a READ, WRITE, or VERIFY command for more than 256 + 64 KB at a time, otherwise the command could overflow the DBI memory. The value of 10 DBI entries assumes half of Track Buffer size and information of VR playback model. The Number of entries field in Enhanced Defect Reporting Feature Descriptor indicates the number of entries that may be stored in DBI memory.

9.3.4.2 Large DBI buffer memory model

Some logical units (e.g., logical unit that supports hardware defect management) have enough memory to cover the whole medium for defect management purpose. In this case, the logical unit's memory may cover DBI data for all Packets on CD/DVD media. For the ideal case, logical unit may store DBI data into a DBI bitmap that may cover entire disc. For the practical case, the logical unit's memory may store 10% of the different Packet start addresses of the entire disc and length of consecutive defective Packets. Usually spare area size is less than 5% of the entire disc capacity. To cover the spare area, 10% of the entire disc capacity would be enough size for Large DBI buffer memory model.

9.3.4.3 Small DBI cache memory model

The logical unit may have small memory to store DBI data. To minimize the possibility of DBI data overflow and to allow effective host operation, small DBI cache memory model is defined. The DBI data remains in DBI cache even if the data is read by a host. To ensure that a small DBI implementation gives a minimum level of usefulness and efficiency to the host, the DBI cache ***shall*** be capable of storing at least 10 DBI entries.

1. The certification speed may be similar to the maximum writing speed and is usually slower than the maximum reading speed of the logical unit.

9.3.4.3.1 Three types of memory blocks in DBI memory

In the small DBI cache memory model, the DBI memory is divided into three memory blocks to minimize the possibility of DBI data overflow. Each memory block is referred to as Buffer DBI (BDBI), Read DBI (RDBI) cache, and Write DBI (WDBI) cache, respectively.

- Buffer DBI (BDBI) block: to store certification information of sectors in data buffer
- Read DBI (RDBI) cache memory block: to copy data from BDBI by a READ command
- Write DBI (WDBI) cache memory block: to copy data from RDBI by a WRITE command, copy data from BDBI by a VERIFY command

The certification result of READ (10) or READ (12) command is stored in RDBI cache. The certification result of VERIFY (10) command and WRITE AND VERIFY (10) command is stored in WDBI cache. A logical unit ***shall*** check RDBI cache by WRITE (10) or WRITE (12) command. If a defective Packet is found in RDBI cache, the DBI data in RDBI cache is copied to WDBI cache.

Note: In the case of large DBI buffer memory model, the DBI data is stored into a DBI buffer directly, then these three types of memory blocks are unified into single DBI buffer.

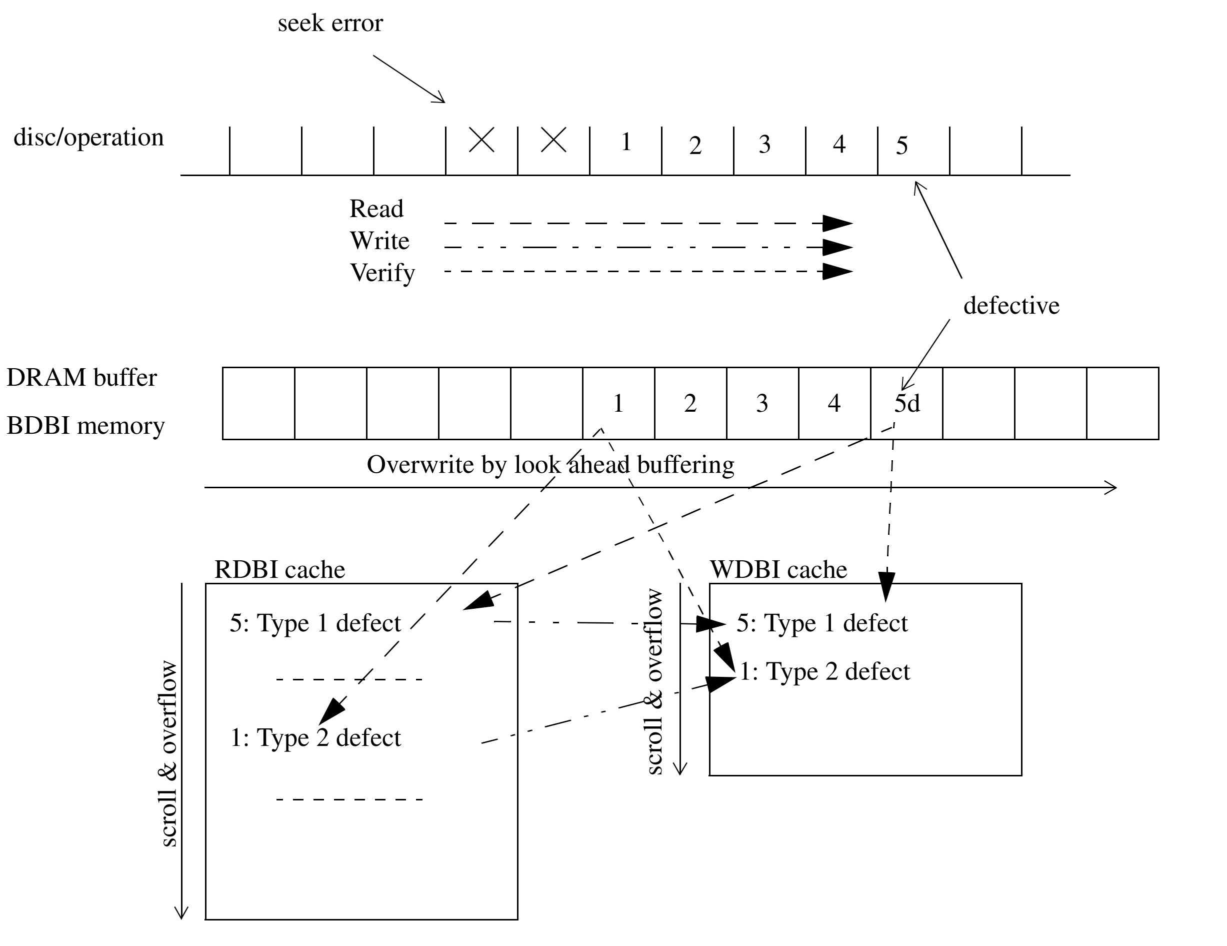


Figure 159 - Example of DBI memory blocks

9.3.4.3.2 Adjust DBI cache for a real-time application

The data in RDBI and WDBI cache memories may easily overflow due to accessing of multiple/large files. To protect DBI data against overflow, disc volume space may be divided into a few zones named DBI cache zone. The RDBI and WDBI caches are allocated for each DBI cache zones. For example, in the case of UDF file system version 2.00 and DVD-VR application, at least two DBI cache zones are required to be supported. Table 175 shows an example of the DBI cache zone image.

Table 175 - Example of DBI cache zone image

DBI cache Zone	Major contents	Remark	Sparing
0[a]	VRS	from 10h	not covered by sparing of UDF very important many overwritten file system data
	AVDP	100h	
	main Volume Descriptor Sequence	by AVDP	
	reserve Volume Descriptor Sequence	by AVDP	
	Logical Volume Integrity Descriptor	by VDS	
	primary Sparing Table	by VDS	
	Spare Area	by VDS	
	secondary Sparing Table	by VDS	
	Beginning of Spareable Partition	by VDS	subject of sparing
	Free Space Bitmap	by VDS	
	root File Entry for root directory	by VDS	
	File Entry for DVD_RTAV	by root File Entry	
	VR_MANAGR.IFO	by VR File Entry	
	VR_MANAGR.BUP	by VR File Entry	
1[b]	VR_MOVIE.VRO	by VR File Entry	subject of sparing but not suitable to spare
	VR_AUDIO.VRO	by VR File Entry	
	VR_STILL.VRO	by VR File Entry	

a. 1st DBI cache zone: from LBA 0 to before VR object files. There are very important UDF descriptors and information that are not covered by Sparing of UDF. And there are important contents that are able to be replaced to Spare Area.
b. 2nd DBI cache zone: from beginning of VR object files to the end of disc volume space. There are real-time contents that should not be replaced to the Spare Area.

9.4 Implicit synchronize cache

When a medium certification is enabled and READ or VERIFY command is issued, and if the data to be read by the command is still remaining in the write cache of the logical unit, the unwritten data ***shall*** be committed to a physical medium prior to the certification and then logical unit ***shall*** read from the medium and certify the data to perform medium certification correctly.

However, if there were an error during READ or VERIFY commands, there may be no way to know if such error occurred during writing the buffered data or an error occurred during the READ or VERIFY operation itself. In order for the host to distinguish such errors, the host should issue SYNCHRONIZE CACHE command to ensure the buffered data be committed to a physical medium.

9.5 Persistent-DM mode behavior

In the Persistent-DM mode, the host ***shall*** check the defect level of the Packets after write. The logical unit stores the certification result corresponding to each READ (10)/READ (12) command with Streaming bit = 0/VERIFY (10)/

WRITE AND VERIFY (10) command in the DBI memory. One of three DBI memory models is used. As for DBI memory model, see *9.3.4, "DBI memory management"* on page 338.

The host ***shall*** enable media certification by setting of PER bit or EMCDR field.

In Persistent-DM mode, media certification by READ (12) command with Streaming bit =1 is not required. Some logical units cannot guarantee real-time streaming playback on 1× CLV speed in PC environment. When READ (12) command with Streaming bit =1 is issued, the rotation speed is usually higher than the speed for certification. Thus, the certification may not be able to be performed. The Type 1 defect level is detected by using READ (10), READ (12) with Streaming bit = 0, or VERIFY (10) command. The Type 1 defect level means the Packet readability is good enough for real-time playback (i.e. READ (12) with Streaming bit = 1 should not have trouble on reading the Packet).

A host ***shall*** check the defect level of the Packet using READ (12) command with Streaming bit = 0 to keep the disc compatible with standard playback model.

9.5.1 RECOVERED ERROR reporting control for Persistent-DM mode

When the PER bit is set to one and/or EMCDR field is set to one or higher, the logical unit perform certification and report RECOVERED ERROR on READ (10)/READ (12) with Streaming bit =0, VERIFY (10), or WRITE AND VERIFY (10) command.

If PER bit is set to zero, the EMCDR field controls the RECOVERED ERROR for defect management as defined in Table 176. In this case, the returned error code ***shall*** be 1/18/05 RECOVERED DATA - RECOMMEND REASSIGNMENT.

If the PER bit is set to one, various kinds of RECOVERED ERROR will be returned for any type of command. And if the EMCDR field is set to zero, the reported RECOVERED ERROR for defect management is vendor specific. If the EMCDR field is set to a value other than zero, the reported RECOVERED ERROR for defect management ***shall*** be 1/18/05 RECOVERED DATA - RECOMMEND REASSIGNMENT.

Table 176 - Definition of PER bit and EMCDR field of Persistent-DM mode

PER bit	EMCDR field value	Media certification [a]	RECOVERED ERROR reporting [b]		
			READ[c]	VERIFY	Other commands
0	0	Disabled	N/A	N/A	No
	1	Enabled	No	No	No
	2	Enabled	No	Yes	No
	3	Enabled	Yes	Yes	No
1	0	Enabled	N/A	N/A	Yes [d]
	1	Enabled	Yes	Yes	Yes
	2	Enabled	Yes	Yes	Yes
	3	Enabled	Yes	Yes	Yes

a. on READ (10), READ (12) with Streaming = 0, VERIFY (10), or WRITE AND VERIFY (10) command
b. 1/18/05 ***shall*** be used for defect management purpose except for footnote <d> case.
c. on READ (10) or READ (12) command with Streaming=0. READ (12) with Streaming =1 is not included
d. logical unit is allowed to use any RECOVERED ERROR code to keep legacy compatibility

9.5.2 Recommend host sequence of Persistent-DM mode

At the time of disc mounting

1. Turn on media certification (EMCDR field in Read/Write Error Recovery Parameters Mode Page)
2. Try to recognize file system of the disc
3. If the host's File System driver does not support the file system on the disc, turn off media certification (EMCDR field in Read/Write Error Recovery Parameters Mode Page). Then pass the disc to the next possible file system driver.

At the time of disc writing

1. Write several Packets
2. Verify the written Packets
3. If a RECOVERED ERROR is reported, retrieve DBI information.

At the time of disc unmounting

1. Synchronize all cached data to the disc
2. Turn off media certification (EMCDR field in Read/Write Error Recovery Parameters Mode Page)
3. Un-mount the disc

9.6 DRT-DM mode behavior

The basic three actions of defect management are performed by different commands and timing. Certification and Detection are separated in READ command and WRITE command respectively, and are connected by DBI memory. Either small DBI cache model or large DBI buffer model ***shall*** be used.

The EMCDR field controls the reporting of RECOVERED ERRORs. The host is able to receive RECOVERED ERROR by use of certain commands (e.g., media access command). The host is able to retrieve DBI data at a time convenient to the host.

1. Certification is performed at READ (10), READ (12) or VERIFY (10) command. The result is stored in DBI memory.
2. Detection is performed at WRITE (10) or WRITE (12) command with checking of DBI memory. The result is reported as RECOVERED ERROR of WRITE (10) or WRITE (12) command.
3. Management is performed by the host. If the host receives a RECOVERED ERROR at completion of a WRITE command, the host ***shall*** perform necessary management of written data. The host is able to retrieve the DBI data from DBI buffer at any time.

There are two types of memory model for DBI memory. One is the large DBI buffer memory model that covers all Packets on the media. This memory model never cause DBI buffer overflow. Another is the small DBI cache memory model. This model has a special scheme to minimize cache overflow. But cache overflow is possible.

The EMCDR field controls DRT-DM behavior. When a logical unit reads medium and the EMCDR field is set to a value other than 0, the logical unit ***shall*** certify Packets on the medium and store the certification result into DBI memory regardless of Streaming bit setting of READ (12) command. In the case of DRT-DM mode, media certification by READ (12) command with Streaming bit = 1 ***shall*** be supported.

In the DRT-DM mode, when a write error happens at WRITE (12) command with Streaming bit = 1, the result ***shall*** be stored in DBI memory. Error reporting is dependent on the PER bit and the EMCDR field setting. If RECOVERED ERROR reporting is disabled, no RECOVERED ERROR ***shall*** be reported. In this case, the host should check DBI data after the writing operation of WRITE (12) command with Streaming =1, if necessary.

9.6.1 Defect Level Transition model

In the case of real-time stream recording, the host and logical unit are not able to perform verify after write operation and defect management. Because data allocation of the real-time stream (e.g., real-time Video data) ***shall*** be determined before writing on the medium to keep data format compatibility and playback compatibility. The real-time stream data flows from host to logical unit continuously. Usually there is no time for verify after write operation and defect management. To guarantee the readability of written Packet, the host needs to verify the Packet before write.

In the DRT-DM mode, the logical unit and media ***shall*** support Defect Level Transition model. If there is neither physical impact to media (e.g., scratch, finger print) nor physical impact to logical unit (e.g., shock, vibration), error level of a Packet ***shall not*** change from non-defect level to fatal defect level. Type 1 defect or Type 2 defect ***shall*** be reported before the Packet becomes unreadable by ordinary direct overwrite cycles.

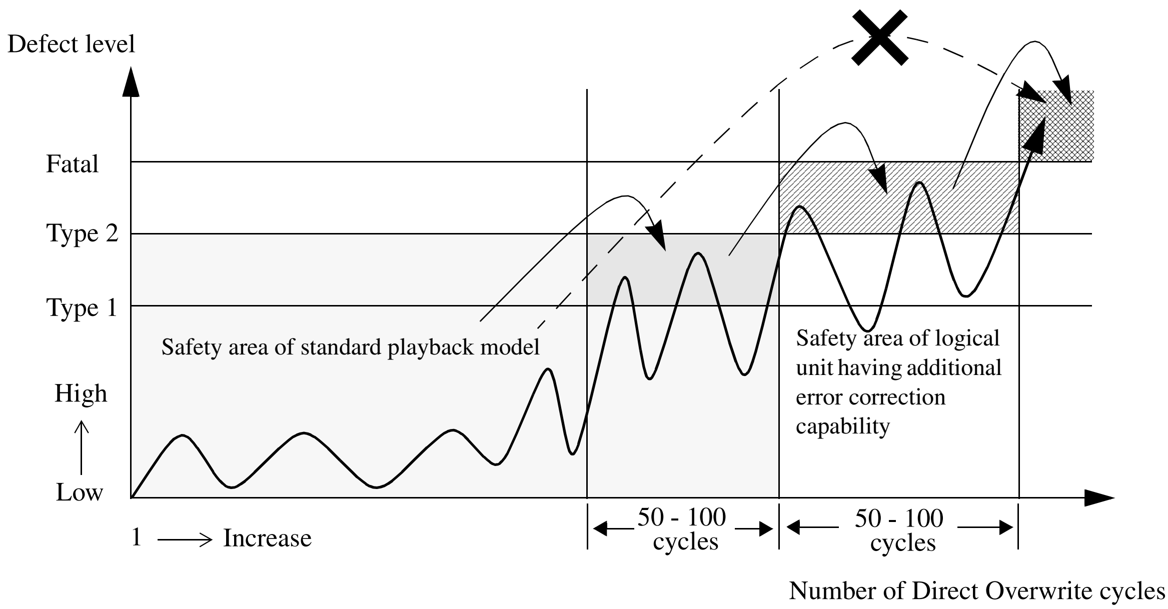


Figure 160 - Example of defect level transition

9.6.2 Certification

At READ command, the logical unit ***shall*** certify specified blocks to be read. The result is stored in DBI memory.

In the case of small DBI cache memory model, the information of actually transferred blocks ***shall*** be stored in RDBI cache. The information of the blocks those are out of range of the command (e.g., read by look ahead buffering but not transferred to host) ***shall not*** be stored in the RDBI cache because the blocks may already be replaced and no longer be used by the host.

If the logical unit finds defective blocks in VERIFY (10) or WRITE AND VERIFY (10) command, the command ***shall*** be terminated with CHECK CONDITION status when all blocks specified by command are certified or when DBI cache overflow occurs. The logical unit ***shall*** report RECOVERED ERROR to the host. The result is stored in DBI memory.

READ (10), READ (12), and VERIFY (10) command ***shall*** be performed normally regardless of certification. If a fatal error is detected, the logical unit ***shall*** report the error normally.

9.6.3 Detecting the use of a defective block

Detection is performed by WRITE (10) or WRITE (12) command. The logical unit ***shall*** check all written block addresses by RDBI cache or DBI buffer. When a defect information is found, the logical unit ***shall*** terminate the WRITE command with CHECK CONDITION status after all data is transferred. The logical unit ***shall*** report a RECOVERED

ERROR to the host. All buffered data ***shall*** be written on the media properly even if WRITE command is terminated with CHECK CONDITION status. In the case of small DBI cache memory model, when defective block is used by a WRITE command, the logical unit ***shall*** store the information in WDBI cache.

If a fatal error is detected, the logical unit ***shall*** report the error normally.

9.6.4 Management of defective block

When the host pauses current real-time operation, the host should perform defect management of used defective blocks, if necessary. Some of the information on defective blocks may have important data to be replaced. Some other may not be needed to replace. In the case of real-time streaming data (e.g., video stream), the data blocks are not allowed to be replaced. The host ***shall*** select suitable defect management method for such data.

If the host receives a RECOVERED ERROR at WRITE command, some of information had been written on defective blocks. The host ***shall*** read the DBI data by GET PERFORMANCE command with Type = 04h. The host ***shall*** determine which data on defective blocks ***shall*** be managed.

9.6.5 Delayed replacement of data on defective block

The RECOVERED ERROR reported by a logical unit means that some of the used sectors by WRITE command are not reliable. After hundred (it may be a few hundred initially, a few times finally) overwrite cycles on the same block, the block may become unreadable. Therefore, the host may read the written data from defective blocks, and may write them into spare area.

9.6.6 RECOVERED ERROR reporting control for DRT-DM mode

When the PER bit is set to one and/or the EMCDR field is set to one or higher, the logical unit ***shall*** perform media certification and ***shall*** report RECOVERED ERROR on READ (10), READ (12), VERIFY (10), or WRITE AND VERIFY (10) command regardless of Streaming bit setting.

If the EMCDR field is set to zero, the logical unit should not store the certification result in DBI memory to avoid overflow when the logical unit supports small DBI cache memory model.

If the PER bit is set to zero, the EMCDR field controls the RECOVERED ERROR for defect management as defined in Table 177. In this case, the returned error code ***shall*** be 1/18/05 RECOVERED DATA - RECOMMEND REASSIGNMENT. See *9.3, "Enhanced defect reporting"* on page 334.

When WRITE (10) or WRITE (12) command is terminated with a RECOVERED ERROR, the logical unit ***shall*** write the data to the medium.

The error code of the write failure on WRITE (10), WRITE (12), or WRITE AND VERIFY (10) command is not defined in this model section. See each media model section and WRITE (10), WRITE (12), or WRITE AND VERIFY (10) command sections.

The error code of the read failure on READ (10) or READ (12) command is not defined in this model section. See each media model section and READ (10) or READ (12) command sections.

If the PER bit is set to one, various kinds of a RECOVERED ERROR will be returned for any type of command. If the EMCDR field is set to zero, the reported RECOVERED ERROR for defect management is vendor specific. If the EMCDR field is set to a value other than zero, the reported RECOVERED ERROR for defect management ***shall*** be 1/18/05 RECOVERED DATA - RECOMMEND REASSIGNMENT.

Table 177 - Definition of PER bit and EMCDR field of DRT-DM mode

PER bit	EMCDR field value	Media certification [a]	RECOVERED ERROR reporting [b]			
			READ[c]	VERIFY	WRITE	Other commands
0	0	Disabled	N/A	N/A	N/A	No
	1	Enabled	No	No	No	No
	2	Enabled	No	Yes	Yes	No
	3	Enabled	Yes	Yes	Yes	No
1	0	Enabled	N/A	N/A	N/A	Yes [d]
	1	Enabled	Yes	Yes	No	Yes
	2	Enabled	Yes	Yes	Yes	Yes
	3	Enabled	Yes	Yes	Yes	Yes

a. on READ (10)/READ (12), VERIFY (10), or WRITE AND VERIFY (10) command
b. 1/18/05 ***shall*** be used for defect management purpose except for footnote <d> case.
c. on READ (10) or READ (12) command
d. logical unit is allowed to use any RECOVERED ERROR code to keep legacy compatibility

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10.0 Changer Model

A changer logical unit will perform exactly like a single logical unit. However it ***shall*** support the commands MECHANISM STATUS and LOAD/UNLOAD MEDIUM.

A changer logical unit provides a storage area for more than one C/DVD Disc. This storage area contains multiple areas called slots. Each slot can contain just one Disc. Once a Disc has been placed in to a given slot, it becomes locked in that position. This specification provides no capability to move a Disc from one slot to another. Thus when a Disc has been moved from a given slot into the playing position, it can only be moved back into the slot that it came from. This ***shall*** be followed even if power is lost while a Disc is in the playing position or while it was being moved.

There are two basic types of changer mechanisms, one that has individually addressable eject and load capability and another that uses a Magazine to hold the discs. In the former, individual disc can be changed, while in the latter all the stored discs ***shall*** be changed at one time.

Any time a Disc/Cartridge is installed from the changer, the logical unit ***shall*** generate a UNIT ATTENTION condition. After the host detects the UNIT ATTENTION on a known changer logical unit, the host may issue a MECHANISM STATUS command. This will provide the host with information on what disc is present or was changed.

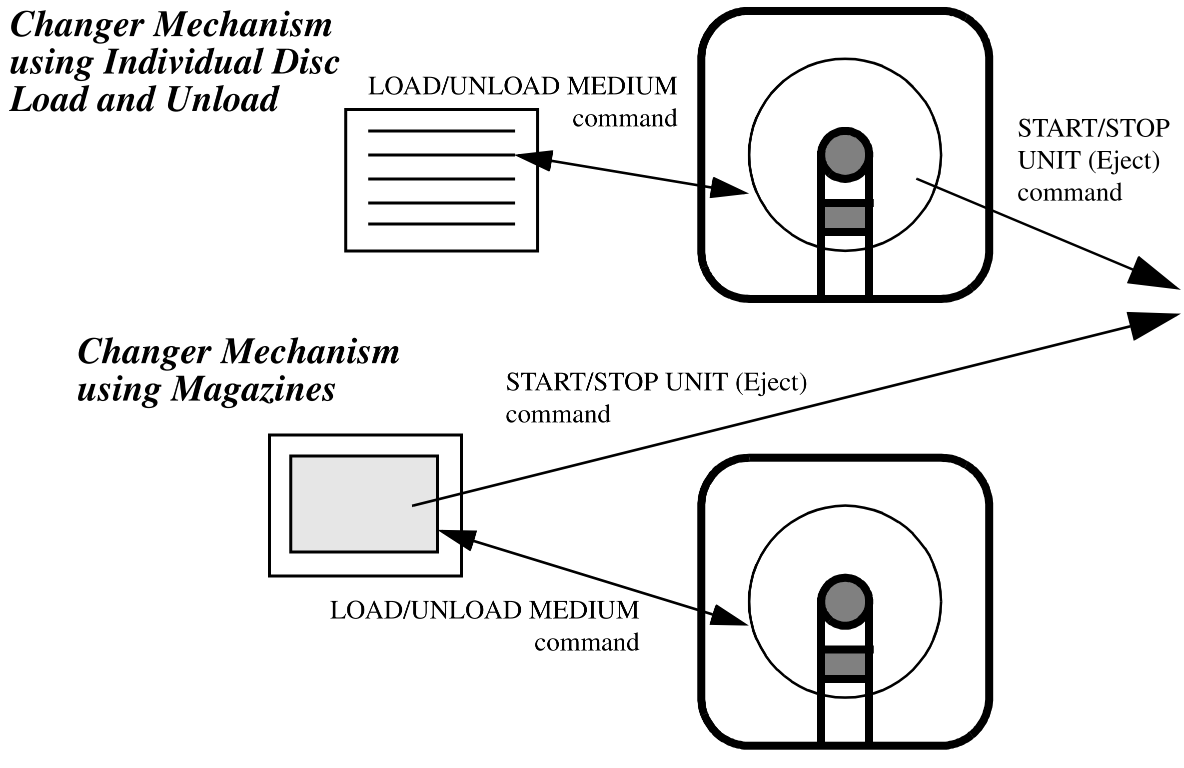


Figure 161 - Example of changer mechanism

10.1 Sidedness

As part of the DVD specifications, there is a type of media supported that includes data on more than one side of the Disc. This will allow devices that can automatically change sides to come into existence. Thus for C/DVD logical units, there is an optional capability to select each side of the Disc. Although this would not normally be thought of as a changer type of operation, the two sides to the Disc are independent and changer like functions are a good match for selecting sides. When the logical unit supports this functionality, each physical slot will have two logical slots. For example referencing slot 0 would be one side of the Disc, and slot 1 would then be the other side.

There are two fundamental techniques used to select each side of DVD media. The first is the most space efficient. It simply moved the Pick Up (laser unit used to read the disc) to the other side. This does add complexity to the laser mechanism to be able to position it on either the bottom or top of the media. The second approach is to actually flip the media over. This type does not exist today, although it is possible. This type of logical unit will pose some problems making sure that the correct side is selected after a power on or hard reset condition. Some way to remember which side was selected when the power was removed would be needed.

For a logical unit that supports changing sides (see *16.4.2.28, "Feature 0102h: Embedded Changer"* on page 445, “Side Change Capable”), the number of Slots reported ***shall*** be even, and every other slot ***shall*** be an alternating side.

10.1.1 Side Changing Only logical unit

There can exist a logical unit that is capable of changing the side of the Disc, but does not have separate Slots from the playing position. This type of logical unit reports that it has a Mechanism type that is not a changer, but also reports Side Change Capable. This style of logical unit will still make use of the LOAD/UNLOAD MEDIUM command to change the currently selected side. This style logical unit ***shall*** report two slots available (see Table 329 - *Mechanism Status Header* on page 486).

A side effect of a logical unit that only has the capability to change sides is that when unloading a Disc does not actually perform any action. This will appear to the host as a logical unit with Delayed Load type of operation (see *10.5, "Delayed Disc load operation"* on page 350).

Note: A DVD logical unit that supports changing sides will not be able to report if there is actually data on both sides until each side has been read.

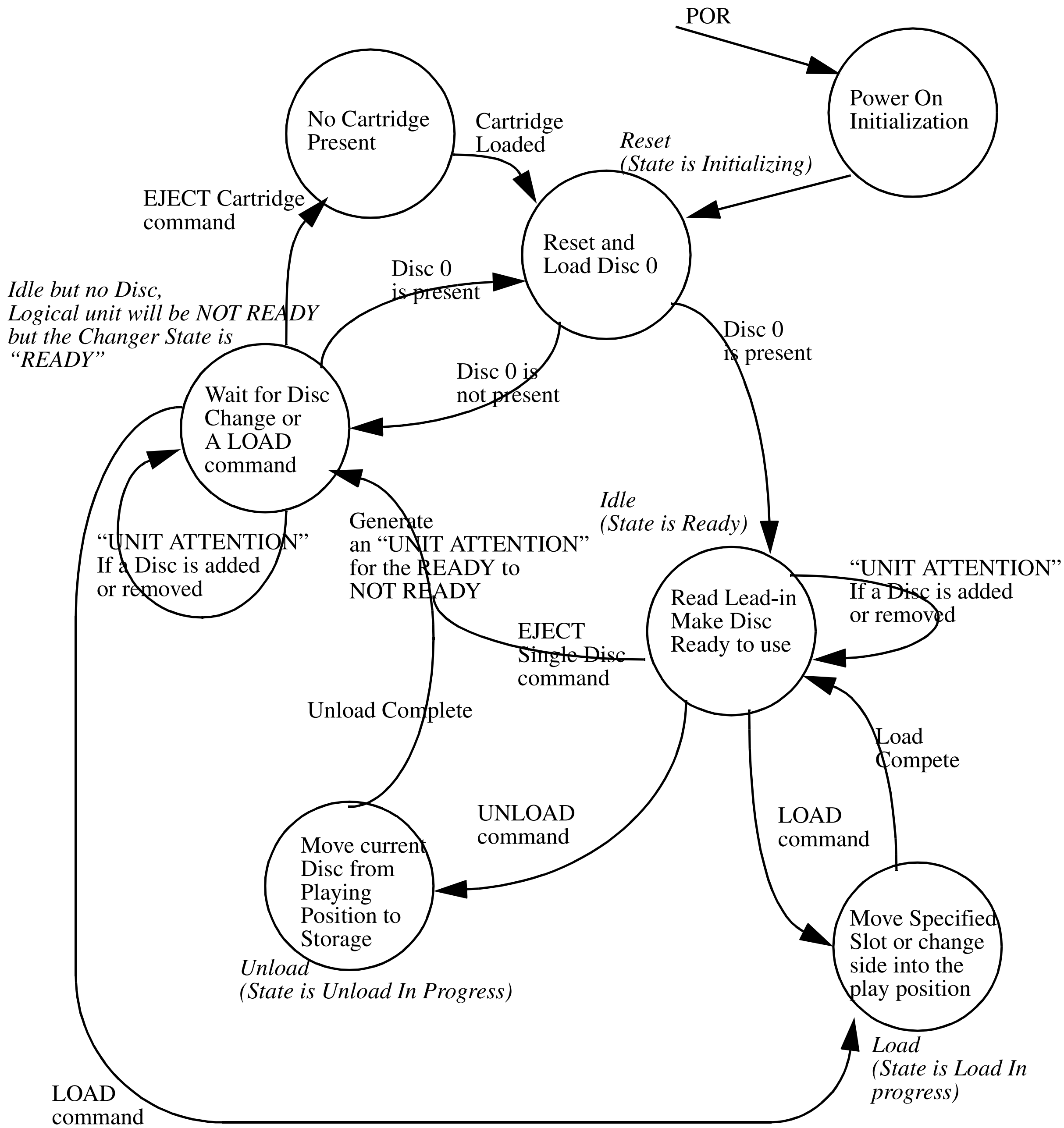
10.1.2 Error conditions for Sided Discs

Devices that support changing sides of a Disc ***shall*** use report CHECK CONDITION Status, 2/06/00 NO REFERENCE POSITION FOUND (medium may be upside down) when the currently selected side does not contain valid data.

10.2 Initialization

The Changer ***shall*** perform its initialization routine at power on or receipt of a hard reset from the host.

“Initializing Changer” is a process that refers to gathering the information that is necessary to respond to the MECHANISM STATUS command. If a changer is in the process of Initializing when it receives a MECHANISM STATUS command, it will respond immediately and provide no slot table information (Only the Header).



A LOAD command is the START/STOP UNIT command with Start *= 1,* LoEj *= 1.*

An EJECT command is the START/STOP UNIT command with Start *=0,* LoEj *= 1.*

Figure 161 - Changer State Diagram

10.3 Changer Addressing

Several Changer specific commands use addresses called “Slots.”

To determine if a logical unit is a changer type logical unit the Embedded Changer Feature (0102h) ***shall*** be reported in response to an appropriate GET CONFIGURATION command. A logical unit that reports Side Change Capable ***shall*** implement all Changer commands.

10.4 Automatic Load and Unload Operations

After initialization is complete the changer ***shall*** have Slot 0 loaded into the play position. This enables drivers which are not changer aware to work with a changer logical unit as if it were a normal single disc logical unit. This also insures compatibility with Bootable C/DVD. In support of this goal the changer ***shall*** also load and unload (Eject) default Disc 0 if the changer supports loading and unloading (Ejecting) individual Discs unless otherwise commanded by the use of one of the changer specific Load/Unload commands.

When a LOAD/UNLOAD MEDIUM command (Load) is received and a Disc is present in the Playing position, it ***shall*** be unloaded automatically before the specified Load operation is performed.

10.5 Delayed Disc load operation

C/DVD Changer Devices may either move a disc into the playing position immediately upon receipt of a LOAD/ UNLOAD MEDIUM command (Load), or delay the loading of the disc until a media access command is received. It is recommended that the logical unit not load discs into the playing position until data from a disc that is not cached is requested from the host. The delayed operation extends to the LOAD/UNLOAD MEDIUM (Unload) operation as well. Both the Load and Unload operations may be delayed.

Note: Host drivers should expect to encounter load mechanism delays on media accesses in addition to the spin up and seek delays normally introduced with these commands.

If the logical unit supports delayed loading and the selected disc is not in the play position, then the following commands ***shall*** move the selected disc into the play position when data that has not been cached has been requested by the host:

Table 178 - Delayed Load Operation by command

Command	Allowed Action
BLANK	Delay in processing command is allowed
CHANGE DEFINITION	No extra delay for medium movement ***shall*** occur
CLOSE TRACK/RZONE/SESSION/BORDER	Delay in processing command is allowed
FORMAT UNIT	Delay in processing command is allowed
GET CONFIGURATION	No extra delay for medium movement ***shall*** occur
GET EVENT/STATUS NOTIFICATION	No extra delay for medium movement ***shall*** occur
GET PERFORMANCE	No extra delay for medium movement ***shall*** occur
INQUIRY	No extra delay for medium movement ***shall*** occur
LOAD/UNLOAD MEDIUM	Delay in processing command is allowed but is not recommended
LOCK/UNLOCK CACHE	Delay in processing command is allowed
LOG SELECT	No extra delay for medium movement ***shall*** occur
LOG SENSE	No extra delay for medium movement ***shall*** occur
MECHANISM STATUS	No extra delay for medium movement ***shall*** occur
MODE SELECT (10)	No extra delay for medium movement ***shall*** occur
MODE SENSE (10)	No extra delay for medium movement ***shall*** occur
PERSISTENT RESERVE IN/OUT	No extra delay for medium movement ***shall*** occur
PLAY AUDIO (10)	The current slot selected ***shall*** be moved into the play position

Table 178 - Delayed Load Operation by command (Continued)

Command	Allowed Action
PLAY AUDIO MSF	The current slot selected ***shall*** be moved into the play position
PREFETCH	Delay in processing command is allowed
PREVENT/ALLOW MEDIUM REMOVAL	No extra delay for medium movement ***shall*** occur
READ (10) and READ (12)	Delay in processing command is allowed
READ BUFFER	No extra delay for medium movement ***shall*** occur
READ BUFFER CAPACITY	No extra delay for medium movement ***shall*** occur
READ CAPACITY	No extra delay for medium movement ***shall*** occur
READ DISC INFORMATION	Delay in processing command is allowed
READ SUBCHANNEL	Delay in processing command is allowed
READ FORMAT CAPACITIES	No extra delay for medium movement ***shall*** occur
READ CD	Delay in processing command is allowed
READ CD MSF	Delay in processing command is allowed
READ DISC STRUCTURE	Delay in processing command is allowed
READ TOC/PMA/ATIP	Delay in processing command is allowed
READ TRACK/RZONE INFORMATION	Delay in processing command is allowed
RECEIVE DIAGNOSTIC RESULTS	No extra delay for medium movement ***shall*** occur
RELEASE	No extra delay for medium movement ***shall*** occur
REPORT KEY	No extra delay for medium movement ***shall*** occur
REPORT LUNS	No extra delay for medium movement ***shall*** occur
REQUEST SENSE	No extra delay for medium movement ***shall*** occur
RESERVE	No extra delay for medium movement ***shall*** occur
RESERVE TRACK/RZONE/RMZ	Delay in processing command is allowed
SEEK	The current slot selected ***shall*** be moved into the play position
SEND DIAGNOSTIC	No extra delay for medium movement ***shall*** occur
SEND DISC STRUCTURE	Delay in processing command is allowed
SEND EVENT	Delay in processing command is allowed
SEND KEY	No extra delay for medium movement ***shall*** occur
SEND OPC INFORMATION	No extra delay for medium movement ***shall*** occur
SET CD SPEED	No extra delay for medium movement ***shall*** occur
SET READ AHEAD	No extra delay for medium movement ***shall*** occur
SET STREAMING	No extra delay for medium movement ***shall*** occur
STOP PLAY/SCAN	No extra delay for medium movement ***shall*** occur
START/STOP UNIT	The current slot selected ***shall*** be moved into the play position
SYNCHRONIZE CACHE	Delay in processing command is allowed
TEST UNIT READY	No extra delay for medium movement ***shall*** occur
VERIFY (10)	Delay in processing command is allowed
WRITE (10) and WRITE (12)	Delay in processing command is allowed
WRITE BUFFER	No extra delay for medium movement ***shall*** occur
WRITE AND VERIFY (10)	Delay in processing command is allowed

10.6 PREVENT/ALLOW MEDIUM REMOVAL processing

There are two techniques for PREVENT/ALLOW MEDIUM REMOVAL processing: either all the discs ***shall*** be prevented from being ejected by the user or each disc individually ***shall*** be prevented. If the logical unit reports support for Software Slot Selection, then each slot ***shall*** be individually controlled by the PREVENT/ALLOW MEDIUM REMOVAL command.

Note: Changer devices that use a Magazine and not individually controlled slots should not report the Software Slot Selection capability.

10.7 Error Reporting

If any of the following conditions occur during the execution of a command, the C/DVD Changer ***shall*** return CHECK CONDITION status. The appropriate sense key and additional sense code ***shall*** 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 179 - Error conditions and Sense Keys for Changer Mechanisms

Condition	Sense Key
Invalid Slot Number	ILLEGAL REQUEST
Unsupported option requested	ILLEGAL REQUEST
Load or Unload to invalid slot or no Disc in source location	ILLEGAL REQUEST
Device reset or medium change since last command	UNIT ATTENTION
Self diagnostic failed	HARDWARE ERROR

In the case of an invalid Slot number, the sense data information field ***shall*** be set to the Slot number of the first invalid address.

When an error condition is reported to the host, the disc in the selected slot ***shall*** be moved into the play position.

Attempts to eject a Disc if the changer type is Magazine and there is a Disc in the playing position ***shall*** be rejected with CHECK CONDITION Status, 4/3B/16 MECHANICAL POSITIONING OR CHANGER ERROR.

11.0 Write protection model

Random Writable and Overwritable logical unit may be able to perform Write Protection. For example, MO or DVD-RAM cartridge has Write Protection Switch/tabs. User can set or release the Write Protection Switch/tabs for user's purpose, e.g., to disable data modification on the media. In this section, User/host accessible Write Protection Methods and Media Specific Write Inhibition are described.

There are three methods of Write Protection for Device Type 5 logical unit, Software Write Protection until Power down (SWPP), Persistent Write Protection (PWP) and Media Cartridge Write Protection (CWP). SWPP is stored in the logical unit memory. See *16.11.3.5, "Time-out & Protect Mode Page"* on page 506. PWP is a kind of Media write protection for example Write-inhibit flag of DVD-RAM Ver.2.1 and Write Protected Disc Status of DVD-RW Ver.1.2. This Write Protection status is recorded on a media surface. PWP is possible to be set or to be cleared by host via command. CWP is a kind of write protect switch/tab on the Media Cartridge or Magazine. CWP is possible to be set or released by user manually.

For example, DVD-RAM media has Media Specific Write Inhibition (MSWI). Combination of Disc Type Identification field value and cartridge status may set MSWI active. For more information, see *4.15.14, "Write protection of a disc"* on page 118.

These three Write Protection status and MSWI status ***shall*** be applied as logical OR. If one of them is set to active status, a logical unit ***shall not*** report any erasable/formattable/writable Features as current.

11.1 Consideration for compatibility with other device type

In other device type, PWP is defined and its functionality is almost same as the PWP that is explained in this section. In some other device types (e.g., device type 1: Sequential-access device), PWP is defined to be controlled by MODE SENSE (10) and MODE SELECT (10) commands. PWP is included in device specific Mode Parameter. In this case, when the PWP status is changed by the media exchange, the logical unit ***shall*** generate UNIT ATTENTION and SK/ASC/ASCQ ***shall*** be set to 6/2A/01 MODE PARAMETERS CHANGED. Usually this kind of UNIT ATTENTION is not generated, even if the host Operating System supports multi-tasking. To eliminate this UNIT ATTENTION, this specification does not use any Mode Parameter to control and report the PWP status of the media.

11.2 Write Protect Feature and related commands

If logical unit supports one of these Write Protection Methods or Media Specific Write Inhibition, logical unit ***shall*** support Write Protect Feature (0004h) and READ DISC STRUCTURE command with Format Code code C0h and FFh. Reporting of these status ***shall*** be reflected by the current mounted media specification. If the specification of the mounted medium does not specify the Write Protection function, the corresponding bits should be set to zero. For example, if DVD-ROM disc is in a DVD-RAM cartridge, regardless of the Write Protection switch/tabs setting of the cartridge, MSWI, CWP and PWP bits of READ DISC STRUCTURE returned data should be set to zero. If DVD-RAM Ver.1.0 medium is installed, PWP bit ***shall*** be set to zero. If there is no mounted medium in the logical unit, READ DISC STRUCTURE command with Format Code code C0h ***shall*** be terminated with CHECK CONDITION Status, 2/3A/00 MEDIUM NOT PRESENT.

If Supports PWP (SPWP) bit of the Write Protect Feature Descriptor is set to one, SEND DISC STRUCTURE command with Format Code code C0h ***shall*** be supported. In this case, Current bit of the Write Protect Feature Descriptor ***shall*** indicate whether the SEND DISC STRUCTURE command with Format Code code C0h can work on the mounted media. If Supports SWPP (SSWPP) bit of the Write Protect Feature Descriptor is set to one, logical unit ***shall*** support SWPP bit in the *Time-out & Protect* Mode Page (1Dh). SSWPP bit does not affect the Current bit of the Write Protect Feature Descriptor. Because this Mode Parameter Page is always accepted by the logical unit.

If logical unit supports Embedded Changer Feature (0102h), logical unit ***shall*** support CWP_V, CWP bits in Table 330 - *Slot Table Response format* on page 487.

By the SEND DISC STRUCTURE command, the data sent from host may not be written on physical medium at the command completion. It will be applied at appropriate timing defined by the media specification and/or the Format Code code definition. In the case of DVD-RW, PWP status ***shall*** be set on the medium when:

- medium is going to be ejected
- SYNCHRONIZE CACHE command is issued
- RMA is modified by another reason

11.3 Error reporting

When Write Protection status is set to active, logical unit ***shall*** terminate all the commands that cause erasing/formatting/writing on media except PWP status changing with CHECK CONDITION status. If SWPP is set to active, ASC/ASCQ of 7/27/02 LOGICAL UNIT SOFTWARE WRITE PROTECTED ***shall*** be reported via REQUEST SENSE command. If PWP is set to active, ASC/ASCQ of 7/27/04 PERSISTENT WRITE PROTECT ***shall*** be reported. If CWP is set to active, ASC/ASCQ of 7/27/01 HARDWARE WRITE PROTECTED ***shall*** be reported. If MSWI is set to active, ASC/ASCQ of 7/27/00 WRITE PROTECTED ***shall*** be reported. If more than one Write Protections are active, the following order ***shall*** be used for error reporting, SWPP, CWP and PWP. PWP has the lowest priority. Because other types are permanent during medium is mounted in a logical unit.

11.4 Event reporting

When Write Protection status of mounted medium and/or logical unit is changed (e.g., all of Write protections are cleared or one of them is set to active), any Features that allows erasing/formatting/writing on media except Write Protect Feature are changed, then logical unit ***shall*** generate Class 1 Event if logical unit supports the reporting of the Class 1 Event.

11.5 Persistent Write Protection exception

Even if PWP status is active, it may be possible to change the data on the media according to regulations of the media specification or some related specific specification. It depends on the specification.

12.0 Power management model

Four power states are defined. These are named Active, Idle, Standby, and Sleep with Active being the “Full-On” state, Sleep the “Off” state and “Idle, Standby and Sleep” progressively more aggressive power managed states. This model differs significantly from previous ATA and SCSI power management definitions. This new model defines power states in terms of the perceived impact on the end user, instead of absolute power levels. The Idle state is optimized for minimal end user performance impact. The Standby state is optimized for power savings.

To provide consistent behavior across logical units, standard definitions are used for the power states of logical units. These states are defined in terms of the following criteria.

- Power Consumption: How much power the logical unit uses.
- Logical unit Context: How much of internal state of the logical unit is retained by hardware and what ***shall*** be restored by the responsible software.
- Restore time: How long it takes to raise the power level to the active power state and to put the logical unit into operational condition (including mechanical operation such as spin up) required before entering into the Active power state. Restoring is vendor specific and any mechanism can be employed here to raise the power consumption and to put the logical unit in operation condition required in a higher power state. For example, “turning on or raising internal Vcc’s for power hungry circuits such as motors, laser sensors”, “raising internal Vcc or the clock frequency for the digital circuits”. A critical factor is how quickly restoring the logical unit to operation condition required in a higher power state (e.g., spin up).
- De-power time: How long it takes to reduce the power to the desired level in lower power state after entering the lower power state from higher power state. De-powering is vendor specific and any mechanism can be employed here to reduce the power consumption. For example, “turning off or lowering internal Vcc’s for power hungry circuits such as motors, laser sensors”, “lowering internal Vcc or reducing the clock frequency for the digital circuits”, “dynamic clock gating”, “cutting off the DC paths for unused circuits”, “turning off PLLs”.

Table 180 - Power management model states

Logical unit State	Power Consumption	Logical unit Context Retained	Restore Time
Active (D0)	As needed for operation.	All	None
Idle (D1)	Less than Active	All	The logical unit ***shall*** be restored to active state within 1 second on any request to enter active state, independent of the de-powering process.
Standby(D2)	Less than Idle	All buffers are empty before entering Standby state.	Vendor specific: Greater than or equal to Idle to Active
Sleep(D3)	Less than Standby	None, Buffer & All of command queues are empty before entering Sleep state.	Greater than or equal to Standby to Active. Vendor Specific. May Need full initialization. The host may remove Vcc.

Transitions between these power states may occur at the request of the host or the logical unit. Transitions to a higher power state from a lower power state ***shall*** occur after restoring the logical unit to the operating conditions (including mechanical operation if applicable, such as spin up) required in the higher power state. When the logical unit transitions from a higher power state to a lower power state, the logical unit ***shall*** be considered to be in the lower power state when the logical unit is assured of reaching the lower power condition. Actual de-powering occurs after the logical unit enters the lower power state. The logical unit ***shall*** generate a power Event when the logical unit is considered to have entered a power state.

In order to create a robust power management environment, logical units ***shall*** support the following:

- The Power Management Feature.
- Four power states: Active (D0), Idle (D1), Standby (D2) and Sleep (D3).
- Idle Timer. Provides a method for the logical unit to enter Idle state from Active state, following a programmed period of inactivity.
- Standby Timer. Provides a method for the logical unit to enter Standby state from either Active or Idle state, following a programmed period of inactivity.
- START/STOP UNIT command and the Power Condition field: Provides a method for the host to request the logical unit to enter a power state.
- GET EVENT/STATUS NOTIFICATION command: Notifies the host of power state changes and current power status.
- *Power Condition* Mode Page (1Ah): Enables or disables timers and specifies the reload value of the Idle and Standby timers.

12.1 Power state transitions

Active State (D0): The logical unit is completely active and responsive. The logical unit is consuming its highest level of power. During the execution of a media access command (commands that reload both timers) the logical unit ***shall*** be in active state.

The logical unit should minimize power consumption at all times, even when in the active state. Any mechanism can be employed, as long as it is transparent to software and does not prevent the logical unit from performing expected functions. For example, the logical unit may dynamically gate on/off internal clocks by monitoring bus activities and internal activities.

Idle State (D1): In Idle state, the logical unit is capable of responding to commands but may take up to one second longer to complete commands than the Active state. The logical unit is consuming less power than the Active state. Any mechanism can be employed as long as the restoring time is less than one second. The logical unit may, for example:

- Reduce internal clock frequency
- Lower the internal Vcc for digital circuits
- Dynamically gate internal clocks by monitoring bus/internal activities

Standby State (D2): In Standby state the logical unit ***shall*** only be required to accept commands from the host. All other mechanisms are in the power save condition. In Standby state, the logical unit is capable of responding to commands but the logical unit takes longer to complete commands than when in Idle state. Buffers ***shall*** be emptied before entering into Standby state. The logical unit context ***shall*** be preserved. The logical unit is consuming less power than when in Idle state.

Sleep State (D3): Maximum power saving state. Buffers and all command queues, including GET EVENT/STATUS NOTIFICATION commands, ***shall*** be emptied before entering into the Sleep state. When the logical unit enters the sleep state, any GET EVENT/STATUS NOTIFICATION commands present in the command queue, ***shall*** be removed from the command queue, without command completion. In this Sleep state, all functions are stopped and no commands, except for reset can be received. The unit is consuming less power than when in the Standby state. The logical unit context is invalid in the Sleep state.

The host software ***shall*** fully initialize the logical unit after exiting Sleep state, as all context may be lost in the Sleep state. Therefore, disc(s)/cassette may be manually ejected or inserted while in sleep state, independent of any lock/unlock mechanism employed. For the host to consistently rely on the logical unit Media Status Notifications, when the logical unit is unable to determine if media has been changed while the logical unit was in the sleep state, the logical unit ***shall*** report a New Media Event on the next GET EVENT/STATUS NOTIFICATION (Media Status) command.

In the Sleep state, the host may completely remove power from the device by turning off Vcc.

12.1.1 State diagram

The state diagram in Figure 162 - *State transition, events and status* on page 358 and Table 181 - *State transition, events and status* on page 358 define state transitions for the power management model.

A power-on or hard reset always returns the Power State to the Standby state. A Device Reset does not alter the current power state, unless the current power state is Sleep. A Device Reset received while in sleep state returns the power state to Standby.

The Sleep state is entered when the logical unit has been commanded to go to Sleep but Vcc is still applied to the device. Removing Vcc always takes the device to the Power Off state. Removing Vcc is recommended only when all logical units on a given bus are in sleep state.

Table 181 - *State transition, events and status* on page 358 shows transition conditions for this model, and shows the Initial state, the Resultant state, Notification class, and Event class (Media or Power Management). Notification Class and Event class (Power Event/Media Event) fields specify the Events that ***shall*** be generated during the transitions as outlined in the GET EVENT/STATUS NOTIFICATION command.

In Idle or Standby states, the logical unit should attempt to maintain the minimal power level for that state at all times. However, the logical unit may create transitory, higher power level conditions as needed. The transitory power conditions ***shall not*** affect the reported power state, or generate power state Events. Example transitory conditions are: flushing the buffers, emptying command queues, media insertion spin up, or auto off-line. On insertion of new media, the logical unit may enter a transitory, higher power condition and stay in this condition for vendor specific time period. If the logical unit has not received a media access command (commands which reload both timers) during this period, the logical unit ***shall*** return to the normal power level for the current power state. This prevents excessive power consumption while the host is off-line.

It is permissible to enter intermediate states while in transition between states, however, the logical unit ***shall not*** report power change Events for the intermediate states. If the logical unit fails to enter the target power state, the logical unit ***shall*** return to the original power state. Simultaneous expiration of multiple timers, ***shall*** cause the logical unit to enter the lower power state, and ***shall*** only report the result of the transition to that state.

When no media is mounted, the logical unit should enter the Standby State.

If a power change Event has not been reported to the host, when a new Event is generated, the logical unit may choose only to report the most recent power Event.

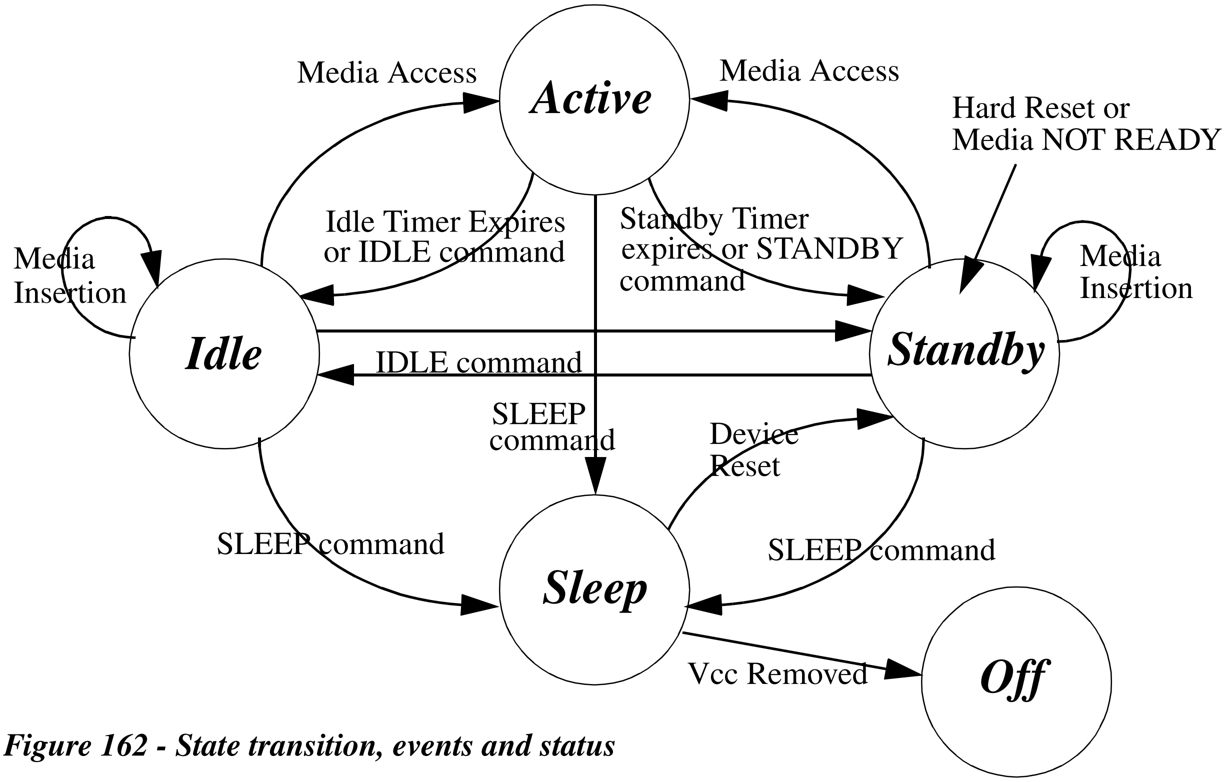


Figure 162 - State transition, events and status

Table 181 - State transition, events and status

Initial State	Resultant State	Cause of Transition	Notification Class	Event
Active	Active	Unsuccessful IDLE, STANDBY, or SLEEP command	Power	PwrChg-Fail
	Idle	Successful completion of IDLE command	Power	PwrChg-Succ
	Idle	The expiration of Idle timer	Power	PwrChg-Succ
	Standby	Successful completion of STANDBY command	Power	PwrChg-Succ
	Standby	The expiration of Standby timer, all buffers are empty	Power	PwrChg-Succ
	Sleep	Successful completion of SLEEP command	Power	PwrChg-Succ
Idle	Idle	Successful completion of an IDLE command	Power	PwrChg-Succ
	Idle	Insertion of media and ready to use	Media	NewMedia
	Standby	The expiration of Standby timer, all buffers are empty	Power	PwrChg-Succ
	Standby	Successful completion of STANDBY command	Power	PwrChg-Succ
	Sleep	Successful completion of SLEEP command	Power	PwrChg-Succ
	Active	Reception of a command which reloads both timers	Power	PwrChg-Succ
Standby	Standby	Successful completion of STANDBY command	Power	PwrChg-Succ
	Standby	Insertion of media and ready to use	Media	NewMedia
	Idle	Successful completion of IDLE command	Power	PwrChg-Succ
	Sleep	Successful completion of SLEEP command	Power	PwrChg-Succ
	Active	Reception of a command which reloads both timers	Power	PwrChg-Succ
Any	Standby	A power-on, or hard reset occurred, or the logical unit becomes NOT READY	Power	PwrChg-Succ
Sleep	Standby	Device Reset	Power	PwrChg-Succ

12.1.2 Timers

The Idle and Standby timers provide a method for the logical unit to enter lower power states after a host programmable period of inactivity, without direct host command.

A timer is deactivated (no longer used by the logical unit, regardless of Enable / Disable setting provided from the host) when the logical unit is in the associated power state or a lower power state.

A timer is both reactivated (the logical unit ***shall*** use the timer if enabled) and reloaded when a logical unit transitions to power state higher than the associated timer.

Timers ***shall*** be reloaded, as specified in Table 182, using the current timer value from the *Power Condition* Mode Page (1Ah).

Timers ***shall*** be disabled/enabled as specified in the *Power Condition* Mode Page (1Ah).

Timers ***shall*** be set to default conditions upon receiving a power-on, or hard reset. The default condition for the Timers ***shall*** be enabled with the values of the timers vendor specific.

12.1.2.1 Standby timer

If the Standby Timer expires the logical unit ***shall*** attempt to flush all buffers.

If this operation fails, the logical unit ***shall*** remain in the current power state, and the Standby timer is reloaded. If the flush succeeds, the logical unit ***shall*** enter the Standby State.

Table 182 - Effects of host actions on timers

host Action	Timer Effects	Comments
BLANK	Reload Both	Recordables only
CLOSE TRACK/RZONE/SESSION/BORDER	Reload Both	Recordables only
COMPARE	Reload Both	SCSI only
EXECUTE DRIVE DIAGNOSTIC	Reload Both	ATA command
FORMAT UNIT	Reload Both	Rewritable only
GET CONFIGURATION	None	
GET EVENT/STATUS NOTIFICATION	None	
GET PERFORMANCE	Reload Both	May need to access media
INQUIRY	None	
LOAD/UNLOAD MEDIUM	Reload Both	
LOCK/UNLOCK CACHE	None	SCSI only: A Lock Cache command ***shall*** prevent the logical unit from entering Standby or Sleep states.
LOG SELECT	None	SCSI only
LOG SENSE	None	SCSI only
MECHANISM STATUS	None	
MODE SELECT (10)	May reload timers	A MODE SELECT (10) command that changes the Standby or Idle timers ***shall*** reload the timer.
MODE SENSE (10)	None	
PLAY AUDIO (10)	Reload Both	
PLAY AUDIO MSF	Reload Both	
PRE-FETCH	Reload Both	SCSI only
PREVENT/ALLOW MEDIUM REMOVAL	Reload Standby	
READ (10) / READ (12)	Reload Both	
READ BUFFER	Reload Standby	
READ BUFFER CAPACITY	None	

Table 182 - Effects of host actions on timers (Continued)

host Action	Timer Effects	Comments
READ CAPACITY	Reload Both	
READ CD	Reload Both	
READ CD MSF	Reload Both	
READ DISC INFORMATION	Reload Both	
READ DISC STRUCTURE	Reload Both	
READ FORMAT CAPACITIES	Reload Standby	
READ SUBCHANNEL	Reload Both	
READ TOC/PMA/ATIP	Reload Both	
READ TRACK/RZONE INFORMATION	Reload Both	
RELEASE (10)	None	SCSI only
REPAIR RZONE	Reload Both	Sequential DVD Recordable
REPORT KEY	Reload Both	
REQUEST SENSE	None	
RESERVE (10)	None	SCSI only
RESERVE TRACK/RZONE/RMZ	Reload Both	Recordables only
SCAN	Reload Both	
SEEK	Reload Both	
SEND DISC STRUCTURE	Reload Both	Sequential DVD Recordable
SEND EVENT	Reload Both	May effect media access
SEND KEY	Reload Both	
SEND OPC INFORMATION	Reload Both	Recordables only
SET CD SPEED	Reload Both	
SET READ AHEAD	Reload Both	
SET STREAMING	Reload Both	
START/STOP UNIT	See START/STOP UNIT command	
STOP PLAY/SCAN	Reload Both	
SYNCHRONIZE CACHE	Reload Both	
TEST UNIT READY	None	
VERIFY (10)	Reload Both	
WRITE (10) / WRITE (12)	Reload Both	Recordables only
WRITE AND VERIFY (10)	Reload Both	Recordables only
WRITE BUFFER	Reload Standby	
Device Reset	Reload Both	Reset operation, the logical unit ***shall not*** return to default timer conditions
Other commands	Vendor Specific	

12.1.3 Power management status reporting

The Power Status field of the GET EVENT/STATUS NOTIFICATION (Power Management Class) Event data ***shall*** report the current logical unit power state. This provides a mechanism for the host to query the current power state, irrespective of state transitions.

13.0 Time-out and Reset models

13.1 Time-outs

Currently, it is difficult for an operating system to determine a correct time-out value to use when issuing commands to a logical unit. Specifically, in instances of commands that may take a long time complete, but usually complete in a relatively short time. An example would be a read command after the logical unit has entered a low power state, and the media ***shall*** spin up before completing the request. This model allows for a method for the logical unit to complete the request with an error that indicates to the host operating system that the request should be retried, but with a longer time-out.

The logical unit will specify up to three time-out parameters in the *Time-out & Protect* Mode Page (1Dh). The first parameter is the minimum time-out that an operating system ***shall*** use for all commands in Group 1. The second parameter is the minimum time-out that an operating system ***shall*** use for all commands in Group 2. The third parameter is the maximum time-out for real-time stream recording/playback that the logical unit ***shall*** use for all commands in Group 3.

For commands in Group 1, the logical unit ***shall*** start an internal timer when the command is received. If the command is unable to complete before the time specified in the Group 1 Time-out field of the*Time-out & Protect* Mode Page (1Dh), bytes 6 and 7, the logical unit may terminate the command, at any time before the Group 1 Time-out expires, with CHECK CONDITION status, 6/2E/00 INSUFFICIENT TIME FOR OPERATION. In addition, the logical unit ***shall*** set the command Specific Information sense bytes (Bytes 8-11) to the value in seconds that corresponds to the minimum time-out that the host should use when retrying this command. Upon receiving this CHECK CONDITION, the operating system ***shall*** retry the command with the requested time-out.

Note: A logical unit may return this CHECK CONDITION at any point after the command is received, it may even return prior to initiating command.

All commands in Group 2 are commands that may not be able to complete successfully if they are retried. Thus, the host ***shall*** ensure that it uses a time-out that is large enough to allow the command to complete under worst case scenarios. This time-out is specified by the logical unit in the Group 2 Time-out parameter of the *Time-out & Protect* Mode Page (1Dh) (Bytes 8-9).

Group 3 is designed for real-time stream recording/playback. The logical unit ***shall*** terminate the command in Group 3 within specified Group 3 time-out duration. When time-out occurs, the logical unit ***shall not*** generate 6/2E/00 INSUFFICIENT TIME FOR OPERATION to expand working time. The logical unit ***shall*** terminate the command as defined by the command. The logical unit may terminate the command with CHECK CONDITION status and error code for a fatal error.

For a complete list of command groupings see Table 183.

Table 183 - NOT READY error & Time-out UNIT ATTENTION reporting (by command)

Command	Returns NOT READY status	Time-out	Comment
BLANK	Yes	Group 2	
CLOSE TRACK/RZONE/SESSION/BORDER	Yes	Group 2	Recordables only
COMPARE	Yes	Group 1	Not Defined in this specification
FORMAT UNIT	Yes	Group 2	
FORMAT UNIT (Immediate)	Yes	Not Allowed	
GET CONFIGURATION	No	Not Allowed	
GET EVENT/STATUS NOTIFICATION	No	Not Allowed	
GET PERFORMANCE	No	Group 1	
INQUIRY	No	Not Allowed	
LOAD/UNLOAD MEDIUM	No	Group 2	
LOG SELECT	No	Group 1	Not Defined in this specification
LOG SENSE	No	Group 1	Not Defined in this specification
MECHANISM STATUS	No	Group 1	
MODE SELECT (10)	No	Group 1	
MODE SENSE (10)	No	Group 1	
PAUSE/RESUME	Yes	Group 1	
PLAY AUDIO (10)	Yes	Group 1	
PLAY AUDIO MSF	Yes	Group 1	
PREVENT/ALLOW MEDIUM REMOVAL	See Table 371 - *Actions for Lock/Unlock/Eject (Persistent bit = 0)* on page 528	Group 1	
READ (10)	Yes	Group 1	
READ (12) with Streaming = 0	Yes	Group 1	
READ (12) with Streaming = 1	Yes	Group 1 or Group 3[a]	
READ BUFFER	No	Group 1	Not Defined in this specification
READ BUFFER CAPACITY	No	Group 1	
READ CAPACITY	Yes	Group 1	
READ CD	Yes	Group 1	
READ CD MSF	Yes	Group 1	
READ DISC INFORMATION	Yes	Group 1	
READ DISC STRUCTURE	Yes	Group 1	
READ FORMAT CAPACITIES	No	Group 1	
READ SUBCHANNEL	Yes	Group 1	
READ TOC/PMA/ATIP	Yes	Group 1	
READ TRACK/RZONE INFORMATION	Yes	Group 1	
RECEIVE DIAGNOSTIC RESULTS	No	Not Allowed	Not Defined in this specification
RELEASE (10)	No	Not Allowed	Not Defined in this specification
REPAIR RZONE	Yes	Group 1	
REPORT KEY	Yes	Group 1	
REQUEST SENSE	No	Not Allowed	
RESERVE (10)	No	Not allowed	Not Defined in this specification
RESERVE TRACK/RZONE/RMZ	Yes	Group 2	Recordables only

Table 183 - NOT READY error & Time-out UNIT ATTENTION reporting (by command)

Command	Returns NOT READY status	Time-out	Comment
SCAN	Yes	Group 1	
SEEK	Yes	Group 1	
SEND DIAGNOSTIC	No	Not Allowed	Not Defined in this specification
SEND DISC STRUCTURE	No	Group 1	
SEND EVENT	Yes	Group 1	
SEND KEY	Yes	Group 1	
SEND OPC INFORMATION	No	Group 1	Recordables only
SET READ AHEAD	Yes	Group 1	
SET CD SPEED	No	Group 1	
SET STREAMING	Yes	Group 1	
START/STOP UNIT	Yes	Group 1	
STOP PLAY/SCAN	Yes	Group 1	
SYNCHRONIZE CACHE	Yes	Group 2	
TEST UNIT READY	Yes	Group 1	
VERIFY (10) with G3tout = 0	Yes	Group 2	
VERIFY (10) with G3tout = 1	Yes	Group 2 or Group 3[a]	
WRITE (10)	Yes	Group 1	
WRITE (12) with Streaming = 0	Yes	Group 1	
WRITE (12) with Streaming = 1	Yes	Group 1 or Group 3[a]	
WRITE AND VERIFY (10)	Yes	Group 1	
WRITE BUFFER	No	Group 1	

a. If the logical unit supports Group3 time-out and the G3Enable bit in *Time-out & Protect* Mode Page (1Dh) is set to 1, the command is categorized as Group 3 time-out. If the G3Enable bit is set to 0, this command is categorized as Group 1 time-out or Group 2 time-out.

Note: The references to “Not Defined in this specification” in the table are to indicate that these commands are currently defined in the SCSI SPC-2, SBC and MMC-2 standards. As these commands are not defined in this specification the usage and actual operation of these commands is specified elsewhere, their reference here are only recommendations to provide better compatibility.

Note: These recommendations are based on common transfer lengths. Long transfer lengths may affect timeouts.

13.1.1 Group 3 time-out for Real Time Stream recording/playback

To adjust application setting of real-time stream recording/playback to recover from fatal error, estimation of expected time length for the command is necessary. *Section 8.3.3, "Fatal error recovery model with Group 3 time-out"* on page 330. Group 3 time-out is assigned for this purpose. A logical unit ***shall*** terminate READ (12)/WRITE (12) command with Streaming = 1 and VERIFY (10) command with G3tout bit=1, within the expected time length defined as follows.

- Group 3 time-out duration = Group3 time unit × Ceil(Transfer length / Unit length) + trace time for requested sectors
  Note: Ceil(x) returns the least integer value greater than or equal to x.
- Group 3 time unit: a unit for Group 3 time-out that correspond to read/write one sector
- Unit length: a unit of block length correspond to increase a unit of Group 3 time unit
- trace time: time to read/write blocks excluding access time and read/write time of the first sector.

Group 3 time unit value shows the maximum time of operation when the transfer length field is set to 1 and when Power state of the logical unit is Active state. In case of DVD-RAM, Group 3 time unit value should include Zone transition time.

The recommended value for Group 3 time unit is 1 to 5 seconds. The recommended value for Unit length is 256 sectors.

It is recommended that transfer length and verification length are set to smaller than the Unit length value. If the host uses transfer length less than the Unit length, the Group 3 time-out duration is almost same as the Group 3 time unit as follows: (in the case of DVD, 256 sectors is only 0.38 second at 1× speed.)

- Group 3 time-out duration = Group 3 time unit + trace time for requested sectors

Group 3 time unit ***shall not*** be changed by medium change. A logical unit may accept the value changed by the host. The host is able to find it from changeable value page of MODE SENSE (10) command.

Unit length is defined as media type specific. A logical unit may change the Unit length value according to the mounted media type.

Group 3 time-out duration of Group 3 time-out has following three exceptions.

- Exception 1: Initial OPC time
- Exception 2: Synchronize cache time
- Exception 3: Power state transition time to Active state

A host is able to control the occurrence of these exceptions by command (e.g., SEND OPC INFORMATION command, SYNCHRONIZE CACHE command). The occurrence of these exceptions is rare case. The logical unit need not treat these exceptions as errors.

If Group 3 time-out is supported, G3tout bit of VERIFY (10) command ***shall*** be supported as described in *16.47, "VERIFY (10) command"* on page 707.

13.1.2 Trace time for requested sectors

Group 3 time unit value shows the minimum time of operation when the transfer length field is set to 1. If transfer length is lager than 1, Group 3 time-out duration is increased to reflect the transfer length of the command. For example, in case of 1× CLV of DVD media, read operation takes 1.48msec/sector. If Group 3 time value is 3 seconds and transfer length is 160, the Group 3 time-out duration is 3.24 second ($= 3 + 0.00148 \times (160 - 1)$).

The transfer length field value of usual READ (12)/WRITE (12) command is assumed 32 or less. The trace time for the requested sectors of usual READ (12)/WRITE (12) command is very small comparing with Group 3 time unit value.

13.1.3 Exception 1: Time for the initial OPC

Optimum Power Calibration before a write operation takes several seconds. When OPC is performed, a logical unit may expand the Group 3 time-out duration with extra time for the initial OPC. To avoid this exception, the host should issue SEND OPC INFORMATION command with DoOpc = 1.

- Group 3 time-out duration with OPC = time for the initial OPC + Group 3 time-out duration

A logical unit should not perform time consuming internal OPC (Subsequent OPC) except the initial OPC during real-time stream recording at the WRITE (12) command with Streaming=1. At WRITE (10)/WRITE (12) command with Streaming=0 and SEND OPC INFORMATION command with DoOpc = 1, the logical unit may perform the Subsequent OPC if necessary. The host may pause the real-time streaming recording and issue SEND OPC INFORMATION command with DoOpc = 1.

Reporting of CHECK CONDITION status, 2/04/08 LOGICAL UNIT NOT READY, LONG WRITE IN PROGRESS to avoid the time-out of WRITE (12) command with Streaming=1 due to insufficient buffer capacity may hide the Exception 1. However, it is not recommended to use this operation for the Subsequent OPC.

13.1.4 Exception 2: Synchronize cache time

If a logical unit has write data in buffer, when the logical unit receives READ (12) command with Streaming=1 or VERIFY (10) command with G3tout=1, the logical unit ***shall*** write the data in buffer. Then the logical unit ***shall*** read the specified blocks. In this case, additional Group 3 time-out duration for synchronize cache is added to the Group 3 time-out duration for READ (12) command with Streaming=1 and VERIFY (10) command with G3tout=1.

- Expected time for synchronize cache = Group 3 time unit + time to synchronize the buffered data
- Group 3 time-out duration with synchronize cache = Expected time for synchronize cache + Group 3 time-out duration

A host is able to assume the Group 3 time-out duration for synchronize cache via READ BUFFER CAPACITY command. For example, if a logical unit has 2 Mbytes buffer, the logical unit may have about 60 ECC blocks of write data in buffer. In case of 1× CLV of DVD media, if Group 3 time value is 3 seconds, the expected time for synchronize cache is 4.42 seconds (= 3 + 0.00148 × (960 - 1)).

To avoid this exception, a host should issue SYNCHRONIZE CACHE command.

The logical unit ***shall*** report the buffer size by Length of Buffer field of Table 383 - *READ BUFFER CAPACITY data when Block bit of CDB = 0* on page 537 if Group3 bit in the Time-out Feature (0105h) is set to 1 and the Time-out Feature (0105h) is current.

13.1.5 Exception 3: Power state transition time to Active state

When a logical unit is in Idle state or Standby state, the logical unit needs a few seconds to be Active state before a operation. When Power state transition is performed, the logical unit may exceed Group 3 time-out duration with extra time for the Power state transition.

- Group 3 time-out duration with Power state transition = time for the Power state transition + Group 3 time-out duration

To avoid this exception, a host should issue START/STOP UNIT command with Start = 1, LoEj = 0 and Power Condition = 0.

13.1.6 Relationship between Group 3 time unit and Unit length

The Group 3 time-out duration of the command termination is increased by Group 3 time unit when the transfer block length is increased by Unit length as shown in Figure 163. Because changing Group 3 time unit causes big direct impact to host software, the Group 3 time unit value ***shall not*** be changed by medium change. If adjustment of the Group 3 time-out duration of the command termination time on different media is necessary, different Unit length value for different media ***shall*** be used.

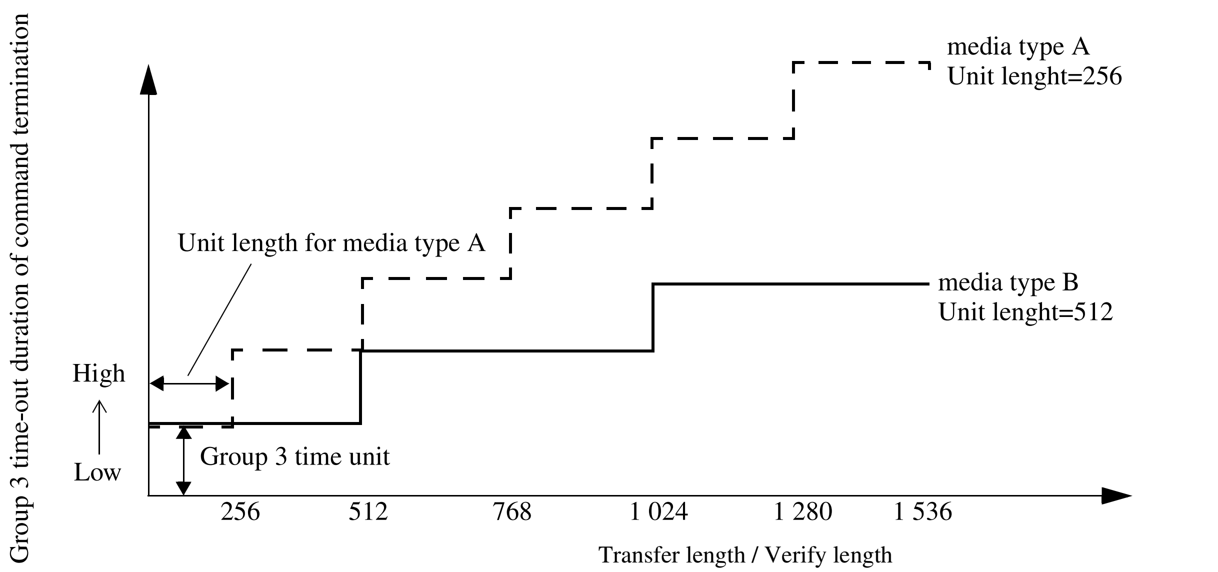


Figure 163 - Adjustment of command termination time on different

13.1.7 Recommended Time-out value handling

The Group 1 Minimum Time-out field, the Group 2 Minimum Time-out field and the Group 3 Time unit field in the *Time-out & Protect* Mode Page (1Dh) may not be changeable. Even if the field is changeable, a logical unit may round up the host specified value, because the logical unit may have its own minimum time to perform retry in a command. The host should check whether these fields are changeable or not by issuing MODE SENSE (10) command with Changeable Value of PC field prior to issue MODE SELECT (10) command. Also the host should check whether the selected value is accepted by issuing MODE SENSE (10) command with Current value after the MODE SELECT (10) command.

13.2 Reset model

Within this specification there are three resets defined. These resets are named:

- Power On Reset
- Hard Reset
- Device Reset

These resets are used differently in each physical interface used. For more information on the use in ATA/ATAPI and SCSI see the sections on implementation notes.

13.2.1 Power On Reset

When power is applied, the logical unit performs a series of electrical circuitry diagnostics, resets logical unit specific parameters (Mode Pages) to default values, and if media is 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.

13.2.2 Hard Reset

For each physical interface the detection of Hard Reset is different. The detection of Hard Reset for ATA/ATAPI and SCSI is defined in the implementation sections of this specification. The logical unit performs a series of electrical circuitry diagnostics, resets logical unit specific parameters (Mode Pages) to default values, and if media is 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 behavior 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.

13.2.3 Device Reset

For each physical interface, the detection of Device Reset is different. The detection of Device Reset for ATA/ATAPI and SCSI is defined in the implementation sections of this specification. The Device Reset is used to bring a hung logical unit into a 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 host interface circuitry.
- Perform hardware initialization and device-internal diagnostics only if necessary.
- Do not revert to default conditions, including ATAPI master/slave address, SCSI Device Number, logical unit Number or TOC information.
- If not in Sleep State, stay in the current Power State.
- Persistent Prevent state is unchanged.
- Key management ***shall*** be reset to the default state.

13.2.4 Mapping of reset functions

The Table 184 shows how the different reset functions specified in the various ATAPI and SCSI specifications are used in this specification.

Note: This table is not intended to show all possible resets or their mapping.

Table 184 - Example Reset Function Mapping in ATAPI and SCSI

Reset Type	ATAPI	SCSI
Power-On Reset	Same as Power-On Reset	Same as Power-On Reset
Hard Reset	Hard Reset	TARGET RESET task management function
	ATA SRST. This is a channel reset and as such is treated as a Hard Reset. However the SRST ***shall*** not reset any mode parameters to the default state.	SAM Reset events. This is SCSI protocol dependent
		SPI Reset Signal
Device Reset	Device Reset in ATA/ATAPI-4	ABORT TASK SET task management function
	ATAPI Soft Reset in SFF8020i (expired)	CLEAR TASK SET task management function

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14.0 Features

Features are sets of commands, Mode Pages, and behaviors or operations specified for a logical unit. Each Feature ***shall*** be implemented entirely to its standard description in order to claim compliance with the Feature. Except as explicitly identified, all commands, Mode Pages, and behaviors within a Feature are mandatory.

Features were designed primarily to support multi-function logical units that could only function as one logical unit at a time, e.g., DVD-RAM logical units act as either a DVD-RAM or DVD-ROM depending on the medium. Virtually all removable medium logical units are in effect multi-function logical units: they can use their medium when present, but cannot perform any media operations when no medium is present.

Mode Pages described and required by Features ***shall*** be present if the Feature is reported by the logical unit, regardless of whether or not the Feature is current. For example, the *CD Audio Control* Mode Page (0Eh) ***shall*** be available for reading and writing if the CD Audio analog play Feature is supported by the logical unit, even if no audio media is present. The current values and changeable masks ***shall not*** change, even across morphing. Default values may change when morphing occurs. Default values ***shall*** reflect a usable set of values for the loaded medium. Changes to the default values ***shall not*** generate a UNIT ATTENTION condition.

The use of Features allows generic host drivers to use logical units that have among their many Features some core functionality. For example, the Random Readable Feature may be reported by a very large variety of logical units: magnetic disk, CD, DVD, HD DVD or Magneto-Optical. A common driver to read data would be usable with all of these logical units; special code would be needed only to manage extensions unique to each technology.

Features implemented by a logical unit are reported to the host via the GET CONFIGURATION command. This command should be used to identify all possible Features, and those Features that are current. A Feature ***shall not*** be current if any of its mandatory commands or behaviors are not available. For example, a logical unit with writable media loaded and a mechanical write protect active ***shall not*** report any writable Features as available. A DVD read-only logical unit with a non-CSS/CPPM-protected DVD-ROM loaded ***shall not*** report the DVD CSS Feature as being available. A logical unit with no medium present ***shall*** have no read or write or other medium dependent Features active. Commands within a Feature that is not current may still operate normally, especially when those commands are described in more than one Feature.

The introduction of Features are not intended to change logical unit behavior. The use of commands that are not current will generate the same errors as legacy logical units. Features simply provide a method for avoiding errors and avoids using errors to convey state information. When Features are used properly by the host, the host should see only true medium errors and not need to do any informational discovery through error codes.

This specification also specifies techniques for the logical unit to notify the host of changes in the list of current Features. In addition, a technique for preventing changes until host approval is granted is defined. The GET EVENT/STATUS NOTIFICATION command is used for notification of changes or change requests; the PREVENT/ALLOW MEDIUM REMOVAL (Persistent) and SEND EVENT commands are used to notify the logical unit of a host control request and for the host to notify the logical unit of permission to change.

For a Feature to be considered current, all commands and behaviors described by that Feature should be available to the host. Even if a Feature is not current, its components should function if appropriate for the logical unit's state. Commands received by a logical unit that are a member of a supported Feature that is not current ***shall*** either perform normally or return an appropriate error (e.g., incompatible medium, medium not present). Logical units ***shall not*** terminate any command that is a member of any supported Feature with an INVALID COMMAND OPERATION CODE Error. For example, if the Formattable Feature is implemented, the READ FORMAT CAPACITIES command should return valid data regardless of whether or not the Formattable Feature is Current. An attempt to format a medium that cannot be formatted by the logical unit may return CHECK CONDITION status, 5/30/06 CANNOT FORMAT MEDIUM - INCOMPATIBLE MEDIUM.

Each Feature Descriptor may contain information specific to that Feature. The Feature specific information in the Feature Descriptor may not be valid if the Feature is not current.

Commands, Pages, and behavior not described by a Feature may exist in the logical unit.

See *16.4, "GET CONFIGURATION command"* on page 407 for more information on the individual Features.

14.1 Implementation of Features

14.1.1 What's a Feature?

This specification introduces Features. Features were designed to be atomic units of functionality. On the first level, Features are only a description in a document. Traditional drivers work without modification with logical units that implement Features. Features were a part of the documentation in SFF-8020i (expired), SFF-8090 rev.1.0 (expired), and MMC; however they were not comprehensive, typically documenting only optional behavior. This specification associates all normal functionality with Features. Detection of a whole group of functions (a "Feature") was typically accomplished by the host by issuing a command unique to that Feature and examining the completion status of that command.

The SFFC and T10 (MMC) groups have been consciously trying to avoid using errors as a method for status detection. Error handling code is typically one of the more complex parts of implementing drivers; reducing the number of cases that need to be handled helps implementations by reserving error status for only true errors. Status information is reported via explicit status reporting commands such as GET EVENT/STATUS NOTIFICATION and GET CONFIGURATION.

The descriptions of Features in this specification appear complex, and they are. However, these descriptions describe almost nothing new; they are simply the descriptions of existing legacy behavior. The only new parts are the descriptors themselves, which are either static identification blocks or groups of information that the logical unit ***shall*** already have to operate, even in a legacy behavior. For example, a logical unit ***shall*** internally identify whether or not a PLAY AUDIO (10) command may succeed; Features are simply a way to let the host in on the secret.

Previously, new logical units had to make a choice: to look completely like an old logical unit with added functionality, or as a new logical unit not compatible with old drivers. Feature and Profiles, a host can first determine if the "right" driver is available by examining the profiles. If "the" right driver isn't available, the host can identify operable subsets when multiple profiles are reported. Finally, the host can identify basic functions to use the logical unit via the Feature reporting.

14.1.2 History

The separation of status and error reporting is very important in multitasking environments. Typically, the operating system needs to constantly be aware of the status of the logical unit. Various applications, operating through a variety of OS interfaces, may also need to be aware of logical unit status. Reporting of status via errors breaks down in this environment; only one process is made aware of state changes via the error, while other processes cannot obtain the same state information because the error (status change) has already been reported to the host (according to the logical unit).

Features **do not** replace legacy behavior. Features, in most cases, define a subset of legacy behavior. Several Features, taken together, are generally equivalent to legacy logical units of the same type. Error and status reporting in legacy host environments is the same as legacy logical units, without any special mode setting.

The Features described in this specification add something new: reporting. Legacy logical units, while implementing the content of the Features, did not have any mechanism to report specifically the logical unit's capabilities. The closest mechanism that has existed is a command that reported implemented commands. Implemented Mode Pages are also reportable via standard mechanisms. However, a command is more than an operation code (opcode). A whole set of commands, Mode Pages, and behavior needs to be grouped together to be useful. For example, write once MO, hard disk drives, and CD-R all use the WRITE (10) command, but it is impossible to use the same strategies for writing these three media. Typically, different drivers or fragments or drivers are used for each kind of media. The previous mechanism would only identify that the WRITE (10) command was implemented, but could not identify how to use it.

The capabilities of a particular logical unit may change at arbitrary times. The most common example of this is seen in a removable medium logical unit. Even a basic removable magnetic medium logical unit changes: from a random read/write logical unit to a virtually functionless logical unit when the medium is removed. Multi-function logical units can change their behavior even more radically when they accept a variety of physical and logical formats.

Before Features, hosts had to use a trial and error method for determining what would or would not function. Medium codes became outdated even before publication of the relevant standard, and still were not adequate to describe all media.

The Profiles, also introduced in this specification, provide an equivalent to the medium type. However, the profile does not indicate exact capabilities for the drive/medium system, only a generic identification of core capabilities.

Feature reporting is not completely new. Operating systems first identify a driver via the device type. The device type implied a core set of functions (e.g., a CD-ROM logical unit would support READ (10), READ TOC/PMA/ATIP). However, even these commands would not work if no medium were loaded. A driver would determine media status by trying a few commands and examining the error codes. After determining that media was present, a driver would have to probe to find out about additional Features such as audio or medium changers. Features were “reportable,” but each Feature had a different mechanism, and many of the mechanisms relied on the success or failure of special “key” commands.

14.1.3 Implementation of Features

There are only two requirements to fully implement Features. The first is the GET CONFIGURATION command. This command is a very basic reporting command that reports some very static information; only a few Features have any dynamic fields; most Features have only one bit that changes. The command is a form of Inquiry: a technique for the host to identify the logical unit on the bus. The GET CONFIGURATION command simply provides more detail, and the information reported is expected to be dynamic.

Implementation of Feature reporting via the GET CONFIGURATION command is simple: the image of the result data can be copied from logical unit ROM to its buffer, a few fields set with information already known to the logical unit (such as the block size), and a few bits set according to already existing flags in the firmware (e.g., DVD vs. CD, audio tracks present). Logical units with non-removable media may have a completely static image that is reported. If a starting point other than the beginning is requested, the logical unit walks the table to find the first requested Feature, subtracts the offset from the data length, and transfers data starting at the same offset.

The second part of Features is reporting when the Features change. As it is important for the host to know what operations will function with the logical unit at any given moment, pre-emptive reporting of Feature changes greatly eases host implementations by reducing the number of error conditions that ***shall*** be handled. The GET EVENT/STATUS NOTIFICATION command is used for status change reporting (an “Event.”) In many drives, implementation simply requires recording an event whenever a UNIT ATTENTION is generated.

As mentioned earlier, Features are not new; their reporting is. This reporting has become very important in modern environments. Multiple drivers are talking to the same logical unit, doing different tasks. For example, a DVD read-only logical unit may use the basic CD-ROM driver when a CD is installed, and another driver when a DVD is installed, and both a basic DVD driver and a separate copy protection process when copy protected media is mounted. All of these processes ***shall*** interact well to provide seamless and solid support. Feature reporting provides a method for clean interaction.

14.1.4 Compatibility

Logical units implementing Feature reporting are fully compatible with legacy systems.

The GET CONFIGURATION command changes no behavior of the logical unit; it simply reports existing state information. Repeated GET CONFIGURATION commands will report the same information (unless the user inserts or removes the medium, etc.). The GET CONFIGURATION command never changes any state information in the logical unit, including UNIT ATTENTION conditions.

14.1.5 Summary

Features do not radically modify any legacy behavior or functionality. The only new parts involve reporting of behavior, and typically reflect state information already required of any firmware implementation, via two new commands. One command reports status, and the other notifies the host that the status may have changed.

The benefits include easier coding of highly robust drivers, fewer error conditions, and forward and backward compatibility with operating system drivers.

14.2 Morphing commands and functionality

The GET CONFIGURATION command is used to discover a logical unit's behavior. The result data of the GET CONFIGURATION command may be dynamic. A Morph occurs whenever the data that would be returned to a GET CONFIGURATION command changes. Figure 164 shows a state diagram for logical units that lock the tray when the NewMedia Event is generated. Figure 165 shows a state diagram for logical units that lock the tray when the NewMedia Event is reported.

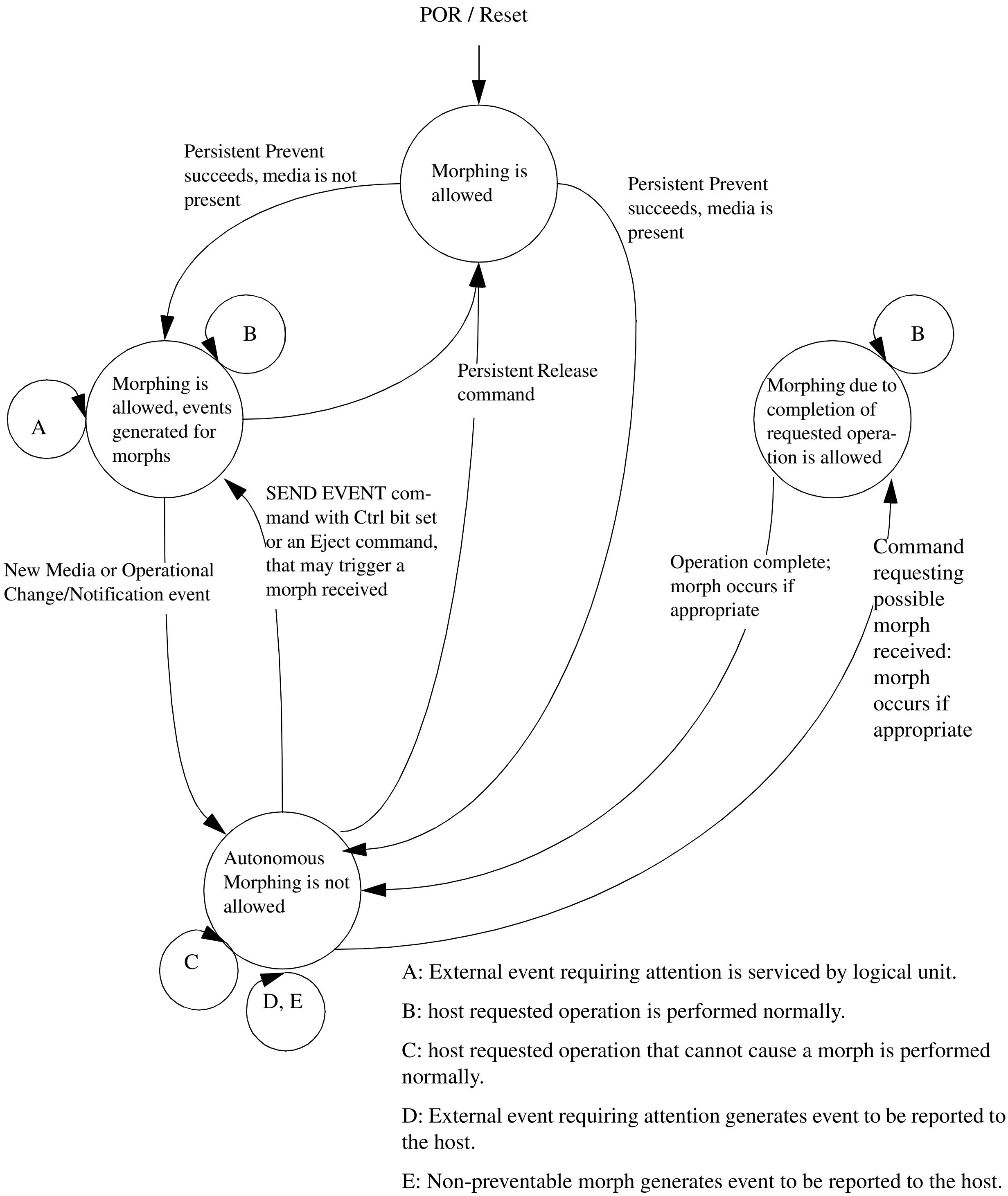


Figure 164 - Morphing States - Event Generation

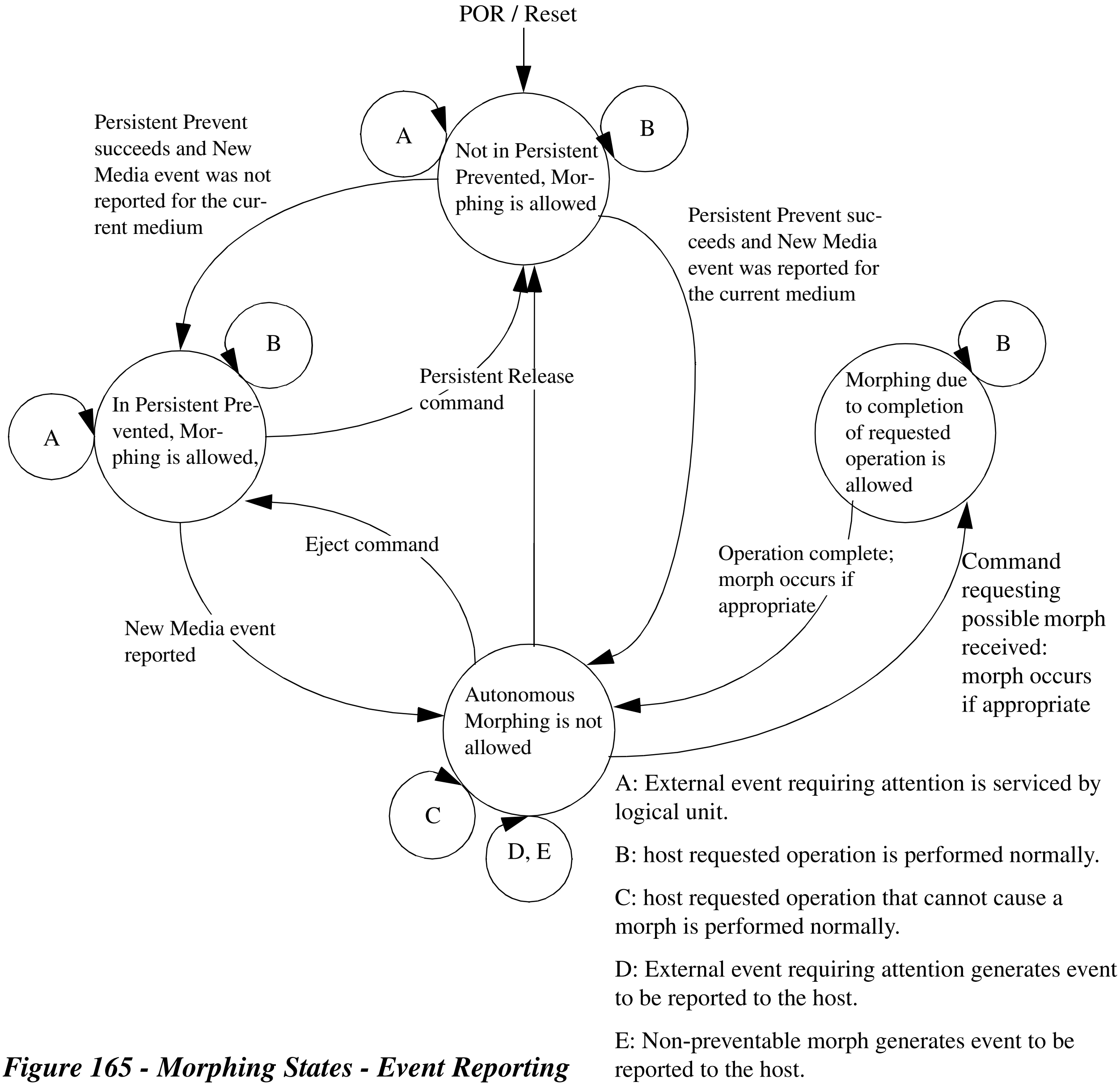


Figure 165 - Morphing States - Event Reporting

14.2.1 Morphing operation

The host may issue a PREVENT/ALLOW MEDIUM REMOVAL command with the Persistent, Prevent bit set to indicate to the logical unit that it ***shall not*** change its behavior without host notification for any preventable action. This will, for example, prevent any front panel buttons from causing an eject, play, or other operation that affects logical unit operation.

When the Persistent Prevent state is entered, the media ***shall*** remain locked in the logical unit and the logical unit ***shall not*** change its behavior, until the host 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 generates or reports the NewMedia event. Prior to generating or reporting the NewMedia event, the logical unit may eject media without an explicit eject command from the host. This allows the user to remove incorrectly inserted media without having to wait for host intervention. In this condition neither the NewMedia event nor the EjectRequest event should be reported by the logical unit. Locking the tray after generating the event allows for a simpler implementation; locking the tray after reporting the event allows a longer window of direct user 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 NewMedia event for this media. If a logical unit allows an eject between generating and reporting the NewMedia event, the logical unit ***shall*** remove the NewMedia event(s) from the Event queue. When the host receives the Eject Request, and determines that it is safe to eject the medium, a START/STOP UNIT command with the LoEj bit set will be issued, at which time the logical unit ***shall*** eject the medium. The Persistent Prevent state ***shall*** be retained.

In the Polling Mode of Event Notification, the host ***shall*** repeatedly issue GET EVENT/STATUS NOTIFICATION commands with an Immediate bit of 1. The interval should be sufficiently short to provide quick user feedback but long enough to avoid performance impacts within the system. The logical unit ***shall*** complete these commands upon receipt, supplying the host with information on the most recent event occurrences, as described in the GET EVENT/STATUS NOTIFICATION command.

If command queuing is supported, the host may issue a GET EVENT/STATUS NOTIFICATION command with an immediate (Immed) bit of 0. This is the Asynchronous mode of operation. The command ***shall not*** complete until an event occurrence of the class(es) requested is either in the event queue or occurs.

The logical unit ***shall*** maintain a separate queue for each class of Event Notification(s) supported. There ***shall*** be one set of queues per host. Events that are generated ***shall*** be placed at the tail of the event queue(s). The depth of the queue(s) is vendor specific, although it ***shall*** be at least one. If an overflow occurs, the logical unit ***shall*** maintain the most recent Events in the queue. All event classes other than Class 3 were designed such that a queue depth of 1 is sufficient.

Each GET EVENT/STATUS NOTIFICATION command ***shall*** report only one event. If multiple Event Classes are requested and multiple events are available, the logical unit ***shall*** report the Event in the Event Class with the lowest Notification Class ordinal.

14.2.2 Morphing compatibility considerations

To maintain compatibility with existing BIOS implementations and operating systems, the logical unit ***shall*** default to Persistent Prevent disabled. When the host enables the support using the PREVENT/ALLOW MEDIUM REMOVAL command, the logical unit ***shall*** respond as described in this specification. When the host disables this Feature, the logical unit ***shall*** default to normal operating modes. A power on or hard reset ***shall*** cause the logical unit to clear the 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 NewMedia event.

Commands ***shall*** be processed exactly the same as they would be if Persistent Prevent was not enabled. For compatibility reasons, UNIT ATTENTION conditions ***shall*** still be returned. However, the logical unit ***shall not*** return the UNIT ATTENTION condition 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 status with UNIT ATTENTION ***shall*** be reported, but the logical unit ***shall*** also report the NewMedia Event with the next available GET EVENT/STATUS NOTIFICATION (Media Status) command. If the GET EVENT/STATUS NOTIFICATION command is received after a UNIT ATTENTION condition is generated, and before it is reported to the host, the GET EVENT/STATUS NOTIFICATION command ***shall*** report the Event.

14.3 Vendor Unique

All Vendor Unique Features ***shall*** be a multiple of 4 bytes in length. Use of Reserved fields in the Feature Descriptor Header is prohibited. Vendors are encouraged to take steps to choose a Feature number unique among all products.

The logical unit's Vendor ID and Product ID ***shall*** be used to qualify which set of Vendor Unique Features may be available.

14.4 Delayed Feature reporting

The Current bit status of the Features listed below may not be reported at medium insertion and may be reported later.

- Incremental Streaming Writable Feature (0021h)
- Restricted Overwrite Feature (0026h)
- CD Track at Once Feature (002Dh)

At the medium insertion, the logical unit ***shall*** check the Write Method of the Track field in the Track Descriptor Blocks of the first and last Tracks in the last Session. For possible Features of other Tracks are not reported unless READ TRACK/RZONE INFORMATION command, READ (10)/READ (12) command or WRITE (10)/WRITE (12) command is issued to the Track.

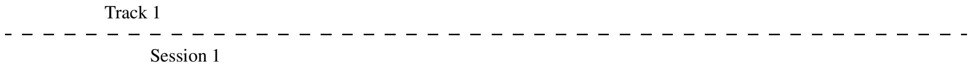
An ordinary writing software uses the last Invisible/Incomplete Track on the disc to record data. Fixed packet writing software uses only one Track and one Session on the CD-RW disc. Variable packet writing software uses Empty Reserved Track at the first Track in the last Session. Therefore, checking of the first Track and the last Track in the last Session is enough to detect available recording Features (Incremental Streaming Writable Feature, Restricted Overwrite Feature or CD Track at Once Feature) on the CD-R/RW disc correctly.

When a new Feature becomes current, if the logical unit supports Class 1 Event, the Class 1 Event ***shall*** be reported after the command is completed.

In the case of the other Features related to CD media, the delayed Feature reporting is not occurred. For example,

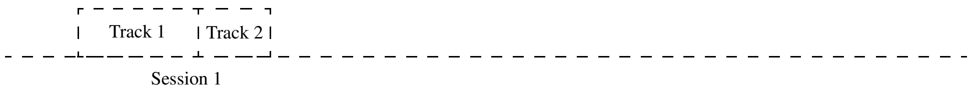
- CD Read Feature is determined by TOC information.
- CD Mastering Feature is determined by the last Session status.
- Audio Track is not allowed to reserve. So CD Audio analog play Feature is determined by reading of PMA.
- Random Readable Feature is determined by the checking of the disc status.

Case-(a) Insertion of Blank medium



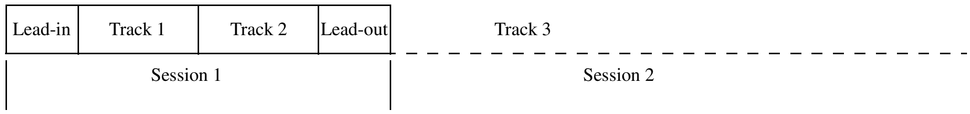
Track 1: Invisible track, Session 1: Empty session

Case-(b) Track 2 is written



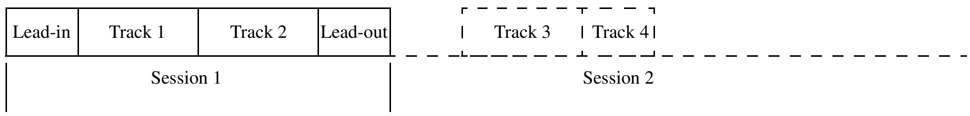
Track 1: TAO Empty Reserved track, Track 2: Variable packet written Incomplete track

Case-(c) Session 1 is closed



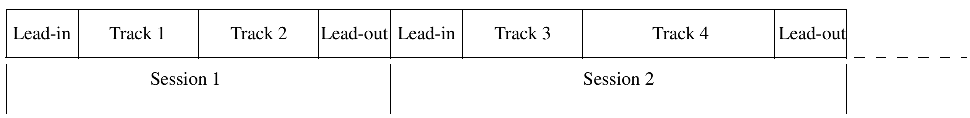
Track 1, 2: Complete track, Track 3: Invisible track, Session 1: Complete session, Session 2: Empty session

Case-(d) Track 4 is written



Track 3: TAO Empty Reserved track, Track 4: Variable packet written Incomplete track, Session 2: Incomplete session

Case-(e) Disc final close



Track 3, 4: Complete track, Session 2: Complete session, No more sessions are allowed

Feature	Current bit status of the Feature for each Case					**comment**
	a	**b**	**c**	**d**	**e**	
Random Readable	0	1	1	1	1	If sector is written and readable, Current bit is set to 1.
CD Read	0	0	1	1	1	If disc is compatible with ROM media, Current bit is set to 1.
Incremental Streaming Writable	1	1	1	1	0	If Packet writing is available, Current bit is set to 1.
CD Track at Once	1	1	1	1	0	If TAO writing is available, Current bit is set to 1.
CD Mastering	1	0	1	0	0	If SAO writing is available, Current bit is set to 1.

	Case				
	a	**b**	**c**	**d**	**e**
First Track number of the last session	1	1	3	3	3
Last Track number of the last session	1	2	3	4	4

Figure 166 - Example of CD-R/RW Feature reporting

15.0 Profiles

Profiles define a base set of functions for logical units. Logical units that list a Profile as current ***shall*** support all Features required by that Profile, but not all Features may be current. Logical units may support Features in addition to those required by the Profile. A single logical unit may implement more than one Profile, and more than one Profile may be active at any given time. All required Features may not be current, depending on the medium installed. If a NOT READY response would be given to a TEST UNIT READY command, no Profile should be current.

For example, a logical unit with unformatted media may not be able to read or write, and the corresponding Features would not be current, but the Profile corresponding to the logical unit/media system may be current. i.e. a DVD-RAM drive with unformatted media loaded may claim compliance to the DVD-RAM Profile; A DVD-RAM drive with no media loaded ***shall*** claim no Profile as current.

15.1 Profile 0001h: Non-removable disk

Logical units identifying Profile 1 as current ***shall*** support the Features listed in Table 185:

Table 185 - Mandatory Features for Non-removable disks

Feature Number	Feature Name	Description
0000h	Profile List	A list of all Profiles supported by the logical unit
0001h	Core	Mandatory behavior for all logical units
0010h	Random Readable	Read ability for storage logical units with random addressing
0020h	Random Writable	Write support for randomly addressed writes
0024h	Hardware Defect Management	Ability of the drive/media system to provide an apparently defect-free space
0100h	Power Management	host and logical unit directed power management
0101h	S.M.A.R.T.	Self Monitoring Analysis and Reporting Technology (Failure prediction)

15.2 Profile 0002h: Removable disk

Logical units identifying Profile 2 as current ***shall*** support the Features listed in Table 186:

Table 186 - Mandatory Features for Removable Disks

Feature Number	Feature Name	Description
0000h	Profile List	A list of all Profiles supported by the logical unit
0001h	Core	Mandatory behavior for all logical units
0002h	Morphing	Ability to notify host about operational changes and accept host requests to prevent operational changes.
0003h	Removable Medium	The medium may be removed from the logical unit
0010h	Random Readable, PP = 1	Read ability for storage logical units with random addressing.
0020h	Random Writable	Write support for randomly addressed writes
0023h	Formattable	Support for formatting of media
0024h	Hardware Defect Management	Ability of the drive/media system to provide an apparently defect-free space
0100h	Power Management	host and logical unit directed power management
0105h	Time-out	Ability to respond to all commands within a specific time

15.3 *Profile 0003h: MO Erasable*

Logical units identifying Profile 3 as current ***shall*** support the Features listed in Table 187:

Table 187 - Mandatory Features for Magneto-Optical Erasable

Feature Number	Feature Name	Description
0000h	Profile List	A list of all Profiles supported by the logical unit
0001h	Core	Mandatory behavior for all logical units
0002h	Morphing	Ability to notify host about operational changes and accept host requests to prevent operational changes.
0003h	Removable Medium	The medium may be removed from the logical unit
0010h	Random Readable, PP = 1	Read ability for storage logical units with random addressing.
0020h	Random Writable	Write support for randomly addressed writes
0022h	Sector Erasable	Write support for erasable media and media that requires an erase pass before over-write.
0023h	Formattable	Support for formatting of media
0024h	Hardware Defect Management	Ability of the drive/media system to provide an apparently defect-free space
0100h	Power Management	host and logical unit directed power management
0105h	Time-out	Ability to respond to all commands within a specific time

15.4 *Profile 0004h: MO Write Once*

Logical units identifying Profile 4 as current ***shall*** support the Features listed in Table 188:

Table 188 - Mandatory Features for Magneto-Optical Write Once

Feature Number	Feature Name	Description
0000h	Profile List	A list of all Profiles supported by the logical unit
0001h	Core	Mandatory behavior for all logical units
0002h	Morphing	Ability to notify host about operational changes and accept host requests to prevent operational changes.
0003h	Removable Medium	The medium may be removed from the logical unit
0010h	Random Readable, PP = 1	Read ability for storage logical units with random addressing.
0024h	Hardware Defect Management	Ability of the drive/media system to provide an apparently defect-free space
0025h	Write Once	Write support for write once media that can be written in random order
0100h	Power Management	host and logical unit directed power management
0105h	Time-out	Ability to respond to all commands within a specific time

15.5 Profile 0005h: AS-MO

Logical units identifying Profile 5 as current ***shall*** support the Features listed in Table 189:

Table 189 - Mandatory Features for AS-MO

Feature Number	Feature Name	Description
0000h	Profile List	A list of all Profiles supported by the logical unit
0001h	Core	Mandatory behavior for all logical units
0002h	Morphing	Ability to notify host about operational changes and accept host requests to prevent operational changes.
0003h	Removable Medium	The medium may be removed from the logical unit
0010h	Random Readable, PP = 1	Read ability for storage logical units with random addressing.
0020h	Random Writable	Write support for randomly addressed writes
0023h	Formattable	Support for formatting of media
0024h	Hardware Defect Management	Ability of the drive/media system to provide an apparently defect-free space
0100h	Power Management	host and logical unit directed power management
0105h	Time-out	Ability to respond to all commands within a specific time
0107h	Real-Time Streaming	Ability to read and write using host requested performance parameters

15.6 Profile 0008h: CD-ROM

Logical units identifying Profile 8 as current ***shall*** support the Features listed in Table 190:

Table 190 - Mandatory features for CD-ROM

Feature Number	Feature Name	Description
0000h	Profile List	A list of all Profiles supported by the logical unit
0001h	Core	Mandatory behavior for all logical units
0002h	Morphing	Ability to notify host about operational changes and accept host requests to prevent operational changes.
0003h	Removable Medium	The medium may be removed from the logical unit
0010h	Random Readable, PP = 1	Read ability for storage logical units with random addressing.
001Eh	CD Read	The ability to read CD-specific structures
0100h	Power Management	host and logical unit directed power management
0105h	Time-out	Ability to respond to all commands within a specific time

15.7 Profile 0009h: CD-R

Logical units identifying Profile 9 as current ***shall*** support the Features listed in Table 191:

Table 191 - Mandatory features for CD-R

Feature Number	Feature Name	Description
0000h	Profile List	A list of all Profiles supported by the logical unit
0001h	Core	Mandatory behavior for all logical units
0002h	Morphing	Ability to notify host about operational changes and accept host requests to prevent operational changes.
0003h	Removable Medium	The medium may be removed from the logical unit
0010h	Random Readable, PP = 1	Read ability for storage logical units with random addressing
001Eh	CD Read	The ability to read CD-specific structures
0021h	Incremental Streaming Writable	Write support for sequential recording
002Dh	CD Track at Once	Ability to write CD with Track at Once recording
0100h	Power Management	host and logical unit directed power management
0105h	Time-out	Ability to respond to all commands within a specific time
0107h	Real-Time Streaming	Ability to read and write using host requested performance parameters

15.8 Profile 000Ah: CD-RW

Logical units identifying Profile Ah as current ***shall*** support the Features listed in Table 192:

Table 192 - Mandatory features for CD-RW

Feature Number	Feature Name	Description
0000h	Profile List	A list of all Profiles supported by the logical unit
0001h	Core	Mandatory behavior for all logical units
0002h	Morphing	The logical unit changes its operational behavior due to events external to the host
0003h	Removable Medium	The medium may be removed from the logical unit
0010h	Random Readable, PP = 1	Read ability for storage logical units with random addressing
001Dh	MultiRead	The logical unit complies with OSTA MultiRead
001Eh	CD Read	The ability to read CD-specific structures
0021h	Incremental Streaming Writable	Write support for sequential recording
0023h	Formattable	Support for formatting of media
0026h	Restricted Overwrite	Write support for media that ***shall*** be written in multiples of logical blocks
002Dh	CD Track at Once	Ability to write CD with Track at Once recording
0100h	Power Management	host and logical unit directed power management
0105h	Time-out	Ability to respond to all commands within a specific time
0107h	Real-Time Streaming	Ability to read and write using host requested performance parameters

15.9 Profile 0010h: DVD-ROM

Logical units identifying Profile 10h as current ***shall*** support the Features listed in Table 193.

Table 193 - Mandatory Features for DVD-ROM

Feature Number	Feature Name	Description
0000h	Profile List	A list of all Profiles supported by the logical unit
0001h	Core	Mandatory behavior for all logical units
0002h	Morphing	The logical unit changes its operational behavior due to events external to the host
0003h	Removable Medium	The medium may be removed from the logical unit
0010h	Random Readable, PP = 1	Read ability for storage logical units with random addressing
001Fh	DVD Read	The ability to read DVD specific structures
0100h	Power Management	host and logical unit directed power management
0105h	Time-out	Ability to respond to all commands within a specific time
0107h	Real-Time Streaming	Ability to read using host requested performance parameters

15.10 Profile 0011h: DVD-R Sequential recording

Logical units identifying Profile 11h as current ***shall*** support the Features listed in Table 194:

Table 194 - Mandatory Features for DVD-R Sequential recording

Feature Number	Feature Name	Description
0000h	Profile List	A list of all Profiles supported by the logical unit
0001h	Core	Mandatory behavior for all logical units
0002h	Morphing	The logical unit changes its operational behavior due to events external to the host
0003h	Removable Medium	The medium may be removed from the logical unit
0010h	Random Readable, PP = 1	Read ability for storage logical units with random addressing
001Fh	DVD Read	The ability to read DVD specific structures
0021h	Incremental Streaming Writable	Write support for sequential recording
002Fh	DVD-R/-RW Write	The ability to write DVD specific structures
0100h	Power Management	host and logical unit directed power management
0105h	Time-out	Ability to respond to all commands within a specific time
0107h	Real-Time Streaming	Ability to read and write using host requested performance parameters
0108h	Logical unit serial number	The logical unit has a unique identifier

15.11 Profile 0012h: DVD-RAM

Logical units identifying Profile 12h as current ***shall*** support the Features listed in Table 195:

Table 195 - Mandatory Features for DVD-RAM and DVD+RW

Feature Number	Feature Name	Description
0000h	Profile List	A list of all Profiles supported by the logical unit
0001h	Core	Mandatory behavior for all logical units
0002h	Morphing	The logical unit changes its operational behavior due to events external to the host
0003h	Removable Medium	The medium may be removed from the logical unit
0010h	Random Readable, PP = 1	Read ability for storage logical units with random addressing
001Fh	DVD Read	The ability to read DVD specific structures
0020h	Random Writable	Write support for randomly addressed writes
0023h	Formattable	Support for formatting of media
0024h	Hardware Defect Management	Ability of the drive/media system to provide an apparently defect-free space
0100h	Power Management	host and logical unit directed power management
0105h	Time-out	Ability to respond to all commands within a specific time
0107h	Real-Time Streaming	Ability to read and write using host requested performance parameters

15.12 Profile 0013h: DVD-RW Restricted Overwrite

Logical units identifying Profile 13h as current ***shall*** support the Features listed in Table 196:

Table 196 - Mandatory Features for DVD-RW Restricted Overwrite

Feature Number	Feature Name	Description
0000h	Profile List	A list of all Profiles supported by the logical unit
0001h	Core	Mandatory behavior for all logical units
0002h	Morphing	The logical unit changes its operational behavior due to events external to the host
0003h	Removable Medium	The medium may be removed from the logical unit
0010h	Random Readable, PP = 1	Read ability for storage logical units with random addressing
001Fh	DVD Read	The ability to read DVD specific structures
0023h	Formattable	Support for formatting of media
002Ch	Rigid Restricted Overwrite	Write support for media that ***shall*** be written from Blocking boundaries with length of integral multiple of Blocking size only
0100h	Power Management	host and logical unit directed power management
0105h	Time-out	Ability to respond to all commands within a specific time
0107h	Real-Time Streaming	Ability to read and write using host requested performance parameters
0108h	Logical unit serial number	The logical unit has a unique identifier.

15.13 Profile 0014h: DVD-RW Sequential recording

Logical units identifying Profile 14h as current ***shall*** support the Features listed in Table 197:

Table 197 - Mandatory Features for DVD-RW Sequential recording

Feature Number	Feature Name	Description
0000h	Profile List	A list of all Profiles supported by the logical unit
0001h	Core	Mandatory behavior for all logical units
0002h	Morphing	The logical unit changes its operational behavior due to events external to the host
0003h	Removable Medium	The medium may be removed from the logical unit
0010h	Random Readable, PP = 1	Read ability for storage logical units with random addressing
001Fh	DVD Read	The ability to read DVD specific structures
0021h	Incremental Streaming Writable	Write support for sequential recording
002Fh	DVD-R/-RW Write	The ability to write DVD specific structures
0100h	Power Management	host and logical unit directed power management
0105h	Time-out	Ability to respond to all commands within a specific time
0107h	Real-Time Streaming	Ability to read and write using host requested performance parameters
0108h	Logical unit serial number	The logical unit has a unique identifier

15.14 Profile 0015h: DVD-R Dual Layer Sequential recording

Logical units identifying Profile 15h as current ***shall*** support the Features listed in Table 198:

Table 198 - Mandatory Features for DVD-R Dual Layer Sequential recording

Feature Number	Feature Name	Description
0000h	Profile List	A list of all Profiles supported by the logical unit
0001h	Core	Mandatory behavior for all logical units
0002h	Morphing	The logical unit changes its operational behavior due to events external to the host
0003h	Removable Medium	The medium may be removed from the logical unit
0010h	Random Readable, PP = 1	Read ability for storage logical units with random addressing
001Fh	DVD Read	The ability to read DVD specific structures
0021h	Incremental Streaming Writable	Write support for sequential recording
002Fh	DVD-R/-RW Write	The ability to write DVD specific structures
0100h	Power Management	host and logical unit directed power management
0105h	Time-out	Ability to respond to all commands within a specific time
0107h	Real-Time Streaming	Ability to read and write using host requested performance parameters
0108h	Logical unit serial number	The logical unit has a unique identifier

15.15 Profile 0016h: DVD-R Dual Layer Jump recording

Logical units identifying Profile 16h as current ***shall*** support the Features listed in Table 199:

Table 199 - Mandatory Features for DVD-R Layer Jump recording

Feature Number	Feature Name	Description
0000h	Profile List	A list of all Profiles supported by the logical unit
0001h	Core	Mandatory behavior for all logical units
0002h	Morphing	The logical unit changes its operational behavior due to events external to the host
0003h	Removable Medium	The medium may be removed from the logical unit
0010h	Random Readable, PP = 1	Read ability for storage logical units with random addressing
001Fh	DVD Read	The ability to read DVD specific structures
0033h	Layer Jump recording	Write support for Layer Jump recording
0100h	Power Management	host and logical unit directed power management
0105h	Time-out	Ability to respond to all commands within a specific time
0107h	Real-Time Streaming	Ability to read and write using host requested performance parameters
0108h	Logical unit serial number	The logical unit has a unique identifier

15.16 Profile 0050h: HD DVD-ROM

Logical units identifying Profile 50h as current ***shall*** support the Features listed in Table 200:

Table 200 - Mandatory Features for HD DVD-ROM

Feature Number	Feature Name	Description
0000h	Profile List	A list of all Profiles supported by the logical unit
0001h	Core	Mandatory behavior for all logical units
0002h	Morphing	The logical unit changes its operational behavior due to events external to the host
0003h	Removable Medium	The medium may be removed from the logical unit
0010h	Random Readable, PP = 1	Read ability for storage logical units with random addressing
0050h	HD DVD Read	The ability to read HD DVD specific structures
0100h	Power Management	host and logical unit directed power management
0105h	Time-out	Ability to respond to all commands within a specific time
0107h	Real-Time Streaming	Ability to read and write using host requested performance parameters

15.17 Profile 0051h: HD DVD-R

Logical units identifying Profile 51h as current ***shall*** support the Features listed in Table 201:

Table 201 - Mandatory Features for HD DVD-R

Feature Number	Feature Name	Description
0000h	Profile List	A list of all Profiles supported by the logical unit
0001h	Core	Mandatory behavior for all logical units
0002h	Morphing	The logical unit changes its operational behavior due to events external to the host
0003h	Removable Medium	The medium may be removed from the logical unit
0010h	Random Readable, PP = 1	Read ability for storage logical units with random addressing
0021h	Incremental Streaming Writable	Write support for sequential recording
0050h	HD DVD Read	The ability to read HD DVD specific structures
0051h	HD DVD Write	The ability to write HD DVD specific structures
0100h	Power Management	host and logical unit directed power management
0105h	Time-out	Ability to respond to all commands within a specific time
0107h	Real-Time Streaming	Ability to read and write using host requested performance parameters
0108h	Logical unit serial number	The logical unit has a unique identifier

15.18 Profile 0052h: HD DVD-Rewritable

Logical units identifying Profile 52h as current ***shall*** support the Features listed in Table 202:

Table 202 - Mandatory Features for HD DVD-Rewritable

Feature Number	Feature Name	Description
0000h	Profile List	A list of all Profiles supported by the logical unit
0001h	Core	Mandatory behavior for all logical units
0002h	Morphing	The logical unit changes its operational behavior due to events external to the host
0003h	Removable Medium	The medium may be removed from the logical unit
0010h	Random Readable, PP = 1	Read ability for storage logical units with random addressing
0020h	Random Writable	Write support for randomly addressed writes
0023h	Formattable	Support for formatting of media
0024h	Hardware Defect Management	Ability of the drive/media system to provide an apparently defect-free space
0050h	HD DVD Read	The ability to read HD DVD specific structures
0051h	HD DVD Write	The ability to write HD DVD specific structures
0100h	Power Management	host and logical unit directed power management
0105h	Time-out	Ability to respond to all commands within a specific time
0107h	Real-Time Streaming	Ability to read and write using host requested performance parameters

15.19 Profile FFFFh: Logical units Not Conforming to a Standard Profile

Logical units identifying Profile FFFFh as current ***shall*** support the Features listed in Table 203:

Table 203 - Mandatory Features for logical units Not Conforming to a Standard Profile

Feature Number	Feature Name	Description
0000h	Profile List	A list of all Profiles supported by the logical unit
0001h	Core	Mandatory behavior for all logical units

16.0 Packet commands

The first byte of all Command Packets ***shall*** contain an operation code as defined in this Specification. This specification is broken down into separate sections. This section describes all commands that are specified in this specification.

Table 204 - Packet commands for C/DVD/HD DVD logical units

Opcode	Command Description	Reference
A1h	BLANK	section 16.1 on page 391
5Bh	CLOSE TRACK/RZONE/SESSION/BORDER	section 16.2 on page 395
39h	COMPARE	SPC-2
2Ch	ERASE (10)	SBC
04h	FORMAT UNIT	section 16.3 on page 399
46h	GET CONFIGURATION	section 16.4 on page 407
4Ah	GET EVENT/STATUS NOTIFICATION	section 16.5 on page 453
ACh	GET PERFORMANCE	section 16.6 on page 465
12h	INQUIRY	section 16.7 on page 477
A6h	LOAD/UNLOAD MEDIUM	section 16.8 on page 483
36h	LOCK/UNLOCK CACHE	SBC
4Ch	LOG SELECT	SPC-2
4Dh	LOG SENSE	SPC-2
BDh	MECHANISM STATUS	section 16.9 on page 485
55h	MODE SELECT (10)	section 16.10 on page 489
5Ah	MODE SENSE (10)	section 16.11 on page 491
4Bh	PAUSE/RESUME	section 16.12 on page 519
45h	PLAY AUDIO (10)	section 16.13 on page 521
47h	PLAY AUDIO MSF	section 16.14 on page 525
BCh	PLAY CD	Obsolete
34h	PRE-FETCH	SBC
1Eh	PREVENT/ALLOW MEDIUM REMOVAL	section 16.15 on page 527
28h	READ (10)	section 16.16 on page 529
A8h	READ (12)	section 16.17 on page 531
3Ch	READ BUFFER	section 16.18 on page 533
5Ch	READ BUFFER CAPACITY	section 16.19 on page 537
25h	READ CAPACITY	section 16.20 on page 539
BEh	READ CD	section 16.21 on page 541
B9h	READ CD MSF	section 16.22 on page 551
51h	READ DISC INFORMATION	section 16.23 on page 553
ADh	READ DISC STRUCTURE	section 16.24 on page 559
23h	READ FORMAT CAPACITIES	section 16.25 on page 589
44h	READ HEADER	Obsolete
42h	READ SUBCHANNEL	section 16.26 on page 595
43h	READ TOC/PMA/ATIP	section 16.27 on page 603
52h	READ TRACK/RZONE INFORMATION	section 16.28 on page 617
1C	RECEIVE DIAGNOSTIC RESULTS	SPC-2
17h	RELEASE (6)	SPC-2
57h	RELEASE (10)	SPC-2
58h	REPAIR RZONE	section 16.29 on page 631
A4h	REPORT KEY	section 16.30 on page 633

Table 204 - Packet commands for C/DVD/HD DVD logical units (Continued)

Opcode	Command Description	Reference
03h	REQUEST SENSE	section 16.31 on page 645
16h	RESERVE (6)	SPC-2
56h	RESERVE (10)	SPC-2
53h	RESERVE TRACK/RZONE/RMZ	section 16.32 on page 651
BAh	SCAN	section 16.33 on page 657
2Bh	SEEK	section 16.34 on page 661
5Dh	SEND CUE SHEET	section 16.35 on page 663
1Dh	SEND DIAGNOSTIC	SPC-2
BFh	SEND DISC STRUCTURE	section 16.36 on page 671
A2h	SEND EVENT	section 16.37 on page 679
A3h	SEND KEY	section 16.38 on page 681
54h	SEND OPC INFORMATION	section 16.39 on page 687
BBh	SET CD SPEED	section 16.40 on page 689
A7h	SET READ AHEAD	section 16.41 on page 691
B6h	SET STREAMING	section 16.42 on page 693
1Bh	START/STOP UNIT	section 16.43 on page 697
4Eh	STOP PLAY/SCAN	section 16.44 on page 701
35h	SYNCHRONIZE CACHE	section 16.45 on page 703
00h	TEST UNIT READY	section 16.46 on page 705
2Fh	VERIFY (10)	section 16.47 on page 707
2Ah	WRITE (10)	section 16.48 on page 709
AAh	WRITE (12)	section 16.49 on page 713
2Eh	WRITE AND VERIFY (10)	section 16.50 on page 715
3Bh	WRITE BUFFER	SPC-2

16.1 BLANK command

C/DVD-RW discs have two properties not available with C/DVD-R: direct-overwrite and the ability to erase. The BLANK command provides the ability to erase any part of a C/DVD-RW disc.

The SET STREAMING command may affect the speed at which the blanking operation is performed.

Table 205 - BLANK Command Descriptor Block

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation Code (A1h)							
1	LUN (Obsolete)			Immed	Reserved	Blanking Type		
2	(MSB) Start Address or Track/RZone Number							
3								
4								
5								(LSB)
6	Reserved							
7	Reserved							
8	Reserved							
9	Reserved							
10	Reserved							
11	Vendor-Specific		Reserved			NACA	Flag	Link

Note: The erasing action performed in this command is a Logical Erase, in that the data is overwritten with Mode 0 data on CD media.

The Immediate (Immed) bit, when set to zero, ***shall*** indicate that the command ***shall*** complete after the blank operation has been performed. When set to one, ***shall*** indicate that the command ***shall*** complete after validating the CDB.

Note: ATAPI logical units may require that the Immed bit be set to one.

Blanking Type identifies the method and coverage of blanking. The codes for Blanking Type are defined in Table 206 and Table 207.

Table 206 - Blanking Types for CD-RW

Code	Type	Name	Description
000b	Mandatory	Blank the disc	The entire disc is to be erased. The Start Address parameter is ignored. This is used for clearing a complete disc. The PCA may be excluded. At completion of the operation, the area from the start time of Lead-in through the last possible start time of Lead-out plus 6,750 blocks and the entire PMA ***shall*** be blank.
001b	Mandatory	Minimally blank the disc	Erases only the PMA, first session TOC and the pre-gap of the first track. The Start Address parameter is ignored. This is used for blanking a disc quickly. After completion of this command the disc is treated as a blank disc. Caution ***shall*** be exercised when using this command as the program area still contains user data.
010b	Optional	Blank a Track	Erases the track specified in the Start Address/Track Number field. This command erases the track only, it does not erase the TOC or the PMA. The track to be erased ***shall*** be in the incomplete session.
011b	Optional	Unreserve a Track	This is valid only when the last recorded track is incomplete, reserved, or is complete and in an incomplete session. If the last track is incomplete the track and PMA entry for incomplete track is erased. If the track is reserved or complete, the track and PMA entry of the track is erased. The Start Address/Track Number parameter is ignored.
100b	Mandatory	Blank a Track Tail	Erase the area between the LBA specified Start Address/Track Number field and the end of the track that includes the LBA specified. The LBA specified ***shall*** be the first user data block within a packet. This blank type is valid for only a Packet track. This may be used to prepare for writing a packet track to a CD-RW disc with the same write process as a CD-R. The track to be erased ***shall*** be in an incomplete session.
101b	Optional	Unclose the last session	Erases the Lead-in and Lead-out of the last session. The last session ***shall*** be complete when this command is issued.
110b	Optional	Erase Session	If the last session is complete, its Lead-in, program area, and Lead-out ***shall*** be erased. If the last session is incomplete, its program area ***shall*** be erased. If the last session is empty, the complete session immediately preceding the empty session ***shall*** be erased. If the empty session is the only session on the disc, erasing ***shall not*** be considered an error.
111b		Reserved	

Table 207 - Blanking Types for DVD-RW

Code	Type	Name	Description
000b	Mandatory	Blank the disc	The entire disc is to be erased. The area from the RMA through the end of Last address of Data Recordable Area[a] plus 3 ECC blocks except RMA Lead-in and six RMD blocks at the beginning of RMA ***shall*** be erased. The Start Address or Track/RZone Number parameter is ignored. If a disc is to be erased that is already fully blanked, no error ***shall*** be reported.
001b	Mandatory	Minimally blank the disc	This operation is used for blanking a disc quickly. Lead-in and the entire RMA except RMA Lead-in and six RMD blocks at the beginning of RMA ***shall*** be erased. The Start Address or Track/RZone Number parameter is ignored. Caution ***shall*** be exercised when using this command as the Data Area still contains user data. If a disc is to be erased that is already fully/minimally blanked, no error ***shall*** be reported.
010b		Reserved	
011b	Optional	Unreserve an RZone	This operation is valid only when the last Bordered Area is incomplete state. If the last RZone is invisible, the RZone that immediately preceding invisible RZone and its RMD entry are erased. If the last RZone is incomplete, the incomplete RZone is erased. The Start Address or Track/RZone Number parameter is ignored.
100b	Optional	Blank an RZone Tail	This blanking type is valid for only a incrementally recorded RZone. The RZone to be erased ***shall*** be in an incomplete Bordered Area. Erase the area between the LBA specified Start Address or Track/RZone Number field and the end of the RZone that includes the LBA specified. When the RZone that is to be erased is complete RZone and if the next RZone is recorded, the last ECC block of the complete RZone ***shall*** be remained as BSGA to guarantee next RZone readable. If attempting to erase an RZone that causes generation of fourth NWA, the command ***shall*** be terminated with CHECK CONDITION status, 5/72/05 NO MORE RZONE RESERVATIONS ARE ALLOWED. The LBA specified ***shall*** be the first user data block of an ECC block and ***shall*** be an existing linking point of an RZone. If the start address sector is not a linking point, the command ***shall*** be terminated with CHECK CONDITION status, 5/21/02 INVALID ADDRESS FOR WRITE.
101b	Optional	Unclose the last Border	This blanking type is valid for only a incrementally recorded disc. This operation is valid only when the last Bordered Area is complete state. Erases the Lead-in/Border-in and Lead-out/Border-out of the last Bordered Area. If the last Bordered Area is empty state, the complete Border immediately preceding the empty Bordered Area ***shall*** be erased.
110b	Optional	Erase Border	If the last Bordered Area is complete state, its Lead-in/Border-in through the end of the Lead-out/Border-out ***shall*** be erased. If the last Bordered Area is incomplete state, all RZone(s) in the incomplete Bordered Area ***shall*** be erased. If the last Bordered Area is empty state, the complete Border immediately preceding the empty Bordered Area ***shall*** be erased. If the disc is blank, erasing ***shall not*** be considered an error.
111b		Reserved	

a. This information is encoded as pre-pit information.

Start Address or Track/RZone Number is the address at which erasure ***shall*** begin:

1. When Blanking Type is Blank a Track/RZone Tail, this field indicates the start LBA.
2. When Blanking Type is Blank a Track, this field indicates the Track.

Morphing may occur when the BLANK operation is requested (to indicate changing to the NOT READY condition) and when the BLANK operation completes (to indicate the Restricted Overwrite Feature and/or others becoming Current).

During the blank operation, the logical unit ***shall*** respond to commands as follows:

1. In response to all commands that can return NOT READY status, the logical unit ***shall*** return CHECK CONDITION status, 2/04/07 LOGICAL UNIT NOT READY, OPERATION IN PROGRESS. INQUIRY, GET CONFIGURATION, GET EVENT/STATUS NOTIFICATION, and REQUEST SENSE are among the commands that ***shall not*** return a NOT READY error (Sense Key 2).
2. In response to the INQUIRY, GET CONFIGURATION, and GET EVENT/STATUS NOTIFICATION commands, the logical unit ***shall*** respond as commanded.
3. In response to the REQUEST SENSE command, unless an error within the command itself has occurred, the logical unit ***shall*** return GOOD status, 2/04/07 LOGICAL UNIT NOT READY, OPERATION IN PROGRESS indicated in the result data and the sense key specific bytes set for progress indication. See the description of deferred error handling that may occur during the blank operation.
4. In response to an ATA SRST, the logical unit ***shall*** provide the diagnostic results and the ATAPI signature. The blank operation ***shall not*** be affected.

Table 208 describes errors that may occur during the operation of the command or which may cause a CHECK CONDITION status to be reported.

Table 208 - BLANK command errors

Error Description
A-1.1, "Deferred Error Reporting" on page 721
Table 630 - *Basic Error Codes* on page 730
Table 631 - *Media Access Error Codes* on page 733
Table 632 - *Write Error Codes* on page 736

16.2 CLOSE TRACK/RZONE/SESSION/BORDER command

The CLOSE TRACK/RZONE/SESSION/BORDER command allows closure of a CD track, a DVD/HD DVD RZone, a CD Session or a DVD/HD DVD Border. For CD/DVD, if the Multisession/Border field in the *Write Parameters* Mode Page (05h) is set to 11b and there is not sufficient space for the next Session/Border, the Session/Border to be closed ***shall*** be closed and next Session/Border ***shall not*** be allowed. For CD, the Session is closed without the B0 pointer. For DVD, the Border is closed with Lead-out and the Start PSN of the next Border-in field of Lead-in/Border-in set to 0. For HD DVD, the *Write Parameters* Mode Page (05h) is not used.

Note: In the case of insufficient space for the next Session, legacy CD-R/RW logical units may generate an error in the above case. In this case, the host should change the Multisession/Border field in the Write Parameters Mode Page (05h) *and retry the command.*

Table 209 - CLOSE TRACK/RZONE/SESSION/BORDER Command Descriptor Block

Byte \ Bit	7	6	5	4	3	2	1	0
0	Operation code (5Bh)							
1	Reserved							Immed
2	Reserved					Close Function		
3	Reserved							
4	(MSB) Track/RZone Number							
5								(LSB)
6	Reserved							
7	Reserved							
8	Reserved							
9	Vendor-Specific		Reserved			NACA	Flag	Link
10	PAD							
11								

The Immediate (Immed) bit allows execution of the CLOSE TRACK/RZONE/SESSION/BORDER function as an immediate operation. If Immed is set to 0, then the requested Close operation is performed to completion prior to returning status. If Immed is set to 1, then status is returned once the Command Packet has been validated.

For DVD-R/HD DVD-R, a logical units may write cached RMD into the RMA/RMZ immediately upon receipt of a CLOSE TRACK/RZONE/SESSION/BORDER command. DVD-R/HD DVD-R logical units may delay the Close operation and writing of cached RMD into RMA/RMZ to allow multiple CLOSE TRACK/RZONE/SESSION/BORDER commands to be issued quickly. In this case, it is recommended that the logical unit not write RMD into the RMA/RMZ until the last CLOSE TRACK/RZONE/SESSION/BORDER command in a sequence has been received.

Note: Determining the end of a sequence of CLOSE TRACK/RZONE/SESSION/BORDER commands is vendor specific.

The Close Function field is defined in Table 210.

Table 210 - Close Function field definition for CD-R/RW, DVD-R/-RW and HD DVD-R[a]

Close Function field value	Close Actions
000b	This condition is reserved and not valid. The logical unit ***shall*** report CHECK CONDITION status, 5/24/00 INVALID FIELD IN CDB.
001b	Close the Track/RZone associated with the Track/RZone number in the CDB. For CD, if this is the incomplete track, the logical unit ***shall*** pad with all zero main data to the minimum length of 4 seconds. No other padding is to be done. If this is the partially recorded or empty reserved track, the logical unit ***shall*** pad the track. In the case of an empty reserved track, the logical unit ***shall*** write the track according to the *Write Parameters* Mode Page (05h). If the *Write Parameters* Mode Page (05h) is inconsistent with the PMA or TDB, the logical unit ***shall*** return CHECK CONDITION status, 5/64/00 ILLEGAL MODE FOR THIS TRACK. For a partially recorded reserved track, the logical unit ***shall*** continue writing in the same mode as the data already recorded. For DVD/HD DVD, if this is the Partially Recorded Reserved RZone or the Empty Reserved RZone, the logical unit ***shall*** pad the RZone with 00h bytes. If the RZone status is Invisible, no close operation is to be done. In the case of an Incomplete RZone, no padding is to be done and cached RMD ***shall*** be written into the RMA/RMZ.
010b	Close Session/Border. If all Tracks/RZones in the last Session/Border are not complete, generate CHECK CONDITION status, 5/72/03 SESSION FIXATION ERROR - INCOMPLETE TRACK IN SESSION. Or if an empty or partially recorded, reserved Tracks/RZones exist in the incomplete Session/Border, generate CHECK CONDITION status, 5/72/04 EMPTY OR PARTIALLY WRITTEN RESERVED TRACK. For CD/DVD, behavior of the closing operation is dependent on the Multisession/Border field in the *Write Parameters* Mode Page (05h). Closing an empty Session/Border not produce an error and a write to the media ***shall*** not occur. For DVD-RW media, when the last Bordered Area is in the intermediate state, Lead-in and/or Border-out are recorded to make the Bordered Area complete state. (If the Bordered Area is to be closed that is the first one, Lead-in and Border-out ***shall*** be recorded. If the Bordered Area is to be closed that is second or later one, only the Border-out ***shall*** be recorded.)
011b	For DVD-RW media, if the disc is in DVD-RW restricted overwrite mode and the last Bordered Area is complete state and Lead-out is not written, Lead-out ***shall*** be appended after the last Border-out. If the last Bordered Area is intermediate state, Border-out and Lead-out is recorded. If the disc is not formatted, the logical unit ***shall*** report CHECK CONDITION status, 5/24/00 INVALID FIELD IN CDB. For all other media, this condition is reserved and not valid. The logical unit ***shall*** report CHECK CONDITION status, 5/24/00 INVALID FIELD IN CDB.
100b	This condition is reserved in this specification and not valid. The logical unit ***shall*** report CHECK CONDITION status, 5/24/00 INVALID FIELD IN CDB.
101b	This condition is reserved and not valid. The logical unit ***shall*** report CHECK CONDITION status, 5/24/00 INVALID FIELD IN CDB.
110b	For HD DVD, finalize the disc. For CD/DVD, this condition is reserved and not valid. The logical unit ***shall*** report CHECK CONDITION status, 5/24/00 INVALID FIELD IN CDB.
111b	This condition is reserved in this specification and not valid. The logical unit ***shall*** report CHECK CONDITION status, 5/24/00 INVALID FIELD IN CDB.

a. See MMC for definition of this field for the other medium that is not specified by this specification.

If a Session/Border or Track/RZone is to be closed that is already closed, no error ***shall*** be reported.

If the Close Function field is 001b, the Track/RZone Number field indicates the number of Tracks/RZones to close. Bytes 4 and 5 of the CDB ***shall*** be ignored if the Close Function field is set to 010b, 011b or 110b.

For a CD to close the incomplete track, the following steps are required:

1. If necessary, the track is padded with all zero main data to the minimum length of 4 seconds.
2. The PMA is consulted in order to locate the largest track number recorded, 'N'.
3. The bounds of the track are determined and a PMA entry is written for track N+1.

Closing a Track or RZone ***shall*** cause cached information for the specified Track or RZone to be committed to the medium prior to closing.

For CD, closing a Session ***shall*** cause the Lead-in and Lead-out to be written for the incomplete Session.

Closing a Session/Border when the last Session/Border is empty ***shall*** cause no actions to be performed and ***shall not*** be considered an error.

For DVD, closing an incomplete or an intermediate Bordered Area ***shall*** cause the Lead-in or Border-in and Border-out to be written for the incomplete or intermediate Bordered Area. If the Multisession/Border field in the *Write Parameters* Mode Page (05h) is set to 00b, a Lead-out ***shall*** be appended to the last Border-out. Once the Lead-out has been written for DVD media, data ***shall not*** be appended to the medium after the Lead-out.

For HD DVD, closing an incomplete Bordered Area ***shall*** cause the Lead-in or Border-in and Border-out to be written for the incomplete Bordered Area. If the unrecorded ECC blocks in Current RMZ exist and the unrecorded ECC blocks in RDZ do not exist, the command with Close Function field = 010b ***shall not*** be performed and the logical unit ***shall*** report CHECK CONDITION status, 5/73/17 RDZ IS FULL. See *5.13.12.6, "Error reporting for "Border closure" by using CLOSE TRACK/RZONE/SESSION/BORDER command"* on page 299

For HD DVD, if the Close Function field is set to 110b and the last Border is incomplete Border, the Border-out whose attribute is a Data Lead-out ***shall*** be written. If the Close Function field is set to 110b and the last Border is empty Border, the Terminator ***shall*** be appended to the last Border-out. Once the Border-out whose attribute is a Data Lead-out or the Terminator has been written, data ***shall not*** be appended to the medium after the Border-out or the Terminator. See *5.13.10, "Disc Final Closure"* on page 291.

During the close operation, the logical unit ***shall*** respond to commands as follows:

1. The logical unit may respond to commands that can return NOT READY status with CHECK CONDITION status, 2/04/07 LOGICAL UNIT NOT READY, OPERATION IN PROGRESS. See *4.6,* on page 92, *3.4,* on page 63, and Table 183 - *NOT READY error & Time-out UNIT ATTENTION reporting (by command)* on page 362.
2. In response to the INQUIRY, GET CONFIGURATION, and GET EVENT/STATUS NOTIFICATION commands, the logical unit ***shall*** respond as commanded.
3. In response to the REQUEST SENSE command, unless an error within the command itself has occurred, the logical unit ***shall*** return GOOD status, 2/04/07 LOGICAL UNIT NOT READY, OPERATION IN PROGRESS or 2/04/08 LOGICAL UNIT NOT READY, LONG WRITE IN PROGRESS indicated in the result data and the sense key specific bytes set for progress indication. See the description of deferred error handling that may occur during the close operation.
4. In response to an ATA SRST, the logical unit ***shall*** provide the diagnostic results and the ATAPI signature. The close operation ***shall not*** be affected.

If Class 1 Event is supported, closing a Track, RZone, Session, or Border ***shall*** cause a Class 1 Event when the command is issued if the logical unit becomes NOT READY. A Class 1 Event ***shall*** occur if the medium returns to READY or if the medium becomes unwritable. Other Class 1 Events may occur due to closing a Track, RZone, Session, or Border.

Table 211 describes errors that may occur during the operation of the command or which may cause a CHECK CONDITION status to be reported.

Table 211 - CLOSE TRACK/RZONE/SESSION/BORDER command errors

Error Description
A-1.1, "Deferred Error Reporting" on page 721
Table 630 - *Basic Error Codes* on page 730
Table 631 - *Media Access Error Codes* on page 733
Table 632 - *Write Error Codes* on page 736
Table 633 - *Session/Border Error Codes* on page 737

16.3 FORMAT UNIT command

The FORMAT UNIT command formats the medium into host addressable logical blocks per the host defined options.

The medium may be certified and control structures may be created for the management of the medium and defects. There is no guarantee that medium has or has not been altered.

The SET STREAMING command may affect the speed used to Format the medium.

Table 212 - FORMAT UNIT Command Descriptor Block

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation Code (04h)							
1	LUN (Obsolete)			FmtData(1)	CmpLst	Format Code (001b)		
2	Reserved							
3	(MSB) Interleave Value (0)							
4								(LSB)
5	Vendor-Specific		Reserved			NACA	Flag	Link
6	PAD							
7								
8								
9								
10								
11								

A Complete List (CmpLst) bit of one indicates that the parameter list is complete and the logical unit is to ignore any existing parameters. On DVD-RAM/HD DVD-Rewritable media, a CmpLst bit is used in conjunction with the Disable Certification (DCRT) bit to determine usage of the existing defect lists (e.g., the existing G_1-list, G_2-list and SDL to construct new G_1-list and G_2-list on DVD-RAM/HD DVD-Rewritable media). See Table 213. On C/DVD-RW media, CmpLst bit ***shall*** be set to 0.

Table 213 - DVD-RAM/HD DVD-Rewritable Defect List Handling

CmpLst	DCRT	Certification	PDL			SDL	Remarks
			P-list	G_1-list	G_2-list		
0	0	Yes	Preserved	New from Certification	Disposed	Disposed	Slow Initialization
0	1	No	Preserved	Preserved	Old + New from SDL	Disposed	Change linear replacement to slipping, quickly
1	0	Yes (Partial) (Obsolete)	Preserved	Old plus New from Certification	Disposed	Disposed	Create new defect list by disposing all except P-list and G_1-list
1	1	No	Preserved	Preserved	Disposed	Disposed	Return to original slipping at the latest certification, quickly

The Format Code ***shall*** be set to 001b.

The Interleave Value field specifies the interleave that is used when performing the format operation. This field ***shall*** be set to zero.

During the format operation, the logical unit ***shall*** respond to other commands as follows:

1. In response to all commands that can return NOT READY status, the logical unit ***shall*** return CHECK CONDITION status, 2/04/04 LOGICAL UNIT NOT READY, FORMAT IN PROGRESS. INQUIRY, GET CONFIGURATION, GET EVENT/STATUS NOTIFICATION, and REQUEST SENSE are among the commands that ***shall not*** return a NOT READY error (Sense Key 2).
2. In response to the INQUIRY, GET CONFIGURATION, and GET EVENT/STATUS NOTIFICATION commands, the logical unit ***shall*** respond as commanded.
3. In response to the REQUEST SENSE command, unless an error within the command itself has occurred, the logical unit ***shall*** return GOOD status, 2/04/04 LOGICAL UNIT NOT READY, FORMAT IN PROGRESS indicated in the result data and the sense key specific bytes set for progress indication. See the description of deferred error handling that may occur during the format operation.
4. In response to an ATA SRST, the logical unit ***shall*** provide the diagnostic results and the ATAPI signature. The format operation ***shall not*** be affected.

During the execution of the FORMAT UNIT command, the logical unit ***shall*** perform a medium defect management algorithm if the Hardware Defect Management Feature is current. The FORMAT UNIT command for DVD-RAM/HD DVD-Rewritable media may not provide a method to receive defect location information from the host.

A format data (FmtData) bit ***shall*** be set to one. A FmtData bit of one indicates that the FORMAT UNIT parameter list (see Table 214) ***shall*** be transferred from the host to the logical unit. The data sent to the logical unit consists of a Format List Header, followed by an initialization pattern descriptor (which may have zero length), followed by one Format descriptor. The Format descriptor ***shall*** be one of Formattable Capacity Descriptors returned by the READ FORMAT CAPACITIES command.

Table 214 - FORMAT UNIT Parameter List

Bit / Byte	7	6	5	4	3	2	1	0
0-3	Format List Header							
-	Initialization Pattern Descriptor (Not Present when IP bit =0)							
	Format Descriptor (only 1 is allowed)							
4 - 11	Format Descriptor 0							

The Format List Header provides several format control bits. Logical units that implement these bits give the host additional control over the formatting operation. If the host attempts to select any function not implemented by the logical unit, the logical unit ***shall*** terminate the command with CHECK CONDITION status, 5/26/00 INVALID FIELD IN PARAMETER LIST.

The Initialization Pattern Descriptor ***shall not*** be included in the Format Unit Parameter data sent to the logical unit.

Table 215 - Format List Header

Bit / Byte	7	6	5	4	3	2	1	0
0	Reserved							
1	FOV	DPRY	DCRT	STPF	IP	Try-out	Immed	VS
2	(MSB) Format Descriptor Length (0008h)							
3								(LSB)

A Format Options Valid (FOV) bit of zero indicates that the logical unit ***shall*** use its default settings for the DPRY, DCRT, STPF, IP and Try-out and Immed bits (see below). When the FOV bit is zero, the host ***shall*** set these bits to zero. If any of these bits are not zero, the logical unit ***shall*** terminate the command with CHECK CONDITION status, 5/ 26/00 INVALID FIELD IN PARAMETER LIST. An FOV bit of one indicates that the logical unit ***shall*** examine the setting of the DPRY, DCRT, STPF, IP and Try-out and Immed bits. When the FOV bit is one, the DPRY, DCRT, STPF, IP and Try-out and Immed bits are defined as follows.

A Disable Primary (DPRY) bit, when set to zero, ***shall*** indicate that the logical unit ***shall*** retain the manufacturer's certification list (PList). When set to one, ***shall*** indicate that the manufacturer's certification list be retained but not used for defect management. DPRY bit ***shall*** be set to zero for DVD-RAM/HD DVD-Rewritable, C/DVD-RW media.

A disable certification (DCRT) bit of zero indicates that the logical unit ***shall*** perform a vendor-specific medium certification operation to generate a G_1-list (C-list) or a Defect Status bitmap (DS #n bits) in the Format 3 RMD on DVD-RW media. A DCRT bit of one indicates that the logical unit ***shall not*** perform any vendor-specific medium certification process or format verification operation while executing the FORMAT UNIT command. DCRT bit ***shall*** be set to zero for CD-RW media.

The Stop Format (STPF) bit ***shall*** be set to zero.

The Initialization Pattern (IP) bit ***shall*** be set to zero. If the IP bit is set to zero, the Initialization Pattern Descriptor ***shall not*** be included in the Format Unit Parameter data sent to the logical unit, and the Format Descriptor ***shall*** begin at byte offset 4.

A Try-out bit of one indicates that the logical unit ***shall not*** change the media format but ***shall*** examine whether the specified FORMAT UNIT command can be performed without error, based on available information before starting the formatting.

An immediate (Immed) bit of zero indicates that status ***shall*** be returned after the format operation has completed. An Immed bit of one indicates that the logical unit ***shall*** return status as soon as the command descriptor block has been validated, and the entire Format Descriptor has been transferred.

If the Immed bit was set to one or the FORMAT UNIT command was queued, then in response to the REQUEST SENSE command during the formatting operation, unless an error in the command has occurred, the logical unit ***shall*** return no CHECK CONDITION status, 2/04/04 LOGICAL UNIT NOT READY, FORMAT IN PROGRESS in the result data and the Sense Key Specific field set to the percentage of the operation that has completed. See Table 528 - *Progress Indication* on page 648 for details.

The logical unit may morph when the Format operation begins and again when it ends. For example, the medium may become inaccessible during the Format operation, and the Random Writable Feature may become current after Formatting.

The Vendor Specific (VS) bit indicates a vendor-specific format.

The Format Descriptor Length field in the Format list header specifies the total length in bytes of the Format descriptors that follow and does not include the initialization pattern descriptor or initialization pattern, if any.

The Format Descriptor Length ***shall*** be set to 8. Any other value in this field ***shall*** return CHECK CONDITION status, 5/26/00 INVALID FIELD IN PARAMETER LIST.

Table 216 - Format Descriptor - From READ FORMAT CAPACITIES

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB)							
1				Number of Blocks				
2								
3								(LSB)
4			Format Type				Reserved	
5	(MSB)							
6				Type Dependent Parameter				
7								(LSB)

The Format descriptor specifies an eight-byte entry.

The Format Type field specifies the type of formatting. Contents of the Number of Blocks field and the Type Dependent Parameter field depend on the type of formatting. The Format Type values are defined in Table 461 - *Format Types* on page 591.

16.3.1 Formatting on Format Type = 00h (Full Format)

Formatting for the whole media is specified.

The Number of Blocks field specifies the number of addressable blocks for the whole disc and the Type Dependent Parameter field specifies the Block Length.

On DVD-RAM/HD DVD-Rewritable media, the defect list handling is specified by the combination of the CmpLst bit and the DCRT bit as shown in Table 213 - *DVD-RAM/HD DVD-Rewritable Defect List Handling* on page 399. In the case that the CmpLst bit is set to zero and the DCRT bit is set to one, the Number of Blocks field ***shall*** be ignored and the number of addressable blocks ***shall*** be retained. In other cases, the Number of Blocks field specifies the number of addressable blocks for the whole disc and the Type Dependent Parameter field specifies the Block Length. Neither field is changeable from the values reported by *16.25, "READ FORMAT CAPACITIES command"* on page 589.

On DVD+RW media, the logical unit ***shall*** use its default parameters for SI and SL and format the whole medium.

On CD-RW media, the whole media ***shall*** be formatted using the *Write Parameters* Mode Page (05h).

On DVD-RW media, this format operation is available on any recording mode and any state of a Bordered Area. The area from the beginning of the RMA to the end of the Lead-out ***shall*** be recorded. There is only one Bordered Area on the medium and the number of RZone is one after this operation. The Disc Status field of Format 3 RMD ***shall*** be set to 12h when the operation is completed.

16.3.2 Formatting on Format Type = 01h (Spare Area Expansion)

In order to keep more space as Spare area, this formatting is used. Eventually the capacity of the formatted area is reduced. Therefore, this formatting type is just available with the case of reduction of formatted capacity.

The logical unit ***shall*** ignore the defect list handling specified by the combination of the CmpLst bit and the DCRT bit. The defect list entries and the written user data within the range of the area that is specified by this command ***shall*** be preserved through the execution of this command. The Number of Blocks field specifies the number of addressable blocks for the whole disc and the Type Dependent Parameter field specifies the Block Length. Neither field is changeable from the values reported by *16.25, "READ FORMAT CAPACITIES command"* on page 589.

16.3.3 Formatting on Format Type = 04h (Zone Reformat)

The Zoned formatting for a zone of the media is specified, where the size of zone is not constant across zones. The defect list handling is specified by the combination of the CmpLst bit and the DCRT bit as shown in Table 213 - *DVD-RAM/*

HD DVD-Rewritable Defect List Handling on page 399. The Number of Blocks field specifies the number of addressable blocks for the zone and the Type Dependent Parameter field specifies the Zone number of the zone to be formatted. If a spare sector is used as a replacement for another zone so that the zoned formatting cannot be preformed, the command ***shall*** be terminated with CHECK CONDITION status, 3/31/02 ZONED FORMATTING FAILED DUE TO SPARE LINKING, with the sense key specific bytes set to zone number of the first zone which has a spare linking into the designated zone.

The discarding of G_1-list, G_2-list, and SDL is only applicable to defects within the zone being reformatted.

16.3.4 Formatting on Format Type = 05h (Zone Format)

The Zoned formatting for a zone of the media is specified, where the size of zone is constant for each zone, e.g., floppy media where each track is labelled a zone. The Number of Blocks field specifies the number of addressable blocks for the zone and the Type Dependent Parameter field specifies the Zone number of the zone to be formatted. The zone number ***shall*** be in the range of 0 to the Type Dependent Parameter reported in *16.25, "READ FORMAT CAPACITIES command"* on page 589, inclusive.

16.3.5 Formatting on Format Type = 10h (C/DVD-RW Full Format)

Formatting to create a Session/Border on C/DVD-RW media is specified. The created Session/Border ***shall*** become the only Session/Border on the medium. The Number of Blocks field specifies the number of addressable blocks for the new Session/Border and the Type Dependent Parameter field specifies the Fixed Packet Size for CD or set to ECC block size (16) for DVD-RW. The Number of Blocks field may be adjusted to a value less than or equal to the values reported by the READ FORMAT CAPACITIES command. The logical unit ***shall*** round the Number of Blocks up to be an integral multiple of the packet size for CD or the ECC block size for DVD. The Packet Size field may not be adjusted. In the case of CD media, if a different Fixed Packet Size is desired, the host ***shall*** modify the Write Parameters Mode Page.

On DVD-RW media, this format operation is available on any recording mode and any state of a Bordered Area. The number of RZone in the created Border is one after this operation. The Disc Status field of Format 3 RMD ***shall*** be set to 12h when the operation is completed.

16.3.6 Formatting on Format Type = 11h (C/DVD-RW Grow Session/Border)

Formatting to expand the last session/Border of a C/DVD-RW medium is specified. The Number of Blocks field specifies the number of addressable blocks to be added to current Session/Border capacity and the Type Dependent Parameter field specifies the Packet Length for CD or set to ECC block size (16) for DVD-RW. The logical unit ***shall*** round the Number of Blocks up to be an integral multiple of the packet size for CD or the ECC block size for DVD. The Packet Size field may not be adjusted.

On DVD-RW media, this format operation is available only when a disc is in Restricted overwrite mode and the last Bordered Area is in a complete state. Growing of border operation ***shall*** start from the next sector of End Sector Number of RZone #n field that is corresponded to the last RZone. End PSN of Data Area and Start PSN of the current Border-out field of Lead-in/Border-in ***shall*** be changed to reflect the expanded Bordered Area. The number of Bordered Areas and RZones does not change after this operation.

16.3.7 Formatting on Format Type = 12h (C/DVD-RW Add Session/Border)

Formatting to add a new session/Border to a C/DVD-RW media is specified. The Number of Blocks field specifies the number of addressable blocks for the new Session/Border and the Type Dependent Parameter field specifies the Fixed Packet Size for CD or set to ECC block size (16) for DVD-RW. The Number of Blocks field may be adjusted to a value less than or equal to the values reported by the READ FORMAT CAPACITIES command. The logical unit ***shall*** round the Number of Blocks up to be an integral multiple of the packet size for CD or the ECC block size for DVD. The Packet Size field may not be adjusted. On CD media, if a different Fixed Packet Size is desired, the host ***shall*** modify the Write Parameters Mode Page.

On DVD-RW media, this format operation is available only when a disc is in Restricted overwrite mode and the last Bordered Area is in a complete state. Start PSN of the next Border-in field in the previous Border-in/Lead-in ***shall*** be updated.

16.3.8 Formatting on Format Type = 13h (DVD-RW Quick Grow the last Border)

Formatting to expand the last Border and enter the last Bordered Area into intermediate state of a DVD-RW medium is specified. The Number of Blocks field specifies the number of addressable blocks to be added to current Border capacity and the Type Dependent Parameter field is set to ECC block size (16). The logical unit ***shall*** round the Number of Blocks up to be an integral multiple of the ECC block size.

This format operation is available only when the disc is in Restricted overwrite mode and the last Bordered Area is complete state. Growing of border operation ***shall*** start from the next sector of End Sector Number of RZone #n field that is corresponded to the last RZone.

The number of Bordered Areas and RZones does not change after this operation. The Disc Status field of Format 3 RMD ***shall*** be set to 13h when the operation is completed. End PSN of Data Area field in Lead-in/Border-in of the last Border ***shall*** be set to 30000h. And Start PSN of the current Border-out and Start PSN of the next Border-in field in Lead-in/Border-in of the last Border ***shall*** be set to 00h.

16.3.9 Formatting on Format Type = 14h (DVD-RW Quick Add Border)

Formatting to add a new intermediate state Border to an existing Border on DVD-RW media is specified. At least one or more Border ***shall*** exist on a medium and the last Border ***shall not*** be an intermediate state before start this operation.

The area from the beginning of Border-in that follows the last Border-out, user data blocks and 32 ECC blocks with Lead-out attribute is recorded. Start PSN of the next Border-in field in the previous Border-in/Lead-in ***shall not*** be changed to reflect the intermediate state Bordered Area that is added.

If FORMAT UNIT command with this Format Type is issued when the last Border is already intermediate state, the command ***shall*** be terminated with CHECK CONDITION status, 5/26/00 INVALID FIELD IN PARAMETER LIST.

The Number of Blocks field specifies the number of addressable blocks for the new Border and the Type Dependent Parameter field is set to ECC block size (16). The Number of Blocks field may be adjusted to a value less than or equal to the values reported by the READ FORMAT CAPACITIES command. The logical unit ***shall*** round the Number of Blocks up to be an integral multiple of the ECC block size.

16.3.10 Formatting on Format Type = 15h (DVD-RW Quick)

Formatting to create a Intermediate state Border on DVD-RW media is specified. The created Border ***shall*** become the only Border on the medium. The Number of Blocks field specifies the number of addressable blocks for the new Border and the Type Dependent Parameter field is set to ECC block size (16). The Number of Blocks field may be adjusted to a value less than or equal to the values reported by the READ FORMAT CAPACITIES command. The logical unit ***shall*** round the Number of Blocks up to be an integral multiple of the ECC block size for DVD.

This format operation is available on any recording mode and any state of a Bordered Area. If a disc is to be formatted that is in Sequential recording mode, new intermediate state Bordered Area is created at the beginning of the disc and the recording mode is changed to Restricted overwrite mode. The number of RZone in the created Border is one after this operation. The Disc Status field of Format 3 RMD ***shall*** be set to 13h when the operation is completed.

16.3.11 Formatting on Format Type = 16h (HD DVD-R Test Zone Expansion)

In order to keep more space as Test Zone, this formatting is used. Eventually the capacity of the Data Area is reduced.

The FOV, DPRY, DCRT, STPF, IP, Try-out and VS bit ***shall*** be set to 0. The Number of Blocks field and the Type Dependent Parameter field ***shall*** be ignored.

The Test Zone can be extended only once. Attempting to extend the Test Zone when the Test Zone is already extended, the command ***shall*** be terminated with CHECK CONDITION status, 5/72/07 NO MORE TEST ZONE EXTENSIONS ARE ALLOWED. See *5.13.8, "Test Zone extension"* on page 290 and *5.13.12.8, "Error reporting for "Test Zone extension" by using FORMAT UNIT command"* on page 300.

This Format Type is used for extending Test zone in HD DVD-R media. Then this Format descriptor ***shall not*** be returned by READ FORMAT CAPACITIES command.

For HD DVD, the Error reporting for the command in each condition of the media is shown in Table 160 - *Error reporting for "Test Zone extension" by using FORMAT UNIT command (1)* on page 300.

16.3.12 Formatting on Format Type = 20h (Full Format with sparing parameters)

Formatting for the whole media is specified. The Number of Blocks field specifies the maximum number of addressable blocks for the whole disc and the Type Dependent Parameter field specifies the sparing parameters SL and SI. The drive ***shall*** verify that SL and SI are usable values (will not cause overflow of the SDL).

Table 217 describes errors that may occur during the operation of the command or which may cause a CHECK CONDITION status to be reported.

Table 217 - FORMAT UNIT command errors

Error Description
A-1.1, "Deferred Error Reporting" on page 721
Table 630 - *Basic Error Codes* on page 730
Table 631 - *Media Access Error Codes* on page 733
Table 632 - *Write Error Codes* on page 736

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16.4 GET CONFIGURATION command

This command is intended to provide information to the host about the overall capabilities of the logical unit and the current capabilities of the logical unit. Configurations reported by logical units, for example, are used by the host for Driver Identification/loading and other user presentation processes.

The GET CONFIGURATION command requests that the logical unit respond with the configuration of the logical unit and medium. The configuration of the logical unit is described by Features (see *Section 14.0, "Features"* on page 369). The maximum number of Features is 65,536; the maximum number of bytes that a logical unit may return to describe its Features in one command is 65,534. Feature lists longer than 65,534 bytes require multiple commands.

Persistent Prevent may be used to control when morphing occurs. If a Persistent Prevent is enabled, the configuration should not change except under host control. See *14.2, "Morphing commands and functionality"* on page 372 for more information on the interoperation of these commands.

This command ***shall not*** return a CHECK CONDITION status due to a pending UNIT ATTENTION condition. Any pending UNIT ATTENTION condition ***shall not*** be cleared for the logical unit issuing the GET CONFIGURATION command.

Table 218 - GET CONFIGURATION Command Descriptor Block

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation code (46h)							
1	LUN (Obsolete)			Reserved			RT	
2	(MSB) Starting Feature Number							
3								(LSB)
4	Reserved							
5	Reserved							
6	Reserved							
7	(MSB) Allocation Length							
8								(LSB)
9	Vendor-Specific		Reserved			NACA	Flag	Link
10	PAD							
11								

The Requested Type (RT) field indicates the set of Feature Descriptors desired from the logical unit.

Table 219 - RT field definition

RT field	Description	Starting Feature Number (SFN) Usage
00b	Indicates that the logical unit ***shall*** return the Feature Header and all Feature Descriptors supported by the logical unit whether or not they are currently active.	The first Feature Descriptor returned ***shall*** have a Feature number greater than or equal to the SFN.
01b	Indicates that the Feature Header and only those Feature Descriptors that have their Current bit set ***shall*** be returned.	
10b	Indicates that exactly one Feature Header and zero or one Feature Descriptors be returned. If the logical unit does not support the indicated Feature, no Feature Descriptor is returned. Note: this may be used to request Feature 0, which is a list of Profiles.	The SFN specifies the Feature Descriptor that ***shall*** be returned.
11b	Reserved	

The Starting Feature Number indicates the first Feature number to be returned. See Table 219 for more complete definition.

The Allocation Length field specifies the maximum length in bytes of the GET CONFIGURATION Response Data. An Allocation Length field of zero indicates that no data ***shall*** be transferred. This condition ***shall not*** be considered an error.

16.4.1 GET CONFIGURATION response data

The Response Data is a Configuration Data list and ***shall*** contain a header followed by zero or more variable length Feature Descriptors. The format of the Configuration Data is shown in Table 220.

Table 220 - GET CONFIGURATION response data format

Bit / Byte	7	6	5	4	3	2	1	0
0-7	Feature Header							
8-n	Feature Descriptor(s)							

The Feature Header ***shall*** be returned as shown in Table 221.

The Feature Descriptor(s) ***shall*** be returned as shown in Table 223 - *Feature Descriptor generic format* on page 412 and in each individual Feature description.

Table 221 - Feature Header

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB)							
1	Data Length							
2								
3								(LSB)
4	Reserved							
5	Reserved							
6	(MSB) Current Profile							
7								(LSB)

The Data Length field indicates the amount of data available given a sufficient Allocation Length following this field. This length ***shall not*** be adjusted due to an insufficient Allocation Length. If the Data Length is greater than 65,530 bytes, multiple GET CONFIGURATION commands with different Starting Feature Numbers will be required for the host to read all configuration data. This field is adjusted as appropriate for the given Starting Feature Number.

The Current Profile field ***shall*** indicate the logical unit's current Profile. The logical unit ***shall*** choose the most appropriate current Profile from the list of Profiles with their CurrentP bit set. If no Profile is current, this field ***shall*** contain zero.

16.4.2 Features

Features are the smallest implementable set of commands, Pages, and behavior. Table 222 lists defined Features.

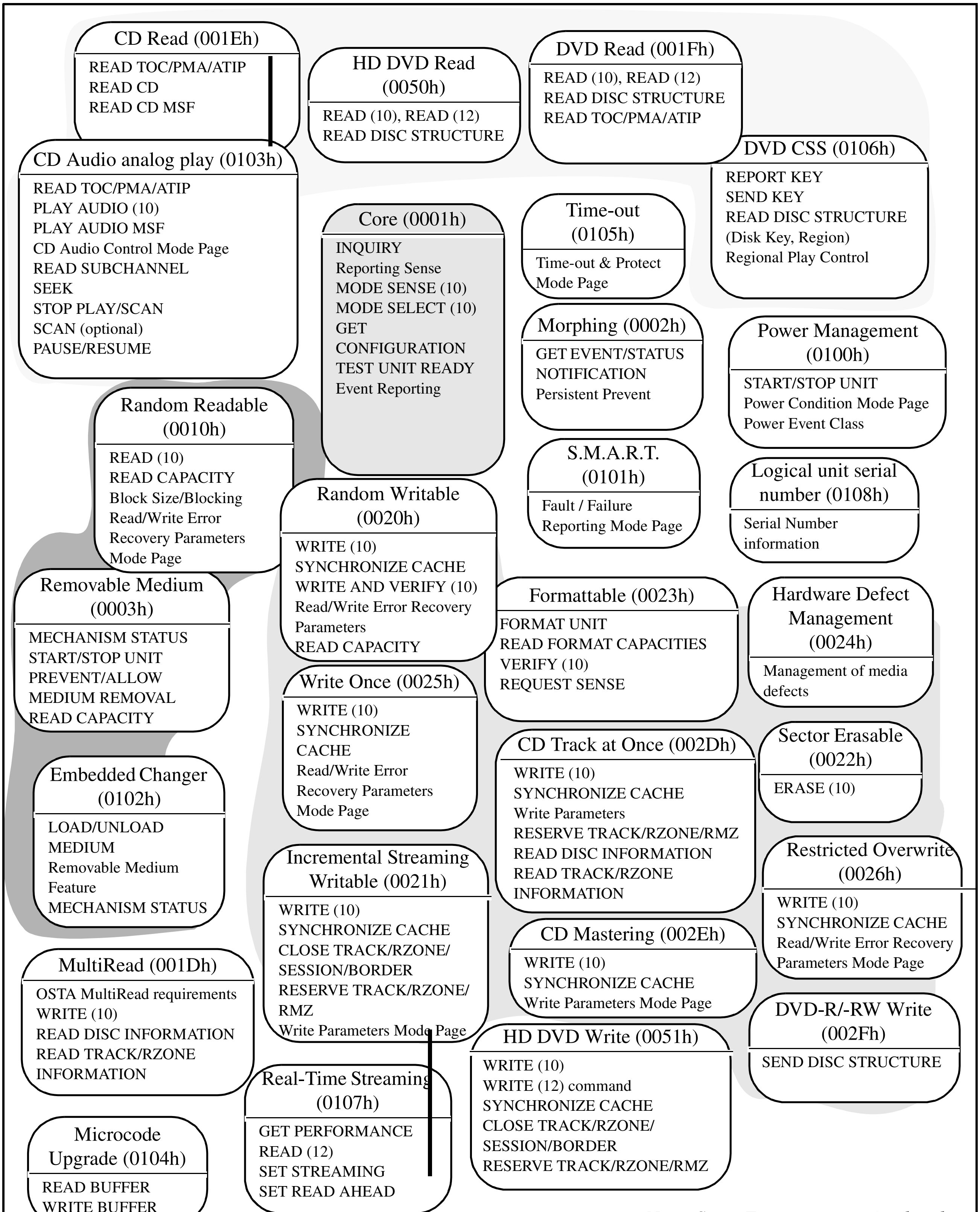
Table 222 - Feature List

Feature Number	Feature Name	Description
0000h	Profile List	A list of all Profiles supported by the logical unit
0001h	Core	Mandatory behavior for all logical units
0002h	Morphing	The ability to notify host about operational changes and accept host requests to prevent operational changes.
0003h	Removable Medium	The medium may be removed from the logical unit
0004h	Write Protect	The ability to control write protection status
0005h-000Fh	Reserved	Reserved
0010h	Random Readable	Read ability for storage logical units with random addressing
0011h-001Ch	Reserved	Reserved
001Dh	MultiRead	The logical unit can read all CD media types; based on OSTA MultiRead
001Eh	CD Read	The ability to read CD specific structures
001Fh	DVD Read	The ability to read DVD specific structures
0020h	Random Writable	Write support for randomly addressed writes
0021h	Incremental Streaming Writable	Write support for sequential recording
0022h	Sector Erasable	Write support for erasable media and media that requires an erase pass before overwrite.
0023h	Formattable	Support for formatting of media
0024h	Hardware Defect Management	The ability of the logical unit/media system to provide an apparently defect-free space
0025h	Write Once	Write support for write once media that may be written in random order
0026h	Restricted Overwrite	Write support for media that ***shall*** be written from Blocking boundaries only
0027h	CD-RW CAV Write	The ability to write high speed CD-RW media
0028h	MRW	See MMC
0029h	Enhanced Defect Reporting	The ability to control RECOVERED ERROR reporting
002Ah	DVD+RW	See MMC
002Bh	DVD+R	See MMC
002Ch	Rigid Restricted Overwrite	Write support for media that ***shall*** be written from Blocking boundaries with length of integral multiple of Blocking size only
002Dh	CD Track at Once	The ability to write CD with Track at Once recording
002Eh	CD Mastering	The ability to write CD with Session at Once or Raw write methods.
002Fh	DVD-R/-RW Write	The ability to write DVD specific structures
0030h-0032h	Reserved	These values were assigned to DDCD media. See MMC4.
0033h	Layer Jump recording	The ability to perform Layer Jump recording mode
0034h-0036h	Reserved	Reserved
0037h	CD-RW Media Write Support	See MMC
0038h-0039h	Reserved	Reserved
0040h	BD Read	See MMC
0041h	BD Write	See MMC
0042h-004Fh	Reserved	Reserved

Table 222 - Feature List (Continued)

Feature Number	Feature Name	Description
0050h	HD DVD Read	The ability to read HD DVD specific structures
0051h	HD DVD Write	The ability to write HD DVD specific structures
0052h-00FFh	Reserved	Reserved
0100h	Power Management	Host and logical unit directed power management
0101h	S.M.A.R.T.	Self Monitoring Analysis and Reporting Technology (Failure prediction)
0102h	Embedded Changer	Single mechanism multiple disc changer
0103h	CD Audio analog play	The ability to play audio CDs via the drive's own analog output
0104h	Microcode Upgrade	The ability for the logical unit to accept new microcode via the interface
0105h	Time-out	The ability to respond to all commands within a specific time
0106h	DVD CSS	The ability to perform DVD CSS/CPPM authentication and RPC
0107h	Real-Time Streaming	The ability to read and write using host requested performance parameters
0108h	Logical unit serial number	The logical unit has a unique identifier.
0109h	Media Serial Number	See MMC
010Ah	Disc Control Blocks	The ability to read and/or write Disc Control Blocks
010Bh	DVD CPRM	The ability to perform DVD CPRM authentication
010Ch	Firmware Information	The ability to report firmware information of the logical unit
010Dh	AACS	The ability to perform AACS authentication
010Eh-FEFFh	Reserved	Reserved
FF00h-FFFFh	Vendor Unique	

Features are related by Profiles. An example of some of the relationships is shown in Figure 167. This diagram shows in a graphic form Features that are defined in this specification. Each Feature is represented by a block in the diagram. Each Feature also shows an abbreviated list of the requirements for that Feature. This diagram serves as an example to help the reader understand the Features described in this specification, but **should not be used as a reference** for Feature implementation. For information on the exact Features and their requirements, see *Section 14.0, "Features"* on page 369. In some cases, Features are independent of other Features. The hierarchical relationship shown in the diagram is given by Profiles. If a Feature is placed underneath another Feature, then the overlaying Feature is usually not implemented without the functionality of the underlying Feature. Items in quotes indicate a functionality that is required but is not a specific command or Page.



Note: Some Features are omitted and some command names are abbreviated.

Figure 167 - Example Feature Relationships

Each Feature supported by a logical unit ***shall*** be described by a Feature Descriptor. Each Feature Descriptor has its own parameters. All Features ***shall*** be a multiple of four bytes long. The format of a Feature Descriptor is shown in Table 223.

Table 223 - Feature Descriptor generic format

Byte \ Bit	7	6	5	4	3	2	1	0
0	(MSB)			Feature Code				
1								(LSB)
2	Reserved		Version				Persistent	Current
3	Additional Length							
4-n	Feature Dependent Data							

The Feature Code field ***shall*** identify a Feature supported by the logical unit.

The Version field ***shall*** be set to zero unless otherwise specified within the Feature description. Future versions of a Feature will be backward compatible, but may contain extra information; incompatible changes will be included in a different Feature. Table 652 - *Feature Descriptor Version* on page 776 shows the current version of each Feature Descriptor.

The Persistent bit, when set to zero, ***shall*** indicate that this Feature may change its current status. When set to one, ***shall*** indicate that this Feature is always active. The logical unit ***shall not*** set this bit to one if the Current bit is, or may become, zero.

The Current bit, when set to zero, indicates that this Feature is not currently active and that the Feature Dependent Data may not be valid. When set to one, this Feature is currently active and the Feature Dependent Data is valid.

The Additional Length field indicates the number of Feature specific bytes that follow this header. This field ***shall*** be an integral multiple of 4.

16.4.2.1 Feature 0000h: Profile List

The Profile List Feature is a Feature to report a list of all Profiles supported by a logical unit. This Feature is always current. The only change allowed in the Profile List Feature during morphing is the setting of the CurrentP bits for each Profile. Logical units that support removable media ***shall not*** have any current Profiles listed. Profile 0 ***shall not*** be reported in the Profile List, but may be reported in the Current Profile field of the GET CONFIGURATION header to indicate compliance to no Profile.

Profiles provide a quick method for identifying the basic functionality of logical units. Logical units may conform to more than one Profile at a time. For example, a DVD-RAM logical unit with DVD-RAM media loaded may report both the Removable Disk and DVD-RAM Profiles. This allows generic removable disk drivers to work with DVD-RAM media while also reporting the additional capabilities required by the DVD-RAM Profile.

Table 224 - Profile List Feature Descriptor

Byte \ Bit	7	6	5	4	3	2	1	0
0	(MSB)			Feature Code = 0000h				
1								(LSB)
2	Reserved		Version				Persistent	Current
3	Additional Length							
4-n	Profile Descriptor(s)							

The Feature Code field *shall* be set to 0000h.

The Version field is reserved and *shall* be set to zero. Future versions of a Feature will be backward compatible; incompatible changes will be included in a different Feature.

The Persistent bit *shall* be set to one to indicate that the reporting of the Profile list is persistently supported.

The Current bit *shall* be set to one.

The Additional Length field *shall* be set to ((number of Profile Descriptors) * 4).

The Profile Descriptors are shown in Table 225. All Profiles supported by the logical unit *shall* be reported. Profile Descriptors are returned in the order of preferred operation - most desirable to least desirable. E.g., a HD DVD-Rewritable that could also read DVD-ROM and CD-ROM would list the HD DVD-Rewritable Profile first, the DVD-ROM Profile second, and the CD-ROM Profile third.

Table 225 - Profile Descriptor

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB) Profile Number							
1	Profile Number							(LSB)
2	Reserved							CurrentP
3	Reserved							

The Profile Number identifies a Profile to which the logical unit conforms. SeeTable 226.

The CurrentP bit, when set to one, *shall* indicate that this Profile is active. If no medium is present, no Profile should be active. Multifunction logical units *shall* select the most appropriate Profile(s), if any, to set as current. The most appropriate current Profile is also reported in the Feature Header - see Table 221 - *Feature Header* on page 408.

Table 226 - Profile List

Profile Number	Profile Name	Description
0000h	Reserved	
0001h	Non-removable disk	Rewritable disk capable with unchanging behavior
0002h	Removable disk	Writable disk capable with removable media
0003h	MO Erasable	Magneto-Optical disk with sector erase capability
0004h	MO Write Once	Magneto-Optical write once
0005h	AS-MO	AS-MO
0006h-0007h	Reserved	
0008h	CD-ROM	Read only Compact Disc capable
0009h	CD-R	Write once Compact Disc capable
000Ah	CD-RW	ReWritable Compact Disc capable
000Bh-000Fh	Reserved	
0010h	DVD-ROM	Read only DVD
0011h	DVD-R Sequential recording	Write once DVD using Sequential recording
0012h	DVD-RAM	Rewritable DVD
0013h	DVD-RW Restricted Overwrite	Re-recordable DVD using Restricted Overwrite
0014h	DVD-RW Sequential recording	Re-recordable DVD using Sequential recording

Table 226 - Profile List (Continued)

Profile Number	Profile Name	Description
0015h	DVD-R Dual Layer Sequential recording	Write once DVD using Sequential recording
0016h	DVD-R Dual Layer Jump recording	Write once DVD using Layer Jump recording
0017h-0019h	Reserved	
001Ah	DVD+RW	See MMC
001Bh	DVD+R	See MMC
001Ch-003Fh	Reserved	Reserved
0040h	BD-ROM	See MMC
0041h	BD-R Sequential Recording Mode (SRM)	See MMC
0042h	BD-R Random Recording Mode (RRM)	See MMC
0043h	BD-RE	See MMC
0044h-004Fh	Reserved	Reserved
0050h	HD DVD-ROM	Read only HD DVD
0051h	HD DVD-R	Write once HD DVD
0052h	HD DVD-Rewritable	Rewritable HD DVD
0053h-FFFEh	Reserved	Reserved
FFFFh	Logical units Not Conforming to a Standard Profile	The logical unit does not conform to any Profile.

Example: A DVD-ROM with CD-ROM read capability would always report two Profiles. If no medium were present, the Current Profile field in the Feature Header would contain 0, and the CurrentP bits in both Profile Descriptors would be set to zero. If DVD-ROM media were inserted, the only change would be to set the CurrentP bit of the DVD-ROM Profile to one. If CD-ROM media were then inserted, the CurrentP bit of the DVD-ROM Profile would be set to zero and the CurrentP bit of the CD-ROM Profile would be set to one.

16.4.2.2 Feature 0001h: Core

This Feature describes basic logical unit functionality. This Feature ***shall*** be current. All commands and functions described ***shall*** function normally.

The INQUIRY command ***shall*** be supported. The INQUIRY command ***shall*** complete without an error if the Command Packet is valid.

Logical units ***shall*** be able to report sense to the host. For logical interfaces that report automatic delivery of logical unit Sense Information to the host ***shall*** use the transport's mechanism. For other logical interfaces, the REQUEST SENSE command ***shall*** be supported. The REQUEST SENSE command ***shall not*** generate any new sense information unless the Command Packet is invalid.

The MODE SENSE (10) command ***shall*** be supported. Logical units may not return Block Descriptors. Page Control (PC) field values of 00b, 01b, and 10b ***shall*** be supported for all supported Mode Pages. Logical units ***shall*** be able to report Mode Pages whether or not appropriate media is loaded.

The MODE SELECT (10) command ***shall*** be supported. The Save Pages (SP) bit may not be supported. Logical units ***shall*** be able to accept Mode Pages whether or not appropriate media is loaded.

The GET CONFIGURATION command ***shall*** be supported. UNIT ATTENTION conditions ***shall not*** be reported to the GET CONFIGURATION command.

The TEST UNIT READY command ***shall*** be supported. TEST UNIT READY is a legacy command used to check for the existence of media and to discover UNIT ATTENTION conditions. The GET CONFIGURATION or GET EVENT/STATUS NOTIFICATION commands should be used instead to determine media status.

Logical units ***shall*** be able to report Events to the host. For logical interfaces that support Event reporting to the host ***shall*** use the transport's mechanism. For other logical interfaces, the GET EVENT/STATUS NOTIFICATION command

shall be supported. The host should determine supported events by issuing a GET EVENT/STATUS NOTIFICATION command with the Immediate (Immed) bit set. Zero or more event classes may be supported.

Table 227 - Core Feature Descriptor

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB)	Feature Code = 0001h						
1								(LSB)
2	Reserved		Version = 1				Persistent	Current
3	Additional Length = 08h							
4	(MSB)							
5	Physical Interface Standard							
6								
7								(LSB)
8	Reserved							DBEvent
9	Reserved							
10	Reserved							
11	Reserved							

The Feature Code field ***shall*** be set to 0001h.

The Persistent bit ***shall*** be set to one.

The Current bit ***shall*** be set to one.

The Version field ***shall*** be set to 1h.

The Additional Length field ***shall*** be set to 04h.

The Physical Interface Standard field ***shall*** be set to the current host to logical unit communication path as shown in Table 228.

The Device Busy Class Events (DBEvent) bit, when set to one, indicates that the *16.5.6, "Device Busy Class Events"* on page 461 of the GET EVENT/STATUS NOTIFICATION command ***shall*** be supported. Device Busy Class Events provides progress indication in time unit. When set to zero, the response data of the Device Busy Class Events is not defined in this document. The DBEvent bit ***shall*** be set to 1.

Note: If the version field is set to 0 or if the Additional Length field is set to 4, the response data of the Device Busy Class Events is not reliable due to the unclear description of the old version of this document.

Table 228 - Physical Interface Standard

Physical Interface Standard	Description	Application
00000000h	Unspecified	
00000001h	SCSI Family	See *Appendix C - "SCSI Implementation Notes (Normative)"* on page 749
00000002h	ATAPI	See *Appendix B - "ATAPI Implementation Notes (Normative)"* on page 739
00000003h	IEEE 1394-1995 Family	
00000004h	IEEE 1394A Family	
00000005h	Fibre Channel	See Fibre Channel (FCP) Implementation
00000006h-0000FFFEh	Reserved	
0000FFFFh	Vendor Unique	
00010000h-0001FFFFh	Defined by INCITS	
00020000h-0002FFFFh	Defined by SFFC	
00030000h-0003FFFFh	Defined by IEEE	
00040000h-FFFFFFFFh	Reserved	

16.4.2.3 Feature 0002h: Morphing

The Morphing Feature provides a method for identifying changes in logical unit behavior, and to some extent, preventing changes in logical unit behavior without host involvement. This Feature includes a mechanism for notifying the host about events that have occurred and requests for operational changes, a mechanism for identifying the logical unit's current behavior, and a mechanism for allowing the logical unit to change its behavior. This Feature, if implemented, ***shall*** be current.

The PREVENT/ALLOW MEDIUM REMOVAL command and the Persistent, Prevent bits ***shall*** be supported. When a persistent prevent is in place, the logical unit ***shall not*** allow, to the limit of its design, non-host events to change the operational behavior of the logical unit. Logical units with a mechanical eject may not be able to prevent ejecting the media. When a persistent prevent is in place, events are reported to the host via the GET EVENT/STATUS NOTIFICATION command instead of causing action within the logical unit. For example, if the user presses the eject button while a persistent prevent is in effect, the only action is to report the button press to the host. The logical unit ***shall*** behave as shown in Figure 164 - *Morphing States - Event Generation* on page 373.

The SEND EVENT command ***shall*** be supported for any *16.5.3, "External Request Class Events"* on page 457 that the logical unit may generate. This Command is used to tell the logical unit to perform an action that was previously requested by the logical unit via a External Request Class Events. The host, after receiving a External Request Class Events, prepares for a possible logical unit change by notifying its drivers and flushing buffers as needed. After the host is prepared for a possible logical unit change, it sends the External Request Class Events descriptor back to the logical unit for processing. Support for External Request Class Events is optional.

The GET CONFIGURATION command ***shall*** be supported.

The *16.5.4, "Media Class Events"* on page 459 of GET EVENT/STATUS NOTIFICATION command ***shall*** be supported.

Table 229 - Morphing Feature Descriptor

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB) Feature Code = 0002h							
1								(LSB)
2	Reserved		Version = 1				Persistent	Current
3	Additional Length = 04h							
4	Reserved						OCEvent	Async
5	Reserved							
6	Reserved							
7	Reserved							

The Feature Code field ***shall*** be set to 0002h.

The Persistent bit ***shall*** be set to one.

The Current bit ***shall*** be set to one.

The Version field ***shall*** be set to 1h.

The Additional Length field ***shall*** be set to 04h.

The Async bit, when set to zero, indicates that the logical unit supports only the polling implementation of GET EVENT/STATUS NOTIFICATION (Immed bit set to one). When set to one, indicates that the logical unit supports both polling and asynchronous GET EVENT/STATUS NOTIFICATION (Immed bit set to zero or one).

The Operational Change Request/Notification Class Events (OCEvent) bit, when set to one, indicates that the Operational Change Request/Notification Class Events of GET EVENT/STATUS NOTIFICATION command ***shall*** be supported. When OCEvent bit is set to 0, the response data of the Operational Change Request/Notification Class Events is not described in this document. The implemented logical unit behavior may not be compatible with the description of this document. The OCEvent bit ***shall*** be set to 1.

16.4.2.4 Feature 0003h: Removable Medium

This Feature ***shall*** indicate that the logical unit has removable media. Media ***shall*** be considered removable if it can be removed from the loaded position, i.e. a single mechanism changer, even if the media is captive to the changer. The Feature Descriptor contains information about the logical unit and the loading of media. In particular, the Lock bit indicates the ability of the logical unit to honor at least one aspect of Persistent Prevent.

The logical unit ***shall*** generate Events for media changes. Event Notification Class 4 ***shall*** be supported.

The START/STOP UNIT command ***shall*** be supported. The Immediate (Immed) and Start bits ***shall*** be supported. The load eject (LoEj) bit ***shall*** be supported if the Eject bit in the Removable Medium Feature descriptor is set to one. A Power Condition value of 0 ***shall*** be supported.

The MECHANISM STATUS command ***shall*** be supported.

The PREVENT/ALLOW MEDIUM REMOVAL command with the Persistent bit cleared ***shall*** be supported.

Table 230 - Removable Medium Feature Descriptor

Byte \ Bit	7	6	5	4	3	2	1	0
0	(MSB) Feature Code = 0003h							
1								(LSB)
2	Reserved		Version				Persistent	Current
3	Additional Length = 04h							
4	Loading Mechanism Type			Reserved	Eject	Pvnt Jmpr	Reserved	Lock
5	Reserved							
6	Reserved							
7	Reserved							

The Feature Code field ***shall*** be set to 0003h.

The Persistent bit ***shall*** be set to one.

The Current bit ***shall*** be set to one.

The Additional Length field ***shall*** be set to 04h.

The Loading Mechanism Type field ***shall*** be set according to Table 231.

Table 231 - Loading Mechanism Type

Loading Mechanism Type	Description
000b	Caddy/Slot type loading mechanism
001b	Tray type loading mechanism
010b	Pop-up type loading mechanism
011b	Reserved
100b	Embedded changer with individually changeable discs
101b	Embedded changer using a Magazine mechanism
110b-111b	Reserved

The Eject bit, when set to zero, indicates that the logical unit cannot eject the medium or cartridge via the normal START/STOP UNIT command with the LoEj bit set. When set to one, indicates that the logical unit can eject the medium or cartridge.

The Pvnt Jmpr bit, when set to zero, ***shall*** indicate that the Prevent Jumper is present. The logical unit ***shall*** power up to the allow state and locking the logical unit with the PREVENT/ALLOW MEDIUM REMOVAL command ***shall not*** prevent insertion of the media. When set to one, the Prevent Jumper is not present. The logical unit ***shall*** power up to the prevent state (locked) and ***shall not*** accept new media or allow the ejection of media already loaded until a PREVENT/ ALLOW MEDIUM REMOVAL command (allow) is issued. The Pvnt Jmpr bit ***shall not*** change state, even if the physical jumper is added or removed during operation. Logical units that do not have a Prevent Jumper available should set this bit to 0 to indicate that the logical unit behaves as described for a jumper being present.

The Lock bit, when set to zero, ***shall*** indicate that the medium cannot be locked into the logical unit. When set to one, ***shall*** indicate that the PREVENT/ALLOW MEDIUM REMOVAL command is capable of actually locking the media into the logical unit.

16.4.2.5 Feature 0004h: Write Protect

This Feature identifies reporting capability and changing capability for Write protection status of the logical unit. Current bit ***shall*** indicate that logical unit can currently change PWP status on the medium surface. This bit ***shall*** be set to zero if the logical unit can not set/release the PWP status. The reporting capability of the Write Protect status is persistent and ***shall*** be supported regardless of the Current bit value set to zero.

Note: If logical unit supports reporting Write Protection status but does not support changing, logical unit returns this Feature descriptor. But Current bit is never set to one in the descriptor.

The READ DISC STRUCTURE command with the Format Code code C0h and FFh ***shall*** be supported. See *Section 11.2, "Write Protect Feature and related commands"* on page 353.

Table 232 - Write Protect Feature Descriptor

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB)			Feature Code = 0004h				
1								(LSB)
2	Reserved		Version				Persistent	Current
3	Additional Length = 04h							
4	Reserved						SPWP	SSWPP
5	Reserved							
6	Reserved							
7	Reserved							

The Feature Code field ***shall*** be set to 0004h.

The Persistent bit ***shall*** be defined as in Table 223 - *Feature Descriptor generic format* on page 412. This bit ***shall*** be set to zero if the medium is removable.

The Current bit definition is not same as in Table 223 - *Feature Descriptor generic format* on page 412. The usage of this bit is described in the previous part of this section.

The Additional Length field ***shall*** be set to 04h.

The Supports PWP (SPWP) bit indicates that the logical unit supports set/release PWP status. If SPWP bit is set to one, the SEND DISC STRUCTURE command with the Format Code = C0h ***shall*** be supported.

The Supports SWPP (SSWPP) bit indicates that the logical unit supports SWPP bit of *Time-out & Protect* Mode Page (1Dh). This bit does not affect Current bit of this Feature Descriptor. If SSWPP bit is set to one, the logical unit ***shall*** support SWPP bit of Time-out & Protect Mode Page.

16.4.2.6 Feature 0010h: Random Readable

The Random Readable Feature is for basic sector reading ability found on most storage class logical units for which data are recorded in independently addressable logical blocks which are readable in any order.

The READ (10) command ***shall*** be supported for any recorded sector. The Force Unit Access (FUA) bit ***shall*** be supported when a writable Feature is current. The operation of the READ (10) command is modified by the *Read/Write Error Recovery Parameters* Mode Page (01h) settings.

The READ CAPACITY command ***shall*** be supported.

The Logical Block Size ***shall*** be reported in the Feature Descriptor. The block size for a medium may change for the entire medium after a format operation.

If the PP bit in the Feature Descriptor is set, the TB, RC, PER, DTE, and DCR bits of the *Read/Write Error Recovery Parameters* Mode Page (01h) ***shall*** be supported. An Error Recovery Parameter field of 0 in the *Read/Write Error*

Recovery Parameters Mode Page (01h) ***shall*** be supported. Support for other bits and values in the Page is optional. This Page ***shall not*** change due to medium removal or changes. The changeable fields mask ***shall not*** change due to medium removal or changes. The host ***shall*** be able to change changeable values whether or not media is loaded.

Table 233 - Random Readable Feature Descriptor

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB)			Feature Code = 0010h				
1								(LSB)
2	Reserved		Version				Persistent	Current
3	Additional Length = 08h							
4	(MSB)							
5				Logical Block Size				
6								
7								(LSB)
8	(MSB)			Blocking				
9								(LSB)
10	Reserved							PP
11	Reserved							

The Feature Code field ***shall*** be set to 0010h.

The Persistent bit ***shall*** be defined as in Table 223 - *Feature Descriptor generic format* on page 412. This bit ***shall*** be set to zero if the medium is removable.

The Current bit ***shall*** be defined as in Table 223 - *Feature Descriptor generic format* on page 412. This bit ***shall*** be set to zero if random readable medium is not present.

The Additional Length field ***shall*** be set to 08h.

The Logical Block Size ***shall*** be set to the number of bytes per logical block.

The Blocking field ***shall*** indicate the number of logical blocks per logical unit readable unit. The Blocking field reported in the Feature Descriptor is for performance optimization only. Reads of any sector or sector count ***shall*** be allowed.

*Note: For most CDs and hard disks, this value is 1. For DVD logical units, this number is 10h. For HD DVD logical units, this number id 20h. The Blocking field is used by the host only for performance optimization. If there is more than one Blocking on the medium possible, the Blocking field **shall** be set to zero. See 16.28, "READ TRACK/RZONE INFORMATION command" on page 617 for more information.*

The Page Present (PP) bit, when set to zero, ***shall*** indicate that the *Read/Write Error Recovery Parameters* Mode Page (01h) may not be present. When set to one, ***shall*** indicate that the *Read/Write Error Recovery Parameters* Mode Page (01h) is present.

16.4.2.7 Feature 001Dh: MultiRead

This Feature identifies a logical unit that can read all CD media types. The logical unit ***shall*** conform to the OSTA MultiRead specification 1.00 or greater, with the exception of CD Play capability (the CD Audio analog play Feature is not required). Reading of CD Audio data via the READ CD command ***shall*** be supported.

The READ (10) command ***shall*** be supported.

The Disc Information Block data of the READ DISC INFORMATION command ***shall*** be supported. Logical units that do not have logical Tracks/RZones or logical Sessions ***shall*** identify the media as having one session and one Track/RZone, numbered as Track/RZone 1. Fields that do not apply to the loaded media ***shall*** be marked as invalid or set to zero, as appropriate.

The READ TRACK/RZONE INFORMATION command except Appendable bit ***shall*** be supported. Logical units that do not have logical Tracks/RZones ***shall*** report information as if the medium contains one Track/RZone encompassing all logical blocks on the medium.

Table 234 - MultiRead Feature Descriptor

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB) Feature Code = 001Dh							
1	Feature Code = 001Dh (LSB)							
2	Reserved		Version				Persistent	Current
3	Additional Length = 00h							

The Feature Code field ***shall*** be set to 001Dh.

The Persistent bit ***shall*** be defined as in Table 223 - *Feature Descriptor generic format* on page 412.

The Current bit ***shall*** be defined as in Table 223 - *Feature Descriptor generic format* on page 412.

The Additional Length field ***shall*** be set to 00h.

16.4.2.8 Feature 001Eh: CD Read

This Feature indicates that the logical unit is capable of reading CD media, e.g., CD-ROM, CD-R and CD-RW, with logical formats including fixed and variable packets. When reading fixed packets, the drive ***shall*** perform Method 2 address translation. Reading of digital audio via the READ CD command ***shall*** be supported. The reading of Audio Data ***shall*** be aligned such that contiguous READ CD command return contiguous information, even if buffer overruns or underruns occur.

This Feature ***shall*** indicate support for reading structures specific to CD. This Feature ***shall*** be current only if CD specific structures are available for reading.

The READ TOC/PMA/ATIP command with Format codes of 0h, 1h, and 2h ***shall*** be supported. If the CD-Text bit is set, code 5h ***shall*** be supported.

The READ CD and READ CD MSF commands ***shall*** be supported. All data forms shaded in Table 395 - *Number of Bytes Returned Based on Data Selection Field* on page 545 ***shall*** be supported; non-shaded forms are optional.

Table 235 - CD Read Feature Descriptor

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB) Feature Code = 001Eh							
1	Feature Code = 001Eh (LSB)							
2	Reserved		Version = 1				Persistent	Current
3	Additional Length = 04h							
4	Reserved						C2	CD-Text
5	Reserved							
6	Reserved							
7	Reserved							

The Feature Code field ***shall*** be set to 001Eh.

The Version field ***shall*** be set to one.

The Persistent bit ***shall*** be defined as in Table 223 - *Feature Descriptor generic format* on page 412. This bit ***shall*** be set to zero if the medium is removable.

The Current bit ***shall*** be defined as in Table 223 - *Feature Descriptor generic format* on page 412. This bit ***shall*** be set to zero if CD medium is not present.

The Additional Length field ***shall*** be set to 04h.

The C2 bit, when set to 1, ***shall*** indicate that the logical unit returns C2 error data. When set to 0, the logical unit does not support C2 error data.

The CD-Text bit, when set to 1, ***shall*** indicate that the logical unit supports the READ TOC/PMA/ATIP command with Format = 5. When set to 0, CD-Text is not supported.

16.4.2.9 Feature 001Fh: DVD Read

This Feature identifies a logical unit that can read DVD specific information from the media.

This Feature ***shall*** indicate support for reading DVD specific structures. This Feature ***shall*** be current only if DVD specific structures are available for reading.

The READ DISC STRUCTURE command with Format Code Codes of 00h, 01h, 03h and 04h ***shall*** be supported. If the logical unit also reports the DVD-RAM Profile (*15.11, "Profile 0012h: DVD-RAM"* on page 384) or supports reading of DVD-RAM media, then Format Code code of 08h ***shall*** be supported if DVD-RAM media is present.

The READ (10) command ***shall*** be supported. The READ (12) command ***shall*** be supported.

The READ TOC/PMA/ATIP command ***shall*** be supported, along with fabrication of data for DVD media as specified in the command description.

Table 236 - DVD Read Feature Descriptor

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB)			Feature Code = 001Fh				
1								(LSB)
2	Reserved		Version = 1				Persistent	Current
3	Additional Length = 04h							
4	Reserved							MULTI110
5	Reserved							
6	Reserved							Dual-R
7	Reserved							

The Feature Code field ***shall*** be set to 001Fh.

The Persistent bit ***shall*** be defined as in Table 223 - *Feature Descriptor generic format* on page 412. This bit ***shall*** be set to zero if the medium is removable.

The Current bit ***shall*** be defined as in Table 223 - *Feature Descriptor generic format* on page 412. This bit ***shall*** be set to zero if DVD medium is not present.

The Version field ***shall*** be set to 1h.

The Additional Length field ***shall*** be set to 04h.

If the DVD Multi Specification Version 1.1 (MULTI110) bit is set to one, logical unit ***shall*** comply with the specification. Reserved bits in byte 4 are reserved for DVD Forum future Specifications.

If the DVD-R Dual Layer (Dual-R) bit is set to one, logical unit ***shall*** support reading capability all recording formats of Dual-R disc including Remapping.

16.4.2.10 Feature 0020h: Random Writable

This Feature identifies a logical unit that can write data to logical blocks specified by a WRITE (10) command. There is no requirement that the addresses in sequences of writes occur in any particular order. This Feature ***shall*** be present only if writable media is present. Write protected media ***shall not*** be considered writable.

The WRITE (10) command ***shall*** be supported.

The SYNCHRONIZE CACHE command ***shall*** be supported. The Immediate bit ***shall*** be supported.

The WRITE AND VERIFY (10) command ***shall*** be supported.

The READ CAPACITY command ***shall*** be supported.

Table 237 - Random Writable Feature Descriptor

Byte \ Bit	7	6	5	4	3	2	1	0
0	(MSB)			Feature Code = 0020h				
1								(LSB)
2	Reserved		Version =1				Persistent	Current
3	Additional Length = 0Ch							
4	(MSB)							
5				Last LBA				
6								
7								(LSB)
8	(MSB)							
9				Logical Block Size				
10								
11								(LSB)
12	(MSB)			Blocking				
13								(LSB)
14	Reserved							PP
15	Reserved							

The Feature Code field ***shall*** be set to 0020h.

The Version field ***shall*** be set to 01h.

The Persistent bit ***shall*** be defined as in Table 223 - *Feature Descriptor generic format* on page 412. This bit ***shall*** be set to zero if the medium is removable.

The Current bit ***shall*** be defined as in Table 223 - *Feature Descriptor generic format* on page 412. This bit ***shall*** be set to zero if randomly writable medium is not present.

The Additional Length field ***shall*** be set to 0Ch.

Note: Earlier versions of this specification had the Version field set to zero, and the Additional Length was 4.

The Last LBA field is the address of the last addressable data block.

The Logical Block Size is the number of bytes per logical block. This value ***shall*** be the same as reported by the Random Readable Feature and the READ CAPACITY command.

The Blocking field ***shall*** indicate the number of logical blocks per logical unit writable unit. The Blocking field reported in the Feature Descriptor is for performance optimization only. Writes of any sector or sector count ***shall*** be allowed.

If the Page Present (PP) bit is set to one, all fields in the *Read/Write Error Recovery Parameters* Mode Page (01h) ***shall*** be supported. If set to zero, ***shall*** indicate that the *Read/Write Error Recovery Parameters* Mode Page (01h) may not be present.

16.4.2.11 Feature 0021h: Incremental Streaming Writable

This Feature identifies a logical unit that can write data to a contiguous region, and can append data to a limited number of locations on the media. On CD media, this is known as packet recording.

This Feature ***shall*** indicate support for sequential recording, such as CD Packet, and DVD Incremental recording to write once or rewritable media and HD DVD incremental recording. This Feature ***shall*** become not current after a Disc final closure is performed.

The WRITE (10) command ***shall*** be supported. Writing may be limited to locations identified by the READ DISC INFORMATION command and READ TRACK/RZONE INFORMATION commands. If sequential WRITE (10) commands occur to contiguous locations at a sufficient rate, the logical unit ***shall*** stream the data to the medium without interruption or link generation occurring. If the writing is interrupted due to insufficient data ("underrun") or is forced by a SYNCHRONIZE CACHE or other command, a link ***shall*** be generated (except HD DVD). The nominal size of the link ***shall*** be that specified by the *Write Parameters* Mode Page (05h). The number of padding and link blocks actually recorded may also depend on blocking: the data from the host may first be padded to fill a Blocking unit and then a link ***shall*** be appended. See *4.16.10.2, "ECC boundary padding and Data Type bit in ID field"* on page 136 for an example with DVD-R media.

While a streaming write is in progress (data are in the logical unit's buffer but not committed to the medium), the commands in Table 238 ***shall*** perform normally without interrupting the writing. All other commands ***shall*** perform normally, but may interrupt recording. All other commands may force a SYNCHRONIZE CACHE before execution. Logical units should perform all other commands without flushing the write buffer. This is possible if writing to the medium has not yet started. Normal execution is defined as the behavior the command would have if no data were in the write buffer.

If the host closes the Session or Border, and there is insufficient space for another Session or Border to follow, the logical unit ***shall*** close the Session or Border with no next Session or Border pointer (on CD, point B0 would not exist).

Note: The CD MultiSession standard allows B0 = FF/FF/FF to indicate the same thing, but some legacy drives do not properly handle this means of marking the last Session.

Table 238 - Commands that shall not interrupt streaming writing

COMMAND	COMMENT
TEST UNIT READY	
READ TRACK/RZONE INFORMATION	Required only for current Track/RZone
GET EVENT/STATUS NOTIFICATION	
GET CONFIGURATION	
REQUEST SENSE	
INQUIRY	
READ BUFFER CAPACITY	
WRITE (10)	For NWA in current Track/RZone

The SYNCHRONIZE CACHE command ***shall*** be supported. The SYNCHRONIZE CACHE command ***shall*** force the underrun condition regardless of the state of the Immediate bit.

For C/DVD, the *Write Parameters* Mode Page (05h) ***shall*** be supported. If CD media is present, the Packet recording write type ***shall*** be available. If DVD media is present, the Incremental recording write method ***shall*** be available. The Write Parameters Mode Page may contain or be actively set to settings that are incompatible with the current medium, or be set when no medium is present. If writing is attempted when the Write Parameters Mode Page is not compatible with the current track, RZone, or medium, the logical unit ***shall*** return CHECK CONDITION status, 5/64/00 ILLEGAL

MODE FOR THIS TRACK, and the sense key specific information set to the byte and field of the incompatible parameter in the Mode Page.

The CLOSE TRACK/RZONE/SESSION/BORDER command ***shall*** be supported.

The Reservation Size Mode Reservation of the RESERVE TRACK/RZONE/RMZ command ***shall*** be supported.

The Disc Information Block data of the READ DISC INFORMATION command ***shall*** be supported.

The READ TRACK/RZONE INFORMATION command except Appendable bit ***shall*** be supported.

If the Erasable flag in the READ DISC INFORMATION command is set to one, the BLANK command ***shall*** be supported with Blanking Types of 000b, 001b, and 100b for CD, 000b and 001b for DVD.

If OPC information is ever returned via the READ DISC INFORMATION command, the SEND OPC INFORMATION command ***shall*** be supported.

Table 239 - Incremental Streaming Writable Feature Descriptor

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB)			Feature Code = 0021h				
1								(LSB)
2	Reserved		Version = 3				Persistent	Current
3	Additional Length							
4	(MSB)			Data Block Type Supported				
5								(LSB)
6	Reserved					NWAI	ARSV	BUF
7	Number of Link Sizes							
8-n	Link Size							
n-?	Pad							

The Feature Code field ***shall*** be set to 0021h.

The Version field ***shall*** be set to 3h.

The Persistent bit ***shall*** be defined as in Table 223 - *Feature Descriptor generic format* on page 412. This bit ***shall*** be set to zero if the medium is removable.

The Current bit ***shall*** be defined as in Table 223 - *Feature Descriptor generic format* on page 412. This bit ***shall*** be set to zero if sequential write medium is not present. The Current bit may not be set at the medium insertion even if this Feature is available on the medium. See *14.4, "Delayed Feature reporting"* on page 376.

For C/DVD, the Additional Length field ***shall*** be set to 4 + (Number of Link Sizes) + (Number of Pad bytes). For HD DVD, the Additional Length field ***shall*** be set to 4.

The Data Block Type Supported field is a bit field that identifies the supported Data Block Type. A bit set to zero indicates the Data Type is not supported. A bit set to one indicates the Data Block Type is supported. Bit 0 equates to Data Block Type 0 and bit 15 equates to Data Block Type 15, etc.

The BUF bit, when set to 1, ***shall*** indicate that Buffer Under-run Free recording is available for the current mounted media.

The ARSV bit, when set to 1, ***shall*** indicate that Address Mode Reservation of RESERVE TRACK/RZONE/RMZ command is available for the current mounted media.

The NWAI bit, when set to 1, ***shall*** indicate that Assigned Track information of READ DISC INFORMATION command and Appendable bit of READ TRACK/RZONE INFORMATION command are available for the current mounted media. This bit may not be set to 1 for CD-R/RW media.

ARSV bit and NWAI bit may be changed according to the mounted medium. If logical unit does not support the capability on the mounted medium when Incremental Streaming Writable Feature Descriptor is current, the bit ***shall not*** be set to one. When this Feature is not current if these options are supported on some sequential recording medium logical unit ***shall*** set the option bit to 1.

The Number of Link Sizes ***shall*** specify the number of link sizes available for the current media. For HD DVD-R, this field ***shall*** be set to 0.

Note: For CD media, this field should be 1. For DVD-R, this field should be 2.

Each Link Size field ***shall*** indicate the number of logical blocks per link. Links occur on sequentially written media between independent write operations. The link size does not include any logical blocks written by the logical unit to satisfy the writable unit specified by the Blocking field in the Random Readable Feature. Link Size fields are reported by the logical unit in the logical unit's preferred order, most desirable first.

Note: This field is 7 for CD-R media, and may be 0, 1, or 16 for DVD media.

The Pad field ***shall*** contain zeros. The number of Pad bytes ***shall*** be *4 * IP((Number of Link Sizes + 3)/4) - (Number of Link Sizes)*, where "*IP()*" is the integer part of the number. The Pad field is present to make the length of the Feature Descriptor a multiple of 4 bytes.

16.4.2.12 Feature 0022h: Sector Erasable

This Feature identifies a logical unit that supports erasable media and media that requires an erase pass before overwrite, such as some magneto-optical technologies.

Note: This Feature does not apply to DVD-RAM/-RW, DVD+RW or HD DVD-Rewritable, which use a direct overwrite technology.

This Feature ***shall*** identify a system in which sectors ***shall*** be erased before overwriting. The default operation of the logical unit is to perform an erase pass before writing.

The logical unit ***shall*** generate a CHECK CONDITION status, 8/--/-- BLANK CHECK if the host attempts to read an erased logical block.

The Erase By-pass (EBP) bit in the WRITE (10) command ***shall*** be supported. If the EBP bit is set to one, the host is indicating to the logical unit that the block(s) addressed are known to be erased and therefore don't require erasure before recording. If the EBP bit is set to zero, the logical unit ***shall*** perform an erase pass before recording.

The ERASE (10) command ***shall*** be supported.

The blank verify (BlkVfy) bit of the VERIFY (10) command ***shall*** be supported.

Table 240 - Sector Erasable Feature Descriptor

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB)			Feature Code = 0022h				
1								(LSB)
2	Reserved		Version				Persistent	Current
3	Additional Length = 00h							

The Feature Code field ***shall*** be set to 0022h.

The Persistent bit ***shall*** be defined as in Table 223 - *Feature Descriptor generic format* on page 412. This bit ***shall*** be set to zero if the medium is removable.

The Current bit ***shall*** be defined as in Table 223 - *Feature Descriptor generic format* on page 412. This bit ***shall*** be set to zero if non-sector erasable medium is present.

The Additional Length field ***shall*** be set to 00h.

16.4.2.13 Feature 0023h: Formattable

This Feature identifies the ability to format media. The type of formatting that may be performed is defined in the FORMAT UNIT command (see Table 214 - *FORMAT UNIT Parameter List* on page 400).

The READ FORMAT CAPACITIES command ***shall*** be supported. All descriptors returned ***shall*** be valid for the current medium. A Format Type of 00h ***shall*** be supported.

The FORMAT UNIT command with a Format Code of 001b ***shall*** be supported. Format Type of 00h ***shall*** be supported.

The VERIFY (10) command ***shall*** be supported.

The REQUEST SENSE command ***shall*** be supported.

Table 241 - Formattable Feature Descriptor

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB)			Feature Code = 0023h				
1								(LSB)
2	Reserved		Version				Persistent	Current
3	Additional Length = 00h							

The Feature Code field ***shall*** be set to 0023h.

The Persistent bit ***shall*** be defined as in Table 223 - *Feature Descriptor generic format* on page 412. This bit ***shall*** be set to zero if the medium is removable.

The Current bit ***shall*** be defined as in Table 223 - *Feature Descriptor generic format* on page 412. This bit ***shall*** be set to zero if non-formattable medium is present.

The Additional Length field ***shall*** be set to 00h.

16.4.2.14 Feature 0024h: Hardware Defect Management

This Feature identifies a logical unit that ***shall*** be able to perform defect management to provide the host with an apparently defect-free contiguous address space. This Feature ***shall*** be current only if media with defect management capability is present. If reading of defect managed media type(s) is supported, even if write operations are not supported, the Hardware Defect Management Feature ***shall*** be reported.

When this Feature is current, Enhanced Defect Reporting Feature ***shall not*** be current.

If the current media is writable by the logical unit, the Automatic Write Reallocation Enabled (AWRE) and Automatic Read Reallocation Enabled (ARRE) bits (see *16.11.3.1, "Read/Write Error Recovery Parameters Mode Page"* on page 495) and associated functionality of those bits ***shall*** be supported.

Table 242 - Hardware Defect Management Feature Descriptor

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB)	Feature Code = 0024h						
1								(LSB)
2	Reserved		Version = 1				Persistent	Current
3	Additional Length = 04h							
4	SSA	Reserved						
5	Reserved							
6	Reserved							
7	Reserved							

The Feature Code field ***shall*** be set to 0024h.

The Version field ***shall*** be set to 01h.

The Persistent bit ***shall*** be defined as in Table 223 - *Feature Descriptor generic format* on page 412. This bit ***shall*** be set to zero if the medium is removable.

The Current bit ***shall*** be defined as in Table 223 - *Feature Descriptor generic format* on page 412. This bit ***shall*** be set to zero if managed medium is not present.

Note: Defect Managed media may have no defects.

The Additional Length field ***shall*** be set to 04h.

The SSA bit of one ***shall*** indicate that the logical unit supports the READ DISC STRUCTURE command with Format Code Code 0Ah (Spare Area Information).

16.4.2.15 Feature 0025h: Write Once

This Feature identifies a logical unit that has the ability to record to any previously unrecorded logical block. The recording of logical blocks may occur in any order. Previously recorded blocks ***shall not*** be overwritten.

This Feature identifies a logical unit that can write data to randomly addressed logical blocks specified by a WRITE (10) command. There is no requirement that the addresses in sequences of writes occur in any particular order. This Feature ***shall*** be present only if write once media is present. Write protected media ***shall not*** be considered writable. After being written once, the logical unit cannot record the same block again. If the logical unit detects that all logical blocks are recorded, this Feature ***shall*** become not current.

The Random Readable Feature ***shall*** be current when this Feature is current.

The WRITE (10) and WRITE AND VERIFY (10) commands ***shall*** be supported. Writing may occur to any previously unrecorded logical block. If recording is attempted to any recorded logical block, the logical unit ***shall*** generate CHECK CONDITION status, 8/--/-- BLANK CHECK.

The READ CAPACITY command ***shall*** be supported.

The SYNCHRONIZE CACHE command ***shall*** be supported. The Immediate bit ***shall*** be supported.

The *Read/Write Error Recovery Parameters* Mode Page (01h) ***shall*** be supported.

Table 243 - Write Once Feature Descriptor

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB)	Feature Code = 0025h						
1								(LSB)
2	Reserved		Version				Persistent	Current
3	Additional Length = 08h							
4	(MSB)	Logical Block Size						
5								
6								
7								(LSB)
8	(MSB)	Blocking						
9								(LSB)
10	Reserved							PP
11	Reserved							

The Feature Code field ***shall*** be set to 0025h.

The Persistent bit ***shall*** be defined as in Table 223 - *Feature Descriptor generic format* on page 412. This bit ***shall*** be set to zero if the medium is removable.

The Current bit ***shall*** be defined as in Table 223 - *Feature Descriptor generic format* on page 412. This bit ***shall*** be set to zero if write once medium is not present.

The Additional Length field ***shall*** be set to 08h.

The Logical Block Size is the number of bytes per logical block. This value ***shall*** be the same as reported by the Random Readable Feature and the READ CAPACITY command.

The Blocking field ***shall*** indicate the number of logical blocks per logical unit writable unit. The Blocking field reported in the Feature Descriptor is for performance optimization only. Writes of any sector or sector count ***shall*** be allowed

If the Page Present (PP) bit is set to one, all fields in the *Read/Write Error Recovery Parameters* Mode Page (01h) ***shall*** be supported. When set to zero, ***shall*** indicate that the *Read/Write Error Recovery Parameters* Mode Page (01h) may not be present.

16.4.2.16 Feature 0026h: Restricted Overwrite

The Restricted Overwrite Feature ***shall*** indicate the ability to perform writing only on Blocking boundaries. This Feature replaces the Random Writable Feature for logical units that do not perform read-modify-write operations on write requests smaller than Blocking. This Feature ***shall not*** be current if the Random Writable Feature is current. This Feature may be present only when Restricted Overwritable media, such as CD-RW with a single track containing fixed packets, is loaded. Logical units with write protected media ***shall not*** have this Feature current. If this Feature is current, the Random Writable Feature ***shall not*** be current.

On CD-RW, this Feature should be current only if the first track on the media is formatted for fixed packets and is complete. The Blocking field in the Random Readable Feature ***shall*** be equal to the packet size. The Last Addressable Block ***shall*** be the last addressable block in the first track. If more than one track is present on the media, the host ***shall*** use READ TRACK/RZONE INFORMATION command to obtain a description of the medium.

Writing from the host into the first track ***shall*** be in units of Blocking. Writing ***shall*** begin at Blocking boundaries. The writable units may be sent via multiple WRITE (10) commands. If the logical unit receives a Write that does not begin on a Blocking boundary and is not contiguous with a previous Write that did begin on a Blocking boundary ***shall*** return CHECK CONDITION status, 5/21/02 INVALID ADDRESS FOR WRITE. If an incomplete set of blocks is received and the logical unit is required to flush its cache via SYNCHRONIZE CACHE or other implied causes, the logical unit ***shall*** generate CHECK CONDITION status, 1/0C/0A WRITE ERROR - PADDING BLOCKS ADDED.

The WRITE (10) command ***shall*** be supported.

The Disc Information Block data of the READ DISC INFORMATION command ***shall*** be supported.

The READ TRACK/RZONE INFORMATION command except Appendable bit ***shall*** be supported.

The READ CAPACITY command ***shall*** be supported.

The SYNCHRONIZE CACHE command ***shall*** be supported.

The *Write Parameters* Mode Page (05h) ***shall*** be supported.

Table 244 - Restricted Overwrite Feature Descriptor

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB)			Feature Code = 0026h				
1								(LSB)
2	Reserved		Version				Persistent	Current
3	Additional Length = 00h							

The Feature Code field ***shall*** be set to 0026h.

The Persistent bit ***shall*** be defined as in Table 223 - *Feature Descriptor generic format* on page 412. This bit ***shall*** be set to zero if the medium is removable.

The Current bit ***shall*** be defined as in Table 223 - *Feature Descriptor generic format* on page 412. This bit ***shall*** be set to zero if Restricted Overwritable medium is not present. The Current bit may not be set at the medium insertion even if this Feature is available on the medium. See *14.4, "Delayed Feature reporting"* on page 376.

The Additional Length field ***shall*** be set to 00h.

16.4.2.17 Feature 0027h: CD-RW CAV Write

The CD-RW CAV Write Feature identifies a logical unit that has the ability to perform writing on CD-RW media in CAV mode. The logical unit ***shall*** conform to the Orange Book Part 3 Volume 2 specification. This Feature ***shall not*** be current if high speed recordable CD-RW media is not mounted. Logical units with write protected media ***shall not*** have this Feature current.

The WRITE (10) command ***shall*** be supported.

The Disc Information Block data of the READ DISC INFORMATION command ***shall*** be supported.

The READ TRACK/RZONE INFORMATION command except Appendable bit ***shall*** be supported.

The READ CAPACITY command ***shall*** be supported.

The SYNCHRONIZE CACHE command ***shall*** be supported.

The *Write Parameters* Mode Page (05h) ***shall*** be supported.

Table 245 - CD-RW CAV Write Feature Descriptor

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB) Feature Code = 0027h							
1								(LSB)
2	Reserved		Version				Persistent	Current
3	Additional Length = 04h							
4	Reserved							
5	Reserved							
6	Reserved							
7	Reserved							

The Feature Code field ***shall*** be set to 0027h.

The Persistent bit ***shall*** be defined as in Table 223 - *Feature Descriptor generic format* on page 412. This bit ***shall*** be set to zero if the medium is removable.

The Current bit ***shall*** be defined as in Table 223 - *Feature Descriptor generic format* on page 412. This bit ***shall*** be set to zero if high speed recordable CD-RW medium is not present.

The Additional Length field ***shall*** be set to 04h.

16.4.2.18 Feature 0029h: Enhanced Defect Reporting

The Enhanced Defect Reporting Feature identifies a logical unit that has the ability to perform media certification and RECOVERED ERROR reporting for Logical unit assisted software defect management. In case of Persistent-DM mode, the READ (12) command with Streaming bit = 1 may be performed without medium certification.

When this Feature is current, Hardware Defect Management Feature ***shall not*** be current. This Feature may be current if Restricted Overwrite formatted media or Rigid Restricted Overwrite formatted media is loaded.

The Current bit of this Feature is not affected by EMCDR field and PER bit settings.

The READ (10) command and READ (12) command with Streaming bit = 0 ***shall*** be supported.

The WRITE (10) command and WRITE (12) command with Streaming bit = 0 ***shall*** be supported.

The VERIFY (10) command and WRITE AND VERIFY (10) command ***shall*** be supported.

The PER bit and EMCDR field of *Read/Write Error Recovery Parameters* Mode Page (01h) ***shall*** be supported.

The SYNCHRONIZE CACHE command ***shall*** be supported. Implicit SYNCHRONIZE CACHE operation ***shall*** be supported. See *9.4, "Implicit synchronize cache"* on page 340.

The Disc Information Block data of the READ DISC INFORMATION command ***shall*** be supported.

The GET PERFORMANCE command with Type field of 04h ***shall*** be supported.

If logical unit supports DRT-DM mode, the following additional commands and functions ***shall*** be supported.

The READ (12) command with Streaming bit = 1 and WRITE (12) command with Streaming bit = 1 ***shall*** be supported.

Either large DBI buffer memory model or small DBI cache memory model or both ***shall*** be supported.

When small DBI cache memory model is supported, the SET STREAMING command with Type field of 05h and the GET PERFORMANCE command with Type field of 05h ***shall*** be supported.

See Table 297 - *Type field values description* on page 465 and Table 601 - *Type field values description* on page 693.

Table 246 - Enhanced Defect Reporting Feature Descriptor

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB)			Feature Code = 0029h				
1								(LSB)
2	Reserved		Version				Persistent	Current
3	Additional Length = 04h							
4	Reserved							DRT-DM
5	Number of DBI cache zones							
6	(MSB)			Number of entries				
7								(LSB)

The Feature Code field ***shall*** be set to 0029h.

The Persistent bit ***shall*** be defined as in Table 223 - *Feature Descriptor generic format* on page 412. This bit ***shall*** be set to zero if the medium is removable.

The Current bit ***shall*** be defined as in Table 223 - *Feature Descriptor generic format* on page 412. This bit ***shall*** be set to zero if Hardware Defect Management feature is current.

The Additional Length field ***shall*** be set to 04h.

DRT-DM bit, if set to 1, ***shall*** indicate that the logical unit supports DRT-DM mode. If set to 0, ***shall*** indicate that the logical unit supports Persistent-DM mode.

Number of DBI cache zones field specifies possible maximum number of regions that logical unit can handle DBI cache separately. If this field is set to 0, ***shall*** indicate that logical unit supports *9.3.4.1, "Simple DBI memory model"* on page 338. If this field is set to 1, ***shall*** indicate that logical unit supports *9.3.4.2, "Large DBI buffer memory model"* on page 338. In case of *9.3.4.3, "Small DBI cache memory model"* on page 338, Number of DBI cache zones field ***shall*** be set to 2 or higher (minimum number of this field is 2). The value of Number of DBI cache zones field may be changed by media type. If this Feature is not current, this field is invalid.

Table 247 - Relationship between Value of Number of DBI cache zones field and DBI memory model type

DRT-DM	Value of Number of DBI cache zones field	Number of entries	DBI buffer model type of logical unit
0	0	n[a]	simple memory model, cleared at the beginning of medium certification
0	1	0	large DBI buffer model
0	2 or higher	n[a]	small DBI cache model
1	0	n/a	Reserved
1	1	0	large DBI buffer model
1	2 or higher	n[a]	small DBI cache model

a. Value of n ***shall*** be 10 or higher.

Number of entries filed indicates that the number of entries that in the worst case may cause DBI memory overflow. In case of large DBI buffer model, this field ***shall*** be set to 0. For other DBI memory model, this filed ***shall*** be set to 10 or higher. The value of this field may be changed by media type. If this Feature is not current, this field is invalid.

16.4.2.19 Feature 002Ch: Rigid Restricted Overwrite

The Rigid Restricted Overwrite Feature ***shall*** indicate the ability to perform writing only on Blocking boundaries. This Feature is different from Restricted Overwrite Feature (0026h) because each Write command ***shall*** also end on a Blocking boundary. This Feature replaces the Random Writable Feature for logical units that do not perform read-modify-write operations on write requests smaller than Blocking. This Feature ***shall not*** be current if the Random Writable Feature is current. This Feature may be present when DVD-RW Restricted Overwritable media is loaded. Logical units with write protected media ***shall not*** have this Feature current. If this Feature is current, the Random Writable Feature ***shall not*** be current.

The host ***shall*** use the READ DISC INFORMATION and READ TRACK/RZONE INFORMATION commands to obtain a description of the medium such as Blocking Factor.

If more than one RZone/Border is present on the media, the host ***shall*** use the READ DISC INFORMATION and READ TRACK/RZONE INFORMATION commands to obtain a description of the medium.

Writing from the host into the media ***shall*** be in units of Blocking. Writing ***shall*** begin and ***shall*** stop at Blocking boundaries. The writable units may be sent via multiple WRITE (10) commands. If the logical unit receives a Write that does not begin on a Blocking boundary ***shall*** return CHECK CONDITION status, 5/21/02 INVALID ADDRESS FOR WRITE. And if the logical unit receives a Write that does not end on a Blocking boundary ***shall*** return CHECK CONDITION status, 5/24/00 INVALID FIELD IN CDB.

The WRITE (10) command ***shall*** be supported.

The Disc Information Block data of the READ DISC INFORMATION command ***shall*** be supported.

The READ TRACK/RZONE INFORMATION command except Appendable bit ***shall*** be supported.

The READ CAPACITY command ***shall*** be supported.

The SYNCHRONIZE CACHE command ***shall*** be supported.

The VERIFY (10) command ***shall*** be supported.

Table 248 - Rigid Restricted Overwrite Feature Descriptor

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB) Feature Code = 002Ch							
1								(LSB)
2	Reserved		Version				Persistent	Current
3	Additional Length = 04h							
4	Reserved				DSDG	DSDR	Intermediate	Blank
5	Reserved							
6	Reserved							
7	Reserved							

The Feature Code field ***shall*** be set to 002Ch.

The Persistent bit ***shall*** be defined as in Table 223 - *Feature Descriptor generic format* on page 412. This bit ***shall*** be set to zero if the medium is removable.

The Current bit ***shall*** be defined as in Table 223 - *Feature Descriptor generic format* on page 412. This bit ***shall*** be set to zero if DVD-RW medium is not present.

The Additional Length field ***shall*** be set to 04h.

The Defect Status Data Generate (DSDG) bit, if set to 1, ***shall*** indicate that the logical unit supports to generate Defect Status data during formatting. A disable certification (DCRT) bit of Table 215 - *Format List Header* on page 400 ***shall*** be supported. If set to 0, ***shall*** indicate that the logical unit does not support generating of Defect status data.

The Defect Status Data Read (DSDR) bit, if set to 1, ***shall*** indicate that the logical unit supports to read Defect Status data recorded on a medium. The GET PERFORMANCE command with Type = 2 (Defect Status) ***shall*** be supported if the DSDR bit is set to 1. If this bit is set to 0, ***shall*** indicate that the logical unit does not support reading of Defect Status data.

The Intermediate bit, if set to 1, ***shall*** indicate that the logical unit supports writing on an intermediate state Bordered Area and quick formatting (Format Type of 15h - Quick Format). If set to 0, ***shall*** indicate that the logical unit does not support writing on an intermediate state Bordered Area and quick formatting.

The Blank bit, if set to 1, ***shall*** indicate that the logical unit supports BLANK command, Blanking Type 00h and 01h. If set to 0, ***shall*** indicate that the logical unit does not support BLANK command.

16.4.2.20 Feature 002Dh: CD Track at Once

This Feature ***shall*** indicate support for sequential Track at Once recording to write once or rewritable media. This Feature ***shall*** become not current after a Disc final closure is performed.

The WRITE (10) command ***shall*** be supported. Writing may be limited to locations identified by the READ DISC INFORMATION and READ TRACK/RZONE INFORMATION commands. If sequential WRITE (10) commands occur to contiguous locations at a sufficient rate, the logical unit ***shall*** stream the data to the medium without interruption or link generation occurring. If the writing is interrupted due to insufficient data (“underrun”) or is forced by a SYNCHRONIZE CACHE or other command, run-out and link ***shall*** be generated after padding. Padding ***shall*** consist of (1) sufficient blocks of zeros to make the track the minimum length and (2) padded to fill an existing reservation for the track. If the track is of minimum length and is not reserved, no padding blocks ***shall*** be added.

While a Track at Once write is in progress (data are in the logical unit’s buffer but not committed to the medium), the commands in Table 249 ***shall*** perform normally without interrupting the writing. All other commands ***shall*** perform normally, but may interrupt recording. All other commands may force a SYNCHRONIZE CACHE before execution. Logical units should perform all other commands without flushing the write buffer. This is possible if writing to the medium has not yet started. Normal execution is defined as the behavior the command would have if no data were in the write buffer.

Table 249 - Commands that shall not interrupt Track at Once writing

COMMAND	COMMENT
GET CONFIGURATION	
GET EVENT/STATUS NOTIFICATION	
INQUIRY	
READ BUFFER CAPACITY	
READ TRACK/RZONE INFORMATION	Required only for current Track/RZone
REQUEST SENSE	
TEST UNIT READY	
WRITE (10)	For NWA in current Track/RZone

The SYNCHRONIZE CACHE command ***shall*** be supported. The SYNCHRONIZE CACHE command ***shall*** force the underrun condition regardless of the state of the Immediate bit.

The *Write Parameters* Mode Page (05h) ***shall*** be supported. If CD medium is present, the Track at Once recording write type ***shall*** be available. The Write Parameters Mode Page may contain or be actively set to settings that are incompatible with the current medium, or be set when no medium is present. If writing is attempted when the Write Parameters Mode Page is not compatible with the current Track or medium, the logical unit ***shall*** return CHECK CONDITION status, 5/

64/00 ILLEGAL MODE FOR THIS TRACK, and the sense key specific information set to the byte and field of the incompatible parameter in the Mode Page.

The CLOSE TRACK/RZONE/SESSION/BORDER command ***shall*** be supported.

The Reservation Size Mode Reservation of the RESERVE TRACK/RZONE/RMZ command ***shall*** be supported.

The Disc Information Block data of the READ DISC INFORMATION command ***shall*** be supported.

The READ TRACK/RZONE INFORMATION command except Appendable bit ***shall*** be supported.

If the CD-RW flag is set in the CD Track at Once Feature Descriptor is set, the Erasable bit in the READ DISC INFORMATION result data may be set to one and the BLANK command ***shall*** be supported. Blanking Types 000b, 001b ***shall*** be supported. Overwriting of previously recorded tracks ***shall*** be allowed. Overwriting of previously recorded tracks is performed as if the track had been reserved and not recorded (the PMA entry is unchanged).

If OPC information is ever returned via READ DISC INFORMATION, the SEND OPC INFORMATION command ***shall*** be supported.

Table 250 - CD Track at Once Feature Descriptor

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB)			Feature Code = 002Dh				
1								(LSB)
2	Reserved		Version = 2				Persistent	Current
3	Additional Length = 04h							
4	Reserved	BUF	Reserved	R-W Raw	R-W Pack	Test Write	CD-RW	R-W Subcode
5	Reserved							
6	(MSB)			Data Block Type Supported				
7								(LSB)

The Feature Code field ***shall*** be set to 002Dh.

The Version field ***shall*** be set to 02h.

The Persistent bit ***shall*** be defined as in Table 223 - *Feature Descriptor generic format* on page 412. This bit ***shall*** be set to zero if the medium is removable.

The Current bit ***shall*** be defined as in Table 223 - *Feature Descriptor generic format* on page 412. This bit ***shall*** be set to zero if CD-R or CD-RW medium is not present. The Current bit may not be set at the medium insertion even if this Feature is available on the medium. See *14.4, "Delayed Feature reporting"* on page 376.

The Additional Length field ***shall*** be set to 04h.

The following bits indicate Feature support. If set to zero, the Feature is not supported. If set to one, the Feature is supported.

The Buffer Underrun Free (BUF) bit, when set to 1, ***shall*** indicate that the logical unit supports Buffer Under-run Free recording.

The R-W Raw bit, if set to 1, ***shall*** indicate that the logical unit supports writing R-W subcode in the Raw mode. The R-W Subcode bit ***shall*** be set if this bit is set.

The R-W Pack bit, if set to 1, ***shall*** indicate that the logical unit supports writing R-W subcode in the Packed mode. The R-W Subcode bit ***shall*** be set if this bit is set.

The Test Write bit indicates that the logical unit can perform test writes. See *16.11.3.7, "Write Parameters Mode Page"* on page 512.

The CD-RW bit indicates support for overwriting a Track at Once track with another.

The R-W Subcode bit indicates that the logical unit can record the R-W subchannels with user supplied data.

The Data Block Type Supported field is defined in sub-clause *16.4.2.11, "Feature 0021h: Incremental Streaming Writable"* on page 425.

16.4.2.21 Feature 002Eh: CD Mastering

Two fundamental types of CD mastering are possible - raw and session at once. A logical unit with this Feature ***shall*** support at least one of Raw or Session at Once recording. The type of recording is identified in the Feature Descriptor. This Feature ***shall*** be current only if the last session status is empty.

Note: The raw mode offers additional control but bypasses logical unit data checking and has larger data transfer size. The session at once mode offers logical unit control and supervision but has greater logical unit complexity.

The *Write Parameters* Mode Page (05h) is mandatory.

The Raw bit ***shall*** indicate that the logical unit can record using the raw write type. The Session at Once (SAO) bit ***shall*** indicate that the logical unit can record using the Session at Once write type. Each write type is described in the following sections.

The Test Write bit ***shall*** indicate that the logical unit can perform test writes. In test write mode, the logical unit ***shall*** behave as if data were committed to the medium, but writing to the medium ***shall not*** occur.

If OPC information is ever returned via the READ DISC INFORMATION command, the SEND OPC INFORMATION command ***shall*** be supported.

16.4.2.21.1 CD Mastering - Raw

The Disc Information Block data of the READ DISC INFORMATION command ***shall*** be supported.

The READ TRACK/RZONE INFORMATION command except Appendable bit ***shall*** be supported.

The Raw write type in the *Write Parameters* Mode Page (05h) ***shall*** be supported. Data Block Type 1 ***shall*** be supported. If the R-W bit in the Feature Descriptor is set, then Data Block Types 2 and 3 ***shall*** also be supported.

The WRITE (10) command ***shall*** be supported. The host ***shall*** send all data, from the beginning of Lead-in to the end of Lead-out. The number of bytes per block is determined by the Data Block Type in the Write Parameters Mode Page. The Writes ***shall*** occur to a contiguous sequence of addresses. When an underrun occurs, the logical unit ***shall*** write the last block sent from the host as a link. If the Raw MS bit is set, the logical unit ***shall*** also generate valid PMA entries for the information sent by the host. The logical unit may use the TOC and approximations, or TOC and scanning to determine PMA parameters.

The SYNCHRONIZE CACHE command ***shall*** be supported.

16.4.2.21.2 CD Mastering - Session at Once

The SAO bit ***shall*** indicate that the logical unit can record using the Session at Once write type.

The Disc Information Block data of the READ DISC INFORMATION command ***shall*** be supported.

The READ TRACK/RZONE INFORMATION command except Appendable bit ***shall*** be supported.

The SAO write type in the *Write Parameters* Mode Page (05h) ***shall*** be supported. The Data Block Type field is ignored; the data block type changes dynamically according to the cue sheet.

The WRITE (10) command ***shall*** be supported. The number of bytes per block is determined by the cue sheet. Writes ***shall*** be issued for every user data block, even if the cue sheet indicates that those blocks require no data be sent from the host. In that case, the number of bytes transferred is zero. WRITE (10) commands ***shall*** be issued by the host with an ascending sequence of Logical Block Addresses. The number of blocks per write may change over the course of recording. If an underrun occurs, the logical unit may pad the rest of the session or abort the recording. Underruns may be detected by the host at the next write, which will not be a valid address for writing due to the underrun.

The SEND CUE SHEET command ***shall*** be supported. The logical unit ***shall*** accept cue sheets up to the size specified in the Maximum Cue Sheet Length field.

Table 251 - CD Mastering Feature Descriptor

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB)			Feature Code = 002Eh				
1								(LSB)
2	Reserved		Version = 1				Persistent	Current
3	Additional Length = 04h							
4	Reserved	BUF	SAO	Raw MS	Raw	Test Write	CD-RW	R-W
5	(MSB)							
6				Maximum Cue Sheet Length				
7								(LSB)

The Feature Code field ***shall*** be set to 002Eh.

The Version field ***shall*** be set to 01h.

The Persistent bit ***shall*** be defined as in Table 223 - *Feature Descriptor generic format* on page 412. This bit ***shall*** be set to zero if the medium is removable.

The Current bit ***shall*** be defined as in Table 223 - *Feature Descriptor generic format* on page 412. This bit ***shall*** be set to zero if CD-R or CD-RW media is not present.

The Additional Length field ***shall*** be set to 04h.

The following bits indicate Feature support. If set to zero, the Feature is not supported. If set to one, the Feature is supported.

The Buffer Underrun Free (BUF) bit, when set to 1, ***shall*** indicate that the logical unit supports Buffer Underrun Free recording.

The Session at Once (SAO) bit ***shall*** indicate that the logical unit can record using the Session at Once write type.

The Raw Multisession (Raw MS) bit ***shall*** indicate that the logical unit can record multisession in raw mode.

The Raw bit ***shall*** indicate that the logical unit can record using the raw write type.

The Test Write bit ***shall*** indicate that the logical unit can perform test writes.

The CD-RW bit ***shall*** indicate that the logical unit can overwrite previously recorded data.

The R-W bit ***shall*** indicate that the logical unit can record the R-W subchannels with user supplied information.

The Maximum Cue Sheet Length field indicates the maximum length of a Cue Sheet that can be accepted by the logical unit for Session at Once recording. If the SAO bit is zero, this field ***shall*** be set to zero.

16.4.2.22 Feature 002Fh: DVD-R/-RW Write

This Feature indicates the ability to master a DVD disc on DVD-R/-RW media.

The *Write Parameters* Mode Page (05h) ***shall*** be supported. A Write Type of Session at Once ***shall*** be supported.

The Disc Information Block data of the READ DISC INFORMATION command ***shall*** be supported.

The READ TRACK/RZONE INFORMATION command except Appendable bit ***shall*** be supported.

The Reservation Size Mode Reservation of the RESERVE TRACK/RZONE/RMZ command ***shall*** be supported.

The WRITE (10) command ***shall*** be supported. The number of bytes per block is determined by the block size in the Random Readable Feature. Writes ***shall*** be issued for every user data block. WRITE (10) commands ***shall*** be issued by the host with a contiguous sequence of Logical Block Addresses. The number of blocks per write may change over the course of recording. If an underrun occurs, the logical unit may pad the rest of the disc or abort the recording. Underruns may be detected by the host at the next write, which will not be a valid address for writing due to the underrun.

The SEND DISC STRUCTURE command ***shall*** be supported.

Table 252 - DVD-R/-RW Write Feature Descriptor

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB) Feature Code = 002Fh							
1								(LSB)
2	Reserved		Version = 2				Persistent	Current
3	Additional Length = 04h							
4	Reserved	BUF	Reserved		Dual Layer	Test Write	DVD-RW	Reserved
5	Reserved							
6	Reserved							
7	Reserved							

The Feature Code field ***shall*** be set to 002Fh.

The Version field ***shall*** be set to 2.

The Persistent bit ***shall*** be defined as in Table 223 - *Feature Descriptor generic format* on page 412. This bit ***shall*** be set to zero if the medium is removable.

The Current bit ***shall*** be defined as in Table 223 - *Feature Descriptor generic format* on page 412. This bit ***shall*** be set to zero if DVD-R medium is not present.

The Additional Length field ***shall*** be set to 04h.

The Buffer Underrun Free (BUF) bit, when set to 1, ***shall*** indicate that the logical unit supports Buffer Underrun Free recording.

The Dual Layer bit, when set to 1, ***shall*** indicate that the logical unit supports to write DVD-R/RW Dual Layer media. The READ DISC STRUCTURE command with Format Code values of 20h ***shall*** be supported.

The Test Write bit, when set to zero, ***shall*** indicate that the logical unit is not capable of performing test writes. When set to one, the logical unit is capable of performing test writes.

The DVD-RW bit indicates support for writing and erasing on DVD-RW media. If this bit set to 1, ***shall*** indicate that the logical unit supports BLANK command, Blanking Type 00h and 01h.

16.4.2.23 Feature 0033h: Layer Jump recording

This Feature identifies a logical unit that can write data to contiguous regions that are allocated on multiple Layers, and can append data to a limited number of locations on the media. The logical unit can write two or more recording Layers sequentially and alternately.

This Feature ***shall*** indicate support for Layer Jump recording on DVD-R Dual Layer Ver. 3.0 media. This Feature ***shall*** become not current after a Disc final closure is performed. See *4.17.11, "Disc final closure"* on page 198.

The WRITE (10) command ***shall*** be supported. Writing may be limited to locations identified by the READ DISC INFORMATION command and READ TRACK/RZONE INFORMATION commands. The logical unit ***shall*** stream the data to the medium without interruption or link generation occurring regardless of data transfer rate and BUFE bit setting of *Write Parameters* Mode Page (05h). If the writing is interrupted due to insufficient data (“underrun”), the logical unit ***shall*** perform Buffer Underrun Error Free recording. If the logical unit is forced by a SYNCHRONIZE CACHE or other command, a link ***shall*** be generated. The nominal size of the link ***shall*** be that specified by the *Write Parameters* Mode Page (05h). The number of padding and link blocks actually recorded may also depend on blocking: the data from the host may first be padded to fill a Blocking unit and then a link ***shall*** be appended. See *4.16.10.2, "ECC boundary padding and Data Type bit in ID field"* on page 136 for an example with DVD-R media.

While a streaming write is in progress (data are in the logical unit’s buffer but not committed to the medium), the commands in Table 253 ***shall*** perform normally without interrupting the writing. All other commands ***shall*** perform normally, but may interrupt recording. All other commands may force a SYNCHRONIZE CACHE before execution. Logical units should perform all other commands without flushing the write buffer. This is possible if writing to the medium has not yet started. Normal execution is defined as the behavior the command would have if no data were in the write buffer.

If the host closes the Session or Border, and there is insufficient space for another Session or Border to follow, the logical unit ***shall*** close the Session or Border with no next Session or Border pointer (on CD, point B0 would not exist).

Note: The CD MultiSession standard allows B0 = FF/FF/FF to indicate the same thing, but some legacy drives do not properly handle this means of marking the last Session.

Table 253 - Commands that shall not interrupt streaming writing

COMMAND	COMMENT
TEST UNIT READY	
READ TRACK/RZONE INFORMATION	Required only for current Track/RZone
GET EVENT/STATUS NOTIFICATION	
GET CONFIGURATION	
REQUEST SENSE	
INQUIRY	
READ BUFFER CAPACITY	
WRITE (10)	For NWA in current Track/RZone

The SYNCHRONIZE CACHE command ***shall*** be supported. The SYNCHRONIZE CACHE command ***shall*** force the underrun condition regardless of the state of the Immediate bit.

The *Write Parameters* Mode Page (05h) ***shall*** be supported. If DVD-R Dual Layer Ver. 3.0 media is present, the Layer Jump recording method (Write Type=04h) ***shall*** be available. The Write Parameters Mode Page may contain or be actively set to settings that are incompatible with the current medium, or be set when no medium is present. If writing is attempted when the Write Parameters Mode Page is not compatible with the current track, RZone, or medium, the logical unit ***shall*** return CHECK CONDITION status, 5/64/00 ILLEGAL MODE FOR THIS TRACK, and the sense key specific information set to the byte and field of the incompatible parameter in the Mode Page.

The CLOSE TRACK/RZONE/SESSION/BORDER command ***shall*** be supported.

The RESERVE TRACK/RZONE/RMZ command ***shall*** be supported. Address Mode Reservation and Reservation Size Mode Reservation ***shall*** be supported.

The READ DISC INFORMATION command and both Disc Information Block data and Assigned Track information ***shall*** be supported.

The READ TRACK/RZONE INFORMATION command ***shall*** be supported. Appendable bit in CDB, LJRS field, Next Layer Jump Address field, and Last Layer Jump Address field of Track/RZone Information Block ***shall*** be supported.

The READ DISC STRUCTURE command with Format Code values of 20h, 21h, 22h, 23h, and 24h ***shall*** be supported.

The SEND DISC STRUCTURE command with Format Code values of 21h, 22h, 23h, and 24h ***shall*** be supported.

Table 254 - Layer Jump recording Feature Descriptor

Byte \ Bit	7	6	5	4	3	2	1	0
0	(MSB)	Feature Code = 0033h						
1								(LSB)
2	Reserved		Version				Persistent	Current
3	Additional Length							
4	Reserved							
5								
6								
7	Number of Link Size							
8-n	Link Size							
n-?	Pad							

The Feature Code field ***shall*** be set to 0033h.

The Version field ***shall*** be set to 0h.

The Persistent bit ***shall*** be defined as in Table 223 - *Feature Descriptor generic format* on page 412. This bit ***shall*** be set to zero if the medium is removable.

The Current bit ***shall*** be defined as in Table 223 - *Feature Descriptor generic format* on page 412. This bit ***shall*** be set to zero if Layer Jump recording capable medium is not present.

The Additional Length field ***shall*** be set to 4 + (Number of Link Sizes) + (Number of Pad bytes).

Data Block Type 8 of *Write Parameters* Mode Page (05h) ***shall*** be supported.

Buffer Under-run Free recording ***shall*** be available for the current mounted media.

The Number of Link Sizes ***shall*** specify the number of link sizes available for the current media.

Note: For DVD-R Dual Layer Ver. 3.0, this field may be 1.

Each Link Size field ***shall*** indicate the number of logical blocks per link. Links occur on sequentially written media between independent write operations. The link size does not include any logical blocks written by the logical unit to satisfy the writable unit specified by the Blocking field in the Random Readable Feature. Link Size fields are reported by the logical unit in the logical unit's preferred order, most desirable first.

Note: For DVD-R Dual Layer Ver. 3.0, this field may be 16.

The Pad field ***shall*** contain zeros. The number of Pad bytes ***shall*** be *4 * IP((Number of Link Sizes + 3)/4) - (Number of Link Sizes)*, where "*IP()*" is the integer part of the number. The Pad field is present to make the length of the Feature Descriptor a multiple of 4 bytes.

16.4.2.24 Feature 0050h: HD DVD Read

This Feature identifies a logical unit that can read HD DVD specific information from the media.

This Feature ***shall*** indicate support for reading HD DVD specific structures. This Feature ***shall*** be current only if HD DVD specific structures are available for reading.

The READ DISC STRUCTURE Command with Format Codes of 00h, 03h, 04h and 15h ***shall*** be supported.

The READ (10) command ***shall*** be supported. The READ (12) command ***shall*** be supported.

The READ TOC/PMA/ATIP command ***shall*** be supported, along with fabrication of data for HD DVD media as specified in the command description.

Table 255 - HD DVD Read Feature Descriptor

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB) Feature Code = 0050h							
1								(LSB)
2	Reserved		Version				Persistent	Current
3	Additional Length = 04h							
4	Reserved							HD DVD-R
5	Reserved							
6	Reserved							HD DVD-Rewritable
7	Reserved							

The Feature Code field ***shall*** be set to 0050h.

The Version field ***shall*** be set to 0h.

The Persistent bit ***shall*** be defined as in Table 223 - *Feature Descriptor generic format* on page 412. This bit ***shall*** be set to zero if the medium is removable.

The Current bit ***shall*** be defined as in Table 223 - *Feature Descriptor generic format* on page 412. This bit ***shall*** be set to zero if HD DVD medium is not present.

The Additional Length field ***shall*** be set to 04h.

The HD DVD-R bit, when set to one, indicates support for reading of HD DVD-R media.

The HD DVD-Rewritable bit, when set to one, indicates support for reading of HD DVD-Rewritable media.

16.4.2.25 Feature 0051h: HD DVD Write

This Feature indicates the ability to master a HD DVD disc on HD DVD-R/-Rewritable media.

For HD DVD-R (when HD DVD-R bit in the HD DVD Write Feature Descriptor is set to 1);

The READ DISC INFORMATION command ***shall*** be supported.

The READ TRACK/RZONE INFORMATION command ***shall*** be supported.

The WRITE (10) command ***shall*** be supported.

The WRITE (12) command ***shall*** be supported.

The FORMAT UNIT command with Format Type = 16h ***shall*** be supported.

The RESERVE TRACK/RZONE/RMZ command ***shall*** be supported.

If OPC information is ever returned via the READ DISC INFORMATION command, the SEND OPC INFORMATION command ***shall*** be supported.

The SEND DISC STRUCTURE command with Format Code = 0Fh ***shall*** be supported.

For HD DVD-Rewritable (when HD DVD-Rewritable bit in the HD DVD Write Feature Descriptor is set to 1);

The WRITE AND VERIFY (10) command ***shall*** be supported.

The WRITE (10) command ***shall*** be supported.

The WRITE (12) command ***shall*** be supported.

The FORMAT UNIT command with a Format Code = 001b ***shall*** be supported. Format Type = 00h ***shall*** be supported.

Table 256 - HD DVD Write Feature Descriptor

Byte \ Bit	7	6	5	4	3	2	1	0
0	(MSB) Feature Code = 0051h							
1	Feature Code = 0051h (LSB)							
2	Reserved		Version				Persistent	Current
3	Additional Length = 04h							
4	Reserved							HD DVD-R
5	Reserved							
6	Reserved							HD DVD-Rewritable
7	Reserved							

The Feature Code field ***shall*** be set to 0051h.

The Version field ***shall*** be set to 0h.

The Persistent bit ***shall*** be defined as in Table 223 - *Feature Descriptor generic format* on page 412. This bit ***shall*** be set to zero if the medium is removable.

The Current bit ***shall*** be defined as in Table 223 - *Feature Descriptor generic format* on page 412. This bit ***shall*** be set to zero if HD DVD-R/Rewritable medium is not present.

The Additional Length field ***shall*** be set to 04h.

The HD DVD-R bit, when set to one, indicates support for writing of HD DVD-R media.

The HD DVD-Rewritable bit, when set to one, indicates support for writing of HD DVD-Rewritable media.

16.4.2.26 Feature 0100h: Power Management

This Feature identifies a logical unit that can perform host managed and host directed power management.

The Power Condition field of the START/STOP UNIT command ***shall*** be supported.

The *Power Condition* Mode Page (1Ah) ***shall*** be supported.

The Power Management class event of the GET EVENT/STATUS NOTIFICATION command ***shall*** be supported.

Table 257 - Power Management Feature Descriptor

Byte \ Bit	7	6	5	4	3	2	1	0
0	(MSB) Feature Code = 0100h							
1	Feature Code = 0100h (LSB)							
2	Reserved		Version				Persistent	Current
3	Additional Length = 00h							

The Feature Code field ***shall*** be set to 0100h.

The Persistent bit ***shall*** be set to one.

The Current bit *shall* be set to one.

The Additional Length field *shall* be set to 0.

16.4.2.27 Feature 0101h: S.M.A.R.T.

This Feature identifies a logical unit that can perform Self Monitoring Analysis and Reporting Technology.

The S.M.A.R.T. (Self-Monitoring, Analysis and Reporting Technology) is a technology developed to manage the reliability of data storage logical units. S.M.A.R.T.-capable PC systems have the goal of enhancing system reliability by warning users of some pending logical unit or media failures. With sufficient warning, users may have the opportunity to back up vital data and replace suspect logical units prior to data loss or unscheduled down time. S.M.A.R.T. capability is a key new element in the PC architecture that will one day provide new levels of data integrity and data availability.

Peripheral data storage logical units are complex electro-mechanical logical units and, as such, can suffer performance degradation or failure due to a single event or a combination of events. Some events are immediate and catastrophic while others cause a gradual degradation of the logical unit's ability to perform. It is possible to predict a portion of the failures, but S.M.A.R.T. cannot and will not predict all future logical unit failures. S.M.A.R.T. should be treated as a Feature to assist the computer user in preventing some but not all system down time due to logical unit failure.

S.M.A.R.T. capable logical units monitor a wealth of information internal to the logical unit to assess reliability and predict an impending logical unit or medium failure. This information is, in some cases, available through the interface and can be presented to end-users via drivers and supporting applications. This data should not be presented to or interpreted by system users or managers to predict the integrity or reliability of a S.M.A.R.T. logical unit. The predictive algorithms in a S.M.A.R.T. logical unit are designed to interpret internal conditions in order to detect impending failures and thus users or system managers should not attempt to predict impending logical unit failure from this internal data. S.M.A.R.T. data are not linear predictors of the degrading reliability of a S.M.A.R.T. capable logical unit. It is the responsibility of a S.M.A.R.T. logical unit to predict an impending failure and report that failure via an Informational Exception Condition.

Table 258 - S.M.A.R.T. Feature Descriptor

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB)	Feature Code = 0101h						
1								(LSB)
2	Reserved		Version				Persistent	Current
3	Additional Length = 04h							
4	Reserved							PP
5	Reserved							
6	Reserved							
7	Reserved							

The Feature Code field *shall* be set to 0101h.

The Persistent bit *shall* be defined as in Table 223 - *Feature Descriptor generic format* on page 412.

The Current bit *shall* be defined as in Table 223 - *Feature Descriptor generic format* on page 412.

The Additional Length field *shall* be set to 04h.

If the Page Present (PP) bit is set in the S.M.A.R.T Feature Descriptor, *16.11.3.4, "Fault / Failure Reporting Mode Page"* on page 504 ***shall*** be supported. If the *Fault / Failure Reporting* Mode Page (1Ch) is not supported the logical unit ***shall*** use the following default values:

1. Performance (Perf) bit ***shall*** be 0 (Delays are acceptable).
2. Enable Warning (EWasc) bit ***shall*** be 0 (Disable WARNING Sense Code reporting).
3. Disable Exception Control (DExcept) bit ***shall*** be 0 (Do not Disable reporting of exception conditions).
4. Test bit ***shall*** be 0.
5. Method of Reporting Informational Exceptions (MRIE) ***shall*** be 4 (Unconditionally generate RECOVERED ERROR).
6. Interval Timer ***shall*** be set to 6000.

16.4.2.28 Feature 0102h: Embedded Changer

This Feature identifies a logical unit that can move media from a storage area to the mechanism and back.

For more information on changers, see the description of the *Section 10.0, "Changer Model"* on page 347. If this Feature is current, the Removable Medium Feature ***shall*** also be current.

The LOAD/UNLOAD MEDIUM command ***shall*** be supported.

The MECHANISM STATUS command ***shall*** be supported.

If logical unit supports Write Protect Feature (0004h), the Media Cartridge Write Protection status bits (CWP_V, CWP) of the MECHANISM STATUS command ***shall*** be supported.

Table 259 - Embedded Changer Feature Descriptor

Byte \ Bit	7	6	5	4	3	2	1	0
0	(MSB) Feature Code = 0102h							
1								(LSB)
2	Reserved		Version				Persistent	Current
3	Additional Length = 04h							
4	Reserved			SCC	Reserved	SDP	Reserved	
5	Reserved							
6	Reserved							
7	Reserved			Highest Slot Number				

The Feature Code field ***shall*** be set to 0102h.

The Persistent bit ***shall*** be defined as in Table 223 - *Feature Descriptor generic format* on page 412.

The Current bit ***shall*** be defined as in Table 223 - *Feature Descriptor generic format* on page 412.

The Additional Length field ***shall*** be set to 04h.

The Side Change Capable (SCC) bit, when set to zero, ***shall*** indicate that the logical unit is not capable of selecting both sides of the media. When set to one, ***shall*** indicate that the logical unit is capable of selecting both sides of the media.

The Supports Disc Present (SDP) bit, when set to zero, ***shall*** indicate that the logical unit cannot report the contents of the slots after a reset or Magazine change. When set to one, ***shall*** indicate that the logical unit can report the contents of the slots after a reset or Magazine change and that the response to the MECHANISM STATUS command will contain valid Disc is Present status information for all slots.

Highest Slot Number ***shall*** be set to the number of slots minus one.

16.4.2.29 Feature 0103h: CD Audio analog play

This Feature identifies C/DVD logical units that have an analog audio output port and that can play media that contain CD-DA tracks.

To allow for the legacy method for the host Computer to determine if audio operations are supported, C/DVD logical units ***shall*** respond to a PLAY AUDIO (10) command which has a transfer length of zero, with GOOD status, regardless of whether or not this Feature is current.

The PLAY AUDIO (10), and PLAY AUDIO MSF commands ***shall*** be supported.

The PAUSE/RESUME command ***shall*** be supported.

The STOP PLAY/SCAN command ***shall*** be supported.

The SCAN command may be supported, dependent on the bit in the Feature descriptor.

The SEEK command ***shall*** be supported. The SEEK command ***shall*** halt the playing of audio and set the current position to the LBA specified in the command. This current position may be used by a future PLAY AUDIO (10) or PLAY AUDIO MSF commands.

The READ SUBCHANNEL command ***shall*** be supported.

The READ TOC/PMA/ATIP command ***shall*** be supported.

The *CD Audio Control* Mode Page (0Eh) ***shall*** be supported. This Page ***shall not*** be affected by the insertion or removal of CD Audio media.

Table 260 - CD Audio analog play Feature Descriptor

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB) Feature Code = 0103h							
1								(LSB)
2	Reserved		Version				Persistent	Current
3	Additional Length = 04h							
4	Reserved					Scan	SCM	SV
5	Reserved							
6	(MSB) Number of Volume Levels							
7								(LSB)

The Feature Code field ***shall*** be set to 0103h.

The Persistent bit ***shall*** be defined as in Table 223 - *Feature Descriptor generic format* on page 412.

The Current bit ***shall*** be defined as in Table 223 - *Feature Descriptor generic format* on page 412.

The Additional Length field ***shall*** be set to 04h.

The Separate Channel Mute (SCM) bit, when set to zero, ***shall*** indicate that all audio channels are muted simultaneously. When set to one, ***shall*** indicate that each audio channel can be independently muted.

The Separate Volume (SV) bit, when set to zero, ***shall*** indicate that all audio channels will have the same volume level. When set to one, ***shall*** indicate that audio channel volume may be set independently.

The Scan bit, when set to zero, ***shall*** indicate that the SCAN command is not supported. The Scan bit, when set to one, ***shall*** indicate that the SCAN command ***shall*** be supported.

The Number of Volume Levels ***shall*** indicate the number of discrete volume levels supported by the logical unit. If the logical unit supports only turning audio on and off, the Number of Volume Levels field ***shall*** be set to 2.

16.4.2.30 Feature 0104h: Microcode Upgrade

This Feature identifies logical units that can upgrade their microcode via the logical interface. While the download technique is standard, the microcode data is vendor unique. Logical units ***shall*** validate microcode data before making the microcode permanent.

The READ BUFFER command, Descriptor Mode (Mode = 011b) ***shall*** be supported.

The WRITE BUFFER command, Download Microcode with Offsets and Save Mode (Mode = 111b) ***shall*** be supported. Buffer 0 ***shall*** be usable for microcode upgrades.

Table 261 - Microcode Upgrade Feature Descriptor

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB)	Feature Code = 0104h						
1								(LSB)
2	Reserved		Version				Persistent	Current
3	Additional Length = 00h							

The Feature Code field ***shall*** be set to 0104h.

The Persistent bit ***shall*** be defined as in Table 223 - *Feature Descriptor generic format* on page 412.

The Current bit ***shall*** be defined as in Table 223 - *Feature Descriptor generic format* on page 412.

The Additional Length field ***shall*** be set to 00h.

16.4.2.31 Feature 0105h: Time-out

This Feature identifies a logical unit that can always respond to commands within a set time period. If a command cannot complete normally within the allotted time, it completes with an error.

The *Time-out & Protect* Mode Page (1Dh) ***shall*** be supported. See *16.11.3.5, "Time-out & Protect Mode Page"* on page 506.

Commands that cannot complete normal execution within their specified time limit ***shall*** complete within the specified time limit with CHECK CONDITION status, 6/2E/00 INSUFFICIENT TIME FOR OPERATION.

Event Notification Class 6 ***shall*** be supported if queuing is supported.

Table 262 - Time-out Feature Descriptor

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB)	Feature Code = 0105h						
1								(LSB)
2	Reserved		Version =1				Persistent	Current
3	Additional Length = 04h							
4	Reserved							Group3
5	Reserved							
6	(MSB)	Unit Length (number of sectors)						
7								(LSB)

The Feature Code field ***shall*** be set to 0105h.

The Version field *shall* be set to 1.

The Persistent bit *shall* be defined as in Table 223 - *Feature Descriptor generic format* on page 412.

The Current bit *shall* be defined as in Table 223 - *Feature Descriptor generic format* on page 412.

The Additional Length field *shall* be set to 04h.

The Group3 bit of one indicates that the logical unit supports G3Enable bit and Group3 Time out field in *Time-out & Protect* Mode Page (1Dh). If this bit is set to 1, logical unit *shall* also support VERIFY (10) command and handling of G3tout bit in VERIFY (10) command. See *13.1.1, "Group 3 time-out for Real Time Stream recording/playback"* on page 363. If Real-Time Streaming Feature (0107h) is not supported, this bit ***shall not*** be set to one.

The Unit Length field indicates a unit of block length corresponds to increase a unit of Group 3 time unit. When the Group3 bit is set to 0, Unit Length field is not valid.

16.4.2.32 Feature 0106h: DVD CSS

This Feature identifies a logical unit that can perform DVD CSS/CPPM authentication and key management.

This Feature identifies logical units that support CSS for DVD-Video and CPPM for DVD-Audio. The logical unit *shall* maintain the integrity of the keys by only using DVD CSS authentication and key management procedures. This Feature *shall* be current only if a media containing CSS-protected DVD-Video and/or CPPM-protected DVD-Audio content is loaded.

The REPORT KEY command with Key Class 00h and all KEY Formats except 010001b *shall* be supported. The KEY Format 000100b (TITLE KEY) will not succeed for CPPM protected sectors, since they do not contain a Title Key.

The SEND KEY command with Key Class 00h *shall* be supported.

The READ DISC STRUCTURE command with Format Code Code of 02h (DISC KEY) *shall* be supported.

Table 263 - DVD CSS Feature Descriptor

Byte \ Bit	7	6	5	4	3	2	1	0
0	(MSB)			Feature Code = 0106h				
1								(LSB)
2	Reserved		Version				Persistent	Current
3	Additional Length = 04h							
4	Reserved							
5	Reserved							
6	Reserved							
7	CSS version							

The Feature Code field *shall* be set to 0106h.

The Persistent bit *shall* be defined as in Table 223 - *Feature Descriptor generic format* on page 412.

The Current bit *shall* be defined as in Table 223 - *Feature Descriptor generic format* on page 412. This bit *shall* be set to zero if DVD CSS/CPPM medium is not present.

The Additional Length field *shall* be set to 04h.

The CSS version *shall* be set to 01h.

16.4.2.33 Feature 0107h: Real-Time Streaming

This Feature identifies logical units that support reporting and setting of performance parameters. The host may request that the logical unit perform at a certain data rate. A host may request a lower rate than the logical unit's maximum to identify a need for a continuous stream of data. This is desired because many applications need their average data rate to be constant, even over short periods of time. If a logical unit ***shall*** physically slow the medium to avoid "once around" access delays, this Feature provides the host requirements to the logical unit without specifying how that behavior is to be achieved.

This Feature also indicates whether the logical units support the Stream playback operation (see *8.2, "Stream playback operation"* on page 328).

The GET PERFORMANCE command with Type field of 00h ***shall*** be supported. If the SW bit is set to one, Type field value of 01h ***shall*** be supported.

The SET STREAMING command ***shall*** be supported.

The SET READ AHEAD command ***shall*** be supported.

The READ (12) command with Streaming bit ***shall*** be supported.

The WRITE (12) command with Streaming bit ***shall*** be supported, if the SW bit is set to one.

Table 264 - Real-Time Streaming Feature Descriptor

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB)			Feature Code = 0107h				
1								(LSB)
2	Reserved		Version = 3				Persistent	Current
3	Additional Length = 04h							
4	Reserved			RBCB	SCS	MP2A	WSPD	SW
5	Reserved							
6	Reserved							
7	Reserved							

The Feature Code field ***shall*** be set to 0107h.

The Version field ***shall*** be set to 3h.

The Persistent bit ***shall*** be defined as in Table 223 - *Feature Descriptor generic format* on page 412.

The Current bit ***shall*** be defined as in Table 223 - *Feature Descriptor generic format* on page 412.

The Additional Length field ***shall*** be set to 04h.

The Read Buffer Capacity Block (RBCB) bit indicates that the logical unit supports the READ BUFFER CAPACITY command and its Block bit.

The Set CD Speed (SCS) bit indicates that the logical unit supports the SET CD SPEED command.

The Mode Page 2A (MP2A) bit indicates that the *C/DVD Capabilities & Mechanical Status* Mode Page (2Ah) with the logical unit Write Speed Performance Descriptor Blocks are supported.

A Write Speed Performance Descriptor (WSPD) bit of one indicates that the logical unit supports the Write Speed (Type field = 03h) data of GET PERFORMANCE command and the WRC field of SET STREAMING command. This bit ***shall*** be set to one, if logical unit supports writing speed selection.

A Streaming Writing (SW) bit of one indicates that the logical unit supports the Stream recording operation. A SW bit of zero indicates that the logical unit may not support the Stream recording operation (see *8.1, "Stream recording operation"* on page 327).

16.4.2.34 Feature 0108h: Logical unit serial number

This Feature identifies a logical unit that has a unique serial number. A logical unit can be uniquely identified by checking its vendor ID, model ID, and serial number.

Table 265 - Logical unit serial number Feature Descriptor

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB) Feature Code = 0108h							
1								(LSB)
2	Reserved		Version				Persistent	Current
3	Additional Length							
4-n	Serial Number							

The Feature Code field *shall* be set to 0108h.

The Persistent bit *shall* be set to one.

The Current bit *shall* be set to one.

The Additional Length field *shall* be set to a multiple of 4.

The Serial Number *shall* be ASCII graphic codes (i.e. codes 20h - 7Eh). Any unused bytes in the Serial Number *shall* be padded with spaces (20h). There should not be more than three pad bytes.

16.4.2.35 Feature 010Bh: DVD CPRM

This Feature identifies a logical unit that supports DVD CPRM and can perform DVD CPRM authentication and key management. This Feature *shall* be current only if a DVD CPRM recordable or rewritable medium is loaded.

The REPORT KEY command, with Key Class 00h and KEY Formats 000001b, 000010b, 010001b, and 111111b *shall* be supported.

The SEND KEY command with Key Class 00h and KEY Formats 000001b, 000011b, and 111111b *shall* be supported.

The READ DISC STRUCTURE command, Format Code Code of 06h and 07h *shall* be supported.

Table 266 - DVD CPRM Feature Descriptor

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB) Feature Code = 010Bh							
1								(LSB)
2	Reserved		Version				Persistent	Current
3	Additional Length = 04h							
4	Reserved							
5	Reserved							
6	Reserved							
7	CPRM version							

The Feature Code field *shall* be set to 010Bh.

The Persistent bit *shall* be defined as in Table 223 - *Feature Descriptor generic format* on page 412.

The Current bit ***shall*** be defined as in Table 223 - *Feature Descriptor generic format* on page 412. This bit ***shall*** be set to zero if DVD CPRM media is not present.

The Additional Length field ***shall*** be set to 04h.

The CPRM version field ***shall*** be set to 01h.

16.4.2.36 Feature 010Ch: Firmware Information

This Feature ***shall*** indicate that the logical unit provides the date and time of the compilation of the current firmware revision loaded on the logical unit. The date and time ***shall*** be the date and time of compilation of the firmware. The date and time ***shall*** be UTC, contain only the ASCII digits 0-9, and be zero-padded (i.e. use ’09’, not ’9’). The date (C, Y, M, D Fields) ***shall not*** change for a given firmware revision. The date and time ***shall*** be later on "newer" firmware for a given logical unit. This Feature ***shall*** be persistent and current if present. No commands are required for this Feature.

Note: For example, if the date to be set is April 24, 2003, the Century field is set to "20", the Year field is set to "03", Month field is set to "04", and Day field is set to "24" in numerical ASCII digits.

Table 267 - Firmware Information Feature Descriptor

Byte \ Bit	7	6	5	4	3	2	1	0
0	(MSB) Feature Code = 010Ch							
1								(LSB)
2	Reserved		Version				Persistent	Current
3	Additional Length = 10h							
4	Century (C)							
5								
6	Year (Y)							
7								
8	Month (M)							
9								
10	Day (D)							
11								
12	Hour (h)							
13								
14	Minutes (m)							
15								
16	Seconds (s)							
17								
18	Reserved							
19								

Note: This Feature may be used to help switch default software behavior for logical units with firmware produced after a certain date.

The Feature Code field ***shall*** be set to 010Ch.

The Persistent bit ***shall*** be defined as in Table 223 - *Feature Descriptor generic format* on page 412.

The Current bit ***shall*** be defined as in Table 223 - *Feature Descriptor generic format* on page 412.

The Additional Length field ***shall*** be set to 10h.

Table 269 describes errors that may occur during the operation of the command or which may cause a CHECK CONDITION status to be reported.

16.4.2.37 Feature 010Dh: AACS

This Feature identifies a logical unit that supports AACS and can perform AACS authentication process. This Feature ***shall*** be current only if a AACS medium is loaded.

The REPORT KEY command, with Key Class 02h with KEY Format 000000b, 100001b and 111111b ***shall*** be supported. If Binding Nonce generation is supported, the BNG bit ***shall*** be set to 1 and KEY Format 100000b ***shall*** be supported.

The SEND KEY command with Key Class 02h ***shall*** be supported.

The READ DISC STRUCTURE command, Format Code of 13h, 14h, 16h and 17h ***shall*** be supported.

Table 268 - AACS Feature Descriptor

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB)							
1	Feature Code = 010Dh							(LSB)
2	Reserved		Version				Persistent	Current
3	Additional Length = 04h							
3	Reserved							BNG
3	Block Count for Binding Nonce							
3	Reserved							
3	AACS version							

The Feature Code field ***shall*** be set to 010Dh.

The Persistent bit ***shall*** be defined as in Table 223 - *Feature Descriptor generic format* on page 412.

The Current bit ***shall*** be defined as in Table 223 - *Feature Descriptor generic format* on page 412. This bit ***shall*** be set to zero if AACS media is not present.

The Block Count for Binding Nonce ***shall*** specify how many blocks are required to store the Binding Nonce for the media.

The Additional Length field ***shall*** be set to 04h.

The AACS version field ***shall*** be set to 01h.

Table 269 - GET CONFIGURATION command errors

Error Description	
5/24/00	INVALID FIELD IN CDB

16.5 GET EVENT/STATUS NOTIFICATION command

The GET EVENT/STATUS NOTIFICATION command requests the logical unit to report event(s) and status as specified in the Notification Class Request field and provides asynchronous notification. Two modes of operation are defined here. They are polling and asynchronous modes.

In polling mode, the host will issue GET EVENT/STATUS NOTIFICATION commands at periodic intervals with an immediate (Immed) bit of 1 set. The logical unit ***shall*** complete this command with the most recently available event status requested. The logical unit ***shall*** support polling mode.

In asynchronous mode, the host will issue a single GET EVENT/STATUS NOTIFICATION command with an Immed bit of 0 requested. If the logical unit supports Asynchronous event status notification (through tagged queuing) the model outlined here ***shall*** be used. If the logical unit does not support Asynchronous Mode, the command ***shall*** fail as an illegal request. If the host requests Asynchronous Mode using a non-queable or non-overlappable request, the command ***shall*** fail with CHECK CONDITION status, 5/24/00 INVALID FIELD IN CDB.

When Asynchronous Event Status reporting is supported, the logical unit ***shall not*** complete a GET EVENT/STATUS NOTIFICATION command with an Immed bit of 0 until a change in event status of the requested class occurs. The logical unit ***shall*** complete the GET EVENT/STATUS NOTIFICATION command as soon after the event occurs as possible. It will report the event as outlined below.

Note: Only one Event Descriptor per GET EVENT/STATUS NOTIFICATION command ***shall*** *be reported. The priority of event or status reporting* ***shall*** *be by Event Class number. The lower the class number, the higher the priority.*

This command ***shall not*** return a CHECK CONDITION status due to a pending UNIT ATTENTION condition. Any pending UNIT ATTENTION condition for which a corresponding event is reported ***shall not*** be cleared for the logical unit issuing the GET EVENT/STATUS NOTIFICATION command.

Implementation notes for logical units can be found in *Appendix E - "Example Event Implementation Notes (Informative)"* on page 759, and examples for hosts can be found in *Appendix I - "Sample Applications of Events (Informative)"* on page 779.

Table 270 - GET EVENT/STATUS NOTIFICATION Command Descriptor Block

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation code (4Ah)							
1	LUN (Obsolete)			Reserved				Immed
2	Reserved							
3	Reserved							
4	Notification Class Request							
5	Reserved							
6	Reserved							
7	(MSB)			Allocation Length				
8								(LSB)
9	Vendor-Specific		Reserved			NACA	Flag	Link
10	PAD							
11								

If the Immed bit is set to one, and if there is no Event to report the command ***shall*** return good status.

If the Immed bit is set to zero (and the logical unit supports tagged command queuing) and if there is no event to report, the GET EVENT/STATUS NOTIFICATION command ***shall*** be queued by the logical unit until there is an Event to report.

If the Immed bit is set to zero and the logical unit does not support tagged command queuing, the logical unit ***shall*** return CHECK CONDITION status, 5/24/00 INVALID FIELD IN CDB.

The Notification Class Request field requests the logical unit to report event(s) from the event classes listed requested in this field. See Table 271.

The Allocation Length field indicates the maximum number of bytes that ***shall*** be transferred from the logical unit. Allocation Length 4 or less indicates that the logical unit ***shall*** transfer Event Header only and ***shall not*** clear the event. An event ***shall*** be considered reported if Event Descriptor is transferred at least one byte. An Allocation Length of zero ***shall not*** be considered an error.

Note: The Allocation Length field definition of previous revisions (Fuji5 Rev.1.3 and before) was as follows;
"The Allocation Length field indicates the maximum number of bytes that shall be transferred from the logical unit. An event shall be considered reported even if the result data was truncated due to an insufficient Allocation Length."
The host should set Allocation Length field to 8 or greater to retrieve Event Data correctly. Most of existing products in the market were designed to comply with previous revisions. Therefore the Event is cleared if Allocation Length is less than or equal to 4.

Table 271 - Notification Class Request field definition

Bit	Definition
0	Reserved
1	Operational Change Request/Notification
2	Power Management
3	External Request
4	Media
5	Multi host
6	Device Busy
7	Reserved

Note: A bit field of all 0's indicates that the logical unit should immediately complete this command indicating No Event, and **shall** *list the supported event class in the Event Header. This Method* **shall** *be used to determine which event classes a logical unit supports.*

If a logical unit does not support any of the requested event classes, the logical unit ***shall*** terminate the command successfully, returning only the Event Header, and indicating a returned Notification Class field of 0.

Host Software that manages media event status, may or may not be linked to other software that manages power states. This notification field provides a way that power and media event status notifications can be independently managed by the responsible software. If a driver manages Media, Power Management and Device Busy events, the driver can issue this command with Notification Class Request field set to 01010100b to request the logical unit to report Power Management, Media, and Device Busy events.

The result data format is shown in Table 272. The Event Header is shown in Table 273.

Table 272 - Notification Status List

Bit / Byte	7	6	5	4	3	2	1	0
0-3	Event Header							
0-n	Event Descriptor							

Table 273 - Event Header

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB)			Event Data Length				
1								(LSB)
2	NEA	Reserved				Notification Class		
3	Supported Event Classes							

The Event Data Length field specifies the amount of data that follows this field. The amount of data reported ***shall*** be the number of bytes data following the Event Data Length field.

The Notification Class field specifies the class of notification by number. See Table 274.

Table 274 - Notification Class field definition

Field	Description
000b	No requested Event Classes are supported
001b	Operational Change Request/Notification
010b	Power Management
011b	External Request
100b	Media
101b	Multi-host
110b	Device Busy
111b	Reserved.

The No Event Available (NEA) bit, when set to one, ***shall*** indicate that none of the requested notification classes are supported. When set to zero, ***shall*** indicate that at least one of the requested notification classes is supported.

The Supported Event Classes field specifies the event classes that the logical unit supports as per the Notification Class Request field of Table 271 - *Notification Class Request field definition* on page 454. If an Event Class is supported, the corresponding bit ***shall*** be set to one.

16.5.1 Operational Change Request/Notification Class Events

This Event notifies the host of changes of operational capabilities or parameters of the logical unit.

Table 275 - Operational Change Request/Notification Class Event Descriptor

Bit / Byte	7	6	5	4	3	2	1	0
0	Reserved				Operational Event			
1	Persistent Prevented	Reserved			Operational Status			
2	(MSB)			Operation Request/Report				
3								(LSB)

Table 276 - Operational Event format

Code	Event	Description
0h	NoChg	No changes in operational state performed or requested
1h	Reserved	
2h	Logical unit may have changed Operational State	The Logical unit may have changed operational state.
3h-Fh	Reserved	

If a new Event occurs before an existing Event is reported to the host, the new event ***shall*** replace the old Event if the new Event has a higher Code than the old Event. Otherwise, the new Event ***shall*** be deleted.

The Persistent Prevented bit reports the current state of the Persistent Prevent for the logical unit.

The Operational Status field ***shall*** report 0h.

The Operation Request/Report field reports the operation requested or operation that has been performed. The request usually originates from the unit's own user interface (i.e. front panel buttons) or from another initiator.

Table 277 - Operation Request/Report codes

Code	Event	Description
0h	NoChg	No changes in operational state performed or requested
1h	Feature Change	Current Profile field, Current bit and/or Last LBA field in the GET CONFIGURATION response data of the logical unit may have changed.
2h-FFFFh	Reserved	

16.5.2 Power Management Class Events

Power Management Class Events notify the host about changes in the logical unit's power state.

Table 278 - Power Management Class Event Descriptor

Bit / Byte	7	6	5	4	3	2	1	0
0	Reserved				Power Event			
1	Power Status							
2	Reserved							
3	Reserved							

The Power Event field reports the current change in the power status. This field is set to a new power event if a change in power state occurs.

Upon reporting the current power status change to the host, this field is reported as 0h on subsequent GET EVENT/ STATUS NOTIFICATION commands until a new change in power state occurs.

If the logical unit is commanded to go the same state as the logical unit is currently in, the next GET EVENT/STATUS NOTIFICATION command (Power Management Class) ***shall*** report a Power Change Successful event.

Table 279 - Power Event format

Code	Event	Description
0h	NoChg	No changes in power state, or in power state transition
1h	PwrChg-Succ	The logical unit successfully changed to the specified power state
2h	PwrChg-Fail	The logical unit failed to enter the last requested state, and is still operating at the power state specified in the Power Status field
3h-Fh	Reserved	

The Power Status field indicate the power state of the logical unit. The Power Status field ***shall*** be set to 3h (Standby) by a hard reset, power-on reset or Device reset (issued from Sleep state).

Note: Status 4 is only likely reported with asynchronous event notification.

Table 280 - Power Status codes

Code	Status	Description
0h	Reserved	
1h	Active	The logical unit is in Active state
2h	Idle	The logical unit is in Idle state
3h	Standby	The logical unit is in Standby state
4h	Sleep	The logical unit is about to enter Sleep state
5h-Fh	Reserved	

16.5.3 External Request Class Events

External Request Class Events notify the host of changes in behavior due to requests from the logical unit front panel or another host. If a Persistent Prevent is active, the Event is a request to change rather than a notification of a change.

Table 281 - External Request Class Event Descriptor

<table>
<tr><th>Bit
Byte</th><th>7</th><th>6</th><th>5</th><th>4</th><th>3</th><th>2</th><th>1</th><th>0</th></tr>
<tr><td>0</td><td colspan="4">Reserved</td><td colspan="4">External Request Event</td></tr>
<tr><td>1</td><td>Persistent Prevented</td><td colspan="3">Reserved</td><td colspan="4">External Request Status</td></tr>
<tr><td>2</td><td colspan="8" rowspan="2">(MSB)
External Request
(LSB)</td></tr>
<tr><td>3</td></tr>
</table>

The External Request Event field reports external requests to change state and notifications of changes in logical unit state. If a Persistent Prevent is in place for the host, the action ***shall not*** be performed by the logical unit. If a Persistent Prevent is not in place for the host, the drive ***shall*** notify the host of actions that change drive state. Upon reporting operational change notification to the host, this field is reported as 0h on subsequent GET EVENT/STATUS NOTIFICATION commands until a new External Request occurs. The External Request Events are listed in Table 282.

Table 282 - External Request Event format

Code	Event	Description
0h	NoChg	No changes in operational state performed or requested
1h	logical unit Key Down	A front, back, or remote button has been pressed.
2h	logical unit Key Up	A front, back, or remote button has been released.
3h	External Request Notification	The logical unit has received a command from another host that would require an action that may interfere with the Persistent Prevent owner's operation.
4h-Fh	Reserved	

The host may respond to Events 1-3 with no action, an appropriate action, or with a SEND EVENT command. The host may respond to Event 4 with a GET CONFIGURATION command. Events 1 and 2 should occur in pairs.

The Persistent Prevented bit reports the current state of the Persistent Prevent for the logical unit. This bit ***shall*** be set to 1 if any host has performed a persistent reservation.

The External Request Status field reports the logical unit's ability to respond to the host.

Table 283 - External Request Status codes

Code	Status	Description
0h	Ready	The logical unit is ready for operation.
1h	OtherPrevent	Indicates that another host has an active Persistent Prevent. The Persistent Prevented bit ***shall*** be set to 1.
2h-Fh	Reserved	

The External Request field reports the operation requested or operation that has been performed. The request usually originates from the unit's own user interface (i.e. front panel buttons) or from another host.

Table 284 - External Request codes

Code	Event	Description
0h	NoRequest	No requests are pending.
1h	Overrun	The Request Queue has overflowed, External Request Events may be lost.
2h-100h	Reserved	
101h	Play	The play button was pressed or another host sent a play request
102h	Rewind/back	The rewind/back button was pressed or another host send a rewind/back request

Table 284 - External Request codes

Code	Event	Description
103h	Fast Forward	The fast forward button was pressed or another host sent a fast forward request
104h	Pause	The pause button was pressed or another host sent a pause request.
105h	Reserved	
106h	Stop	The stop button was pressed or another host requested a stop.
107h-1FFh	Reserved	
200h-2FFh	ASCIIButton	A front panel button was pressed or equivalent action requested by another host. The button has an associated ASCII value. The ASCII value ***shall*** be the least significant 8 bits of the Code.
300h-EFFFh	Reserved	
F000h-FFFFh	Vendor Unique	

16.5.4 Media Class Events

The Media Class Event describes events related to the insertion and removal of media.

Table 285 - Media Class Event Descriptor

Bit / Byte	7	6	5	4	3	2	1	0
0	Reserved				Media Event			
1	Media Status							
2	Start Slot							
3	End Slot							

Table 286 - Media Event format

Code	Event	Description
0h	NoChg	Media status is unchanged.
1h	EjectRequest	The logical unit has received a request from the user (usually through a mechanical switch on the logical unit) to eject the specified slot or media.
2h	NewMedia	The specified slot (or the logical unit) has received new media, and is ready to access it.
3h	MediaRemoval	The media has been removed from the specified slot, and the logical unit is unable to access the media without user intervention.
4h	MediaChange	The user has requested that the media in the specified slot be loaded.
5h-Fh	Reserved	

Note: Usually two events are generated when the user requests an eject: first, an EjectRequest, and then a MediaRemoval.

Table 287 - Media Status Byte format

Bit / Byte	7	6	5	4	3	2	1	0
1	Reserved						Media Present	Door or Tray open

Door or Tray open indicates if the Tray or Door mechanism is in the open state. A bit of 1 indicates the door/tray is open.

The Media Present status bit indicates if there is media present in the logical unit. A bit of 1 indicates that there is media present in the logical unit. This bit is reported independently from the Door or Tray open bit. If the logical unit does not support the capability of reporting the media state while the door or tray is open ***shall*** set this bit to zero when the Door or Tray open bit is one.

Start Slot field defines the first slot of a multiple slot logical unit the media status notification applies to. For logical units that do not support multiple slots, this field ***shall*** be reserved.

End Slot field defines the last slot of a multiple slot logical unit the media status notification applies to. For logical units that do not support multiple slots, this field ***shall*** be reserved.

The slot numbers are defined by Table 329 - *Mechanism Status Header* on page 486.

16.5.5 Multi-host Class Events

Multi-host Class Events notify the host of requests for control by other hosts.

Table 288 - Multi-host Class Event Descriptor

Bit / Byte	7	6	5	4	3	2	1	0
0	Reserved				Multi-host Event			
1	Persistent Prevented	Reserved			Multi-host Status			
2	(MSB) Multi-host Priority							
3								(LSB)

The Multi-host Event field reports requests for control of and reporting of changes in logical unit state. If a Persistent Prevent is in place for that host, the action ***shall not*** be performed by the logical unit. If a Persistent Prevent is not in place for that host, the drive ***shall*** notify the host of actions that change drive state. Upon reporting Multi-host Events to the host, this field is reported as 0h on subsequent GET EVENT/STATUS NOTIFICATION commands until a new Multi-host Event occurs. The Multi-host Events are listed in Table 289.

Table 289 - Multi-host Event format

Code	Event	Description
0h	NoChg	No changes in operational state performed or requested
1h	Control Request	Another host has requested logical unit control.
2h	Control Grant	Another host has received logical unit control.
3h	Control Release	Another host has released logical unit control.
4h-Fh	Reserved	

The host may respond to Events 1-3 with no action or an appropriate Persistent Prevent or Persistent Allow.

The Persistent Prevented bit reports the current state of the Persistent Prevent for the logical unit.

The Multi-host Status field reports the logical unit's ability to respond to the host.

Table 290 - Multi-host Status codes

Code	Status	Description
0h	Ready	The logical unit is ready for operation.
1h	OtherPrevent	Indicates that another host has an active Persistent Prevent. The Persistent Prevented bit ***shall*** be set to 1.
2h-Fh	Reserved	

The Multi-host Priority field reports the other host's relative priority. See Table 291.

Table 291 - Multi-host Priority codes

Code	Event	Description
0h	NoRequest	No requests are pending.
1h	Low	There are no tasks pending on the host for this logical unit.
2h	Medium	There are no critical tasks pending on the host for this logical unit.
3h	High	There are critical tasks pending on the host for this logical unit.
4h-FFFFh	Reserved	

16.5.6 Device Busy Class Events

Device Busy Class Events are used to notify the host of the status of an immediate command that is executing but that require a long time to complete. In this case the logical unit may become Busy, thereby limiting the number of commands that may be executed to completion. Conditions that may cause the logical unit to become Busy are defined in *3.5, "Logical Unit Not Busy condition/Busy condition"* on page 63.

Note: The functionality and descriptions of this event is changed completely from the old version of this document. Host should check DBEvent bit in Core Feature (0001h) to detect the implemented function of the logical unit.
To retrieve progress indication synchronously, the Immed bit should be set to 1 and the Notification Class Request field should be set to 40h.

Table 292 - Device Busy Class Event Descriptor

Bit / Byte	7	6	5	4	3	2	1	0
0	Reserved				Device Busy Event			
1	Device Busy Status							
2	(MSB)				Time			
3								(LSB)

When the Device Busy Status field is set to Busy (01h), the Time field is the predicted amount of time remaining for the logical unit to become not busy, in units of 100ms. This field provides progress indication in time unit. If the Device Busy Status field is other than 01h, the contents of the Time field are unspecified. *16.31.1, "Sense-key Specific"* on page 647 describes progress indication in percent.

Table 293 - Device Busy Event format

Code	Event	Description
0h	NoChg	No changes in Logical unit state
1h	Change	Logical Unit Busy condition has been changed.
2h-Fh	Reserved	

Table 294 - Device Busy Status codes

Code	Status	Description
0h	NoEvent	The logical unit is ready to accept a next Command.
1h	Busy	The Logical unit is busy. The Logical unit may not be able to accept media access commands.
2h-FFh	Reserved	

If a GET EVENT/STATUS NOTIFICATION command of Device Busy Class Events is queued, when Logical unit changes the busy state by an immediate command that executes long operations, the queued GET EVENT/STATUS NOTIFICATION command ***shall*** be terminated to notify the Logical unit busy state change. If the queued GET EVENT/ STATUS NOTIFICATION command can be terminated before the completion of the immediate command, the queued GET EVENT/STATUS NOTIFICATION command ***shall*** be terminated first.

If both the host and the Logical unit support command queuing, the host should issue a GET EVENT/STATUS NOTIFICATION command requesting only the Device Busy Class Events with the Immed bit in the CDB set to zero prior to issuing the command that may cause a Logical Unit Busy condition. If the Logical unit becomes busy, the first GET EVENT/STATUS NOTIFICATION command ***shall*** be executed to report the Change (Not-Busy to Busy transition). The host may issue another GET EVENT/STATUS NOTIFICATION command for the purpose of being notified of completion. Once the command has stopped executing, the second GET EVENT/STATUS NOTIFICATION command ***shall*** be executed to report the Change (Busy to Not-Busy transition). Figure 168 shows the flow of execution of a command that may cause a Logical Unit Busy condition.

Implementation example can be found in *I-4.1 "Example of Device Busy Class Events reporting"* on page 784.

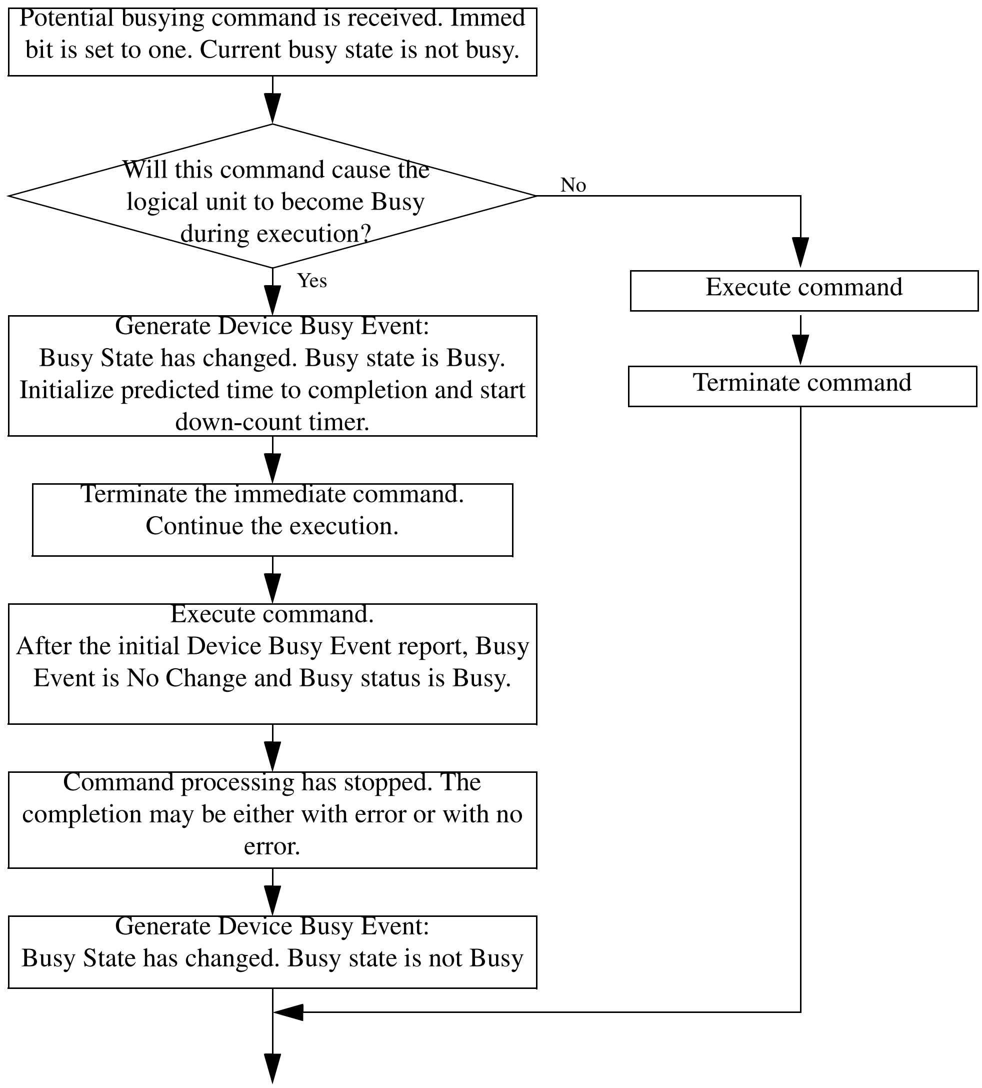


Figure 168 - Execution of a command that may cause Logical Unit Busy

Table 295 describes errors that may occur during the operation of the command or which may cause a CHECK CONDITION status to be reported.

Table 295 - GET EVENT/STATUS NOTIFICATION command errors

Error Description	
5/24/00	INVALID FIELD IN CDB

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16.6 GET PERFORMANCE command

The GET PERFORMANCE command provides a method for the host to profile the performance of the logical unit. The command also provides a means for the host to get unusable area information on the mounted writable medium.

Table 296 - GET PERFORMANCE Command Descriptor Block

<table>
<tr><th>Bit
Byte</th><th>7</th><th>6</th><th>5</th><th>4</th><th>3</th><th>2</th><th>1</th><th>0</th></tr>
<tr><td>0</td><td colspan="8">Operation code (ACh)</td></tr>
<tr><td>1</td><td colspan="3">LUN (Obsolete)</td><td colspan="5">Data Type</td></tr>
<tr><td>2</td><td colspan="8" rowspan="4">(MSB)
Starting LBA
(LSB)</td></tr>
<tr><td>3</td></tr>
<tr><td>4</td></tr>
<tr><td>5</td></tr>
<tr><td>6</td><td colspan="8">Reserved</td></tr>
<tr><td>7</td><td colspan="8">Reserved</td></tr>
<tr><td>8</td><td colspan="8" rowspan="2">(MSB)
Maximum Number of Descriptors
(LSB)</td></tr>
<tr><td>9</td></tr>
<tr><td>10</td><td colspan="8">Type</td></tr>
<tr><td>11</td><td colspan="2">Vendor-Specific</td><td colspan="3">Reserved</td><td>NACA</td><td>Flag</td><td>Link</td></tr>
</table>

The Data Type field definition is dependent upon the Type field value, see Table 297.

The Type field specifies which type of data ***shall*** be transferred. See Table 297.

The definition of the other fields and bits are changed according to the Type field value, see Table 297.

If the logical unit does not support the specified value of Type field on the media, the logical unit ***shall*** terminate this command with CHECK CONDITION status, 5/24/00 INVALID FIELD IN CDB.

Table 297 - Type field values description

<table>
<tr><th rowspan="2">Type field value</th><th rowspan="2">Definition</th><th colspan="4">Data Type field</th><th rowspan="2">Reference</th></tr>
<tr><th>bit 4 - 3</th><th>bit 2</th><th>bit 1</th><th>bit 0</th></tr>
<tr><td>00h</td><td>Performance</td><td>Tolerance</td><td>Write</td><td colspan="2">Except</td><td>see 16.6.1</td></tr>
<tr><td>01h</td><td>Unusable Area</td><td>Reserved</td><td colspan="3">Unusable Area Type</td><td>see 16.6.2</td></tr>
<tr><td>02h</td><td>Defect Status</td><td colspan="4">Reserved</td><td>see 16.6.3</td></tr>
<tr><td>03h</td><td>Write Speed</td><td colspan="4">Reserved</td><td>see 16.6.4</td></tr>
<tr><td>04h</td><td>DBI</td><td colspan="4">Reserved</td><td>see 16.6.5</td></tr>
<tr><td>05h</td><td>DBI cache zone</td><td colspan="4">Reserved</td><td>see 16.6.6</td></tr>
<tr><td>06h-FFh</td><td colspan="6">Reserved</td></tr>
</table>

16.6.1 Performance (Type field = 00h)

The command reports its characteristics of reading/writing performance.

The command can report two groups of parameters: the nominal performance and exception locations that may cause seek delays to occur. These performance parameters are reported separately for read and write.

The corresponding parameter fields allocation are specified in Table 297.

The Tolerance field, when set to 10b, ***shall*** indicate that the descriptors returned ***shall*** have a 10% performance tolerance for the nominal performance and a 20% time tolerance for the exception list. All other values are reserved for future standardization.

The Except field, when set to 00b, ***shall*** indicate that the nominal performance parameters be returned. When set to 01b, the entire performance exception list, qualified by the Starting LBA, ***shall*** be returned. When set to 10b, only performance exceptions that cause the performance to fall outside the nominal ***shall*** be reported. For example, slipped sectors may not be included in the 10b list, but would be included in the 01b list. An Except field of 11b is reserved.

The Write bit, when set to zero, ***shall*** indicate that the performance parameters for reading ***shall*** be returned. When set to one, the performance parameters for writing ***shall*** be returned.

The Starting LBA field is valid only when Except = 01b. If Except = 01b, the Starting LBA field ***shall*** indicate the starting point for returning performance data. All performance data ***shall*** be for logical block addresses equal to this field or greater.

The Maximum Number of Descriptors field ***shall*** indicate the maximum number of descriptors that the logical unit returns. The Maximum Number of Descriptors field should not be set to zero. If the Maximum Number of Descriptors field is set to zero, only the Performance Header ***shall*** be returned.

The result data ***shall*** be formatted as listed in Table 298:

Table 298 - Performance Result Data

Bit / Byte	7	6	5	4	3	2	1	0
0-7	Performance Header							
8-n	Performance Descriptor(s)							

Table 299 - Performance Header

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB)							
1	Performance Data Length							
2								
3								(LSB)
4	Reserved						Write	Except
5	Reserved							
6	Reserved							
7	Reserved							

The Performance Data Length field specifies the length in bytes of the following result data. The Performance Data Length value does not include the Performance Data Length field itself. This value is not modified when the Maximum number of descriptors is insufficient to return all of the Performance data available.

The Write bit, when set to zero, ***shall*** indicate that the result data is for read performance using the nominal command for the data type. When set to one, ***shall*** indicate that the result data is for write performance.

The Except bit, when set to zero, ***shall*** indicate that the result data is for nominal performance. When set to one, ***shall*** indicate that the result data is for exception conditions.

Performance Descriptors ***shall*** be returned for the current medium. If no media is present, Performance Descriptors for the fastest medium ***shall*** be returned.

The Performance Descriptors for nominal performance are intended to give the host an approximation of logical unit performance. All numbers are nominal. On CD media, all sectors ***shall*** be reported as 2352 byte sectors.

For example, a 4×-6× CD-ROM logical unit (CAV/CLV combination) with a data disc loaded may return two nominal performance descriptors. The first would indicate a Start LBA of 0, Start Performance of 706 kB/s, and an end LBA in the middle and a performance of 1058 kB/s. The second would indicate a start LBA adjacent to the ending LBA of the previous descriptor, a start performance of 1058 kB/s, and an end LBA at the end of the medium and an ending performance of 1058 kB/s. The data rate may vary according to the mounted medium, i.e. CD Audio Tracks may have a different spin rate than Data Tracks.

1kB/s is 1000 Bytes per second.

Table 300 - Performance Descriptor - Nominal Performance

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB)							
1				Start LBA				
2								
3								(LSB)
4	(MSB)							
5				Start Performance				
6								
7								(LSB)
8	(MSB)							
9				End LBA				
10								
11								(LSB)
12	(MSB)							
13				End Performance				
14								
15								(LSB)

The Start LBA field contains the first logical block address of the extent described by this descriptor.

The Start Performance field contains the nominal logical unit performance at the Start LBA in kB/s.

The End LBA field contains the last logical block address of the extent described by this descriptor.

The End Performance field contains the nominal logical unit performance at the End LBA in kB/s.

Table 301 - Performance Descriptor - Exceptions

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB)							
1				LBA				
2								
3								(LSB)
4	(MSB)			Time				
5								(LSB)

The LBA field ***shall*** indicate that there is a seek delay between (LBA - 1) and LBA.

The Time field ***shall*** indicate the expected additional delay between (LBA - 1) and LBA from nominal, in units of tenths of milliseconds (100 microseconds). This seek delay may be due to linear replacement, zone boundaries, or other media dependent features. The expected additional delay should represent the typical time expected for the type of exception described.

Note: A block replaced by linear replacement may cause two exceptions to appear in the Exception Descriptor list - one between the non-replaced area and the beginning of the replaced block, and one from the end of the replaced block back to the non-replaced area.

16.6.2 Unusable Area Data (Type field = 01h)

This command reports data to the host that how the physically unusable areas are allocated on the mounted writable media. If the mounted media is not a writable media, the logical unit terminates the command with CHECK CONDITION status, 5/24/00 INVALID FIELD IN CDB.

The corresponding parameter fields allocation are specified in Table 297.

The Unusable Area Type field specifies the type of the unusable area to be transferred. See Table 302.

Table 302 - Unusable Area Type values

Unusable Area Type value	Description
000b	Zone boundary information
001b	PDL information
010b	SDL information
Others	Reserved

The Starting LBA field in CDB ***shall*** indicate the starting point for returning Unusable Area data. All Unusable Area data ***shall*** be for logical block addresses equal to this field or greater.

The Maximum Number of Descriptors field ***shall*** indicate the maximum number of descriptors that the logical unit returns.

The Unusable Area data ***shall*** be formatted as listed in Table 303. The Unusable Area data contains a header, followed by zero or more Descriptors. Each Descriptor contains information about an Unusable Area such as an entry of defect list and Zone boundary, see *4.15.1, "Logical layout of DVD-RAM media"* on page 101 or *5.14.1, "Logical layout of HD DVD-Rewritable media"* on page 303.

Table 303 - Unusable Area Data

Bit / Byte	7	6	5	4	3	2	1	0
0-7	Unusable Area Header							
8-n	Unusable Area Descriptor(s)							

Each Unusable Area Descriptor(s) ***shall*** be transferred to the host in ascending order of the Starting LBA.

Table 304 - Unusable Area Header

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB) Unusable Area Data Length							
1								
2								
3								(LSB)
4-7	Reserved							

The Unusable Area Data Length field specifies the length in bytes of the following result data. The Unusable Area Data Length value does not include the Unusable Area Data Length field itself. This value is not modified when the Maximum number of descriptors is insufficient to return all of the Unusable Area data available.

Table 305 - Unusable Area Descriptor

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB) LBA							
1								
2								
3								(LSB)
4	(MSB) Number of Unusable Physical Blocks							
5								
6								
7								(LSB)

The LBA field ***shall*** indicate the first LBA of the unusable area if the Unusable Area Type field in CDB is set to 010b. The LBA field ***shall*** indicate the LBA just before the unusable area when the Unusable Area Type field in CDB is set to 000b or 001b.

The Number of Unusable Physical Blocks field ***shall*** indicate number of physical blocks included in the specified unusable area. When the Unusable Area Type field in CDB is set to 000b, this field is reserved.

16.6.3 Defect Status Data (Type field = 02h)

This command reports Defect Status data to the host that is created by certification on the Restricted Overwrite media. If the mounted media is not a Restricted Overwrite media or if the logical unit does not support certification, this command ***shall*** be terminated with CHECK CONDITION status, 5/24/00 INVALID FIELD IN CDB.

The Data Type field in CDB ***shall*** be set to 0.

The Starting LBA field in CDB ***shall*** indicate the starting point for returning Defect Status data. All Defect Status data ***shall*** be for logical block addresses equal to this field or greater.

The Maximum Number of Descriptors field ***shall*** indicate the maximum number of descriptors that the logical unit returns.

The Defect Status data ***shall*** be formatted as listed in Table 306. The Defect Status data contains a header, followed by zero or more Descriptors. Each Descriptor contains information about an Defect Status such as a Defect Status bitmap on DVD-RW media, see Table 4.19.6.10 - *Format 3 RMD Field 4 to Field 12* on page 234. A Defect Status Descriptor size ***shall*** be 2048 bytes.

Table 306 - Defect Status Data

Bit / Byte	7	6	5	4	3	2	1	0
0-7	Defect Status Header							
8-n	Defect Status Descriptor(s)							

Each Defect Status Descriptor(s) ***shall*** be transferred to the host in ascending order of the Starting LBA. If the certified areas are non-contiguous and scattered, the Defect Status Descriptor(s) ***shall*** be returned by separate descriptors to exclude the void areas.

Table 307 - Defect Status Header

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB)							
1	Defect Status Data Length							
2								
3								(LSB)
4-7	Reserved							

The Defect Status Data Length field specifies the length in bytes of the following result data. The Defect Status Data Length value does not include the Defect Status Data Length field itself. This value is not modified when the Maximum number of descriptors is insufficient to return all of the Defect Status data available. If there is no Defect Status data on the media, Defect Status Data Length field ***shall*** be set to 4 and no Defect Status Descriptor ***shall*** be transferred.

Table 308 - Defect Status Descriptor

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB)							
1	Start LBA							
2								
3								(LSB)
4	(MSB)							
5	End LBA							
6								
7								(LSB)
8	Blocking Factor							
9	Reserved					First Bit offset		
10	DS #8	DS #7	DS #6	DS #5	DS #4	DS #3	DS #2	DS #1
:	:	:	:	:	:	:	:	:
2047	DS #16304	DS #16303	DS #16302	DS #16301	DS #16300	DS #16299	DS #16298	DS #16297

The Start LBA field contains the start Logical Block Address of the certified sector where the following Defect Status (DS #n bits) starts. The returned Logical Block Address ***shall*** be the first sector of a Block that contains logical blocks specified by the Blocking Factor field.

The End LBA field contains the end Logical Block Address of the certified sector where the following Defect Status (DS #n bits) ends. The returned Logical Block Address ***shall*** be the last sector of a Block that contains logical blocks specified by the Blocking Factor field.

The Blocking Factor field ***shall*** indicate the number of logical blocks per DS #m bit. In the case of DVD-RW, this filed ***shall*** be set to 16 as an ECC block.

The First Bit offset field ***shall*** indicate the start valid bit number in the byte 10. The lower bits in the byte 10 are invalid. For example, if First Bit offset field contains 3, bit 3 of byte 10 has the defect status of the block that contains the Logical block specified Start LBA field. From bit 2 to bit 0 are invalid in this case.

DS #n bit contains the certification result of the block #m. When DS #n bit is set to 0, indicate that the block has no defect and is able to read and write the block safely. When DS #n bit is set to 1, indicates that the block has defect and might not be able to read and write the block safely.

16.6.4 Write Speed (Type field = 03h)

This command reports a list of possible Write Speed descriptors. If recordable media is mounted, logical unit ***shall*** report the list of speeds that are available for the Blocks of the current mounted medium. If no recordable media is mounted, logical unit ***shall*** report the most appropriate list of speeds such as the list for CD-R media or just maximum recording speed. Logical unit ***shall*** report Write Speed descriptors in descending order of the Write Speed value. If the logical unit supports both CLV and CAV on the media, then the logical unit ***shall*** report all CLV descriptors first. Host should detect a possible Write Speed descriptor by this command, then set the Write Speed via SET STREAMING command. To apply this descriptor to SET STREAMING command, the Start LBA field is set to 0, the Read Time field and the Write Time filed are set to 1000 (1sec).

The result data ***shall*** be formatted as listed in Table 309:

Table 309 - Write Speed Result Data

Bit / Byte	7	6	5	4	3	2	1	0
0-7	Write Speed Header							
8-n	Write Speed Descriptor(s)							

Table 310 - Write Speed Header

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB)							
1	Write Speed Data Length							
2								
3								(LSB)
4 - 7	Reserved							

The Write Speed Data Length field specifies the length in bytes of the following result data. The Write Speed Data Length value does not include the Write Speed Data Length field itself. This value is not modified when the Maximum number of descriptors is insufficient to return all of the Write Speed data available.

Table 311 - Write Speed Descriptor

Bit / Byte	7	6	5	4	3	2	1	0
0	Reserved			WRC		RDD	Exact	MRW
1	Reserved							
2	Reserved							
3	Reserved							
4	(MSB)							
5	End LBA							
6								
7								(LSB)
8	(MSB)							
9	Read Speed							
10								
11								(LSB)
12	(MSB)							
13	Write Speed							
14								
15								(LSB)

The Write Rotation Control (WRC) field specifies the type of the medium Rotation Control. See Table 312.

Table 312 - Write Rotation Control values

Write Rotation Control value	Description
00b	Media default rotation control
01b	CAV
Others	Reserved

Media default rotation control is the rotation control defined by the media specification originally. Media default rotation control is as follows:

- CD-R/RW CLV
- DVD-R/-RW CLV
- DVD-RAM ZCLV
- DVD+RW CAV

If default rotation control is CAV, this field ***shall*** be set to 0.

RDD bit ***shall*** be set to 0.

Exact bit of one indicates that the logical unit can perform the recording operation specified by Write Speed Descriptor on the whole media mounted. If the logical unit is uncertain, this bit ***shall*** set to 0.

The MRW bit indicates that this Write Speed Descriptor is suitable for mixture of read and write (e.g., overwrite mode).

The End LBA field ***shall*** indicate the medium capacity if a medium is mounted. The value ***shall*** be same as the value reported by READ CAPACITY command. If no medium is mounted, the logical unit ***shall*** report the maximum capacity of the most appropriate media.

The Read Speed field ***shall*** indicate the lowest read performance data of all Blocks in kilobytes per second.

The Write Speed field ***shall*** indicate the lowest write performance data of all Blocks in kilobytes per second.

Note: The Write Speed (Type field = 03h) format cannot show the difference between 6×CLV and 6×-8×ZCLV on DVD-R/+R media. 6×-8×ZCLV may be regarded as 8×CLV. The correct write speed profile and read speed profile that are selected are shown by Performance (Type field = 00h) format.

16.6.5 DBI (Type field = 04h)

This command reports a list of Defective Block Information (DBI) data that is a certification result of a medium. To keep compatibility among three DBI memory models described in *9.3.4, "DBI memory management"* on page 338, the host ***shall*** specify the correct logical block address to be read for defect information in the Starting LBA field of GET PERFORMANCE Command Descriptor Block.

If the logical unit supports Enhanced Defect Reporting Feature but this Feature is not current, only DBI data Header ***shall*** be reported. If logical unit does not support Enhanced Defect Reporting Feature, this command ***shall*** be terminated with CHECK CONDITION status, 5/24/00 INVALID FIELD IN CDB.

The result data ***shall*** be formatted as listed in Table 313.

Table 313 - DBI data

Bit / Byte	7	6	5	4	3	2	1	0
0-7	DBI data Header							
8-n	DBI Descriptor(s)							

Table 314 - DBI data Header

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB)							
1	DBI Data Length							
2								
3								(LSB)
4 - 7	Reserved							

The DBI Data Length field specifies the length in bytes of the following result data. The DBI Data Length value does not include the DBI Data Length field itself. This value is not modified when the Maximum number of descriptors is insufficient to return all of the DBI data available.

Table 315 - DBI Descriptor

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB)							
1	Start LBA of defective blocks							
2								
3								(LSB)
4	(MSB)							
5	Number of consecutive defective blocks							(LSB)
6	Reserved			DBIF	Error Level Type			
7	Reserved							

The Start LBA of defective blocks field indicates the start LBA of defective blocks on the medium. The value ***shall*** be the packet start LBA that the packet includes the sector specified by the Starting LBA field in CDB.

The Number of consecutive defective blocks field indicates the number of consecutive defective blocks from the LBA specified by the Start LBA of defective blocks field.

The DBI Full (DBIF) bit indicates that incomplete verify operation occurs due to DBI memory full when Simple DBI memory model or small DBI cache memory model is used (see *9.3.4, "DBI memory management"* on page 338). If this bit is set to 1, the VERIFY (10) or WRITE AND VERIFY (10) command was terminated at the address calculated from this descriptor before certification completion of specified number of blocks in CDB. The actual terminated address of VERIFY (10) or WRITE AND VERIFY (10) command is "Start LBA of defective blocks" + "Number of consecutive defective blocks" - 1. To continue the verification of the blocks, the host ***shall*** issue VERIFY (10) command from "Start LBA of defective blocks" + "Number of consecutive defective blocks" address.

If this bit is set to 0, indicates that the VERIFY (10) or WRITE AND VERIFY (10) command is terminated without DBI memory full.

At the beginning of the next VERIFY (10)/WRITE AND VERIFY (10) command or at the medium change, the DBIF bit ***shall*** be set to 0. By transferring the DBI descriptor of DBIF = 1 or by performing of READ (10)/READ (12) command, this bit ***shall not*** be cleared.

In the case of small DBI cache memory model, when WDBI cache is updated by the WRITE (10)/WRITE (12) command, the DBIF bit ***shall*** be set to 0.

Error Level Type field indicates the type of the error level of the defective blocks. See Table 316.

Table 316 - Error Level Type values

Error Level Type value	Error Level Type	Description
0	Type 1	Recovered light defect in specified defective blocks. Data in the blocks can be recovered by error correction.
1	Type 2	Recovered heavy defect in specified defective blocks. Data in the blocks can be recovered by error correction and multiple retry seek/read action.
2	Type 3	Un-recovered read/seek error defect in specified defective blocks.
3	Type 4	Write error occurs in the specified defective blocks. Data had not be written on the sectors.
Others	Others	Reserved

16.6.6 DBI cache zone (Type field = 05h)

The DBI cache zone descriptor provides a way for the host to indicate to the logical unit that the application has specific request for drive behavior of small DBI cache model in DRT-DM mode. Disc volume space is divided into a few DBI cache zones. RDBI and WDBI memory ***shall*** be allocated for each DBI cache zones. Minimally 2 DBI cache zones ***shall*** be supported. Number of supported DBI cache zone is shown in Number of DBI cache zones field of Table 246 - *Enhanced Defect Reporting Feature Descriptor* on page 433.

If logical unit does not support *9.3.4.3, "Small DBI cache memory model"* on page 338, the logical unit ***shall*** terminate this command with CHECK CONDITION status, 5/24/00 INVALID FIELD IN CDB. If the logical unit supports both Small DBI cache memory model and Large DBI buffer memory model and if the Large DBI buffer memory model is currently used, the logical unit ***shall*** report single DBI cache zone that starts from LBA 0 to the end of the medium.

The descriptor data ***shall*** be formatted as listed in Table 603 - *DBI cache zone Descriptor* on page 695.

Table 317 describes errors that may occur during the operation of the command or which may cause a CHECK CONDITION status to be reported.

Table 317 - GET PERFORMANCE command errors

Error Description	
	A-1.1, "Deferred Error Reporting" on page 721
5/24/00	INVALID FIELD IN CDB

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16.7 INQUIRY command

The INQUIRY command requests that information regarding parameters of the logical unit be sent to the host Computer. Options allow the host to request additional information about the logical unit.

Table 318 - INQUIRY Command Descriptor Block

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation Code (12h)							
1	LUN (Obsolete)			Reserved			CmdDt	EVPD
2	Page or Operation Code							
3	Reserved							
4	Allocation Length							
5	Vendor-Specific		Reserved			NACA	Flag	Link
6	PAD							
7								
8								
9								
10								
11								

The INQUIRY command ***shall*** return CHECK CONDITION status only when the logical unit cannot return the requested INQUIRY data. The INQUIRY data should be returned even though the peripheral logical unit may not be ready for other commands.

If an INQUIRY command is received with a pending UNIT ATTENTION condition (i.e. before the logical unit reports CHECK CONDITION status), the logical unit ***shall*** perform the INQUIRY command and ***shall not*** clear the UNIT ATTENTION condition.

The Enable Vital Product Data (EVPD) bit is optional. When set to zero, ***shall*** indicate that INQUIRY data ***shall*** be returned as shown in Table 319. When set to one, ***shall*** indicate that the page identified by the Page or Operation Code field be returned.

The Page or Operation Code field is valid when the EVPD bit is set to one. The Page or Operation Code field ***shall*** identify the requested INQUIRY Page.

The command Support Data (CmdDt) is used to request the logical unit return the command support data specified by the Page or Operation Code field. This capability is not used by C/DVD/HD DVD logical units. If this bit is set to one, the logical unit ***shall*** return CHECK CONDITION status, 5/24/00 INVALID FIELD IN CDB.

The Allocation Length field ***shall*** indicate the maximum number of bytes that may be transferred to the host.

The INQUIRY data should be returned even though the logical unit is not ready for other commands. To minimize delays after a power on or hard reset, the standard INQUIRY data should be available without incurring any media access delays. If the logical unit does store some of the INQUIRY data on the media, it may return zeros or ASCII spaces (20h) in those fields until the data is available from the media.

16.7.1 Standard INQUIRY Data

The standard INQUIRY data contains 36 required bytes, followed by a variable number of vendor-specific parameters. Bytes 58 through 95, if returned, are reserved for future standardization.

Table 319 - INQUIRY Data Format

<table>
<tr><th>Bit
Byte</th><th>7</th><th>6</th><th>5</th><th>4</th><th>3</th><th>2</th><th>1</th><th>0</th></tr>
<tr><td>0 SCSI</td><td colspan="3">Peripheral Qualifier</td><td colspan="5" rowspan="2">Peripheral Device Type</td></tr>
<tr><td>0 ATAPI</td><td colspan="3">Reserved</td></tr>
<tr><td>1</td><td>RMB</td><td colspan="7">Reserved</td></tr>
<tr><td>2 SCSI</td><td colspan="2" rowspan="2">ISO Version (0)</td><td colspan="3" rowspan="2">ECMA Version (0)</td><td colspan="3">ANSI Version (>0)</td></tr>
<tr><td>2 ATAPI</td><td colspan="3">ANSI Version (0)</td></tr>
<tr><td>3 SCSI</td><td>AERC</td><td>Obsolete</td><td>NormACA</td><td>HiSup</td><td colspan="4" rowspan="2">Response Data Format</td></tr>
<tr><td>3 ATAPI</td><td colspan="4">ATAPI Transport Version (3)</td></tr>
<tr><td>4</td><td colspan="8">Additional Length (Number of bytes following this one)</td></tr>
<tr><td>5</td><td>SCCS</td><td colspan="7">Reserved</td></tr>
<tr><td>6 SCSI</td><td>BQue</td><td>EncServ</td><td>VS</td><td>MultiP</td><td>MChngr</td><td>AckReqQ[a]</td><td>Addr32[a]</td><td>Addr16</td></tr>
<tr><td>6 ATAPI</td><td colspan="8">Reserved</td></tr>
<tr><td>7 SCSI</td><td>RelAdr</td><td>WBus32[a]</td><td>WBus16</td><td>Sync</td><td>Linked</td><td>TranDis</td><td>CmdQue</td><td>VS</td></tr>
<tr><td>7 ATAPI</td><td colspan="8">Reserved</td></tr>
<tr><td>8-15</td><td colspan="8">Vendor Identification</td></tr>
<tr><td>16-31</td><td colspan="8">Product Identification</td></tr>
<tr><td>32-35</td><td colspan="8">Product Revision Level</td></tr>
<tr><td>36-55</td><td colspan="8">Vendor-specific</td></tr>
<tr><td>56</td><td colspan="8">Reserved</td></tr>
<tr><td>57</td><td colspan="8">Reserved</td></tr>
<tr><td>:</td><td colspan="8">:</td></tr>
<tr><td>74-95</td><td colspan="8">Reserved</td></tr>
<tr><td>96-n</td><td colspan="8">Vendor Specific Parameters</td></tr>
</table>

a. These bits are obsoleted. See SPC-2.

The Peripheral Qualifier value is defined in Table 320.

Table 320 - Peripheral Qualifier definitions

Peripheral Qualifier	Definition
000b	The specified Peripheral Device Type is currently connected to this logical unit. If the logical unit cannot determine whether or not a physical device is currently connected, it also ***shall*** use this Peripheral Qualifier when returning the INQUIRY data. This Peripheral Qualifier does not mean that the device is ready for access by the host.
001b	The logical unit is capable of supporting the specified Peripheral Device Type on this logical unit. However, the physical device is not currently connected to this logical unit.
010b	Reserved
011b	The logical unit is not capable of supporting a physical device on this logical unit. For this Peripheral Qualifier the Peripheral Device Type ***shall*** be set to 1Fh to provide compatibility with previous versions of SCSI. All other Peripheral Device Type values are reserved for this Peripheral Qualifier.
1xxb	Vendor Specific

The Peripheral Device Type field identifies the device as defined in Table 321. The Peripheral Device Type ***shall*** be set to 05h to indicate a C/DVD/HD DVD logical unit.

Table 321 - Peripheral Device Types

Code	Description
00h	Direct-access logical unit (e.g., magnetic disk)
01h - 04h	Reserved
05h	C/DVD/HD DVD logical unit (ROM, R, RW, RAM and +RW types, and HD DVD-ROM, R and Rewritable types)
06h	Reserved
07h	Optical memory logical unit (e.g., some optical disks)
08h - 1Eh	Reserved
1Fh	Unknown or no logical unit type

A Removable Medium (RMB) bit of zero indicates that the medium is not removable. A RMB bit of one indicates that the medium is removable. C/DVD/HD DVD read-only logical units should always report "Removable."

The usage of non-zero code values in the ISO Version and ECMA Version fields are defined by the International Organization for Standardization and ECMA, respectively.

The ANSI Version field ***shall*** contain a non-zero value to comply with this version of the Specification for a SCSI logical unit or zero for an ATAPI logical unit.

The ATAPI Transport Version field ***shall*** contain 03h to comply with this version of the Specification. This field indicates the version of the ATAPI Transport that is being used. For more information on the transport, see the INCITS T13/1153D standard. For a SCSI logical unit this field is defined by the SCSI SPC-2 standard.

The asynchronous event reporting capability (AERC) bit indicates that the logical unit supports the asynchronous event reporting capability as defined in SAM-2. The AERC bit is qualified by the Peripheral Device Type field as follows:

1. Processor device-type definition: An AERC bit of one indicates that the processor device is capable of accepting asynchronous event reports. An AERC bit of zero indicates that the processor device does not support asynchronous event reports; or
2. All other device-types: This bit is reserved.

Details of the asynchronous event reporting support are protocol-specific.

The Normal ACA Supported (NormACA) bit of one indicates that the logical unit supports setting the NACA bit to one in the Control Byte of the CDB (as defined in SAM-2). A NormACA bit of zero indicates that the logical unit does not support setting the NACA bit to one.

A hierarchical support (HiSup) bit of zero indicates the logical unit does not use the hierarchical addressing model to assign LUNs to logical units. A HiSup bit of one indicates the logical unit uses the hierarchical addressing model to assign LUNs to logical units. When the HiSup bit is one, the logical unit ***shall*** support the REPORT LUNS command (see SPC-2).

A Response Data Format value of 02h indicates that the data ***shall*** be in the format specified in this Specification. Response Data Format values less than two are obsolete. Response Data Format values greater than two are reserved.

The Additional Length field ***shall*** specify the length in bytes of the parameters. If the allocation length of the Command Packet is too small to transfer all of the parameters, the Additional Length ***shall not*** be adjusted to reflect the truncation.

An SCC Supported (SCCS) bit of one indicates that the device contains an embedded storage array controller component. See SCC-2 for details about storage array controller devices. An SCCS bit of zero indicates that the device does not contain an embedded storage array controller component.

Note: The embedded changer model is not the one presented in this document.

The basic queuing (BQue) bit ***shall*** be zero if the CmdQue bit is one. When the CmdQue bit is zero, the BQue bit ***shall*** have the following meaning. A BQue bit of zero indicates that the device does not support tagged tasks (command queuing) for this logical unit. A value of one indicates that the device supports, for this logical unit, the basic task management model defined by SAM-2.

An Enclosure Services (EncServ) bit of one indicates that the device contains an embedded enclosure services component. See SES for details about enclosure services, including a device model for an embedded enclosure services device. An EncServ bit of zero indicates that the device does not contain an embedded enclosure services component.

A Multi Port (MultiP) bit of one ***shall*** indicate that this is a multi-port (2 or more ports) device and conforms to the SCSI-3 multi-port device requirements found in the applicable standards. A value of zero indicates that this device has a single port and does not implement the multi-port requirements.

A medium changer (MChngr) bit of one indicates that the device is embedded within or attached to a medium transport element. See SMC for details about medium changers, including a device model for an attached medium changer device. The MChngr bit is valid only when the RMB bit is equal to one. A MChngr bit of zero indicates that the device is not embedded within or attached to a medium transport element.

Note: The MChngr bit is unrelated to the changer model described in this specification.

A relative addressing (RelAdr) bit of one indicates that the logical unit supports the relative addressing mode. If this bit is set to one, the linked command (Linked) bit ***shall*** also be set to one; since relative addressing is only allowed with linked commands. A RelAdr bit of zero indicates the logical unit does not support relative addressing.

A linked command (Linked) bit of one indicates that the logical unit supports linked commands (see SAM-2). A value of zero indicates the logical unit does not support linked commands.

A command queuing (CmdQue) bit of one indicates that the device supports tagged tasks (command queuing) for this logical unit (see SAM-2). A value of zero indicates the logical unit may support tagged tasks for this logical unit (see the BQue bit, above). Table 322 summarizes the relationship of the BQue and CmdQue bits.

Table 322 - Relationship of BQue and CmdQue bits

BQue	CmdQue	Description
0	0	No command queuing of any kind supported.
0	1	Command queuing with all types of task tags supported.
1	0	Basic task set model supported (see SAM-2)
1	1	Illegal combination of BQue and CmdQue bits.

ASCII data fields ***shall*** contain only graphic codes (i.e. code values 20h through 7Eh). Left-aligned fields ***shall*** place any unused bytes at the end of the field (highest offset) and the unused bytes ***shall*** be filled with space characters (20h). Right-aligned fields ***shall*** place any unused bytes at the start of the field (lowest offset) and the unused bytes ***shall*** be filled with space characters (20h).

The Vendor Identification field contains 8 bytes of ASCII data identifying the vendor of the product[1]. The data ***shall*** be left aligned within this field.

The Product Identification field contains 16 bytes of ASCII data as defined by the vendor. The data ***shall*** be left-aligned within this field.

The Product Revision Level field contains 4 bytes of ASCII data as defined by the vendor. The data ***shall*** be left-aligned within this field.

1. It is intended that this field provide a unique vendor identification of the manufacturer of the logical unit. In the absence of a formal registration procedure, INCITS T10 maintains a list of vendor identification codes in use. Vendors are requested to voluntarily submit their identification codes to INCITS T10 to prevent duplication of codes.

16.7.2 Using the INQUIRY command

The INQUIRY command may be used by a host to determine the configuration of the logical unit. Logical units respond with information that includes their type and Specification level and may include the vendor's identification, model number and other useful information.

Table 323 describes errors that may occur during the operation of the command or which may cause a CHECK CONDITION status to be reported.

Table 323 - INQUIRY command errors

Error Description	
5/24/00	INVALID FIELD IN CDB

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16.8 LOAD/UNLOAD MEDIUM command

The LOAD/UNLOAD MEDIUM command requests that the logical unit changer load or unload a Disc. New LOAD/ UNLOAD MEDIUM commands issued before the changer posts a state of READY, will cause the changer to abort the LOAD/UNLOAD MEDIUM command in progress and begin processing the new LOAD/UNLOAD MEDIUM command.

Table 324 - LOAD/UNLOAD MEDIUM Command Descriptor Block

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation Code (A6h)							
1	LUN (Obsolete)			Reserved				Immed
2	Reserved							
3	Reserved							
4	Reserved						LoUnlo	Start
5	Reserved							
6	Reserved							
7	Reserved							
8	Slot							
9	Reserved							
10	Reserved							
11	Vendor-Specific		Reserved			NACA	Flag	Link

An immediate (Immed) bit of one indicates that the logical unit ***shall*** return status as soon as the command Descriptor Block has been validated. An Immed bit of zero indicates that the status ***shall not*** be returned until the operation has been completed.

A Start bit of one requests the logical unit be made ready for use. A Start bit of zero requests that the logical unit be stopped (media cannot be accessed by the host).

Table 325 - Load/Unload or Optional Selection Operations

LoUnlo	Start	Operation to be Performed
0	0	Abort any Prior Changer command (Stop)
0	1	Reserved
1	0	Unload media. The Slot Parameter is ignored for this operation.
1	1	Either Move the Disc in the selected Slot to the play position or select the Slot specified for use with future Media Access commands

The Slot field indicates the Slot to be loaded. Changers compatible with the Bootable CD specification should always initialize (Load) Slot 0 on Power On or Hard Reset.

Any attempt to Load or Unload a Disc when the logical unit does not support that capability ***shall*** result in CHECK CONDITION status, 5/24/00 INVALID FIELD IN CDB.

Loading when the slot does not contain a Disc will be rejected with CHECK CONDITION status, 2/3A/00 MEDIUM NOT PRESENT. When this error is returned there are two possible actions by the logical unit. If the logical unit reports Software Slot Selection (SSS) = 1, then the slot specified ***shall*** be selected for use. The SSS bit is defined in *16.11.3.6, "C/DVD Capabilities & Mechanical Status Mode Page"* on page 507. If the logical unit reports SSS = 0 then the previously used slot ***shall*** continue to selected for use.

If the logical unit is capable of caching data then a delayed load of a disc into the playing position can be supported.

If delayed loading of a disc into the playing position is supported, the logical unit ***shall*** have previously cached the Lead-in data from that disc. If the medium is DVD then the caching of the Lead-in information ***shall*** be performed. If the medium is CD then the caching of the TOC ***shall*** be performed. If the logical unit has not read the Lead-in for a disc that is being loaded into the playing position, then delayed loading ***shall not*** be performed and the disc ***shall*** be loaded into the playing position immediately. If the loading of the Disc into the playing position is delayed, then the logical unit ***shall*** report that the Disc is ready, even though the Disc is not spinning and installed in the playing position. In all cases the behavior seen by the host (other than a longer subsequent media access latency) ***shall not*** be different between delayed and immediate loading of a disc.

A UNIT ATTENTION condition ***shall not*** be generated for the host issuing the LOAD/UNLOAD MEDIUM command when discs are loaded or unloaded from the playing position.

Unloading when the Play Position does not contain a Disc will be rejected CHECK CONDITION status, 5/24/00 INVALID FIELD IN CDB for the Slot Byte.

Table 326 describes errors that may occur during the operation of the command or which may cause a CHECK CONDITION status to be reported.

Table 326 - LOAD/UNLOAD MEDIUM command errors

Error Description	
	A-1.1, "Deferred Error Reporting" on page 721
	Table 630 - *Basic Error Codes* on page 730
4/3B/16	MECHANICAL POSITIONING OR CHANGER ERROR
4/53/00	MEDIA LOAD OR EJECT FAILED

16.9 MECHANISM STATUS command

The MECHANISM STATUS command requests that the respond with the current status of the logical unit, including any Changer Mechanism that adheres to this specification. This command is intended to provide information to the host about the current operational state of the logical unit. The logical units take operational direction from both the host and the user (Person). Movement of media in/out of the logical unit may be due to external conditions beyond the control of the host. This command has been provided to allow the host to know what as transpired at the user level.

Table 327 - MECHANISM STATUS Command Descriptor Block

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation Code (BDh)							
1	LUN (Obsolete)			Reserved				
2	Reserved							
3	Reserved							
4	Reserved							
5	Reserved							
6	Reserved							
7	Reserved							
8	(MSB) Allocation Length							
9								(LSB)
10	Reserved							
11	Vendor-Specific		Reserved			NACA	Flag	Link

The Allocation Length field specifies the maximum length in bytes of the Returned Data that ***shall*** be transferred from the logical unit to the host. An Allocation Length of zero indicates that no data ***shall*** be transferred. This condition ***shall not*** be considered as an error.

The Mechanism Status Parameter List contains a header, followed by zero or more fixed-length Slot Tables. If the logical unit does not support the changer Feature, then the number of slot tables returned to the host ***shall*** be zero. The number of slot tables returned ***shall*** be same as reported in the Number of Slots Available (Byte 5 of the Mechanism Status Header) field.

Table 328 - Mechanism Status Parameter List

Bit / Byte	7	6	5	4	3	2	1	0
0-7	Mechanism Status Header							
8-n	Slot Table(s)							

Each Slot Table contains the a slot number and status information.

Table 329 - Mechanism Status Header

Bit / Byte	7	6	5	4	3	2	1	0
0	Fault	Changer State		Current Slot				
1	C/DVD Mechanism State			DoorOpen	Reserved			
2	(MSB)							
3	Current LBA							
4								(LSB)
5	Reserved		Number of Slots Available					
6	(MSB)							
7	Length of Slot Table(s)							(LSB)

Bit 0-4, Current Slot — This field indicates the current Changer Slot selected. Changers compatible with a Bootable CD specification/standard, should always initialize (Load) Slot 0 on Power On or Hard Reset. This value ***shall*** only be changed when a LOAD/UNLOAD MEDIUM command is processed. Operations initiated by a user ***shall not*** cause this value to change. If the logical unit is not a changer, then this field is reserved.

Bit 5-6, Changer State — This field indicates the current state of the logical unit.

- 0h Ready
- 1h Load in Progress
- 2h Unload in Progress
- 3h Initializing

Bit 7, Fault — This bit indicates that the changer failed to complete the operation reported in the Changer State field. If the logical unit is not a changer, then this bit is reserved.

Bit 4, DoorOpen — This bit indicates that the Door(s) or Tray(s) is open or the Magazine is not present.

Bit 7-5, C/DVD Mechanism State — This field encodes the current operation of the logical unit.

- 0h Idle
- 1h Active with Audio Port in use (i.e. Playing, Paused)
- 2h Scan in progress
- 3h Active with host, Composite or Other Ports in use (i.e. READ, SCAN during a PLAY CD).[1]
- 4-6h Reserved
- 7h No State Information Available

The Current LBA value returns the location that was last used while reading or playing. Once a Read or Play operation has been completed the value of this field may be undefined. While a Read or Play is in progress this field will contain the LBA of the current block being processed.

The Number of Slots Available field ***shall*** return the number of logical Slots that the logical unit supports and ***shall*** be a maximum of 32.

The Length of Slot Table(s) field specifies the length in bytes of the all the slot information that follows (e.g., for a 2 slot logical unit this value would be 8).

1. MMC does not make use of this value.

Table 330 - Slot Table Response format

Bit / Byte	7	6	5	4	3	2	1	0
0	Disc Present	Reserved						Change
1	Reserved						CWP_V	CWP
2	Reserved							
3	Reserved							

Bit 0, Change (mandatory) — Change indicates that the Disc in that slot has been changed since the last time the Disc was loaded.

Bit 7, Disc Present (Optional) — This bit reports the presence of a Disc in a Slot, or if the Disc for a given Slot is in the Playing Position. A value of 1 indicates the Disc is present, and 0 indicates that it is not.

SDP=0 — Changer logical units may not support the capability of reporting the presence of a Disc in each of the slots after reset or a Magazine change. In this case the logical unit ***shall*** report this in the Changer Feature (See *16.4.2.28, "Feature 0102h: Embedded Changer"* on page 445 “Supports Disc Present Reporting bit (SDP)”). In this case the logical unit ***shall*** report that ALL Discs are present, until the logical unit can determine that there is no Disc present (i.e. when a LOAD/UNLOAD MEDIUM command is processed for an empty slot).

SDP=1 — If the Changer logical unit does support the reporting of the Disc Present then this bit ***shall*** be valid for all slots. It is not acceptable for the logical unit to actually load and unload each slot to compute this information.

CWP_V, if set to one, indicates that the Media Cartridge Write Protection (CWP) of the Cartridge in that slot has been checked and CWP bit is valid. If set to 0, the CWP bit is invalid.

CWP, if set to 1, indicates that the CWP status is active on the Cartridge. If CWP_V is set to 0, CWP bit is invalid and ***shall*** be set to 0.

Table 331 describes errors that may occur during the operation of the command or which may cause a CHECK CONDITION status to be reported.

Table 331 - MECHANISM STATUS command errors

Error Description
A-1.1, "Deferred Error Reporting" on page 721
Table 630 - *Basic Error Codes* on page 730

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16.10 MODE SELECT (10) command

The MODE SELECT (10) command provides a means for the host to specify medium or logical unit parameters to the logical unit. Hosts should issue a MODE SENSE (10) command prior to each MODE SELECT (10) command to determine supported Pages, Page Lengths, and other parameters.

Table 332 - MODE SELECT (10) Command Descriptor Block

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation code (55h)							
1	LUN (Obsolete)			PF (1)	Reserved			SP
2	Reserved							
3	Reserved							
4	Reserved							
5	Reserved							
6	Reserved							
7	(MSB) Parameter List Length							
8								(LSB)
9	Vendor-Specific		Reserved			NACA	Flag	Link
10	PAD							
11								

A Save Pages (SP) bit of zero indicates the logical unit ***shall*** perform the specified MODE SELECT (10) operation, and ***shall not*** save any Pages. An SP bit of one indicates that the logical unit ***shall*** perform the specified MODE SELECT (10) operation, and ***shall*** save to a non-volatile vendor-specific location all the savable Pages. If a logical unit supports saved Pages, it ***shall*** save only one copy of the Page. The SP bit is optional, even when Mode Pages are supported by the logical unit. Pages that are saved are identified by the parameter savable (PS) bit that is returned in the Page Header by the MODE SENSE (10) command. If the PS bit is set in the MODE SENSE (10) data then the Page ***shall*** be savable by issuing a MODE SELECT (10) command with the SP bit set. If the logical unit does not implement saved Pages and the SP bit is set to one, the command ***shall*** be terminated with CHECK CONDITION status, 5/24/00 INVALID FIELD IN CDB.

The Parameter List Length field specifies the maximum length in bytes of the mode parameter list that ***shall*** be transferred from the host to the logical unit after the Command Packet is transferred. A Parameter List Length of zero indicates that no data ***shall*** be transferred. This condition ***shall not*** be considered as an error.

If the Parameter List Length results in the truncation of any mode parameter header or Mode Page, the logical unit ***shall*** terminate the command with CHECK CONDITION status, 5/1A/00 PARAMETER LIST LENGTH ERROR.

The mode parameter list for the MODE SELECT (10) and MODE SENSE (10) commands is defined in *16.11.3, "Mode Select/Sense Parameters"* on page 493.

The logical unit ***shall*** terminate the MODE SELECT (10) command with CHECK CONDITION status, 5/26/00 INVALID FIELD IN PARAMETER LIST, and ***shall not*** change any mode parameters for the following conditions:

1. If the host sets any field (except for reserved fields) that is reported as not changeable by the logical unit to a value other than its current value.
2. If the host sets any unreserved field in the mode parameter header to an unsupported value.
3. If a host sends a Mode Page with a Page Length not equal to the Page Length returned by the MODE SENSE (10) command for that Page.
4. If the host sends an unsupported value for a mode parameter and rounding is not implemented for that mode parameter.

If the host sends a value for a mode parameter that is outside the range supported by the logical unit and rounding is implemented for that mode parameter, the logical unit may either:

1. round the parameter to an acceptable value and terminate the command with CHECK CONDITION status, 1/37/00 ROUNDED PARAMETER;
2. terminate the command with CHECK CONDITION status, 5/26/00 INVALID FIELD IN PARAMETER LIST.

A logical unit may alter any mode parameter in any Mode Page (even those reported as non-changeable) as a result of changes to other mode parameters[1].

The logical unit validates the non-changeable mode parameters against the current values that existed for those mode parameters prior to the MODE SELECT (10) command.

Mode Pages are maintained per logical unit. The Pages are thus used for multiple media insertions/removals. In the case of a Changer Mechanism all the media in the changer make use of the same Mode Pages. Changing of media ***shall not*** cause a CHECK CONDITION status, 6/2A/01 MODE PARAMETERS CHANGED, nor ***shall*** any Mode Parameter change.

Table 333 describes errors that may occur during the operation of the command or which may cause a CHECK CONDITION status to be reported.

Table 333 - MODE SELECT (10) command errors

Error Description	
	A-1.1, "Deferred Error Reporting" on page 721
	Table 630 - *Basic Error Codes* on page 730
5/39/00	SAVING PARAMETERS NOT SUPPORTED

1. If the current values calculated by the logical unit affect the host's operation, the host ***shall*** issue a MODE SENSE (10) command after each MODE SELECT (10) command.

16.11 MODE SENSE (10) command

The MODE SENSE (10) command provides a means for a logical unit to report parameters to the host. It is a complementary command to the MODE SELECT (10) command.

Table 334 - MODE SENSE (10) Command Descriptor Block

Byte \ Bit	7	6	5	4	3	2	1	0
0	Operation Code (5Ah)							
1	LUN (Obsolete)			Reserved	DBD	Reserved		
2	PC		Page Code					
3	Reserved							
4	Reserved							
5	Reserved							
6	Reserved							
7	(MSB)			Allocation Length				
8								(LSB)
9	Vendor-Specific		Reserved			NACA	Flag	Link
10	PAD							
11								

The Disable Block Descriptor (DBD), when set to zero, ***shall*** specify that a Block Descriptor may be returned. When set to one, it ***shall*** specify that the Block Descriptor ***shall not*** be returned. This bit ***shall*** be set to one for an ATAPI logical unit. For a SCSI logical unit this bit may be set to zero only in a legacy environment.

16.11.1 Page Control

The Page Control (PC) field defines the type of mode parameter values to be returned in the Mode Pages. See Table 335 and 16.11.1.1 - 16.11.1.4.

Table 335 - Page Control (PC) field

Code	Type of Parameter	Section
00b	Current values	16.11.1.1
01b	Changeable values	16.11.1.2
10b	Default values	16.11.1.3
11b	Saved values	16.11.1.4

Note: The PC field only affects the mode parameters within the Mode Pages, however the PS bit, Page Code and Page Length fields ***shall*** *return current values since they have no meaning when used with other types. The mode parameter header* ***shall*** *return current values. (see also 16.11.3, "Mode Select/Sense Parameters" on page 493)*

The Page Code specifies which Mode Page(s) to return[1]. See Table 340 - *Mode Page Codes* on page 494 for a description of the Mode Pages.

A host may request any one or all of the supported Mode Pages from a logical unit. If a host issues a MODE SENSE (10) command with a Page Code value not implemented by the logical unit, the logical unit ***shall*** return CHECK CONDITION status, 5/24/00 INVALID FIELD IN CDB.

1. Mode Pages ***shall*** be returned in ascending Page Code order except for Mode Page 00h.

A Page Code of 3Fh indicates that all Mode Pages implemented by the logical unit ***shall*** be returned to the host. If the mode parameter list exceeds 65534 bytes for ATAPI or 65535 for SCSI in a MODE SENSE (10) command, the logical unit ***shall*** return CHECK CONDITION status, 5/24/00 INVALID FIELD IN CDB.

Mode Page 00h, if implemented, ***shall*** be returned after all other Mode Pages.

16.11.1.1 Current Values

A PC field value of 0h requests that the logical unit return the current values of the mode parameters. The current values returned are:

1. the current values of the mode parameters established by last successful MODE SELECT (10) command.
2. the saved values of the mode parameters if a MODE SELECT (10) command has not successfully completed since the last power-on, hard RESET condition.
3. the default values of the mode parameters, if saved values, are not available or not supported.

16.11.1.2 Changeable Values

A PC field value of 1h requests that the logical unit return a mask denoting those mode parameters that are changeable. In the mask, the fields of the mode parameters that are changeable ***shall*** be set to all one bits and the fields of the mode parameters that are non-changeable (i.e. defined by the logical unit) ***shall*** be set to all zero bits.

An attempt to change a non-changeable mode parameter (via MODE SELECT (10)) results in an error condition.

The host should issue a MODE SENSE (10) command with the PC field set to 1h and the Page Code field set to 3Fh to determine which Mode Pages are supported, which mode parameters within the Mode Pages are changeable, and the supported length of each Mode Page prior to issuing any MODE SELECT (10) commands.

16.11.1.3 Default Values

A PC field value of 2h requests that the logical unit return the default values of the mode parameters. Parameters not supported by the logical unit ***shall*** be set to zero. Default values are accessible even if the logical unit is NOT READY condition.

16.11.1.4 Saved Values

A PC field value of 3h requests that the logical unit return the saved values of the mode parameters. Implementation of saved Page parameters is optional. Mode parameters not supported by the logical unit ***shall*** be set to zero. If saved values are not implemented, the command ***shall*** be terminated with CHECK CONDITION status, 5/39/00 SAVING PARAMETERS NOT SUPPORTED.

The method of saving parameters is vendor-specific. The parameters are preserved in such a manner that they are retained when the logical unit is powered down. All savable Pages can be considered saved when a MODE SELECT (10) command issued with the SP bit set to one has returned a “good” status.

Note: As C/DVD/HD DVD logical units do not have writable media and the media is removable, most will not support Saved Values. It is recommended that the host software not make use of saved Pages.

16.11.2 Initial Responses

After a power-up condition or hard reset condition or for ATAPI the DEVICE RESET, the logical unit ***shall*** respond in the following manner:

1. If default values are requested, report the default values.
2. If saved values are requested, report valid restored mode parameters, or restore the mode parameters and report them. If the saved values of the mode parameters are not able to be accessed from the non-volatile, vendor-specific

location, terminate the command with 5/39/00 SAVING PARAMETERS NOT SUPPORTED. If saved parameters are not implemented, respond as defined in 16.11.1.4.

3. If current values are requested and the current values of the mode parameters have not been sent by the host (via a MODE SELECT (10) command), the logical unit may return either the default or saved values as defined above. If current values have been sent, the current values ***shall*** be reported.

Table 333 describes errors that may occur during the operation of the command or which may cause a CHECK CONDITION status to be reported.

Table 336 - MODE SENSE (10) command errors

Error Description	
	A-1.1, "Deferred Error Reporting" on page 721
	Table 630 - *Basic Error Codes* on page 730
5/39/00	SAVING PARAMETERS NOT SUPPORTED

16.11.3 Mode Select/Sense Parameters

This section describes the Pages used with MODE SELECT (10) and MODE SENSE (10) commands.

The Mode Parameter List contains a header, followed by zero or more variable-length Mode Pages.

Table 337 - Mode Parameter List

Bit / Byte	7	6	5	4	3	2	1	0
0-7[a]	Mode Parameter Header							
0-m	Mode Page(s)							

a. In the case of MODE SENSE (6) / SELECT (6) commands, Mode Parameter Header length is different. These commands are not specified by this specification.

Mode Parameter Header and generic Mode Page format are defined as shown in Table 338 and Table 339.

Table 338 - Mode Parameter Header

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB)	Mode Data Length						
1								(LSB)
2	Obsolete (Medium Type Code)							
3-5	Reserved							
6	(MSB)	Block Descriptor Length 0 (8 for legacy SCSI logical units)						
7								(LSB)

Table 339 - Mode Page Format

Bit / Byte	7	6	5	4	3	2	1	0
0	PS / Reserved	Reserved	Page Code					
1	Page Length (n-1)							
2-n	Mode Parameters							

Each Mode Page contains a Page Code, a Page Length, and a set of Mode Parameters.

Table 340 - Mode Page Codes

Page Code	Page Description	Section
00h	Vendor-specific (does not require Page Format)	
01h	Read/Write Error Recovery Parameters	16.11.3.1
02h-04h	Reserved	
05h	Write Parameters	16.11.3.7
06h-0Dh	Reserved	
0Eh	CD Audio Control	16.11.3.2
0Fh-19h	Reserved	
1Ah	Power Condition	16.11.3.3
1Bh	Reserved	
1Ch	Fault / Failure Reporting	16.11.3.4
1Dh	Time-out & Protect	16.11.3.5
1Eh-1Fh	Reserved	
20h-29h	Vendor-specific (Page Format required)	
2Ah	C/DVD Capabilities & Mechanical Status	16.11.3.6
2Bh-3Eh	Vendor-specific (Page Format required)	
3Fh	Return all Pages (valid only for the MODE SENSE (10) command)	

When using the MODE SENSE (10) command, a Parameters Savable (PS) bit of one ***shall*** indicate that the Mode Page can be saved by the logical unit in a non-volatile, vendor-specific location. A PS bit of zero ***shall*** indicate that the supported parameters cannot be saved. When using the MODE SELECT (10) command, the PS bit is reserved.

The Page Code field identifies the format and parameters defined for that Mode Page.

When using the MODE SENSE (10) command, if Page Code 00h (vendor-specific Page) is implemented, the logical unit ***shall*** return that Page last in response to a request to return all Pages (Page Code 3Fh). When using the MODE SELECT (10) command, this Page ***shall*** be sent last.

The Page Length field specifies the length in bytes of the mode parameters that follow. If the host does not set this value to the value that is returned for the Page by the MODE SENSE (10) command, the logical unit ***shall*** terminate the command with CHECK CONDITION status, 5/26/00 INVALID FIELD IN PARAMETER LIST. The logical unit is permitted to implement a Mode Page that is less than the full Page Length defined in this specification, provided no field is truncated and the Page Length field correctly specifies the actual length implemented.

The mode parameters for each Page are defined here. Mode parameters not implemented by the logical unit ***shall*** be set to zero.

When using the MODE SENSE (10) command, the Mode Data Length field specifies the length in bytes of the following data that is available to be transferred. The Mode Data Length is the total byte count of all data following the Mode Data Length field. When using the MODE SELECT (10) command, this field is reserved.

The block descriptor associated with the MODE SELECT (10) and MODE SENSE (10) commands is used for legacy system support for SCSI systems. If supported, block sizes (see Table 341) ***shall*** include 2048 for C/DVD/HD DVD media and may include 512, 2056, 2324, 2332, 2336, 2340, 2352, 2368, and 2448 bytes. Table 341 shows the implementation of the various block sizes. These definitions apply for reading with the Read commands. Other block sizes are allowed and the contents of those blocks are not specified by this specification.

Table 341 - Block Descriptor Block Sizes for Read

Size	Readable block types
512	Mode 1 or Mode 2 Form 1 sectors divided into four blocks each.
2048	Mode 1, Mode 2 Form 1, or DVD/HD DVD
2056	Mode 2 Form 1 with sub-header. Equivalent to READ CD, Flag = 50h.
2324	Mode 2 Form 2 with no sub-header. Note: There is no mapping to READ CD, as the 4 spare bytes are not returned.
2332	Mode 2, form 1 or 2 data. The drive ***shall*** operate as specified for 2048 byte blocks except: Both forms send 2332 byte blocks. Form 1 blocks return the third layer ECC with the user data. Note: There is no mapping to READ CD, as the 4 spare bytes are not returned.
2336	Mode 2 data The drive ***shall*** operate as specified for 2048 byte blocks lengths. This mode will include all data, including Yellow Book Mode 2 sectors and Form 1 and Form 2. Equivalent to READ CD, Flag = 58h.
2340	All bytes except the synchronization field. Equivalent to READ CD, Flag = 78h.
2352	Audio or raw blocks. The drive ***shall*** operate as specified for 2048 byte blocks. Reads of data mode sectors ***shall*** return descrambled data. Equivalent to READ CD, Flag = F8h.
2448 or 2368	Audio or raw blocks with raw sub-channel. The drive ***shall not*** perform the data descrambling operation. Equivalent to READ CD, Flag = F8, Sub-channel data selection = 010b (2448) or Sub-channel data selection = 001b (2368).

16.11.3.1 Read/Write Error Recovery Parameters Mode Page

The Read/Write Error Recovery Parameters Mode Page specifies the error recovery parameters the logical unit ***shall*** use during any command that performs a data read or write operation from or to the media (e.g., READ (10), READ TOC/PMA/ATIP, WRITE (10)).

Table 342 - Read/Write Error Recovery Parameters Mode Page Format

Bit / Byte	7	6	5	4	3	2	1	0
0	PS	Reserved	Page Code (01h)					
1	Page Length (0Ah)							
2	Error Recovery Parameter, Default 0							
	AWRE	ARRE	TB	RC	Reserved	PER	DTE	DCR
3	Read Retry Count							
4	Correction Span							
5	Head Offset count							
6	Data Strobe Offset Count							
7	Reserved						EMCDR	
8	Write Retry Count							
9	Reserved							

Table 342 - Read/Write Error Recovery Parameters Mode Page Format (Continued)

Bit / Byte	7	6	5	4	3	2	1	0
10	(MSB)			Recovery Time Limit				
11								(LSB)

The Parameters Savable (PS) bit is only used with the MODE SENSE (10) command. This bit is reserved with the MODE SELECT (10) command. A PS bit of one indicates that the logical unit is capable of saving the Page in a non-volatile vendor-specific location.

Note: The implementation of error recovery procedures for C/DVD/HD DVD logical units is markedly different from those used for magnetic medium disk drives. At least one level of error correction is required to transfer the data stream. Therefore, the performance of the logical unit may differ substantially from what would be expected by sending the same error recovery parameters to a magnetic medium logical unit.

An automatic write reallocation enabled (AWRE) bit of one indicates that the logical unit ***shall*** enable automatic reallocation to be performed during write operations. An AWRE bit of zero indicates that the logical unit ***shall not*** perform automatic reallocation of defective data blocks during write operations.

An automatic read reallocation enabled (ARRE) bit of one indicates that the logical unit ***shall*** enable automatic reallocation of defective data blocks during read operation. An ARRE bit of zero indicates that the logical unit ***shall not*** perform automatic reallocation of defective data blocks during read operation. When ARRE is enabled other error recovery modes ***shall not*** be used. The Disable Correction (DCR) and Read Continuous (RC) ***shall not*** be enabled while ARRE is enabled.

A Transfer Block (TB) bit of one indicates that a data block that is not recovered within the recovery limits specified, ***shall*** be transferred to the host before CHECK CONDITION status is returned. A TB bit of zero indicates that such a data block ***shall not*** be transferred to the host. The TB bit does not affect the action taken for recovered data.

A Read Continuous (RC) bit of one indicates that the logical unit ***shall*** transfer the entire requested length of data without adding delays to perform error recovery procedures. This implies that the logical unit may send data that is erroneous or fabricated in order to maintain a continuous flow of data. A RC bit of zero indicates that error recovery operations that cause delays are acceptable during the data transfer.

A Post Error (PER) bit controls recovered error reporting of logical unit. This bit is used in conjunction with the EMCDR field if logical unit supports Enhanced Defect Reporting Feature. The description of this bit is described in *16.11.3.1.1, "Description of PER bit and EMCDR field"* on page 499.

A Disable Transfer on Error (DTE) bit of one indicates that the logical unit ***shall*** terminate the data transfer to the host upon detection of a recovered error. A DTE bit of zero indicates that the logical unit ***shall not*** terminate the data transfer upon detection of a recovered error.

A Disable Correction (DCR) bit of one indicates that error correction codes ***shall not*** be used for data error recovery. A DCR bit of zero allows the use of error correction codes for data error recovery.

As an example, interpretation of the bits 5-0 in the Error Recovery Parameter byte for CD-ROM logical units and DVD/HD DVD logical units are given in Table 343 and Table 344.

Table 343 - Error Recovery Descriptions (CD media)

Code	Error Recovery Description
00h	The maximum error recovery procedures available are used. If an error occurs which is uncorrectable with the error correction codes (ECC) on the media, data transfer is terminated with CHECK CONDITION status. The block with the error is not transferred. The sense key is set to MEDIUM ERROR. The information bytes give the address of the block where the unrecovered error was detected. Recovered errors are not reported.
01h	Only retries of the read operation and CIRC are used (layered error correction is not used). Only CIRC unrecovered data errors are reported. If a CIRC unrecovered data error occurs, data transfer is terminated with CHECK CONDITION status. The block with the error is not transferred. The sense key is set to MEDIUM ERROR. The information bytes give the address of the block where the unrecovered error was detected. Recovered errors are not reported.
04h	The maximum error recovery procedures available are used. Recovered data errors are reported. If a recovered data error occurs, data transfer is not terminated. However, when the data transfer has completed CHECK CONDITION status is reported. The sense key is set to RECOVERED ERROR. The information bytes give the address of the last block where a recovered data error was detected. If a data error occurs that is uncorrectable with the ECC information available on the media, data transfer is terminated and CHECK CONDITION status is reported. The block with the error is not transferred. The sense key is set to MEDIUM ERROR. The information bytes give the address of the block where the uncorrectable error was detected.
05h	Only retries of the read operation and CIRC are used (layered error correction is not used). Recovered data errors are reported. If a recovered data error occurs, data transfer is not terminated. However, when the data transfer has completed CHECK CONDITION status is reported. The sense key is set to RECOVERED ERROR. The information bytes give the address of the last block where a CIRC recovered data error was detected. If an unrecovered data error occurs, data transfer is terminated and CHECK CONDITION status is reported. The block with the error is not transferred. The sense key is set to MEDIUM ERROR. The information bytes give the address of the block where the unrecovered error was detected.
06h	The maximum error recovery procedures are used. Recovered data errors are reported. If a recovered data error occurs data transfer is terminated and CHECK CONDITION status is reported. The block with the recovered error is not transferred. The sense key is set to RECOVERED ERROR. The information bytes give the address of the block where the recovered data error was detected. If a data error occurs that is uncorrectable with the ECC information on the medium, data transfer is terminated with CHECK CONDITION status. The block with the error is not transferred. The sense key is set to MEDIUM ERROR. The information bytes give the address of the block where the uncorrectable error was detected.
07h	Only retries of the read operation are used (layered error correction is not used) and CIRC recovered data errors are reported. If a CIRC recovered data error occurs, data transfer is terminated with CHECK CONDITION status. The block with the recovered error is not transferred. The sense key is set to RECOVERED ERROR. The information bytes give the address of the block where the recovered data error was detected. If a CIRC unrecovered data error occurs, data transfer is terminated with CHECK CONDITION status. The block with the error is not transferred. The sense key is set to MEDIUM ERROR. The information bytes give the address of the block where the unrecovered error was detected.
10h	If data transfer can be maintained, the maximum error recovery procedures available are used. (RC = 1.) If an error occurs which is uncorrectable with the error correction codes (ECC) on the media, or is uncorrectable in time to maintain data transfer, the data transfer is not terminated. However, when the data transfer has completed, CHECK CONDITION status is reported. The sense key is set to MEDIUM ERROR. The information bytes give the address of the block where the first unrecovered error was detected. Recovered errors are not reported.
14h	If data transfer can be maintained, the maximum error recovery procedures available are used. (RC = 1.) Recovered data errors are reported. If a recovered data error occurs, data transfer is not terminated. However, when the data transfer has completed, CHECK CONDITION status is reported. The sense key is set to RECOVERED ERROR. The information bytes give the address of the block where a recovered data error was detected. If an data error occurs that is uncorrectable with the ECC information available on the media, or is uncorrectable in time to maintain data transfer, the data transfer is not terminated. However, when the data transfer has completed CHECK CONDITION, status is reported. The sense key is set to MEDIUM ERROR. The information bytes give the address of the block where the first uncorrectable error was detected. Reporting unrecovered errors takes precedence over reporting recovered errors.
20h	The maximum error recovery procedures available are used. If an error occurs which is uncorrectable with the error correction codes (ECC) on the media, data transfer is terminated with CHECK CONDITION status. The block with the error is transferred. The sense key is set to MEDIUM ERROR. The information bytes give the address of the block where the unrecovered error was detected. Recovered errors are not reported.

Table 343 - Error Recovery Descriptions (CD media) (Continued)

Code	Error Recovery Description
21h	Only retries of the read operation and CIRC are used (layered error correction is not used). Only CIRC unrecovered data errors are reported. If a CIRC unrecovered data error occurs data transfer is terminated with CHECK CONDITION status. The block with the error is transferred. The sense key is set to MEDIUM ERROR. The information bytes give the address of the block where the unrecovered error was detected. Recovered errors are not reported.
24h	The maximum error recovery procedures available are used. Recovered data errors are reported. If a recovered data error occurs data transfer is not terminated. However, when the data transfer has completed, CHECK CONDITION status is reported. The sense key is set to RECOVERED ERROR. The information bytes give the address of the last block where a recovered data error was detected. If a data error occurs that is uncorrectable with the ECC information available on the media data transfer is terminated and CHECK CONDITION status is reported. The block with the error is transferred. The sense key is set to MEDIUM ERROR. The information bytes give the address of the block where the uncorrectable error was detected.
25h	Only retries of the read operation and CIRC are used (layered error correction is not used). Recovered data errors are reported. If a recovered data error occurs, data transfer is not terminated. However, when the data transfer has completed, CHECK CONDITION status is reported. The sense key is set to RECOVERED ERROR. The information bytes give the address of the last block where a CIRC recovered data error was detected. If an unrecovered data error occurs, data transfer is terminated and CHECK CONDITION status is reported. The block with the error is transferred. The sense key is set to MEDIUM ERROR. The information bytes give the address of the block where the unrecovered error was detected.
26h	The maximum error recovery procedures are used. Recovered data errors are reported. If a recovered data error occurs, data transfer is terminated and CHECK CONDITION status is reported. The block with the recovered error is transferred. The sense key is set to RECOVERED ERROR. The information bytes give the address of the block where the recovered data error was detected. If a data error occurs that is uncorrectable with the ECC information on the media, data transfer is terminated with CHECK CONDITION status. The block with the error is transferred. The sense key is set to MEDIUM ERROR. The information bytes give the address of the block where the uncorrectable error was detected.
27h	Only retries of the read operation are used (layered error correction is not used). CIRC recovered data errors are reported. If a CIRC recovered data error occurs, data transfer is terminated with CHECK CONDITION status. The block with the recovered error is transferred. The sense key is set to RECOVERED ERROR. The information bytes give the address of the block where the recovered data error was detected. If a CIRC unrecovered data error occurs, data transfer is terminated with CHECK CONDITION status. The block with the error is transferred. The sense key is set to MEDIUM ERROR. The information bytes give the address of the block where the unrecovered error was detected.

Table 344 - Error Recovery Descriptions (DVD/HD DVD media)

Code	Error Recovery Description
00h	The maximum error recovery procedures available are used. If an error occurs which is uncorrectable with the error correction codes (ECC) on the media, data transfer is terminated with CHECK CONDITION status. The block with the error is not transferred. The sense key is set to MEDIUM ERROR. The information bytes give the address of the block where the unrecovered error was detected. Recovered errors are not reported.
04h	The maximum error recovery procedures available are used. Recovered data errors are reported. If a recovered data error occurs, data transfer is not terminated. However, when the data transfer has completed CHECK CONDITION status is reported. The sense key is set to RECOVERED ERROR. The information bytes give the address of the last block where a recovered data error was detected. If a data error occurs that is uncorrectable with the ECC information available on the media, data transfer is terminated and CHECK CONDITION status is reported. The block with the error is not transferred. The sense key is set to MEDIUM ERROR. The information bytes give the address of the block where the uncorrectable error was detected. The only possible recovered errors are when a block is automatically reassigned using ARRE.
10h	If data transfer can be maintained, the maximum error recovery procedures available are used. (RC = 1.) If an error occurs which is uncorrectable with the error correction codes (ECC) on the media, or is uncorrectable in time to maintain data transfer, the data transfer is not terminated. However, when the data transfer has completed, CHECK CONDITION status is reported. The sense key is set to MEDIUM ERROR. The information bytes give the address of the block where the first unrecovered error was detected. Recovered errors are not reported.
20h	The maximum error recovery procedures available are used. If an error occurs which is uncorrectable with the error correction codes (ECC) on the media, data transfer is terminated with CHECK CONDITION status. The block with the error is transferred. The sense key is set to MEDIUM ERROR. The information bytes give the address of the block where the unrecovered error was detected. Recovered errors are not reported.
24h	The maximum error recovery procedures available are used. Recovered data errors are reported. If a recovered data error occurs data transfer is not terminated. However, when the data transfer has completed, CHECK CONDITION status is reported. The sense key is set to RECOVERED ERROR. The information bytes give the address of the last block where a recovered data error was detected. If a data error occurs that is uncorrectable with the ECC information available on the media data transfer is terminated and CHECK CONDITION status is reported. The block with the error is transferred. The sense key is set to MEDIUM ERROR. The information bytes give the address of the block where the uncorrectable error was detected. The only possible recovered errors are when a block is automatically reassigned using ARRE.

The Read Retry Count field specifies the number of times that the logical unit ***shall*** attempt its read recovery algorithm.

The Correction Span field should be set to zero.

The Head Offset count field should be set to zero.

The Data Strobe Offset Count field should be set to zero.

An Enhanced Media Certification and Defect Reporting (EMCDR) bit controls medium certification and error reporting of logical unit. This field is used in conjunction with PER bit. Host ***shall*** set this field to 0 if logical unit does not support Enhanced Defect Reporting feature. The description of this bit is described in 16.11.3.1.1.

The Write Retry Count field specifies the number of times that the logical unit ***shall*** attempt its write recovery algorithm. This may not have any affect if the logical unit does not support read after write operations.

The Recovery Time Limit field should be set to zero.

16.11.3.1.1 Description of PER bit and EMCDR field

Description of PER bit and EMCDR field is different if Enhanced Defect Reporting Feature is supported and is current. Following subsection 16.11.3.1.2 and 16.11.3.1.3 describe the description. By the setting PER bit and EMCDR field to 0, DBI data ***shall not*** be cleared.

16.11.3.1.2 In case of Enhanced Defect Reporting Feature is not supported or is not current

If logical unit does not support Enhanced Defect Reporting Feature, host ***shall*** set EMCDR field to 0.

If logical unit supports Enhanced Defect Reporting Feature and Enhanced Defect Reporting Feature is not current, logical unit ***shall*** ignore EMCDR field setting.

A Post Error (PER) bit of one indicates that the logical unit ***shall*** report recovered errors. A PER bit of zero indicates that the logical unit ***shall not*** report recovered errors. Error recovery procedures ***shall*** be performed within the limits established by the error recovery parameters. This capability is very different for DVD/HD DVD media. To be able to recover the data from DVD/HD DVD media, error correction ***shall*** be used. Thus it is not reasonable to report when ECC is used to recover the data. This bit for DVD/HD DVD media ***shall*** only be used to report when auto reallocation of a logical block has been performed. For CD media this capability is used to report when the Layered Error correction has been used to recover the data. Again as the CIRC is mandatory for recovery of data, then CIRC Recovered Data Error is defined as follows.

A CIRC Recovered Data Error is defined as a block for which the CIRC based error correction algorithm was unsuccessful for a read attempt, but on a subsequent read operation no error was reported. The number of subsequent read operations is limited to the read retry count. Layered error correction was not used.

A CIRC Unrecovered Data Error is defined as a block for which the CIRC based error correction algorithm was unsuccessful on all read attempts up to the read retry count. Layered error correction was not used.

An L-EC Recovered Data Error is defined as a block for which the CIRC based error correction algorithm was unsuccessful, but the layered error correction was able to correct the block within the read retry count.

An L-EC Uncorrectable Data Error is defined as a block which could not be corrected by layered error correction within the read retry count.

16.11.3.1.3 In case of Enhanced Defect Reporting Feature is current

Enhanced Defect Reporting Feature is supported and is current, logical unit behavior is described in *9.0, "Logical unit assisted software defect management model"* on page 333.

PER bit, if set to 1, logical unit ***shall*** certify medium on read operation and verify operation. Recovered error ***shall*** be reported regardless EMCDR field setting. If EMCDR field is set to a value other than 0, returned recovered error ***shall*** be 1/18/05 RECOVERED DATA - RECOMMEND REASSIGNMENT for defect management purpose. If EMCDR field is set to 0, ASC/ASCQ of RECOVERED ERROR of CD media and DVD media is described in 16.11.3.1.2.

PER bit, if set to 0, logical unit ***shall*** follow the control by EMCDR field.

EMCDR field controls logical unit behavior for logical unit assisted software defect management (Enhanced Defect Reporting).

If EMCDR field is set to 0 and PER bit is set to 0, logical unit ***shall*** not certify medium on read operation and ***shall not*** report recovered error.

If EMCDR field is set to 1 and PER bit is set to 0, logical unit ***shall*** certify medium on read operation and verify operation, and ***shall*** not report recovered error.

If EMCDR field is set to 2 and PER bit is set to 0, logical unit ***shall*** certify medium on read operation and verify operation, and ***shall*** report recovered error or unrecovered error on verify operation. In case of DRT-DM mode, logical unit ***shall*** check the DBI memory and ***shall*** report recovered error on write operation.

If EMCDR field is set to 3 and PER bit is set to 0, logical unit ***shall*** certify medium on read operation and verify operation, and ***shall*** report recovered error or unrecovered error on read operation and verify operation. In case of DRT-DM mode, logical unit ***shall*** check the DBI memory and ***shall*** report recovered error or unrecovered error on write operation.

If EMCDR field is set to a value other than 0, returned recovered error of the verify operation ***shall*** be 1/18/05 RECOVERED DATA - RECOMMEND REASSIGNMENT. See Table 176 - *Definition of PER bit and EMCDR field of Persistent-DM mode* on page 341 and Table 177 - *Definition of PER bit and EMCDR field of DRT-DM mode* on page 345.

16.11.3.2 CD Audio Control Mode Page

The CD Audio Control Mode Page sets the playback modes and output controls for subsequent PLAY AUDIO (10) commands and any current audio playback operation.

Table 345 - CD Audio Control Mode Page Format

Bit / Byte	7	6	5	4	3	2	1	0
0	PS	Reserved	Page Code (0Eh)					
1	Page Length (0Eh)							
2	Reserved					Immed Always 1	SOTC Default 0	Reserved
3	Reserved							
4	Reserved							
5	Reserved							
6	Obsolete (75)							
7	Obsolete (75)							
8	Reserved				CDDA Output Port 0 Channel Selection			
9	Output Port 0 Volume (Default FFh)							
10	Reserved				CDDA Output Port 1 Channel Selection			
11	Output Port 1 Volume (Default FFh)							
12	Reserved				CDDA Output Port 2 Channel Selection			
13	Output Port 2 Volume (Default 00h)							
14	Reserved				CDDA Output Port 3 Channel Selection			
15	Output Port 3 Volume (Default 00h)							

The Parameters Savable (PS) bit is only used with the MODE SENSE (10) command. This bit is reserved with the MODE SELECT (10) command. A PS bit of one indicates that the logical unit is capable of saving the Page in a non-volatile vendor-specific location.

The Immediate (Immed) bit is used for information purposes only; the audio commands will always send completion status as soon as the playback operation has been started. This bit ***shall*** be set to 1.

A Stop On Track Crossing (SOTC) bit of zero indicates the logical unit ***shall*** terminate the audio playback operation when the transfer length is satisfied. Multiple tracks ***shall*** be played as necessary. Periods of time encoded as audio pause/silence at the beginning of tracks, (index 0) ***shall*** also be played. An SOTC bit of one indicates the logical unit ***shall*** terminate the audio playback operation when the beginning of a following track is encountered. The SOTC bit is mandatory.

The CDDA Output Port Channel Selection field specifies the Red Book audio channels from the disc to which a specific output port ***shall*** be connected. More than one output port may be connected to an audio channel. More than one audio channel may be connected to an output port.

Table 346 - Example CDDA Output Port Channel Selection Codes

Code	Description
0000b	Output port muted
0001b	Connect audio channel 0 to this output port
0010b	Connect audio channel 1 to this output port
0011b	Connect audio channel 0 and audio channel 1 to this output port
0100b	Connect audio channel 2 to this output port
1000b	Connect audio channel 3 to this output port

The Output Port Volume Control indicates the relative volume level for this audio output port. The value used is specified as an attenuation of the normal volume level. A value of zero indicates the minimum volume level (Mute), and a value of FFh indicates maximum volume (No attenuation) level. It is recommended that the Mute and Volume functions should be supported on a per channel basis. The attenuation used ***shall*** be as specified in Table 347. All values not shown in the table ***shall*** be valid, with the attenuation selected by interpolating using the known table values.

It is recommended that the logical unit support at least 16 volume levels. The actual attenuation levels for any given Binary attenuation value ***shall*** be given by the following equation: 20 Log ((Binary Level + 1)/ 256)

Note: Audio channel volume control regarding channel selection of Mute vs. Volume Level setting of 0. It is recommended that logical units allow the setting of the Channel Selection fields to Mute and also allow the setting of the Volume Level field to 0. It is up to the logical unit to determine how to shut off the volume, either via muting circuitry or via the volume control.

Table 347 - Attenuation Levels for Audio

Binary Level	Attenuation
FFh	0db (On)
F0h	-0.52
E0h	-1.12
C0h	-2.45
80h	-5.95
40h	-11.9
20h	-17.8
10h	-23.6
0Fh	-24.1
0Eh	-24.6
0Ch	-25.9
08h	-29.1
04h	-34.2
02h	-38.6
01h	-42.1
00h	Mute (Off)

16.11.3.3 Power Condition Mode Page

The Power Condition Mode Page provides the host the means to control the length of time a logical unit will delay before changing its power requirements. There are notification events to the host that a logical unit has entered into one of the power conditions.

Table 348 - Power Condition Mode Page Format

Bit / Byte	7	6	5	4	3	2	1	0
0	PS	Reserved	Page Code (1Ah)					
1	Page Length (0Ah)							
2	Reserved							
3	Reserved						Idle	Standby
4	(MSB)							
5	Idle Timer							
6								
7								(LSB)
8	(MSB)							
9	Standby Timer							
10								
11								(LSB)

On the receipt of a command the logical unit ***shall*** adjust itself to the power condition which allows the command to perform. The timer which maps to this power condition and any lower power condition timers ***shall*** be reset on receipt of the command. On completion of the command the timer associated with this power condition ***shall*** be restarted.

The Parameters Savable (PS) bit is only used with the MODE SENSE (10) command. This bit is reserved with the MODE SELECT (10) command. A PS bit of one indicates that the logical unit is capable of saving the Page in a non-volatile vendor-specific location.

An Idle bit of one indicates a logical unit ***shall*** use the Idle Timer to determine the length of inactivity time to wait before entering the Idle condition. If the Idle bit is zero, or a value of zero in the Idle Timer field indicates the logical unit ***shall*** disable the Idle Timer.

The Idle Timer field indicates the inactivity time in 100 millisecond increments that the logical unit ***shall*** wait before entering the Idle condition. A value of zero disables the Idle Timer.

A Standby bit of one indicates a logical unit ***shall*** use the Standby Timer to determine the length of inactivity time to wait before entering the Standby condition.

If the Standby bit is zero, or a value of zero in the Standby Timer field indicates the logical unit ***shall*** disable the Standby Timer.

The Standby Timer field indicates the inactivity time in 100 millisecond increments that the logical unit ***shall*** wait before entering the Standby condition. A value of zero disables the Standby Timer.

For more information on these timers see *12.1.2, "Timers"* on page 359.

16.11.3.4 Fault / Failure Reporting Mode Page

The Fault / Failure Reporting Mode Page defines the methods used by the logical unit to control the reporting and the operations of specific informational exception conditions. This page ***shall*** only apply to informational exception that report CHECK CONDITION status, 1/5D/XX FAILURE PREDICTION THRESHOLD EXCEEDED to the host.

Informational exception conditions occur as result of vendor specific events within a logical unit. An informational exception condition may occur asynchronously to any commands issued by a host.

Table 349 - Fault / Failure Reporting Mode Page Format

<table>
<tr><th>Bit
Byte</th><th>7</th><th>6</th><th>5</th><th>4</th><th>3</th><th>2</th><th>1</th><th>0</th></tr>
<tr><td>0</td><td>PS</td><td>Reserved</td><td colspan="6">Page Code (1Ch)</td></tr>
<tr><td>1</td><td colspan="8">Page Length (0Ah)</td></tr>
<tr><td>2</td><td>Perf</td><td colspan="2">Reserved</td><td>EWasc</td><td>DExcept</td><td>Test</td><td>Reserved</td><td>LogErr (0)</td></tr>
<tr><td>3</td><td colspan="4">Reserved</td><td colspan="4">MRIE</td></tr>
<tr><td>4</td><td colspan="8" rowspan="4">(MSB)
Interval Timer
(LSB)</td></tr>
<tr><td>5</td></tr>
<tr><td>6</td></tr>
<tr><td>7</td></tr>
<tr><td>8</td><td colspan="8" rowspan="4">(MSB)
Report Count
(LSB)</td></tr>
<tr><td>9</td></tr>
<tr><td>10</td></tr>
<tr><td>11</td></tr>
</table>

The Parameters Savable (PS) bit is only used with the MODE SENSE (10) command. This bit is reserved with the MODE SELECT (10) command. A PS bit of one indicates that the logical unit is capable of saving the Page in a non-volatile vendor-specific location.

A Performance (Perf) bit of zero indicates that informational exception operations that are the cause of delays are acceptable. A Perf bit of one indicates the logical unit ***shall not*** cause delays while doing informational exception operations. A Perf bit set to one may cause the logical unit to disable some or all of the informational exception operations, thereby limiting the reporting of informational exception conditions.

An enable warning sense code (EWasc) bit of zero indicates the logical unit ***shall*** disable reporting of the WARNING Sense Code. The MRIE field is ignored when DExcept is set to one and EWasc is set to zero. A EWasc bit of one indicates WARNING Sense Code reporting ***shall*** be enabled. The method for reporting the warning when the EWasc bit is set to one is determined from the Method of Reporting Informational Exceptions (MRIE) field.

A disable exception control (DExcept) bit of zero indicates informational exception operations ***shall*** be enabled. The reporting of informational exception conditions when the DExcept bit is set to zero is determined from the MRIE field. A DExcept bit of one indicates the logical unit ***shall*** disable all information exception operations. The MRIE field is ignored when DExcept is set to one and EWasc is set to zero.

A Test bit of one ***shall*** create a false logical unit failure at the next interval time (as specified by the Interval timer field), if the DExcept bit is not set. When the Test bit is one, the MRIE and Report Count fields ***shall*** apply as if the Test bit were zero. The false logical unit failure ***shall*** be reported with CHECK CONDITION status, 1/5D/FF FAILURE PREDICTION THRESHOLD EXCEEDED (FALSE). If both the Test and the DExcept bits are one, the logical unit ***shall*** terminate the MODE SELECT (10) command with CHECK CONDITION status, 5/26/00 INVALID FIELD IN PARAMETER LIST. A Test bit of zero ***shall*** instruct the logical unit not to generate any false logical unit failure notifications.

A log errors (LogErr) bit of zero indicates that the logging of informational exception conditions within a logical unit is vendor specific.

The Method of Reporting Informational Exceptions field (MRIE) indicates the methods that ***shall*** be used by the logical unit to report informational exception conditions (see Table 350). The priority of reporting multiple information exceptions is vendor specific.

Table 350 - Method of Reporting Informational Exceptions (MRIE) field

MRIE	Description
0h	**No reporting of informational exception condition**: This method instructs the logical unit to not report information exception conditions.
1h-3h	Reserved
4h	**Unconditionally generate recovered error**: This method instructs the logical unit to report informational exception conditions, regardless of the value of the PER bit of the Read/Write Error Recovery Parameters Mode Page, by returning CHECK CONDITION status, 1/5D/XX FAILURE PREDICTION THRESHOLD EXCEEDED. The command that has the CHECK CONDITION ***shall*** complete without error before any informational exception condition may be reported.
5h-Bh	Reserved
Ch-Fh	Vendor specific

The Interval Timer field indicates the period in 100 millisecond increments that a informational exception condition has occurred. The logical unit ***shall not*** report informational exception conditions more frequently than the time specified by the Interval Timer field and as soon as possible after the timer interval has elapsed. After the informational exception condition has been reported the interval timer ***shall*** be restarted. A value of zero or FFFFFFFFh in the Interval Timer field ***shall*** indicate the timer interval is vendor specific.

The Report Count field indicates the number of times to report an informational exception condition to the host. A value of zero in the Report Count field indicates there is no limit on the number of times the logical unit ***shall*** report an informational exception condition. The default value of this field ***shall*** be zero.

The maintaining of the Interval Timer and the Report Count field across power cycles and/or resets by the logical unit ***shall*** be vendor specific.

16.11.3.5 Time-out & Protect Mode Page

The Time-out & Protect Mode Page specifies parameters that affect operation of many commands.

Table 351 - Time-out & Protect Mode Page Format

Bit / Byte	7	6	5	4	3	2	1	0
0	PS	Reserved	Page Code (1Dh)					
1	Page Length (0Ah)							
2	Reserved							
3	Reserved							
4	Reserved				G3Enable	TMOE	DISP	SWPP
5	Reserved							
6	(MSB)	Group 1 Minimum Time-out (Seconds)						
7								(LSB)
8	(MSB)	Group 2 Minimum Time-out (Seconds)						
9								(LSB)
10	(MSB)	Group 3 Time-unit (100 milliseconds)						
11								(LSB)

The Parameters Savable (PS) bit is only used with the MODE SENSE (10) command. This bit is reserved with the MODE SELECT (10) command. A PS bit of one indicates that the logical unit is capable of saving the Page in a non-volatile vendor-specific location.

G3Enable bit, when set to 1, enables the Group 3 time-out capability. A G3Enable bit of zero disables the Group 3 time-out capability. In order to minimize compatibility problems, the default value for G3Enable bit should be set to zero.

The Time-out Enable (TMOE) bit, when set to 1, enables the Group 1 time-out capability. A TMOE bit of zero disables the time-out reporting capability. The default value of this bit ***shall*** be zero.

The Disable until Power cycle (DISP) bit, when set to 1, ***shall*** make the logical unit unavailable until power has been removed and then reapplied. The logical unit ***shall*** report NOT READY for all media access after this bit has been set to 1. The default value of this bit ***shall*** be zero. Support for the DISP bit is optional.

The SWPP bit provides a Software Write Protect until Powerdown. When this bit is set to 1 the logical unit ***shall*** prevent writes to the media. When the bit is set to 1, the logical unit ***shall*** flush any data in the Cache to the media before preventing any further writes. The default value of this bit ***shall*** be zero. Support for the SWPP bit is optional.

See *13.0, "Time-out and Reset models"* on page 361 for more information on the Group 1 & 2 Minimum Time-out fields and Group 3 Time unit field.

16.11.3.6 C/DVD Capabilities & Mechanical Status Mode Page

The C/DVD Capabilities & Mechanical Status Mode Page is read only and may not be set with MODE SELECT (10).

Note: This information is available via the GET CONFIGURATION command.

Table 352 - C/DVD Capabilities and Mechanical Status Mode Page Format

Byte \ Bit		7	6	5	4	3	2	1	0
0		PS	Reserved	Page Code (2Ah)					
1		Page Length (30+4*(maximum number of n))							
2		Reserved		DVD-RAM Read	DVD-R Read	DVD-ROM Read	Method 2	CD-RW Rd	CD-R Rd
3		Reserved		DVD-RAM Wr	DVD-R Write	Reserved	Test Write	CD-RW Wr	CD-R Wr
4	Media Function Capabilities	BUF/ Reserved	Multi-session	Mode 2 Form 2	Mode 2 Form 1	Digital Port(2)	Digital Port(1)	Composite	Audio Play
5		Read Bar Code Capable	UPC	ISRC	C2 Pointers Supported	R-W D&C	R-W Supported	CDDA Stream Accurate	CD-DA
6		LMT			Reserved	Eject	Prevent Jumper	Lock State	Lock
7		Reserved		R-W in Lead-in Readable	Side Change Capable	S/W Slot Selection (SSS)	Supports Disc Present (SDP)	Separate Channel Mute	Sep. vol.
8		(MSB)			Obsolete				
9									(LSB)
10		(MSB)			Number of Volume Levels Supported				
11									(LSB)
12		(MSB)			Buffer Size supported by logical unit (in KBytes)				
13									(LSB)
14		(MSB)			Obsolete				
15									(LSB)
16		Obsolete							
17		Reserved		Length		LSBF	RCK	BCKF	Reserved
18		(MSB)			Obsolete				
19									(LSB)
20		(MSB)			Obsolete				
21									(LSB)
22		(MSB)			Copy Management Revision Supported				
23									(LSB)
24-26		Reserved							
27		Reserved						Rotation Control Selected	
28		(MSB)			Current Write Speed Selected (kbytes/sec)				
29									(LSB)
30		(MSB)			Number of logical unit Write Speed Performance Descriptor Tables (n)				
31									(LSB)
32-35		Logical unit Write Speed Performance Descriptor Block #1							
36-39		Logical unit Write Speed Performance Descriptor Block #2							

Table 352 - C/DVD Capabilities and Mechanical Status Mode Page Format (Continued)

Bit / Byte	7	6	5	4	3	2	1	0
:	:							
n*4+28- n*4+31	Logical unit Write Speed Performance Descriptor Block #n							
:	Padding							

The Parameters Savable (PS) bit is only used with the MODE SENSE (10) command. This bit is reserved with the MODE SELECT (10) command. A PS bit of one indicates that the logical unit is capable of saving the Page in a non-volatile vendor-specific location.

The Page Length field ***shall*** be set to maximum length that contains maximum number of logical unit Write Speed Performance Descriptor Blocks. The Page Length is fixed for a logical unit, but may be different from one logical unit to the other. If the logical unit Write Speed Performance Descriptor Block for mounted media is shorter than the maximum length of the logical unit Write Speed Performance Descriptor Block, then the rest of the field ***shall*** be padded with 0.

If logical unit does not support high speed CD-R/RW recording, the logical unit ***shall not*** return the mode page data after byte 26.

Media Function Capabilities, when set to one, indicates support for the identified item. When set to zero, indicates no support:

If CD-R Read (CD-R Rd) bit is set to one, the logical unit ***shall*** support the read function of CD-R disc (Orange Book Part II).

If CD-RW Read (CD-RW Rd) bit is set to one, the logical unit ***shall*** support the read function of CD-RW disc (Orange Book Part III).

If Method 2 bit is set to one, the logical unit ***shall*** support the read function of CD-R media written using fixed packet tracks using Addressing Method 2.

If DVD-ROM Read bit (read only field) is set to one, the logical unit ***shall*** support the read function of DVD-ROM disc.

If DVD-R Read bit (read only field) is set to one, the logical unit ***shall*** support the read function of DVD-R disc.

If DVD-RAM Read bit (read only field) is set to one, the logical unit ***shall*** support the read function of DVD-RAM disc.

If CD-R Write (CD-R Wr) bit is set to one, the logical unit ***shall*** support the write function of CD-R disc (Orange Book Part II).

If CD-RW Write (CD-RW Wr) bit is set to one, the logical unit ***shall*** support the write function of CD-RW disc (Orange Book Part III).

If DVD-R Write bit (read only field) is set to one, the logical unit ***shall*** support the write function of DVD-R disc. If the Test Write bit is set to one, the logical unit ***shall*** only accept data from the host and not write to the media.

If DVD-RAM Write (DVD-RAM Wr) bit (read only field) is set to one, the logical unit ***shall*** support the write function of DVD-RAM disc.

The individual capabilities of the logical unit are specified by bytes 4 through 7. Each of the bits indicate if that specific capability is supported. A value of zero indicates that the capability is NOT supported; a value of one indicates the capability IS supported.

Bit 0, Sep. vol.	Separate Volume Levels. The audio level for each channel can be controlled independently.
Bit 1, Separate Channel Mute	The mute capability for each channel can be controlled independently.

Bit 2, SDP	Supports Disc Present. This bit indicates that the logical unit contains an embedded changer, and that after a reset condition or if a cartridge is changed, it can report the exact contents of the slots. The response to the MECHANISM STATUS command will contain valid Disc is Present status information for all slots.
Bit 3, SSS	Software Slot Selection. This bit controls the behavior of the LOAD/UNLOAD MEDIUM command when trying to load a Slot with no Disc present (see Table 325 - *Load/Unload or Optional Selection Operations* on page 483).
Bit 4, Side Change Capable	This bit indicates that the logical unit is capable of selecting both sides of the Discs. This capability can be reported for logical units that have changer functions.
Bit 5, R-W in Lead-in Readable	This bit indicates that the logical unit is capable of reading R-W subcode in the Lead-in. This is used with CD-Text.
Bits 7-6, Reserved	Reserved.
Bit 8, Lock	The PREVENT/ALLOW MEDIUM REMOVAL command is capable of actually locking the media into the logical unit.
Bit 9, Lock State	This indicates the current state of the logical unit. 0 The logical unit is currently in the allow (Unlocked) state. Media may be inserted or ejected. 1 The logical unit is currently in the prevent (Locked) state. Media loaded in the logical unit may not be removed via a soft or hard eject. If the logical unit is empty, media may not be inserted if the Prevent Jumper is not present. If the jumper is present, then media may be inserted.
Bit 10, Prevent Jumper	This indicates the state of the (Optional) Prevent/Allow Jumper. 0 Jumper is present. Logical unit will power up to the allow state. Locking the logical unit with the PREVENT/ALLOW MEDIUM REMOVAL command ***shall not*** prevent the insertion of media. 1 Jumper is not present. Logical unit will power up to the Prevent State (Locked). The logical unit will not accept new media or allow the ejection of media already loaded until an allow command is issued.
Bit 11, Eject	The logical unit can eject the disc via the normal START/STOP UNIT command with the LoEj bit set. If the mechanism is a Changer that uses a Cartridge, then this bit indicates that the Cartridge can be ejected.
Bit 12, Reserved	Reserved
Bit 15-13, LMT	Loading Mechanism Type. This field specifies the type of disc loading the logical unit supports. See Table 353.

Table 353 - Loading Mechanism Type (LMT)

Bit 15	Bit 14	Bit 13	Definition
0	0	0	Caddy type loading mechanism
0	0	1	Tray type loading mechanism
0	1	0	Pop-up type loading mechanism
0	1	1	Reserved
1	0	0	Changer with individually changeable discs
1	0	1	Changer using a Cartridge Mechanism
1	1	0	Reserved
1	1	1	Reserved

Bit 16, CD-DA	Red Book audio can be read using the READ CD command.
Bit 17, CDDA Stream Accurate	This bit indicates that the logical unit supports an advanced feature that allows it to return to an audio location without losing place to continue the READ CD command. 0: The logical unit is incapable of accurately restarting the CD-DA read operation, and CHECK CONDITION status, B/11/11 READ ERROR - LOSS OF STREAMING ***shall*** be reported whenever a loss of streaming occurs. This error will be fatal and the command will have to be repeated from the beginning. 1 The logical unit can continue from a loss of streaming condition and no error will be generated.
Bit 18, R-W Supported	The commands that return Sub-channel data can return the combined R-W information.
Bit 19, R-W D&C	R-W De-interleaved & Corrected. This indicates that the R-W sub-channel data will be returned de-interleaved and error corrected.
Bit 20, C2 Pointers Supported	This indicates that the logical unit supports the C2 Error Pointers. This also indicates that the logical unit is capable of returning the C2 Error Pointers and C2 Block Error flags in the READ CD command.
Bit 21, ISRC	The logical unit can return the International Standard Recording Code Information.
Bit 22, UPC	The logical unit can return the Media Catalog Number (UPC)
Bit 23, Read Bar Code Capable	The logical unit is capable of reading the disc bar code.
Bit 24, Audio Play	The logical unit is capable of Audio Play operation. This also indicates that the logical unit is capable of overlapping Play and other commands such as reading of the Sub-channel information.
Bit 25, Composite	The logical unit is capable of delivering a composite Audio and Video data stream.
Bit 26, Digital Port(1)	The logical unit supports digital output (IEC958) on port 1
Bit 27, Digital Port(2)	The logical unit supports digital output(IEC958) on port 2
Bit 28, Mode 2 Form 1	The logical unit is capable of reading sectors in Mode 2 Form 1 (XA) format.
Bit 29, Mode 2 Form 2	The logical unit is capable of reading sectors in Mode 2 Form 2 format.
Bit 30, Multi-session	The logical unit is capable of reading multiple session or Photo-CD discs.
Bit 31, BUF/Reserved	For CD logical unit, this bit indicates that the logical unit is capable of buffer underrun free recording on CD-R/RW media. For non-CD logical unit, this bit is reserved.

The Number of Volume Levels Supported field returns the number of discrete levels. If the logical unit only supports turning audio on and off, the Number of Volume Levels Supported field ***shall*** be set to 2.

The Buffer Size Supported field returns the number of bytes of buffer dedicated to the data stream returned to the host. This value is returned in Kbytes (Size/1024). If the logical unit does not have a buffer cache, the value returned ***shall*** be zero.
Byte 17 is used to describe the format of the logical unit's digital output. See Table 354.

Table 354 - Digital Output format

Bit	Name	Behavior
1	BCKF	Set if data valid on the falling edge of the BCK signal. Clear if data valid on the rising edge of the BCK signal
2	RCK	Set if HIGH on LRCK indicates left channel. Clear if HIGH on LRCK indicates right channel.
3	LSBF	Set if LSB first. Clear if MSB first.
4-5	Length	00 32 BCKs 01 16 BCKs 10 24 BCKs 11 24 BCKs (I^2S)

The Copy Management Revision Supported field indicates the version of the DVD content protection scheme that is supported by the logical unit. This ***shall*** be 0001h if DVD CSS/CPPM is supported or 0000h otherwise.

The Rotation Control Selected field indicates the actual Rotation Control to the current disc.

The Current Write Speed Selected field indicates the actual data rate that the logical unit is currently using.

Number of Drive Write Speed Performance Descriptor Tables field specifies the number of logical unit Write Speed Performance Descriptor Blocks that follow this field.

Each logical unit Write Speed Performance Descriptor Block ***shall*** contain rotation control information and write speed that is supported by the logical unit.

The logical unit Write Speed Performance Descriptor Block is structured as shown inTable 355.

Table 355 - logical unit Write Speed Performance Descriptor Table format

Byte \ Bit	7	6	5	4	3	2	1	0
0	Reserved							
1	Reserved						Rotation Control	
2	(MSB) Write Speed Supported (kbytes/sec)							
3								(LSB)

Table 356 - Rotation Control field definition

Value	Definition
00b	Non-pure CAV and CLV
01b	Pure CAV
10b	Reserved
11b	Reserved

The Write Speed Supported field indicates the write speed that is supported by the logical unit. In the case of non-CLV rotational control, the Logical unit Write Speed ***shall*** be assumed to reference the speed at 79:59:74 MSF, regardless of actual capacity or disc diameter.

The logical unit ***shall*** report a record speed in descending order. If the logical unit supports both CLV and CAV on the medium, then the logical unit ***shall*** report all CLV descriptors first.

In the case of no recordable media mounted, the logical unit Write Speed Performance Descriptor Table ***shall*** report the most appropriate list of the speed such as the list for CD-R disc or just maximum recording speed.

16.11.3.7 Write Parameters Mode Page

The writing of a disc requires the host read a set of parameters from the device, selecting the parameters to be used, setting those parameters in the write parameters of the device and then using the normal WRITE command. Once the write process has begun, data is streamed from the host to the device.

The Write Parameters Mode Page contains parameters needed for the correct execution of WRITE commands.

The values in this Page do not necessarily reflect the status on a given medium. They will be used as applicable when a write operation occurs. If any parameters have values incompatible with the current medium, the logical unit ***shall*** generate a CHECK CONDITION status, 5/64/00 ILLEGAL MODE FOR THIS TRACK when a write is attempted.

Fields that are ignored for the current medium may contain 0 for the default mode parameter value.

For DVD-RW media, if a medium is in Sequential recording mode, usage of this mode page ***shall*** conform to descriptions for DVD-R unless otherwise specified. If a medium is in Restricted overwrite mode, this mode page ***shall not*** be used.

For HD DVD, this mode page ***shall not*** be used.

Table 357 - Write Parameters Mode Page

Bit / Byte	7	6	5	4	3	2	1	0
0	PS	Reserved	Page Code(05h)					
1	Page Length(32h)							
2	Reserved	BUFE	LS_V	Test Write	Write Type			
3	Multisession/Border		FP[a]	Copy	Track Mode[a]			
4	Reserved				Data Block Type[a]			
5	Link Size							
6	Reserved							
7	Reserved		Host Application Code[a]					
8	Session Format[a]							
9	Reserved							
10	(MSB)							
11	Packet Size							
12								
13								(LSB)
14	(MSB)		Audio Pause Length[a]					
15								(LSB)
16	(MSB)							
:	Media Catalog Number[a]							
31								(LSB)
32	(MSB)							
:	International Standard Recording Code[a]							
47								(LSB)
48	Sub-header Byte 0[a]							
49	Sub-header Byte 1[a]							
50	Sub-header Byte 2[a]							
51	Sub-header Byte 3[a]							

a. Ignored when DVD-R medium is present.

The Parameters Savable (PS) bit is only used with the MODE SENSE (10) command. This bit is reserved with the MODE SELECT (10) command. A PS bit of one indicates that the logical unit is capable of saving the Page in a non-volatile vendor-specific location.

The Buffer Underrun Free Enable (BUFE) bit, when set to one, ***shall*** indicate that Buffer Under-run Free recording is enabled for sequential recording. The logical unit ***shall*** perform Lossless-Link and continue the writing when the buffer becomes empty. The value zero ***shall*** indicate that logical unit ***shall*** terminate writing and perform linking. The following WRITE (10) command is terminated with CHECK CONDITION status, 5/21/02 INVALID ADDRESS FOR WRITE. In order to minimize compatibility problems, the default value for BUFE bit should be zero for CD-R/RW logical units. For DVD-R Dual Layer discs, this bit is ignored and the logical unit ***shall*** assume this bit is set to one.

The Link Size Valid (LS_V) bit ***shall*** be set to one to indicate that the value in the Link Size field is valid. The value zero is for compatibility with legacy logical units that did not implement the Link Size field; such logical units assume a Link Size of 7.

On CD-R or CD-RW media, the Test Write bit is valid only for Write Type 1 or 2 (Track at Once or Session at Once).

On DVD-R media, the Test Write bit is valid only for Write Type 0 or 2 (Incremental or Disc-at-once).

The validity of the Test Write bit is vendor specific for other media types.

When the Test Write bit is set to one, it indicates that the logical unit performs the write process, but does not write data to the media. When the bit is set to zero the Write laser power is set such that user data is transferred to the media. In addition, all Track/RZone and disc information collected, during test write mode, ***shall*** be cleared. It should be noted that the number of Track/RZones reserved or written may be limited in test write mode.

Write Type field specifies the stream type to be used during writing. See Table 358.

Table 358 - Write Type field

Value	Definition
00h	Packet/Incremental recording
01h	Track-at-once recording[a]
02h	Session-at-once/Disc-at-Once recording
03h	Raw recording[a]
04h	Layer Jump recording[b]
05h-0Fh	Reserved

a. Invalid when non-CD medium is present.
b. Invalid when non-Layer Jump recording capable medium is present.

Packet/incremental - the logical unit ***shall*** perform packet/incremental writing when WRITE (10) commands are issued.

Track-at-once - the logical unit ***shall*** perform track at once recording when WRITE (10) commands are issued.

Session-at-once/Disc-at-once - For CD, the logical unit ***shall*** perform session at once recording. This mode requires that a cue sheet be sent prior to sending WRITE (10) commands. For DVD, the logical unit ***shall*** perform Disc at once recording. All data, includes Lead-in and Lead-out, is recorded on the media sequentially without interruption.

Raw - the logical unit ***shall*** write data as received from the host. In this mode, the host sends the Lead-in. As the host ***shall*** provide Q sub-channel in this mode, the only valid Data Block Types are 1, 2, and 3. The NWA starts at the beginning of the Lead-in (which ***shall*** be a negative LBA on a blank disc). In RAW record mode, the drive ***shall not*** generate run-in and run-out blocks (main and sub-channel 1 data) but ***shall*** generate and record the link block.

Layer Jump recording - the logical unit ***shall*** perform Layer Jump recording when WRITE (10) commands are issued. When this write type is specified, regardless of BUFE bit setting, Buffer Underrun Error Free recording ***shall*** be performed.

The Multisession/Border field defines how a Session/Border closure affects the opening of the next Session/Border. See Table 359.

Table 359 - Multisession/Border field definition

Multisession/Border Field	Action Upon Session/Border Closure
00b	For CD, No B0 pointer. Next Session not allowed. For DVD, next Border not allowed. When current Border is closed, Lead-out ***shall*** be appended after the last Border-out. In the case of DVD-R media, the Next Border Marker in last Border-out ***shall*** be padded with 00h bytes and ***shall*** have the Lead-out attribute set.
01b	For CD, B0 pointer = FF:FF:FF. Next session not allowed. For DVD, Reserved
10b	Reserved
11b	For CD, Next session allowed. B0 pointer = next possible program area. For DVD, Next Border allowed. Lead-out ***shall not*** be appended after the last Border-out.

The Fixed Packet (FP) bit, when set to one indicates that the packet type is fixed. Otherwise, the packet type is variable. This bit is ignored unless the Write Type is set to 0 (Packet). For DVD-R, this bit ***shall*** be set to one and ignored.

A Copy bit with value one indicates that this is the first or higher generation copy of a copyright protected track. When set to one, the copyright bit in the control nibble of each mode 1 Q sub-channel ***shall*** alternate between 1 and 0 at 9.375 Hz. The duty cycle is 50%, changing every 4 blocks. The initial value on the medium is zero. For DVD-R, this field ***shall*** be ignored.

Track Mode is the Control nibble in all mode 1 Q sub-channel in the track. This field ***shall*** be ignored for DVD-R recording. The default value of this field for DVD-R logical units should be 5.

Data Block Type defines both the specific data fields in a user data block and its size. The Data Block Type is as defined in Table 360. This size is used for writing instead of the block size set in the Mode Select Header. For DVD-R, this field ***shall*** be ignored. The default value of this field for DVD-R logical units should be 8.

Table 360 - Data Block Type codes

Value	Block Size	Definition	Requirement
0	2352	Raw data 2352 bytes of raw data (not valid for Write Type = packet)	Optional
1	2368	Raw data with P and Q sub-channel 2352 bytes of raw data, 16 bytes buffer for Q sub-channel: Bytes 0..9 are Q sub-channel data Bytes 10..11 are Q sub-channel EDC Bytes 12..14 are zero Byte 15, most significant bit has state of P sub-channel bit (not valid for Write Type = packet) (Q sub-channel data is in binary format.)	Optional
2	2448	Raw data with P-W sub-channel appended: 2352 bytes of raw data. 96 bytes of pack form R-W sub-channel in the low order 6 bits of each byte. Bit 7 of each byte contains the P sub-channel state and bit 6 of each byte contains the Q sub-channel bit. (not valid for Write Type = packet)	Optional
3	2448	Raw data with raw P-W sub-channel appended: 2352 bytes of raw data. 96 bytes of raw P-W sub-channel. (not valid for Write Type = packet)	Optional
4-6		Reserved values	-
7	NA	Vendor Specific	Optional
8	2048	Mode 1 (ISO/IEC 10149): 2048 bytes of user data	Mandatory
9	2336	Mode 2 (ISO/IEC 10149): 2336 bytes of user data	Optional
10	2048	Mode 2 (CD-ROM XA, form 1): 2048 bytes of user data, sub-header from write parameters	Mandatory
11	2056	Mode 2 (CD-ROM XA, form 1): 8 bytes of sub-header, 2048 bytes of user data	Optional
12	2324	Mode 2 (CD-ROM XA, form 2): 2324 bytes of user data, sub-header from write parameters	Optional
13	2332	Mode 2 (CD-ROM XA, form 1, form 2, or mixed form): 8 bytes of sub-header 2324 bytes of user data	Mandatory
14	-	Reserved	-
15	NA	Vendor Specific	Optional

General Writing Requirements

- When a track has been designated for packet writing, the device ***shall*** ensure that the TDB is written upon receipt of the WRITE (10) command.
- With the exceptions of data block types 1, 2, and 3, the device ***shall*** generate all P sub-channel and all mode 1, mode 2, and mode 3 Q sub-channel.
- For data block types 8 through 13, the device ***shall*** generate all sync fields and all headers.
- For data blocks of mode 1 or of mode 2, form 1, the device ***shall*** generate EDC and L-EC parity.
- For data block types 0, 1, 2, and 3, the device ***shall*** perform no data scrambling per ISO/IEC 10149.
- For data block types 8 through 13, the device ***shall*** perform data scrambling per ISO/IEC 10149.

The Link Size field specifies the Linking Loss Area size in sectors. The Link Size field is valid only for Write Type “Packet/Incremental” or "Layer Jump recording". When another Write Type is specified, device ***shall*** ignore LS_V bit and Link Size field. The logical unit ***shall*** accept values that are valid for the logical unit but not valid for the current medium. If writing is attempted when an invalid Link Size is set, the logical unit ***shall*** generate CHECK CONDITION status, ILLEGAL REQUEST, ILLEGAL MODE FOR THIS TRACK/RZONE.

Table 361 - Link Size field definition

Value	Description
00h	Linking Loss Area size is 0 bytes.
01h	Linking Loss Area size is 2048 bytes.
02h	Linking Loss Area size is 4096 bytes.
:	:
10h	Linking Loss Area size is 32768 bytes.
:	:
FFh	Linking Loss Area size is 522240 bytes.

The Host Application Code is typically zero. When the Unrestricted Use Disc (URU) bit in Disc Information Block is one, the Host Application Code ***shall*** be ignored by the device. If the URU bit is zero, then the Host Application Code ***shall*** be set to the appropriate value for the medium in order that writing be allowed. A Host Application Code of zero is used for a Restricted Use - General Purpose Disc. The Host Application Code field is ignored for DVD-R recording.

The Session Format code is to be written in the TOC of the session containing this track. The Session Format code is the PSEC byte of the mode 1, point A0 TOC entry. See Table 362. The Session Format code is ignored for DVD-R/-RW recording.

Table 362 - Session Format codes

Disc Type Code	Session Format
00h	CD-DA, CD-ROM, or other data disc
10h	CD-I Disc
20h	CD-ROM XA Disc
All Other Values	Reserved

The Packet Size field, if FP bit is set to 1, specifies the number of User Data Blocks per fixed packet. The Packet Size field, if FP bit is set to 0, ***shall*** be ignored. For DVD-R media, the default Packet Size ***shall*** be 16. The Packet Size ***shall*** be set to 16 to record to DVD-R media.

Audio Pause Length is the number of blocks from the beginning of the track for which the mode 1 Q sub-channel INDEX ***shall*** be zero. If this number is zero, then there is no period where the Mode 1 Q sub-channel INDEX ***shall*** be zero. The default value ***shall*** be 150. This field is valid only for audio tracks, otherwise it is ignored.

The Media Catalog Number (MCN) will be written in a mode 2 Q sub-channel in at least one out of every 100 blocks in the program area.

The International Standard Recording Code (ISRC) is valid only for audio tracks. Otherwise it is ignored. ISRC is formatted as in Table 474 - *ISRC Format of Data Returned to host* on page 600.

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16.12 PAUSE/RESUME command

The PAUSE/RESUME command requests that the logical unit stop or start an audio play operation. This command is used with PLAY AUDIO (10) command that are currently executing in immediate mode.

Table 363 - PAUSE/RESUME Command Descriptor Block

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation Code (4Bh)							
1	LUN (Obsolete)			Reserved				
2	Reserved							
3	Reserved							
4	Reserved							
5	Reserved							
6	Reserved							
7	Reserved							
8	Reserved							Resume
9	Vendor-Specific		Reserved			NACA	Flag	Link
10	PAD							
11								

A Resume bit of zero causes the logical unit to enter the hold track state with the audio output muted after the current block is played. A Resume bit of one causes the logical unit to release the pause/scan and begin play at the block following the last block played/scanned.

If an audio play operation cannot be resumed and the Resume bit is one, the command ***shall*** be terminated with CHECK CONDITION status, 5/2C/00 COMMAND SEQUENCE ERROR. If the Resume bit is zero and an audio play operation cannot be paused, (no audio play operation has been requested, or the requested audio play operation has been completed), the command is terminated with CHECK CONDITION status. See Figure 172 - *Stop Play/Play Audio/Audio Scan/Pause/Resume Sequencing* on page 701 for additional information.

It ***shall not*** be considered an error to request a PAUSE when a pause is already in effect or to request a RESUME when a play operation is in progress.

Table 364 describes errors that may occur during the operation of the command or which may cause a CHECK CONDITION status to be reported.

Table 364 - PAUSE/RESUME command errors

Error Description
A-1.1, "Deferred Error Reporting" on page 721
Table 630 - *Basic Error Codes* on page 730
Table 631 - *Media Access Error Codes* on page 733

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16.13 PLAY AUDIO (10) command

The PLAY AUDIO (10) command requests that the CD logical unit begin an audio playback operation. The command function and the output of audio signals ***shall*** be as specified by the settings of the *CD Audio Control* Mode Page (0Eh), including the SOTC bit.

Table 365 - PLAY AUDIO (10) Command Descriptor Block

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation Code (45h)							
1	LUN (Obsolete)			Reserved				
2	(MSB)							
3	Starting Logical Block Address							
4								
5								(LSB)
6	Reserved							
7	(MSB)							
8	Play Length							(LSB)
9	Vendor-Specific		Reserved			NACA	Flag	Link
10	PAD							
11								

This command responds with immediate status, allowing overlapped commands.

If any commands related to audio operations are implemented then the PLAY AUDIO (10) command ***shall*** be implemented to allow a method for the host to determine if audio operations are supported. A CD logical unit responding to a PLAY AUDIO (10) command that has a transfer length of zero with CHECK CONDITION status, 5/20/00 INVALID COMMAND OPERATION CODE does not support audio play operations.

The Starting Logical Block Address field specifies the logical block at which the audio playback operation ***shall*** begin. PLAY AUDIO (10) commands with a Starting Logical Block Address of FFFF FFFFh ***shall*** implement audio play from the current location of the pickup. PLAY AUDIO (10) commands with a Starting LBA of 0000 0000h ***shall*** begin the audio play operation at 00/02/00.

The Play Length field specifies the number of contiguous logical blocks that ***shall*** be played. A Play Length field of zero indicates that no audio operation ***shall*** occur. This condition ***shall not*** be considered an error.

If the Starting Logical Block Address is not found the command ***shall*** be terminated with CHECK CONDITION status, 5/21/00 LOGICAL BLOCK ADDRESS OUT OF RANGE. If the address is not within an audio track the command ***shall*** be terminated with CHECK CONDITION status, 5/64/00 ILLEGAL MODE FOR THIS TRACK. If a NOT READY condition exists, the command ***shall*** be terminated with CHECK CONDITION Status with the Sense Key set to 2 unless the Play Length is set to 0.

If the CD information type (data vs. audio) changes within the Transfer Length, the command ***shall*** be terminated with a CHECK CONDITION status, 5/63/00 END OF USER AREA ENCOUNTERED ON THIS TRACK at the time of encountering the transition.

If the logical block address requested is not within an audio track and the Play Length is non-zero, the command ***shall*** be terminated with CHECK CONDITION status, 5/64/00 ILLEGAL MODE FOR THIS TRACK.

16.13.1 PLAY AUDIO (10) with Immediate Packet commands

The PLAY AUDIO (10) and SCAN commands will continue to play while other commands are processed by the logical unit. Some commands can be accepted without disrupting the audio operations, while others will cause the Play operation to stop. The following section describes the operation of other commands while playing audio.

The CD logical unit ***shall*** accept and perform the commands as specified in Table 366. If any other command than described in Table 366 is received, the Audio playback or scan may be terminated.

See Figure 172 - *Stop Play/Play Audio/Audio Scan/Pause/Resume Sequencing* on page 701 for additional information.

For ATAPI logical units, the ATA commands other than A2 or A0 ***shall*** stop any play or scan.

When any command generates CHECK CONDITION status, 5/24/00 INVALID FIELD IN CDB, it may terminate the play operation.

Table 366 - Play or Scan overlapped command operation

Opcode	Command Description	Action Taken
A1h	BLANK	Play operation ***shall*** be stopped.
5Bh	CLOSE TRACK/RZONE/SESSION/BORDER	Play operation ***shall*** be stopped.
04h	FORMAT UNIT	Play operation ***shall*** be stopped
46h	GET CONFIGURATION	Play operation ***shall not*** be stopped
4Ah	GET EVENT/STATUS NOTIFICATION	Play operation ***shall not*** be stopped
ACh	GET PERFORMANCE	Play operation may be stopped
12h	INQUIRY	Play operation ***shall not*** be stopped
A6h	LOAD/UNLOAD MEDIUM	Play operation ***shall*** be stopped
BDh	MECHANISM STATUS	Play operation ***shall not*** be stopped
55h	MODE SELECT (10)	Play operation ***shall not*** be stopped
5Ah	MODE SENSE (10)	Play operation ***shall not*** be stopped
4Bh	PAUSE/RESUME	Play operation ***shall*** stop or continue based on command type
45h	PLAY AUDIO (10)	Play ***shall*** continue from the new address.
47h	PLAY AUDIO MSF	Play ***shall*** continue from the new address.
1Eh	PREVENT/ALLOW MEDIUM REMOVAL	Play operation ***shall not*** be stopped
28h/A8h	READ (10), READ (12)	Play operation ***shall*** be stopped.
3Ch	READ BUFFER	Play operation may be stopped
5Ch	READ BUFFER CAPACITY	Play operation ***shall not*** be stopped
25h	READ CAPACITY	Play operation ***shall not*** be stopped
BEh	READ CD	If the READ CD command requests only the Q sub-channel data then the Play will continue and the command will return the data from the current location. If any data other than the Q sub-channel is requested the command ***shall*** be performed and the Play operation will be aborted.
B9h	READ CD MSF	If the READ CD command requests only the Q sub-channel data then the Play will continue and the command will return the data from the current location. If any data other than the Q sub-channel is requested the command ***shall*** be performed and the Play operation will be aborted.
51h	READ DISC INFORMATION	Play operation may be stopped
ADh	READ DISC STRUCTURE	Play operation may be stopped
23h	READ FORMAT CAPACITIES	Play operation may be stopped

Table 366 - Play or Scan overlapped command operation (Continued)

Opcode	Command Description	Action Taken
42h	READ SUBCHANNEL	Only the current position information (Format Code 01h) will be supported while the play is in progress. If any other type of information is requested the READ SUB-CHANNEL may not be performed and a CHECK CONDITION status will be generated.
43h	READ TOC/PMA/ATIP	Only logical units that cache the TOC will be able to respond to this command while the play is in progress. If the logical unit does not support caching the TOC, the command may not be performed and a CHECK CONDITION will be generated.
52h	READ TRACK/RZONE INFORMATION	Play operation may be stopped
58h	REPAIR RZONE	Play operation ***shall*** be stopped
A4h	REPORT KEY	Play operation may be stopped
03h	REQUEST SENSE	Play operation ***shall not*** be stopped
53h	RESERVE TRACK/RZONE/RMZ	Play operation may be stopped
BAh	SCAN	SCAN command will be performed and the PLAY command will resume at completion of the Scan.
2Bh	SEEK	Play operation ***shall*** be stopped
5Dh	SEND CUE SHEET	Play operation may be stopped
BFh	SEND DISC STRUCTURE	Play operation may be stopped
A2h	SEND EVENT	Play operation may be stopped
A3h	SEND KEY	Play operation may be stopped
54h	SEND OPC INFORMATION	Play operation may be stopped
A7h	SET READ AHEAD	Play operation ***shall not*** be stopped
B6h	SET STREAMING	Play operation may be stopped
1Bh	START/STOP UNIT	Play operation ***shall*** be stopped
4Eh	STOP PLAY/SCAN	Play operation ***shall*** be stopped
35h	SYNCHRONIZE CACHE	Play operation ***shall not*** be stopped
00h	TEST UNIT READY	Play operation ***shall not*** be stopped
2Fh	VERIFY (10)	Play operation ***shall*** be stopped
2Ah/AAh	WRITE (10) / WRITE (12)	Play operation ***shall*** be stopped
2Eh	WRITE AND VERIFY (10)	Play operation ***shall*** be stopped
3Bh	WRITE BUFFER	Play operation may be stopped

Table 367 describes errors that may occur during the operation of the command or which may cause a CHECK CONDITION status to be reported.

Table 367 - PLAY AUDIO (10) command errors

Error Description
A-1.1, "Deferred Error Reporting" on page 721
Table 630 - *Basic Error Codes* on page 730
Table 631 - *Media Access Error Codes* on page 733

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16.14 PLAY AUDIO MSF command

The PLAY AUDIO MSF command requests that the CD logical unit begin an audio playback operation. The command function and the output of audio signals ***shall*** be as specified by the settings of the mode parameters including the SOTC Default 0 bit described in Table 345 - *CD Audio Control Mode Page Format* on page 501.

Table 368 - PLAY AUDIO MSF Command Descriptor Block

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation Code (47h)							
1	LUN (OBsolete)			Reserved				
2	Reserved							
3	Starting M							
4	Starting S							
5	Starting F							
6	Ending M							
7	Ending S							
8	Ending F							
9	Vendor-Specific		Reserved			NACA	Flag	Link
10	PAD							
11								

This command responds with immediate status, allowing overlapped commands.

The Starting M field, the Starting S field, and the Starting F field specify the absolute MSF address at which the audio play operation ***shall*** begin. The Ending M field, the Ending S field, and the Ending F field specify the absolute MSF address where the audio play operation ***shall*** end. All contiguous audio sectors between the starting and the ending MSF address ***shall*** be played.

If the Starting M, Starting S and Starting F fields are set to FFh, the starting address is taken from the Current Optical Head location. This allows the Audio Ending address to be changed without interrupting the current playback operation.

A Starting MSF address equal to an Ending MSF address causes no audio play operation to occur. This ***shall not*** be considered an error. If the Starting MSF address is greater than the Ending MSF address, the command ***shall*** be terminated with CHECK CONDITION status, 5/24/00 INVALID FIELD IN CDB.

If the starting address is not found the command ***shall*** be terminated with CHECK CONDITION status, 5/21/00 LOGICAL BLOCK ADDRESS OUT OF RANGE. If the address is not within an audio track the command ***shall*** be terminated with CHECK CONDITION status, 5/64/00 ILLEGAL MODE FOR THIS TRACK. If a NOT READY condition exists, the command ***shall*** be terminated with CHECK CONDITION status and the Sense Key set to 2, unless the Starting and Ending MSF fields are equal.

See *16.13.1, "PLAY AUDIO (10) with Immediate Packet commands"* on page 522 for information on overlapped commands during an Audio Playback.

Table 369 describes errors that may occur during the operation of the command or which may cause a CHECK CONDITION status to be reported.

Table 369 - PLAY AUDIO MSF command errors

Error Description
A-1.1, "Deferred Error Reporting" on page 721
Table 630 - *Basic Error Codes* on page 730
Table 631 - *Media Access Error Codes* on page 733

16.15 PREVENT/ALLOW MEDIUM REMOVAL command

The PREVENT/ALLOW MEDIUM REMOVAL command requests that the logical unit enable or disable the removal of the medium in the logical unit. The prevention of media removal (when implemented) ***shall*** be accomplished through the use of a Locking Mechanism. The use of a physical locking mechanism is optional. If a non persistent prevent is issued and the logical unit does not support a physical locking mechanism, the logical unit ***shall*** return CHECK CONDITION status, 5/24/00 INVALID FIELD IN CDB. If the operation is persistent then the Prevent will not be reset when media is removed or inserted. This will allow new media to become captive without host interaction. The Persistent Prevent is to be used in conjunction with the GET EVENT/STATUS NOTIFICATION command, to prevent media from being ejected with dirty file system buffers.

Table 370 - PREVENT/ALLOW MEDIUM REMOVAL Command Descriptor Block

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation Code (1Eh)							
1	LUN (Obsolete)			Reserved				
2	Reserved							
3	Reserved							
4	Reserved						Persistent	Prevent
5	Vendor-Specific		Reserved			NACA	Flag	Link
6	PAD							
7								
8								
9								
10								
11								

The Persistent bit, when set, indicates that this will be a Persistent PREVENT/ALLOW MEDIUM REMOVAL command. If the Prevent and Persistent bits are both 1, upon receiving this command, the logical unit ***shall*** disable any eject mechanisms, and all media after initial drive spin up ***shall*** remain locked in the drive until the host issues an eject request, or the Persistent Prevent status is reset and the hardware eject mechanism again becomes available.

The Persistent Prevent status ***shall*** be reset upon receipt of a PREVENT/ALLOW MEDIUM REMOVAL command (from the same host that originally set the Persistent Prevent state) with the Persistent bit set and the Prevent bit cleared, a bus reset, or a power reset condition.

Upon insertion of new media, under Persistent Prevent conditions, the logical unit eject controls ***shall*** remain functional up until the drive generates or reports a New Media event as defined in the Media Events section. After this event has been generated or reported, the media ***shall*** remain locked as defined above. The logical unit is allowed to morph from the no medium present state to the medium present state without explicit direction from the host.

The logical unit ***shall not*** report a New Media Event if the medium is removed between the generation of the Event and the next GET EVENT/STATUS NOTIFICATION command issued.

The Persistent Prevent state ***shall not*** prevent an eject request from the host from succeeding.

See *14.2, "Morphing commands and functionality"* on page 372 for more information.

The behavior of the PREVENT/ALLOW MEDIUM REMOVAL command with a Persistent bit of 0 is not affected by the Persistent Prevent state. The prevention of medium removal ***shall*** begin when the host issues a PREVENT/ALLOW

MEDIUM REMOVAL command with a Prevent bit of one and a Persistent bit of zero (medium removal prevented). The prevention of medium removal for the logical unit ***shall*** terminate:

1. after the host has issued a PREVENT/ALLOW MEDIUM REMOVAL command with a prevent bit of zero (Unlock), and the logical unit has successfully performed a Flush cache operation; or
2. upon a Hard Reset condition; or
3. upon a DEVICE RESET in an ATAPI environment; or
4. if the drive does not support a locking mechanism.

While a prevention of medium removal condition is in effect (Locked) the logical unit ***shall*** inhibit mechanisms that normally allow removal of the medium by an operator. This is also the case for changers.

The default state of the drive at power on is unlocked, unless the drive supports a prevent/allow jumper and the jumper is in the prevent state (See *16.11.3.6, "C/DVD Capabilities & Mechanical Status Mode Page"* on page 507.)

This command will affect the actions of the START/STOP UNIT command (See *16.43, "START/STOP UNIT command"* on page 697) and other mechanisms external to this specification (manual ejection / media removal systems.)

Table 371 - Actions for Lock/Unlock/Eject (Persistent bit = 0)

Operation	Locked / Unlocked	If logical unit NOT READY (No Media)	If logical unit READY (Media Present)
Unlock (Prevent = 0)	Unlocked	No Error	No Error
	Locked	No Error, Now media may be inserted	No Error, Now media may be removed
Lock (Prevent = 1)	Unlocked	No Error, Logical unit door locked and will not allow media to be inserted	No Error, Logical unit door locked and will not allow media to be removed
	Locked	No Error	No Error
Lock when the drive does not support a Locking Mechanism	Would always be Unlocked	CHECK CONDITION status, 5/24/00 INVALID FIELD IN CDB	CHECK CONDITION status, 5/24/00 INVALID FIELD IN CDB
Eject (START/STOP UNIT command with LoEj set)	Unlocked	No Error and Tray is opened if a tray exists.	No Error: Media Ejects
	Locked	CHECK CONDITION status, 2/53/02 MEDIUM REMOVAL PREVENTED	CHECK CONDITION status, 5/53/02 MEDIUM REMOVAL PREVENTED
Manual Eject	Unlocked	Tray opens (If tray exists)	Media is Ejected
	Locked	No operation occurs	No operation, Media stays locked in drive

Table 372 describes errors that may occur during the operation of the command or which may cause a CHECK CONDITION status to be reported.

Table 372 - PREVENT/ALLOW MEDIUM REMOVAL command errors

Error Description
A-1.1, "Deferred Error Reporting" on page 721
Table 630 - *Basic Error Codes* on page 730
Table 631 - *Media Access Error Codes* on page 733

16.16 READ (10) command

The READ (10) command requests that the logical unit transfer data to the host. The most recent data value written in the addressed logical block ***shall*** be returned. Any read by the host to a Logical Block with a Title Key present in the sector (DVD-ROM media Only), when the Authentication Success Flag (ASF) is set to zero ***shall*** be blocked. The command ***shall*** be terminated with CHECK CONDITION status, 5/6F/03 READ OF SCRAMBLED SECTOR WITHOUT AUTHENTICATION. For more information on the authentication process, see Figure 18 - *Device Key Exchange and Authentication State Diagram* on page 94. For more information on the Authentication Success Flag, see Figure 19 - *Authentication Flag Sequence* on page 94.

If Enhanced Defect Reporting Feature (0029h) is current, the logical unit ***shall*** follow the setting of the PER bit and the EMCDR field in *Read/Write Error Recovery Parameters* Mode Page (01h). See *9.0, "Logical unit assisted software defect management model"* on page 333.

Table 373 - READ (10) Command Descriptor Block

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation Code (28h)							
1	LUN (Obsolete)			DPO (0)	FUA	Reserved		RelAdr
2	(MSB)							
3	Logical Block Address							
4								
5								(LSB)
6	Reserved							
7	(MSB)							
8	Transfer Length							(LSB)
9	Vendor-Specific		Reserved			NACA	Flag	Link
10	PAD							
11								

The RelAdr bit is only used for SCSI logical units. For information on this bit see *C-3.1, "Use of the RelAdr bit"* on page 749.

The Disable Page Out (DPO) bit is not used by logical units and ***shall*** be set to zero. A DPO bit of zero indicates the priority ***shall*** be determined by the retention priority fields in the Cache Page if supported. All other aspects of the algorithm implementing the cache memory replacement strategy are vender specific.

A Force Unit Access (FUA) bit of one indicates that the logical unit ***shall*** access the media in performing the command. Read commands ***shall*** access the specified logical blocks from the media (i.e. the data is not directly retrieved from the cache). In the case where the cache contains a more recent version of a logical block than the media, the logical block ***shall*** first be written to the media.

An FUA bit of zero indicates that the logical unit may satisfy the command by accessing the cache memory. For read operations, any logical blocks that are contained in the cache memory may be transferred to the host directly from the cache memory.

The Transfer Length field specifies the number of contiguous logical blocks of data that ***shall*** be transferred. A Transfer Length of zero indicates that no logical blocks ***shall*** be transferred. This condition ***shall not*** be considered an error. Any other value indicates the number of logical blocks that ***shall*** be transferred.

When Restricted Overwrite method is performed (Restricted Overwrite Feature (0026h) or Rigid Restricted Overwrite Feature (002Ch)), READ (10) command or READ (12) command ***shall*** be performed normally after data in buffer is written on the disc.

Although the logical unit is capable of returning a variety of data, this command ***shall*** only return the “User Data” portion of the sector. Currently for HD DVD, DVD and CD media this length is 2048 bytes, and is specified according to the Feature that is currently active (e.g., the Random Readable Feature, see *16.4.2.6, "Feature 0010h: Random Readable"* on page 420).

For CD media, Mode 1 and Mode 2 Form 1 sectors are the only sector types allowed for reading with the READ (10) or READ (12) commands. For all other sector types, the logical unit ***shall*** set the ILI bit in the Request Sense Standard Data and return CHECK CONDITION status, 5/64/00 ILLEGAL MODE FOR THIS TRACK error if any read to them using this command is attempted.

For DVD media, all the sectors are of the same type, thus the user data portion of any sector in the user area of the media can be read with this command.

Table 374 describes errors that may occur during the operation of the command or which may cause a CHECK CONDITION status to be reported.

Table 374 - READ (10) command errors

Error Description
A-1.1, "Deferred Error Reporting" on page 721
Table 630 - *Basic Error Codes* on page 730
Table 631 - *Media Access Error Codes* on page 733

16.17 READ (12) command

The READ (12) command requests that the logical unit transfer data to the host. The most recent data value written in the addressed logical block ***shall*** be returned. Any read by the host to a Logical Block with a Title Key present in the sector (DVD-ROM media only), when the Authentication Success Flag (ASF) is set to zero ***shall*** be blocked. The command ***shall*** be terminated with CHECK CONDITION status, 5/6F/03 READ OF SCRAMBLED SECTOR WITHOUT AUTHENTICATION. For more information on the authentication process, see Figure 18 - *Device Key Exchange and Authentication State Diagram* on page 94. For more information on the Authentication Success Flag, see Figure 19 - *Authentication Flag Sequence* on page 94.

If Enhanced Defect Reporting Feature is current, logical unit ***shall*** follow the setting of PER bit and EMCDR field in *Read/Write Error Recovery Parameters* Mode Page (01h). See *9.0, "Logical unit assisted software defect management model"* on page 333.

Table 375 - READ (12) Command Descriptor Block

Byte \ Bit	7	6	5	4	3	2	1	0
0	Operation Code (A8h)							
1	LUN (Obsolete)			DPO (0)	FUA	Reserved		RelAdr
2	(MSB)							
3	Logical Block Address							
4								
5								(LSB)
6	(MSB)							
7	Transfer Length							
8								
9								(LSB)
10	Streaming	Reserved						
11	Vendor-Specific		Reserved			NACA	Flag	Link

The Streaming bit of one specifies that the Stream playback operation ***shall*** be used for the command (see *8.2, "Stream playback operation"* on page 328). The Streaming bit of zero specifies that the conventional READ operation ***shall*** be used for the command. If the Streaming bit is set to one, the cache control Mode parameter may be ignored.

If Streaming bit is set to 1 and if the logical unit supports Group3 time-out and if G3Enable bit in *Time-out & Protect* Mode Page (1Dh) is set to 1, the logical unit ***shall*** terminate this command within Group 3 time-out duration. If G3Enable bit is set to 0, this command is categorized as Group 1 time-out.

When the Streaming bit is set to one, the FUA bit ***shall*** be set to zero. If both the Streaming bit and the FUA bit are set to one, the logical unit ***shall*** terminate the command with CHECK CONDITION status, 5/24/00 INVALID FIELD IN CDB.

See *16.16, "READ (10) command"* on page 529 for a description of the parameters for this command.

See Table 374 - *READ (10) command errors* on page 530 for information on the error conditions.

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16.18 READ BUFFER command

The READ BUFFER command is used in conjunction with the WRITE BUFFER command as a diagnostic function for testing logical unit memory in the target SCSI device and the integrity of the service delivery subsystem. This command ***shall not*** alter the medium.

Table 376 - READ BUFFER Command Descriptor Block

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation code (3Ch)							
1	LUN (Obsolete)			Reserved		Mode		
2	Buffer ID							
3	(MSB)							
4	Buffer offset							
5								(LSB)
6	(MSB)							
7	Allocation length							
8								(LSB)
9	Vendor-Specific		Reserved			NACA	Flag	Link
10	PAD							
11								

If reservations are active, they ***shall*** affect the execution of the READ BUFFER command as follows. A reservation conflict ***shall*** occur when a READ BUFFER command is received from a host other than the one holding a logical unit or element reservation.

The function of this command and the meaning of fields within the command descriptor block depend on the contents of the Mode field. The Mode field is defined in Table 377.

Table 377 - READ BUFFER Mode field

Mode	Description	Implementation requirements
000b	Combined header and data	Optional
001b	Vendor-specific	Vendor-specific
010b	Data	Optional
011b	Descriptor	Optional
100b	Reserved	Reserved
101b	Reserved	Reserved
110b	Reserved	Reserved
111b	Reserved	Reserved

16.18.1 Combined header and data mode (000b)

In this mode, a four-byte header followed by data bytes is returned to the host in the Data-In Buffer. The Buffer ID and the Buffer offset fields are reserved.

The four-byte READ BUFFER header (see Table 378) is followed by data bytes from the buffer.

Table 378 - READ BUFFER header

bit / byte	7	6	5	4	3	2	1	0
0	Reserved							
1	(MSB)							
2	Buffer Capacity							
3								(LSB)

The Buffer Capacity field specifies the total number of data bytes available in the buffer. This number is not reduced to reflect the Allocation length; nor is it reduced to reflect the actual number of bytes written using the WRITE BUFFER command. Following the READ BUFFER header, the logical unit ***shall*** transfer data from the buffer. The logical unit ***shall*** terminate filling the Data-In Buffer when allocation length bytes of header plus data have been transferred or when all available header and buffer data have been transferred to the host, whichever is less.

16.18.2 Vendor-specific mode (001b)

In this mode, the meaning of the Buffer ID, Buffer offset, and Allocation length fields are not specified by this specification.

16.18.3 Data mode (010b)

In this mode, the Data-In Buffer is filled only with logical unit buffer data. The Buffer ID field identifies a specific buffer within the logical unit from which the data ***shall*** be transferred. The vendor assigns Buffer ID codes to buffers within the logical unit. Buffer ID zero ***shall*** be supported. If more than one buffer is supported, additional Buffer ID codes ***shall*** be assigned contiguously, beginning with one. Buffer ID code assignments for the READ BUFFER command ***shall*** be the same as for the WRITE BUFFER command. If an unsupported Buffer ID code is selected, the logical unit ***shall*** return CHECK CONDITION Status, 5/24/00 INVALID FIELD IN CDB.

The logical unit ***shall*** terminate filling the Data-In Buffer when allocation length bytes have been transferred or when all the available data from the buffer has been transferred to the host, whichever amount is less.

The Buffer offset field contains the byte offset within the specified buffer from which data ***shall*** be transferred. The host should conform to the offset boundary requirements returned in the READ BUFFER descriptor (see Table 379). If the logical unit is unable to accept the specified Buffer offset, it ***shall*** return CHECK CONDITION Status, 5/24/00 INVALID FIELD IN CDB.

16.18.4 Descriptor mode (011b)

In this mode, a maximum of four bytes of READ BUFFER descriptor information is returned. The logical unit ***shall*** return the descriptor information for the buffer specified by the Buffer ID (see the description of the Buffer ID in 16.18.3). If there is no buffer associated with the specified Buffer ID, the logical unit ***shall*** return all zeros in the READ BUFFER descriptor. The Buffer offset field is reserved in this mode. The Allocation length should be set to four or greater. The logical unit ***shall*** transfer the lesser of the Allocation length or four bytes of READ BUFFER descriptor. The READ BUFFER descriptor is defined as shown in Table 379.

Table 379 - READ BUFFER descriptor

bit / byte	7	6	5	4	3	2	1	0
0	Offset Boundary							
1	(MSB)							
2	Buffer Capacity							
3								(LSB)

The Offset Boundary field returns the boundary alignment within the selected buffer for subsequent WRITE BUFFER and READ BUFFER commands. The value contained in the Offset Boundary field ***shall*** be interpreted as a power of two.

The value contained in the Buffer offset field of subsequent WRITE BUFFER and READ BUFFER commands should be a multiple of $2^{\text{offset boundary}}$ as shown in Table 380.

Table 380 - Buffer offset boundary

Offset Boundary	$2^{\text{Offset Boundary}}$	Buffer Offsets
00h	$2^0 = 1$	Byte boundaries
01h	$2^1 = 2$	Even-byte boundaries
02h	$2^2 = 4$	Four-byte boundaries
03h	$2^3 = 8$	Eight-byte boundaries
04h	$2^4 = 16$	16-byte boundaries
...		
FFh	Not Applicable	0 is the only supported buffer offset

The Buffer Capacity field ***shall*** return the size of the selected buffer in bytes.

Note: In a system employing multiple hosts, a buffer may be altered between the WRITE BUFFER and READ BUFFER commands by another host. Buffer testing applications should insure that only a single host is active. Use of reservations (to all logical units on the device) or linked commands may be helpful in avoiding buffer alteration between these two commands.

Table 381 describes errors that may occur during the operation of the command or which may cause a CHECK CONDITION status to be reported.

Table 381 - READ BUFFER command Errors

Error Description
A-1.1, "Deferred Error Reporting" on page 721
Table 630 - *Basic Error Codes* on page 730

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16.19 READ BUFFER CAPACITY command

The READ BUFFER CAPACITY command checks the total length of buffer and the length of blank area.

Table 382 - READ BUFFER CAPACITY Command Descriptor Block

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation code (5Ch)							
1	LUN (Obsolete)			Reserved				Block
2	Reserved							
3	Reserved							
4	Reserved							
5	Reserved							
6	Reserved							
7	(MSB) Allocation Length							
8								(LSB)
9	Vendor-Specific		Reserved			NACA	Flag	Link
10	PAD							
11								

The logical unit reports the length of the buffer during Session at Once Recording or Track at Once Recording, or Disc at once recording.

The Block bit, if set to one, indicates that the host is requesting buffer data returned in blocks.

An Allocation Length of zero is not an error.

The READ BUFFER CAPACITY data is sent in response to this command.

Table 383 - READ BUFFER CAPACITY data when Block bit of CDB = 0

bit / byte	7	6	5	4	3	2	1	0
0	(MSB) Data Length							
1								(LSB)
2	Reserved							
3	Reserved							
4	(MSB) Length of Buffer							
5								
6								
7								(LSB)
8	(MSB) Blank Length of Buffer							
9								
10								
11								(LSB)

The Data Length field defines the number of data bytes to be transferred by the logical unit. The Data Length value does not include the Data Length field itself.

The Length of Buffer indicates the whole capacity of the buffer in bytes.

The Blank Length of Buffer indicates the length of unused area of the buffer in bytes.

If the READ BUFFER CAPACITY command is issued in a condition except Session at Once Recording or Track at Once Recording, or Disc at once recording, the Blank Length of Buffer field may be invalid.

Table 384 - READ BUFFER CAPACITY data when Block bit of CDB = 1

bit / byte	7	6	5	4	3	2	1	0
0	(MSB) Data Length							
1	Data Length							(LSB)
2	Reserved							
3	Reserved							Block
4	Reserved							
5	Reserved							
6	Reserved							
7	Reserved							
8	(MSB) Available Buffer (blocks)							
9	Available Buffer (blocks)							
10	Available Buffer (blocks)							
11	Available Buffer (blocks)							(LSB)

The Data Length field indicates the number of data bytes to be transferred by the logical unit. The Data Length value does not include the Data Length field itself.

The Available Buffer field indicates the number of blocks of buffer currently available to be written to by the host. The logical unit ***shall*** be able to immediately accept at least this much data for writing. If the Available Buffer becomes zero, the logical unit ***shall*** begin writing. The logical unit may begin writing before the Available Buffer reaches zero.

The Block bit, if set to one, indicates the current number of blocks is being returned. If set to zero, the host assumes legacy behavior of number of bytes being returned.

Table 385 describes errors that may occur during the operation of the command or which may cause a CHECK CONDITION status to be reported.

Table 385 - READ BUFFER CAPACITY command errors

Error Description
A-1.1, "Deferred Error Reporting" on page 721
Table 630 - *Basic Error Codes* on page 730

16.20 READ CAPACITY command

The READ CAPACITY command provides a means for the host to request information regarding the capacity of the logical unit.

This command may not report the correct capacity of the recorded data for CD-R, CD-RW and DVD-R/-RW, HD DVD-R media that do not have a Lead-out in the last Session or Border-out in the last Bordered Area.

Table 386 - READ CAPACITY Command Descriptor Block

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation code (25h)							
1	LUN (Obsolete)			Reserved				RelAdr (0)
2	Reserved							
3								
4								
5								
6	Reserved							
7	Reserved							
8	Reserved							PMI (0)
9	Vendor-Specific		Reserved			NACA	Flag	Link
10	PAD							
11								

The RelAdr and the PMI bits ***shall*** be reserved for C/DVD/HD DVD-R logical units.

Eight bytes of READ CAPACITY data ***shall*** be returned to the host. The returned logical block address and the block length in bytes are those of the last logical block on the logical unit.

Table 387 - READ CAPACITY DATA

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB) Logical Block Address							
1								
2								
3								(LSB)
4	(MSB) Block Length							
5								
6								
7								LSB

The Logical Block Address field identifies the last addressable user data block. If no complete session exists on the medium, this field ***shall*** be set to zero. For CD media, the logical unit ***shall*** use the AAh point found in the last Table of Contents, convert to an LBA, and subtract one. If that block is a run-out block (found on incrementally recorded CD-R and CD-RW), the logical unit ***shall*** subtract two. For DVD/HD DVD media, this field identifies the maximum LBA on the disc that contains the host supplied user data.

The Block Length field specifies, in bytes, the length of each Logical Block. For CD or DVD/HD DVD media, this value ***shall*** be 2048.

Table 388 describes errors that may occur during the operation of the command or which may cause a CHECK CONDITION status to be reported.

Table 388 - READ CAPACITY command errors

Error Description
A-1.1, "Deferred Error Reporting" on page 721
Table 630 - *Basic Error Codes* on page 730
Table 631 - *Media Access Error Codes* on page 733

16.21 READ CD command

The READ CD command (Family) provides one standard, universal way of accessing CD data. Rather than breaking the types of data into several related commands, this command is generic to all CD data types.

This command returns any of the CD data streams, including the headers, EDC and ECC, ROM data and CD-DA data. Each type of data is enabled via the use of flags. These flags indicate which information from the CD is to be returned in the data stream. If a flag is cleared, then that particular information will not be returned. If all the flags are cleared, no data will be returned to the host and this condition is not treated as an error.

Table 389 - READ CD Command Descriptor Block

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation Code (BEh)							
1	LUN (Obsolete)			Expected Sector Type			Reserved	RelAdr
2	(MSB)							
3	Starting Logical Block Address							
4								
5								(LSB)
6	(MSB)							
7	Transfer Length in Blocks							
8								(LSB)
9	Sync Field	Header(s) Code		User Data	EDC & ECC	Error Flag(s)		Reserved
10	Reserved					Sub-Channel Data Selection Bits		
11	Vendor-Specific		Reserved			NACA	Flag	Link

The RelAdr bit is only used for SCSI logical units. For information on this bit see *C-3.1, "Use of the RelAdr bit"* on page 749.

The Expected Sector Type field is used to limit the amount of information returned to the host. If the Requested Sector(s) do not match the specified type, the command will be terminated with CHECK CONDITION status, 5/64/00 ILLEGAL MODE FOR THIS TRACK. The Sector that does not match will not be transferred to the host.

Note: The Expected Sector Type is used to generate an error and terminate the transfer when the sectors found on the media, do not match the type desired. This field has NO control of the actual number of bytes transferred.

Table 390 - READ CD, Expected Sector Type field definition

Expected Sector Type	Definition	Description
000b	Any Type (Mandatory)	No checking of the Sector Type will be performed. The logical unit ***shall*** terminate a command, at the sector where a transition between CD-Rom and CD-DA occurs.
001b	CD DA (Optional)	Only Red Book (CD-DA) sectors ***shall*** be returned. An attempt to read any other format ***shall*** result in the reporting of an error.
010b	Mode 1 (Mandatory)	Only Yellow Book sectors which have a “user” data field of 2048 bytes ***shall*** be returned. An attempt to read any other format ***shall*** result in the reporting of an error.
011b	Mode 2 (Mandatory)	Only Yellow Book sectors which have a “user” data field of 2336 bytes ***shall*** be returned. An attempt to read any other format ***shall*** result in the reporting of an error.

Table 390 - READ CD, Expected Sector Type field definition (Continued)

Expected Sector Type	Definition	Description
100b	Mode 2 Form 1 (Mandatory)	Only Green Book sectors which have a "user" data field of 2048 ***shall*** be returned. An attempt to read any other format ***shall*** result in the reporting of an error.
101b	Mode 2 Form 2 (Mandatory)	Only Green Book sectors which have a "user" data field of 2324 ***shall*** be returned. An attempt to read any other format ***shall*** result in the reporting of an error. The spare data is included in the user data making the size 2324+4= 2328.
110b-111b		Reserved

See also Figure 2 - *CD-ROM sector formats* on page 59.

Byte 9 is collectively identified as Flag Bits.

The Sync Field bit, when set to one indicates that the Sync Field from the sector will be included in the data stream. The data fields that are requested to be included in the data stream ***shall*** be contiguous. The Sync Field information (if selected) will be the first information in the data stream; all other fields will follow.

The Header(s) Code is an encoded field that indicates the Header/Subheader information to be placed in the data stream. See Table 391.

Table 391 - READ CD, Header(s) Code field definition

Header(s) Code	Definition	Description
00b	None	None of the header data ***shall*** be returned.
01b	HdrOnly	Only the Mode 1 or Form 1 4-byte header will be returned in the data stream.
10b	SubheaderOnly	Only the Mode 2 Form 1 or 2 Subheader will be placed into the data stream.
11b	All Headers	Both the Header and Subheader will be placed in the data stream.

The User Data bit, when set to one, indicates that the Data part of a CD Sector ***shall*** be returned in the data stream. When set to 1, the whole user data will be returned to the host. The setting of the Mode Select Block size and Density Code does not apply to this command, and the physical user data will be returned. If the current track is an Audio Track then the Audio Data will be returned, else the normal CD data will be returned.

The EDC & ECC bit, when set to one, indicates that the EDC and ECC (L-EC) field ***shall*** be included in the data stream. For Mode 1 CDs this will include the 8 bytes of pad data.

Error Flag(s) is an encoded field that indicates which (if any) of the C2 and/or Block Error data will be included in the data stream. All the field types are mandatory. If the logical unit does not support the C2 pointers (as reported in the *C/DVD Capabilities & Mechanical Status* Mode Page (2Ah)) the data returned ***shall*** be zero filled. See Table 392.

Table 392 - READ CD, Error Flag(s) field definition

Error Flags	Definition	Description
00b	None	No Error information will be included in the data stream.
01b	C2 Error Flag data	The C2 Error Flag (Pointer) bits (2352 bits or 294 bytes) will be included in the data stream. When the C2 Error pointer bits are included in the data stream, there will be one bit for each byte in error in the sector (2352 total). The bit ordering is from the most significant bit to the least significant bit in each byte. The first bytes in the sector will be the first bits/bytes in the data stream.
10b	C2 & Block Error Flags	Both the C2 Error Flags (2352 bits or 294 bytes) and the Block Error Byte will be included in the data stream. The Block Error byte is the OR of all the C2 Error Flag bytes. So that the data stream will always be an even number of bytes, the Block Error byte will be padded with a byte (undefined). The Block Error byte will be first in the data stream followed by the pad byte.
11b	Reserved	Reserved for future enhancement.

The Sub-Channel Data Selection Bits field indicate which CD Sub-Channel information is to be included in the data stream, the Q information and/or the "Raw" Sub-channel information (All eight channels, one byte from each of the small frames.) If the bit is set, then that Sub-channel data will be included in the data stream to the host. See Table 393.

Table 393 - READ CD, Sub-Channel Data Selection Bits field definition

Sub-channel Data Selection	Definition	Description	Type
000b	No Sub-channel Data	No Sub-channel data will be transferred	Mandatory
001b	RAW	Raw Sub-channel data will be transferred	Optional
010b	Q	Q data will be transferred	Optional
011b	Reserved		
100b	R - W	R-W data will be transferred	Optional
101b-111b	Reserved		

Support of Sub-channel data is optional. In the case of R-W the logical unit may return the data de-interleaved and error-corrected, RAW or padded with zeros depending on the R-W Supported and R-W de-interleaved and error-corrected bits in the *C/DVD Capabilities & Mechanical Status* Mode Page (2Ah). Changing the DCR bit on the*Read/Write Error Recovery Parameters* Mode Page (01h) will affect error correction of subcode data. The inclusion of the sub-channel data will only be valid for Audio sectors. See Table 394 for a description of sub-channel data.

If the Starting Logical Block Address is set to FFFFFFFFh and the **only** information requested to be placed in the data stream is the Sub-channel data and there is currently a PLAY AUDIO (10) command in process, the actual address used will be from the current location (of the Play). If the logical unit is not playing audio, the logical unit will respond with CHECK CONDITION status, 5/2C/00 COMMAND SEQUENCE ERROR.

When the Starting Logical Block Address is set to F0000000h and P-W raw data is selected, the drive returns P-W raw data from the Lead-in Area, and the current location ***shall*** be incremented by one. If there are no P-W data recorded in the Lead-in Area, the command ***shall*** be terminated with CHECK CONDITION status, 5/64/00 ILLEGAL MODE FOR THIS TRACK. If the Starting Logical Block Address is set to FFFFFFFFh after the above command, the Sub-channel data ***shall*** be returned from the current location within the Lead-in Area, and the current location ***shall*** be incremented by one. It is the responsibility of the device driver to convert this data to CD-Text format.

Table 394 - Formatted Q-subcode Data (A Total of 16 Bytes)

Byte	Description
0	Control (4 M.S. bits), ADR (4 L.S. bits)
1	Track number
2	Index number
3	Min
4	Sec
5	Frame
6	Reserved (00h)
7	AMin
8	Asec
9	AFrame
10	CRC[a] or 00h (hex)
11	CRC[a] or 00h (hex)
12	00h (pad)
13	00h (pad)
14	00h (pad)
15	Most Significant Bit is P for this sector (Optional) all other bits are zero.

a. CRC is optional

Table 395 - Number of Bytes Returned Based on Data Selection Field

Data to be transferred	Flag Bits	CD-DA	Mode 1	Mode 2 non XA	Mode 2 Form 1	Mode 2 Form 2
No Data	00h	0	0	0	0	0
User Data	10h	2352	2048	2336	2048	2328
User Data + EDC/ECC	18h	(10h)	2336	(10h)	2328	(10h)
Header Only	20h	(10h)	4	4	4	4
Header Only + EDC/ECC	28h	(10h)	Illegal	Illegal	Illegal	Illegal
Header & User Data	30h	(10h)	2052	2340	Illegal	Illegal
Header & User Data + EDC/ECC	38h	(10h)	2340	(30h)	Illegal	Illegal
Sub Header Only	40h	(10h)	0	0	8	8
Sub Header Only + EDC/ECC	48h	(10h)	Illegal	Illegal	Illegal	Illegal
Sub Header & User Data	50h	(10h)	(10h)	(10h)	2056	2336
Sub Header & User Data + EDC/ECC	58h	(10h)	(18h)	(10h)	2336	(50h)
All Headers Only	60h	(10h)	4	4	12	12
All Headers Only + EDC/ECC	68h	(10h)	Illegal	Illegal	Illegal	Illegal
All Headers & User Data	70h	(10h)	(30h)	(30h)	2060	2340
All Headers & User Data + EDC/ECC	78h	(10h)	(38h)	(30h)	2340	2340
Sync & User Data	90h	(10h)	Illegal	Illegal	Illegal	Illegal
Sync & User Data + EDC/ECC	98h	(10h)	Illegal	Illegal	Illegal	Illegal
Sync & Header Only	A0h	(10h)	16	16	16	16
Sync & Header Only + EDC/ECC	A8h	(10h)	Illegal	Illegal	Illegal	Illegal
Sync & Header & User Data	B0h	(10h)	2064	2352	Illegal	Illegal
Sync & Header & User Data + EDC/ECC	B8h	(10h)	2352	(B0h)	Illegal	Illegal
Sync & Sub Header Only	C0h	(10h)	Illegal	Illegal	Illegal	Illegal
Sync & Sub Header Only + EDC/ECC	C8h	(10h)	Illegal	Illegal	Illegal	Illegal
Sync & Sub Header & User Data	D0h	(10h)	Illegal	Illegal	Illegal	Illegal
Sync & Sub Header & User Data + EDC/ECC	D8h	(10h)	Illegal	Illegal	Illegal	Illegal
Sync & All Headers Only	E0h	(10h)	16	16	24	24
Sync & All Headers Only + EDC/ECC	E8h	(10h)	Illegal	Illegal	Illegal	Illegal
Sync & All Headers & User Data	F0h	(10h)	2064	2352	2072	2352
Sync & All Headers & User Data + EDC/ECC	F8h	(10h)	2352	(F0h)	2352	(F0h)
Repeat All Above and Add Error Flags	02h	+294	+294	+294	+294	+294
Repeat All Above and Add Block & Error Flags	04h	+296	+296	+296	+296	+296

The lengths of the data returned from the READ CD command vary based on the type of sector that is being read and the requested fields to be returned to the host. Many combinations are possible, but most are not very useful. Table 395 specifies how the logical unit responds to many of the requests possible. Requests for transfers not specified by this table ***shall not*** be supported and treated as Illegal. Illegal values will cause the command to be aborted with CHECK CONDITION status, 5/24/00 INVALID FIELD IN CDB.

The Values in () indicate that the amount of data is the same as the Flag byte setting specified by the contents of the parenthesis.

Values that are shaded are most useful to the host and ***shall*** return the number of bytes specified if supported.

See Figure 2 - *CD-ROM sector formats* on page 59 for a description of the data available for each sector type.

The CD-DA audio data includes 16 bits of information for each channel, and will be formatted as follows when an audio track is read.

Table 396 - CD-DA (Digital Audio) Data Block Format

Bit / Byte	7	6	5	4	3	2	1	0
	Cell 1 (1st of 588)							
0	Left Channel (Lower Byte)							
	b7	b6	b5	b4	b3	b2	b1	b0
1	Left Channel (Upper Byte)							
	b15	b14	b13	b12	b11	b10	b9	b8
2	Right Channel (Lower Byte)							
	b7	b6	b5	b4	b3	b2	b1	b0
3	Right Channel (Upper Byte)							
	b15	b14	b13	b12	b11	b10	b9	b8
. . .	...							
2348	Left Channel (Lower Byte)							
	b7	b6	b5	b4	b3	b2	b1	b0
2349	Left Channel (Upper Byte)							
	b15	b14	b13	b12	b11	b10	b9	b8
2350	Right Channel (Lower Byte)							
	b7	b6	b5	b4	b3	b2	b1	b0
2351	Right Channel (Upper Byte)							
	b15	b14	b13	b12	b11	b10	b9	b8

If the CD-ROM logical unit does not support the CD-DA Stream-Is-Accurate capability (See *16.11.3.6, "C/DVD Capabilities & Mechanical Status Mode Page"* on page 507) then the Digital Audio data ***shall*** be read as a continuous stream. If while streaming the logical unit ***shall*** stop, the logical unit ***shall*** generate CHECK CONDITION status, B/11/11 READ ERROR - LOSS OF STREAMING. This is due to the 1 second uncertainty of the address (There is no header in CD-DA Data). Reissuing the command may not return exactly the same data as the previous try. When the logical unit supports the Stream Accurate capability, there will be no error, only some time delay for rotational latency.

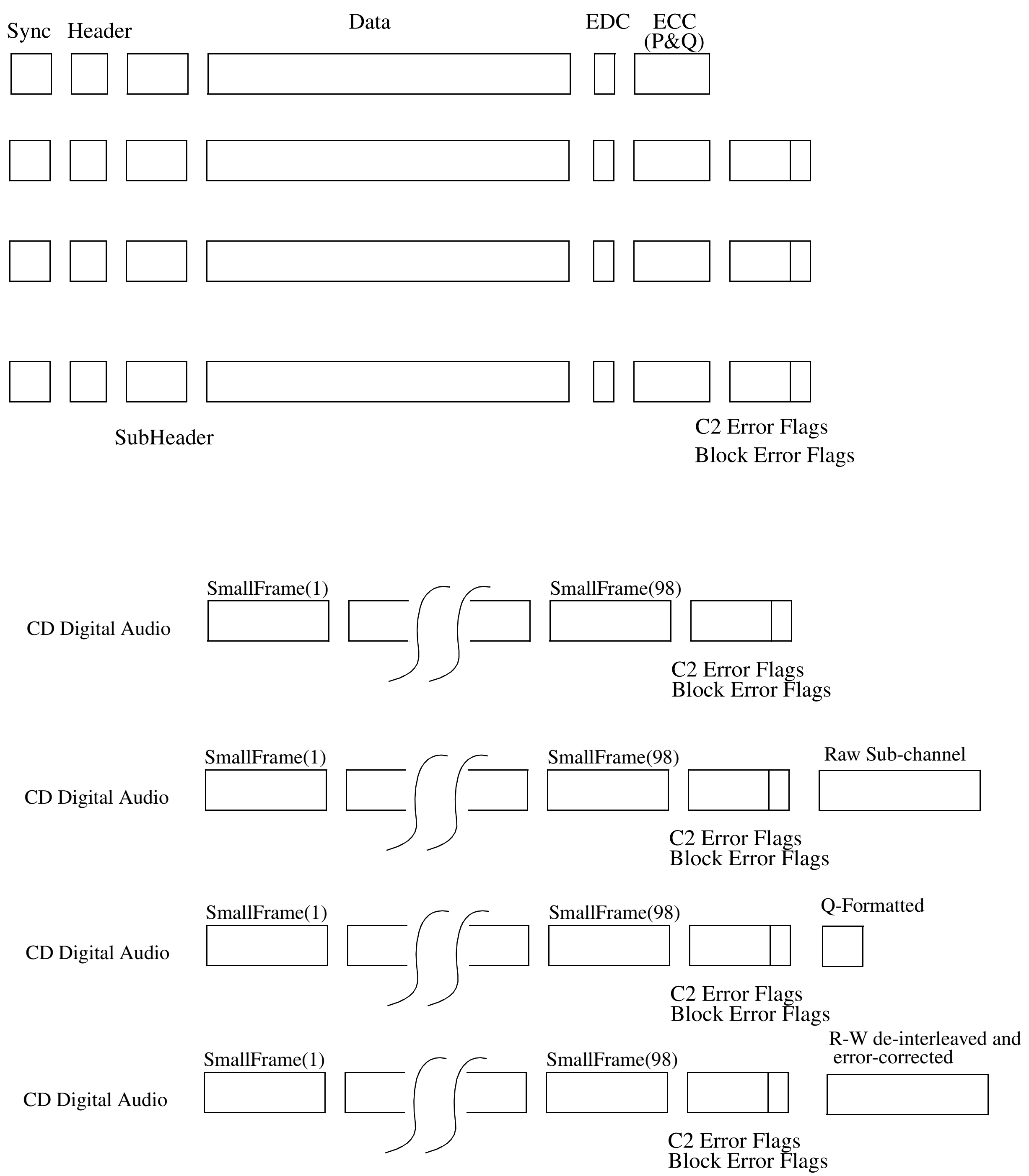
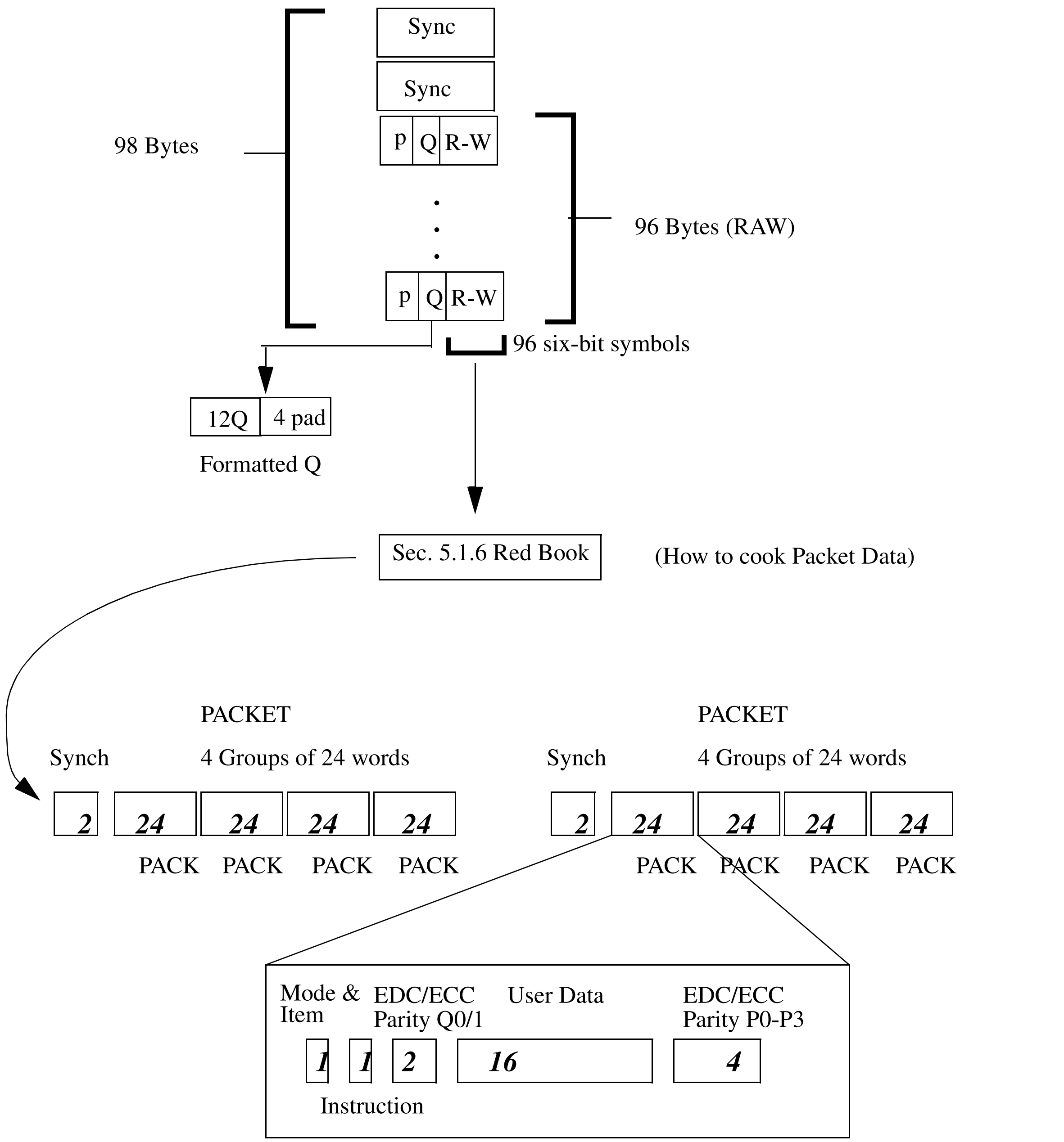


Figure 169 - READ CD Data Stream Order

16.21.0.1 Description of Sub-channels R-W



Note: the sizes shown are in 6 bit words.

Figure 170 - Read CD Sub-channel, R-W (100b)

Table 397 - P-W Raw

Bit Byte	7	6	5	4	3	2	1	0
0	P-W (0)							
1	P-W (1)							
...	...							
95	P-W (95)							

P-W Raw is returned in the format and order found on the media. It is the responsibility of the host to deinterleave and perform error detection and correction on the RAW data to make it usable to higher level applications. The P and Q bits may be set to 0 or read from the medium.

Table 398 - R-W De-Interleaved & Error Corrected

Bit Byte	7	6	5	4	3	2	1	0
0	P	Q	PACK1(0)					
1	P	Q	PACK1(1)					
...	...							
23	P	Q	PACK1(23)					
24	P	Q	PACK2(0)					
25	P	Q	PACK2(1)					
...	...							
47	P	Q	PACK2(23)					
48	P	Q	PACK3(0)					
49	P	Q	PACK3(1)					
...	...							
71	P	Q	PACK3(23)					
72	P	Q	PACK4(0)					
73	P	Q	PACK4(1)					
...	...							
95	P	Q	PACK4(23)					

logical units that can not return P or Q code with PACK data will return 0 in the unsupported P or Q bits. Each PACK is generated after 2 contiguous Sub Channel data frames consisting of 24 bytes with 6 bits of PACK data per byte. Each 96 byte Packet consists of 4 PACKs of 24 bytes each.

The basic RAW format is shown in Figure 170 - *Read CD Sub-channel, R-W (100b)* on page 548. The data is synchronized with the subcode synch patterns S0 and S1. Each group of 6 bits (R-W) is called a "symbol". The symbol following the synchs S0 and S1 is the first symbol of the first pack in a packet. The packs following the sync bytes in R-W data ***shall*** be from the same block and in chronological order.

To guard the data in the subcoding channels R-W, a (24,20) Reed-Solomon Error Correction Code is used. To improve the burst error correction capability, eight-way interleaving is added to this error correction system.

The first two symbols in a pack have additional protection with a (4,2) Read-Solomon Error Correction Code. The first symbol of a pack contains a mode-switch of 3 bits and a 3-bit subdivision of mode, called "item." The defined mode-item combinations are defined in the following table.

Table 399 - Sub-channel R-W, Allowed Mode/Item Combinations

Mode	Item	Description
000b (0d)	000b (0d)	The ZERO mode
001b (1d)	000b (0d)	The LINE GRAPHICS mode
	001b (1d)	The TV GRAPHICS mode
111b (7d)	000b (0d)	The USER mode
All Others		Reserved for future use

The R-W information is returned as part of the “raw” sub-channel data. The lower 6 bits of each of the bytes contain the R-W data. This data follows the format shown in Figure 170 - *Read CD Sub-channel, R-W (100b)* on page 548. If the Q information needs to be taken from the raw data, then it ***shall*** be deinterleaved according the Red book formats.

Table 400 describes errors that may occur during the operation of the command or which may cause a CHECK CONDITION status to be reported.

Table 400 - READ CD command errors

Error Description
A-1.1, "Deferred Error Reporting" on page 721
Table 630 - *Basic Error Codes* on page 730
Table 631 - *Media Access Error Codes* on page 733

16.22 READ CD MSF command

The READ CD command (Family) provides one standard, universal way of accessing CD data. Rather than breaking the types of data into several related commands, this command is generic to all CD data types.

This command returns any of the CD data streams, including the headers, EDC and ECC, ROM data and CD-DA data. Each type of data is enabled via the use of flags. These flags indicate which information from the CD is to be returned in the data stream. If a flag is cleared, then that particular information will not be returned. If all the flags are cleared, no data will be returned to the host and this condition is not treated as an error.

Table 401 - READ CD MSF Command Descriptor Block

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation code (B9h)							
1	LUN (Obsolete)			Expected Sector Type			Reserved	
2	Reserved							
3	Starting M Field							
4	Starting S Field							
5	Starting F Field							
6	Ending M Field							
7	Ending S Field							
8	Ending F Field							
9	Sync Field	Header(s) Code		User Data	EDC & ECC	Error flag(s)		Reserved
10	Reserved					Sub-Channel Data Selection Bits		
11	Vendor-Specific		Reserved			NACA	Flag	Link

The Starting M Field, the Starting S Field, and the Starting F Field specify the absolute MSF address at which the Read operation ***shall*** begin. The Ending M Field, the Ending S Field, and the Ending F Field specify the absolute MSF address where the Read operation ***shall*** end. All contiguous sectors between the starting and the ending MSF address ***shall*** be read.

A starting MSF address equal to an ending MSF address prevents a read operation. This ***shall not*** be considered an error. If the starting MSF address is greater than the ending MSF address, the command ***shall*** be terminated with CHECK CONDITION status, 5/24/00 INVALID FIELD IN CDB.

If the starting address is not found, or if a NOT READY condition exists, the command ***shall*** be terminated with CHECK CONDITION status.

See *16.21, "READ CD command"* on page 541 for a description of Expected Sector Type, Sync Field, Header(s) Code, User Data, EDC & ECC, Error Flag(s), and Sub-Channel Data Selection Bits fields.

Table 402 describes errors that may occur during the operation of the command or which may cause a CHECK CONDITION status to be reported.

Table 402 - READ CD command errors

Error Description
A-1.1, "Deferred Error Reporting" on page 721
Table 630 - *Basic Error Codes* on page 730
Table 631 - *Media Access Error Codes* on page 733

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16.23 READ DISC INFORMATION command

The READ DISC INFORMATION command provides information about all discs and requests that the logical unit transfer general information about the medium that is mounted to the host. The parameters returned by the logical unit are specific to the media that is currently installed in the logical unit. In the case of a DVD read-only logical unit, the disc information returned may be for the last closed Session/Border. In the case of media that does not have logical Tracks, the number of RZones and Borders is considered one. If this command is required by an implemented Feature, this command ***shall*** function, even if that Feature's Current bit becomes zero.

If this command is issued during a long immediate operation, e.g., CLOSE TRACK/RZONE/SESSION/BORDER operation, the logical unit ***shall*** return NOT READY status with CHECK CONDITION Status, 2/04/07 LOGICAL UNIT NOT READY, OPERATION IN PROGRESS.

Table 403 - READ DISC INFORMATION Command Descriptor Block

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation Code (51h)							
1	LUN (Obsolete)			Reserved		Data Type		
2	Reserved							
3	Reserved							
4	Reserved							
5	Reserved							
6	Reserved							
7	(MSB) Allocation Length							
8								(LSB)
9	Vendor-Specific		Reserved			NACA	Flag	Link
10	PAD							
11								

The Data Type field indicates the type of information that is requested to be sent to the host. When this field is set to 000b, it requests the logical unit to transfer the Disc Information Block data shown in Table 404 with Returned Data Type field set to 000b. When this field is set to 001b, it requests the logical unit to transfer Assigned Track information defined in Table 410. If NWAI bit in Incremental Streaming Writable Feature is set to one, Data Type of 001b ***shall*** be supported. It is recommended to check the Returned Data Type field of the data that is sent by logical unit. If logical unit does not support the Data Type field, Returned Data Type field is set to incorrect value (e.g., zero).

The number of information bytes returned is limited by the Allocation Length parameter of the CDB. An Allocation Length of zero ***shall not*** be considered an error. If the Allocation Length is greater than the amount of available information bytes, only the available data will be transferred.

16.23.1 Disc Information Block data

This information reports the disc information of the mounted medium via Table 404 - *Disc Information Block* on page 554.

Table 404 shows the definition of the Disc Information Block.

Table 404 - Disc Information Block

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB)			Data Information Length				
1								(LSB)
				Information Block				
2	Returned Data Type			Erasable	Status of Last Session/ Border		Disc Status	
3	Number of First Track/RZone on Disc							
4	Number of Sessions/Borders (LSB)							
5	First Track/RZone Number in Last Session/Border (LSB)							
6	Last Track/RZone Number in Last Session/Border (LSB)							
7	DID_V[a]	DBC_V[a]	URU	DAC_V[b]	Reserved	Dbit[b]	BG Format Status[b]	
8	Disc Type[a]							
9	Number of Sessions/Borders (MSB)							
10	First Track/RZone Number in Last Session/Border (MSB)							
11	Last Track/RZone Number in Last Session/Border (MSB)							
12	(MSB)							
13				Disc Identification[a]				
14								
15								(LSB)
16	(MSB)							
17				Lead-in Start Time of Last Session[a]				
18				MSF				
19								(LSB)
20	(MSB)							
21				Last Possible Start Time for Start of Lead-out[a]				
22				MSF				
23								(LSB)
24	(MSB)							
:				Disc Bar Code[a]				
31								(LSB)
32	Disc Application Code[b]							
33	Number of OPC Table Entries (Obsolete)[c]							
34-n	OPC Table Entries (Obsolete)							

a. Inapplicable field for non-CD media. Shall be set to zero.
b. These fields may be valid for DVD+R/+RW media. See MMC.
c. Logical unit should transfer Number of OPC Table Entries (Obsolete) filed with Zero value.

The invalid field for corresponded media, will return 0.

The Data Information Length is the number of bytes available in both the recording information area and the appended OPC table. Data Information Length excludes itself.

The Returned Data Type field indicates the type of information be sent to the host. This field ***shall*** be set to 0 for Disc Information Block.

The Erasable bit, when set to 1, indicates that DVD-RAM, DVD+RW, C/DVD-RW or HD DVD-Rewritable medium is present. Otherwise, such a medium is not present.

Status of Last Session/Border is valid only for discs with either empty or incomplete status and given by the following table. For media that does not use Sessions/Borders, this field will return "Complete" (11b).

Table 405 shows the definition of the Status of Last Session/Border field.

Table 405 - Status of Last Session/Border field definition

Status of Last Session/Border	Definition
00b	Empty Session/Border
01b	Incomplete Session/Border[a]
10b	Reserved / Damaged Border (Only for DVD-R/-RW media)
11b	Complete Session/Border (Only possible when Disc Status is Complete)

a. When a disc is in DVD-RW restricted overwrite mode and the last Bordered Area is Intermediate state, this status code is returned.

The Disc Status field indicates the status of the disc and is shown in Table 406. The logical unit which does not have the ability to write for the inserted medium (e.g., C/DVD/HD DVD read-only logical unit) will return "Complete"(10b) status.

For DVD-RW media, if Status of Last Session/Border field value is 10b, the returned value of the Disc Status field value ***shall*** be 01b.

Table 406 - Disc Status field definition

Disc Status	Definition
00b	Empty Disc
01b	Incomplete Disc (Appendable)[a]
10b	Complete Disc (Not Appendable. C/DVD/HD DVD-ROM, complete CD-R/RW, DVD-R/-RW, HD DVD-R or write protected Random Writable media)
11b	Others (non-write protected Random Writable media)

a. When a disc is in DVD-RW restricted overwrite mode and the last Bordered Area is Intermediate state, this status code is returned.

The Number of First Track/RZone on Disc field:

For non-CD media, this field ***shall*** be set to 1.

For CD media,

1. If Disc Status field is set to 00b (Empty Disc), the Number of First Track/RZone on Disc field ***shall*** be 1.
2. If there are no entries in the PMA and the first track is an Incomplete Track, the Number of First Track/RZone on Disc field ***shall*** be equal to 1.
3. If the only session on the disc is an Incomplete Session, the Number of First Track/RZone on Disc field is from the PMA.
4. Otherwise, the Number of First Track/RZone on Disc field contains the track number for the first TOC entry in the first Session.

The Number of Sessions/Borders on the disc refers to all complete Sessions/Borders plus any incomplete or empty Sessions/Borders. A Blank Disc will always have a session/Border count equal to 1.

First Track Number in Last Session/Border (bytes 5 & 10) is the track/RZone number of the first track/RZone in the last session/Border. In order for Track/RZones in the last Session/Border, that may be open, to be scanned by the READ TRACK/RZONE INFORMATION command, the First Track/RZone Number in Last Session/Border is identified. This is inclusive of the invisible track/RZone.

Last Track Number in Last Session/Border (bytes 6 & 11) is the track/RZone number of the last track/RZone in the last session/Border. In order for Track/RZones in the last Session/Border, that may be open, to be scanned by READ TRACK/RZONE INFORMATION command, the Last Track/RZone Number in Last Session/Border is identified. This is inclusive of the invisible track/RZone.

The Disc Identification Valid (DID_V) bit specifies the validity of the Disc Identification field. If it is set to 1, then the Disc Identification field is valid. Otherwise, it is invalid.

The Disc Bar Code Valid (DBC_V) bit specifies the validity of the Disc Bar Code field. If it is set to 1, then the Disc Bar Code field is valid. Otherwise, it is invalid.

The Unrestricted Use Disc (URU) bit, when set to one, indicates that the mounted DVD-R, CD-R/RW disc is defined for unrestricted use. When the URU bit is set to zero, the mounted DVD-R, CD-R/RW disc is defined for restricted use. To record data to the mounted disc the appropriate Host Application code ***shall*** be set through the *Write Parameters* Mode Page (05h). A Host Application Code of zero may be used to indicate a restricted use disc - general purpose. Logical units that cannot determine the state of the URU bit from the medium should set this bit to one. For HD DVD-R, this bit ***shall*** be set to one.

For CD, the Disc Type specifies the type of the data on the whole disc. A disc has only one disc type. The disc type is recorded in the A0/PSEC field in the TOC of the first session in which there is at least one data track, or is recorded together with disc ID in PMA. In the case of a session that contains no data tracks (only audio), A0/PSEC field in the TOC of the session is always 00h regardless of actual disc type. For CD disc, the Disc type ***shall*** be determined from the following sequence:

1. Disc ID (Disc Type) as written in PMA.
2. From the first Complete Session that includes at least one data track.
3. From the first session of a Complete Disc (not appendable).
4. The Disc type is NOT decided, the Disc Type field of Disc Information Block ***shall*** contain FFh.

Table 407 - Disc Type field definition

Disc Type Code	Disc Type
00h	CD-DA or CD-ROM Disc
10h	CD-I Disc
20h	CD-ROM XA Disc
FFh	Undefined
All other values	Reserved

For CD, the Disc Identification Number field returns Disc Identification Number that is recorded in the PMA. The Disc Identification Number is recorded in the PMA as a six-digit BCD number. It is returned in the Disc Information Block as a 32 bit binary integer.

The Lead-in Start Time of Last Session field is valid only for CD medium. Otherwise, this field ***shall*** be set to 0. This field indicates the location of the next Lead-in to be recorded. If the disc is Empty as specified in the Disc Status field or has no Complete Session, then the Lead-in Start Time of Last Session is set to the address encoded in the ATIP. If the last session, which is the second or greater, is an Empty or Incomplete Session, this field ***shall*** be set to the B0 pointer of the previous session - 60 seconds. If the Disc Status is Complete, the Lead-in Start Time of Last Session field ***shall*** be filled with FFh. The Lead-in Start Time of Last Session is given in the MSF format.

The Last Possible Start Time for Start of Lead-out field is valid only for CD media. Otherwise this field ***shall*** be set to 0. If the disc is a Complete disc, the Last Possible Start Time of Lead-out field is filled with FFh. The Last Possible Start Time for Start of Lead-out is returned as the address encoded in the ATIP and it is given in MSF format.

Disc Bar Code. If the logical unit has the ability to read Disc Bar Code and a bar code is present, then the Disc Bar Code field contains the 12 hex digits of the bar code.

Number of OPC Table Entries (Obsolete). This field is obsoleted and is no more used. This field ***shall*** be set to 0. No OPC Table Entries (Obsolete) ***shall*** be returned. Original definition is as follows.

An OPC (Optimum Power Calibration) Table is attached only if the values are known for the mounted disc. Since OPC values are likely to be different for different recording speeds, each table entry is associated with a recording speed. The Number of OPC Table Entries (Obsolete) is used to compute the number of bytes that will follow. The number of bytes that follow will be the number of entries times 8. This number ***shall*** be the same for all values of Allocation Length.

Note: The Number of OPC Table Entries (Obsolete) will always be zero for CD-ROM, DVD-ROM, DVD-RAM, DVD+RW and HD DVD-Rewritable discs and for CD-R/RW discs for which OPC have not yet been determined. For DVD-R/-RW and HD DVD-R, the use of OPC table entries is vendor-specific.

Table 408 - OPC Table Entry (Obsoleted)

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB)			Speed				
1								(LSB)
2	(MSB)							
3								
4				OPC Value				
5								
6								
7								(LSB)

The Speed field indicates the speed for which this OPC value is valid. This value is the number of kilobytes per/second (Speed/1000) that the data is read from the logical unit.

Table 409 - Example Data Rates

Speed	CD(ROM/R/RW) Data Rate
X1	176 kBytes/second
X2	353 kBytes/second
X4	706 kBytes/second
X8	1400 kBytes/second
X16	2800 kBytes/second

The OPC Value field is associated with given speed and its contents are vendor specific.

16.23.2 Assigned Track information

This information reports the Assigned Track information of the mounted medium via Table 410 - *Assigned Track information* on page 558.

Table 410 shows the definition of the Assigned Track information.

Table 410 - Assigned Track information

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB) Data Information Length							
1	Data Information Length (LSB)							
Information Block								
2	Returned Data Type			Reserved				
3	Reserved							
4	(MSB) Maximum possible number of the Tracks on the disc							
5	Maximum possible number of the Tracks on the disc (LSB)							
6	(MSB) Number of the assigned Tracks on the disc							
7	Number of the assigned Tracks on the disc (LSB)							
8	(MSB) Maximum possible number of appendable Tracks on the disc							
9	Maximum possible number of appendable Tracks on the disc (LSB)							
10	(MSB) Current number of appendable Tracks on the disc							
11	Current number of appendable Tracks on the disc (LSB)							

The Data Information Length is the number of bytes transfered to host. Data Information Length excludes itself.

The Returned Data Type field indicates the type of information be sent to the host. This field ***shall*** be set to 1 for Assigned Track information.

Maximum possible number of the Tracks on the disc field indicates the possible maximum number of track that can be assinged to the disc. In case of CD, this value is 99. In case of DVD, this value may be number of current existing RZones plus number of remaining empty ECC blocks in RMA.

Number of the assigned Tracks on the disc field indicates number of current existing Tracks/RZones.

Maximum possible number of appendable Tracks on the disc field indicates the possible maximum number of appendable track that can have NWA of the disc. In case of CD, this value is 99 minus number of closed Tracks. In case of DVD-R Dual Layer Ver. 3.0, this value is 4. In case of DVD-R for General Ver. 2.1, this value is 3.

Current number of appendable Tracks on the disc field indicates number of current existing appendable Tracks/ RZones that have NWA.

Table 411 describes errors that may occur during the operation of the command or which may cause a CHECK CONDITION status to be reported.

Table 411 - READ DISC INFORMATION command errors

Error Description
A-1.1, "Deferred Error Reporting" on page 721
Table 630 - *Basic Error Codes* on page 730
Table 631 - *Media Access Error Codes* on page 733

16.24 READ DISC STRUCTURE command

The READ DISC STRUCTURE command requests that the logical unit transfer data from areas on the specified media to the host.

For DVD/HD DVD media, there are several control structures, including the Lead-in and Burst Cutting Area (BCA). The Lead-in Area for DVD/HD DVD media contains information about the media as well as information used by the logical unit to allow it to recover information from the media. The BCA for DVD media is optional which contents are specified by media manufacturer.

Table 412 - READ DISC STRUCTURE Command Descriptor Block

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation code (ADh)							
1	LUN (Obsolete)			Reserved	Sub-command			
2	(MSB) Address							
3								
4								
5								(LSB)
6	Layer Number							
7	Format Code							
8	(MSB) Allocation Length							
9								(LSB)
10	AGID		Reserved					
11	Vendor-Specific		Reserved			NACA	Flag	Link

The Sub-command field indicates the type of command definition to expand this command for other media type than DVD/HD DVD. This value ***shall*** be set to 0000b for DVD/HD DVD media.

Table 413 - Sub-command field definition

Sub-command value	Supported Media Type
0000b	DVD-ROM, DVD-RAM, DVD-R, DVD-RW, DVD+RW, DVD+R, HD DVD-ROM, HD DVD-R, and HD DVD-Rewritable media
0001b	BD-RE, BD-R, BD-ROM media
Others	Reserved

The Format Code field indicates the type of information that is requested to be sent to the host.

The Layer Number field specifies the Layer number for which the READ DISC STRUCTURE data will be returned.

The AGID field is described in the REPORT KEY command. This field is used only when the Format Code field contains 2h, 6h or 7h with Address field of 00000000h, 13h, 14h, or 16h for all other values it is reserved.

Requests for Format Code FFh ***shall*** be fulfilled, even if no or incompatible media is installed.

When a READ DISC STRUCTURE command is issued for media that is not supported by the Sub-command field, with Format Codes 00h - BFh, this command ***shall*** be terminated with CHECK CONDITION status, 5/30/02 CANNOT READ MEDIUM - INCOMPATIBLE FORMAT. When the device/media does not support specified Format Code value, this command ***shall*** be terminated with CHECK CONDITION status, 5/24/00 INVALID FIELD IN CDB.

In the case of DVD-R/-RW/HD DVD-R, the logical unit may have cache memory for the Lead-in Control Data. If the disc has no Lead-in and there are no structures in the cache, the logical unit ***shall*** generate CHECK CONDITION status, 5/24/00 INVALID FIELD IN CDB. If the Lead-in is already written or there are DISC STRUCTURE data in the cache, the logical unit ***shall*** return the requested structure.

The number of READ DISC STRUCTURE data bytes returned is limited by the Allocation Length field of the CDB. An Allocation Length of zero is not an error.

The Address field contains a value which depends on the value in the Format Code field.

For Format Code field = 05h (Copyright Management) or 0Bh (Recording Type Information), the Address field contains an LBA (Logical Block Address).
For Format Code field = 07h (Media Key Block), the Address field contains the Pack Number.
For Format Code field = 0Ch (RMD in the last Border-out), the Address field contains the Field number of RMD block which is recorded in the last Border-out. Field number of RMD block are integers assigned in ascending order in the range 0 to 14 for DVD, 0 to 21 for HD DVD.
For Format Code field = 0Dh (RMD in RMA), for DVD, the Address field contains sector number of RMA where the RMA read operation ***shall*** begin. The RMA sector size is 2KB. The RMA sector number is assigned to each sector of RMA, including RMD Linking Loss Area. The RMA sector numbers are integers assigned in ascending order starting with zero. Each successive sector of RMA has a number increased by 1. When the Address field specifies an unrecorded RMA sector, this command ***shall*** be terminated with CHECK CONDITION status, Sense Key BLANK CHECK. Cached RMD information ***shall*** be returned by this command as if it had been committed to the medium. For HD DVD, this Format Code ***shall not*** be supported.
For Format Code field = 15h (Copyright data section), the Address field contains the starting address of the Copyright data section sector position where the read operation ***shall*** begin.
For Format Code field = 1Ah (last recorded RMD in the latest RMZ), the Address field contains the Field number of last recorded RMD block which is recorded in the latest RMZ. Field number of the last recorded RMD block is assigned in ascending order in the range 0 to 21 for HD DVD.
For Format Code field = 17h (Madia Key Block of AACS), the Address field contains the Pack Number.
For Format Code field = 30h (Disc Control Blocks), the Address field contains the Content Descriptor desired.
Other values - The Address field ***shall*** be reserved.

Table 414 - Format Code field definitions for Sub-command = 0000b

Format Code	Returned Data	Layer Byte Usage	Address Field Explanation	Applicable media type	Description
00h	Physical format information	Layer Number	Reserved	All DVD/ All HD DVD	Returns physical format information in the DVD/HD DVD Lead-in Area[a]
01h	Copyright	Layer Number	Reserved	All DVD	Returns the Copyright information from DVD Lead-in
02h	Disc Key	Reserved	Reserved	DVD-ROM	Returns the Disc Key obfuscated by using a Bus Key
03h	BCA	Reserved	Reserved	All DVD All HD DVD	Returns the BCA information on DVD/ HD DVD media
04h	Manufacturer's	Layer Number	Reserved	All DVD All HD DVD	Returns the Disc Manufacturing information from DVD/HD DVD Lead-in
05h	Copyright Management	Reserved	LBA	All DVD	Returns Copyright Management information from specified sector
06h	Media Identifier	Reserved	Reserved	DVD-ROM	Returns the Media Identifier protected by using a Bus Key
07h	Media Key Block	Reserved	Pack Number	DVD-ROM	Returns the Media Key Block protected by using a Bus Key

Table 414 - Format Code field definitions for Sub-command = 0000b (Continued)

Format Code	Returned Data	Layer Byte Usage	Address Field Explanation	Applicable media type	Description
08h	DDS	Reserved	Reserved	DVD-RAM/ HD DVD-RW	Returns the DDS information on DVD-RAM/HD DVD-Rewritable media
09h	DVD-RAM/ HD DVD-RW Medium status	Reserved	Reserved	DVD-RAM/ HD DVD-RW	Returns the medium status information on DVD-RAM/HD DVD-Rewritable media
0Ah	Spare Area Information	Reserved	Reserved	DVD-RAM/ HD DVD-RW	Returns the Spare Area information for the media
0Bh	Recording Type Information	Reserved	LBA	DVD-RAM/ HD DVD-RW	Returns Recording Type information from specified sector
0Ch	RMD in the last Border-out	Reserved	Start Field Number of RMD block	DVD-R/ HD DVD-R	Returns the Field of RMD in the last Border-out
0Dh	RMD	Reserved	Start RMA Sector Number	DVD-R	Returns RMD sectors which are recorded in RMA
0Eh	Pre-recorded information in Lead-in	Reserved	Reserved	DVD-R	Returns Pre-recorded information in Lead-in
0Fh	Unique Disc Identifier	Reserved	Reserved	DVD-R/ HD DVD-R	Returns Unique Disc Identifier of the disc
10h	Physical in the Lead-in	Layer Number	Reserved	DVD-R/-RW/ HD DVD-R	Returns Physical format information of Control Data Zone in the Lead-in
11h	ADIP information	Reserved	Reserved	DVD+R/+RW	See MMC
12h	HD DVD Copyright Protection Info.	Layer Number	Reserved	All HD DVD	Returns the Copyright Protection Information from HD DVD Lead-in
13h	Volume ID of AACS	Reserved	Reserved	DVD-ROM 3X All HD DVD	Returns the Volume Identifier specified by AACS
14h	Serial Number of AACS	Reserved	Reserved	DVD-ROM 3X All HD DVD	Returns the Pre-recorded Media Serial Number specified by AACS
15h	Copyright data section	Layer Number	Start Copyright data section Sector Number	All HD DVD/ DVD-ROM 3X	Returns the Copyright Data Section from HD DVD Lead-in or DVD-ROM 3× adapted to AACS Lead-in
16h	Media ID of AACS	Reserved	Reserved	DVD-ROM 3X All HD DVD	Returns the Media Identifier specified by AACS
17h	Media Key Block of AACS	Layer Number	Pack Number	DVD-ROM 3X All HD DVD	Returns the Media Key Block in Lead-in specified by AACS
18h	Reserved				
19h	HD DVD-R Medium Status	Reserved	Reserved	HD DVD-R	Returns the medium status information on HD DVD-R media
1Ah	Last recorded RMD in the latest RMZ	Reserved	Start Field Number of RMD block	HD DVD-R	Returns the last recorded RMD in the latest RMZ
1Bh-1Fh	Reserved				
20h	Layer Boundary Information	Reserved	Reserved	DVD-R DL[b] DVD+R DL	Returns the Layer boundary information of DVD-R Dual Layer / +R Double Layer disc

Table 414 - Format Code field definitions for Sub-command = 0000b (Continued)

Format Code	Returned Data	Layer Byte Usage	Address Field Explanation	Applicable media type	Description
21h	Shifted Middle Area Start Address	Reserved	Reserved	DVD-R DL	Returns the start logical block address of the Shifted Middle Area on L0
22h	Jump Interval size	Reserved	Reserved	DVD-R DL	Returns the Jump Interval size of Regular Interval Layer Jump recording
23h	Manual Layer Jump Address	Reserved	Reserved	DVD-R DL	Returns the start logical block address of the Manual Layer Jump
24h	Remapping Address	Reserved	Anchor Point Number	DVD-R DL	Returns one Remapping information of the specified Anchor Point
25h-2Fh	Reserved				
30h	Disc Control Blocks	Reserved	Content Descriptor	DVD+R/+RW	Returns the Disc Control Block identified by the Content Descriptor. See MMC
31h-BFh	Reserved				

a. For DVD-R/-RW/HD DVD-R multi-border disc, this Format Code returns information in the last Border-in.
b. "DVD-R DL" in this table indicates the DVD-R Dual Layer media

The Format Code value of C0h through FFh are used to return media independent information. Regardless of the Sub-command field value in CDB, the same information is returned to the host.

Table 415 - Format Code field definitions for media independent information

Format Code	Returned Data	Layer Byte Usage	Address Field Explanation	Applicable media type	Description
C0h	Write Protection	Reserved	Reserved	All[a]	Returns Write Protection Status and MSWI status
C1h-FEh	Reserved				
FFh	Structure List	Layer Number	Reserved	All[a]	Returns a list of DISC STRUCTURE data present in the specified Layer.

a. All media types other than CD

The following sections 16.24.1 through 16.24.32 specifies the returned DISC STRUCTURE data for DVD/HD DVD media (Sub-command = 0000b).

16.24.1 Physical Format Information (Format Code = 00h)

For DVD-R/-RW/HD DVD-R media, this Format code returns the last updated Physical format information. For example, if a medium is recorded with multi-Border, this information is retrieved from the last Border-in. To retrieve the Control Data Zone information in the Lead-in Area, Format 10h (Table 437) ***shall*** be used.

Physical Format Information is shown in Table 416.

Table 416 - READ DISC STRUCTURE Data format (With Format Code = 00h)

Byte \ Bit	7	6	5	4	3	2	1	0
0	(MSB)	DISC STRUCTURE Data Length						
1								(LSB)
2	Reserved							
3	Reserved							
Physical format information								
0	Book Type				Part Version			
1	Disc Size				Maximum Rate			
2	Reserved	Number of Layers		Track Path	Layer Type			
3	Linear Density				Track Density			
4	00h							
5	(MSB)	Starting Physical Sector Number of Data Area						
6								
7								(LSB)
8	00h							
9	(MSB)	End Physical Sector Number of Data Area						
10								
11								(LSB)
12	00h							
13	(MSB)	End Sector Number in L0						
14								
15								(LSB)
16	BCA Flag	Reserved						
17-2047	Media Specific							

This information is returned for DVD/HD DVD media Only. The information for the Layer specified by the Layer Number field in the CDB is returned. If there is only one Layer then the only valid Layer is L0. If a non-existent Layer is requested then the command ***shall*** be aborted with CHECK CONDITION status, 5/24/00 INVALID FIELD IN CDB. If the media has more than one Layer, but is recorded using the Opposite Track Path method, then the same information ***shall*** be returned for all Layers.

The DISC STRUCTURE Data Length field indicates the length in bytes of the following DISC STRUCTURE data that is available to be transferred to the host. The DISC STRUCTURE Data Length value does not include the DISC STRUCTURE Data Length field itself.

The Book Type field specifies with which DVD/HD DVD Book this media complies. See Table 15 - *Book Type field definition* on page 83 or Table 116 - *Book Type field definition* on page 255.

The Part Version specifies the version of the specified book that this media complies with.

The Disc Size specifies the physical size of the media. A value of 0000b specifies 120mm, a value of 0001b specifies a size of 80mm.

The Maximum Rate is used to specify to the logical unit the read rate to use for this media. See Table 17 - *Maximum Transfer Rate field definition* on page 83 or Table 118 - *Maximum Transfer Rate field definition* on page 256.

The Number of Layers field specifies the number of Layers for this side of the media. A value of 00b indicates that the media has only one Layer. A value of 01b specifies that this side of the media has two Layers. Currently only one and two Layer discs are specified.

The Track Path bit specifies the direction of the Layers when more than one Layer is used. If the bit is cleared to 0 then this media uses Parallel Track Path (PTP). When PTP is used each Layer is independent and has its own Lead-in and Lead-out Areas on the media. If the bit is set to 1 then the media uses Opposite Track Path (OTP). With opposite track path both Layers are tied together. There is only one Lead-in and Lead-out. In the middle of the media there is an area called the Middle Area. The addresses of blocks in one Layer are mirrored in the other Layer.

The Layer Type field ***shall*** identify the Layer according to Table 18 - *Layer Type field definition* on page 84 or Table 119 - *Layer Type field definition* on page 257.

The Linear Density field indicates the minimum/maximum pit length used for this Layer. See Table 19 - *Linear Density field definition* on page 84 or Table 120 - *Linear Density field definition* on page 257.

The Track Density field indicates the track width used for this media. See Table 20 - *Track Density field definition* on page 84 or Table 121 - *Track Density field definition* on page 257.

The Starting Physical Sector Number of Data Area field specifies the first block that contains user data. See Table 417. For HD DVD-Rewritable, this field indicates the starting PSN of Data Area in land track (= 030000h).

Table 417 - Starting Physical Sector Number of Data Area

Starting Sector Number	Media Type
30000h	DVD-ROM, DVD-R/-RW and HD DVD
31000h	DVD-RAM
Others	Reserved

The End Physical Sector Number of Data Area field specifies the last sector of the user Data Area in the last Layer of the media. For DVD-RAM, the End Physical Sector Number of Data Area is the PSN for the last spare sector of the last zone. It should not be used for counting user capacity. For HD DVD-R, this field specifies Outer limit of Data Recordable area. For HD DVD-Rewritable, this field specifies End PSN of Data Area in land track. The value of this field is 4ED73Fh.

The End Sector Number in L0 field specifies the last sector of the user data in L0, if the media contains multiple Layers with using the Opposite Track Path. For HD DVD-Rewritable, the End Sector Number in L0 field specifies offset value between start PSN of the Data Area in land track and start PSN of the Data Area in groove track. The value of this field is 800000h. In other cases, this value is set to 000000h.

The Media Specific field contains information as specified in the associated DVD/HD DVD specification.

The BCA Flag indicates the presence of data in the Burst Cutting Area. A bit of zero indicates BCA data does not exist. A bit of one indicates BCA data exist.

16.24.2 DVD Copyright Information (Format Code = 01h)

Table 418 - READ DISC STRUCTURE Data format (With Format Code = 01h)

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB)			DISC STRUCTURE Data Length				
1								(LSB)
2				Reserved				
3				Reserved				
				DVD Copyright Information				
0				Copyright Protection System Type				
1				Region Management Information				
2				Reserved				
3				Reserved				

The DISC STRUCTURE Data Length field indicates the length in bytes of the following DISC STRUCTURE data that is available to be transferred to the host. The DISC STRUCTURE Data Length value does not include the DISC STRUCTURE Data Length field itself.

The Copyright Protection System Type field indicates the presence of data structures specific to a copyright protection system. Four values are defined, 00h indicates there is no such data, 01h indicates a specific data structure for CSS/CPPM exists, 02h indicates a specific data structure for CPRM exists, and 03h indicates a specific data structure for AACS exists. All other values are reserved. Please note that this command with Format Code = 01h ***shall*** be applicable only to DVD discs. For HD DVD Copyright Protection Information, this command with Format Code = 12h ***shall*** be used.

The Region Management Information field describes the regions in which the disc can be played. Each bit represents one of eight regions. If a bit is Cleared in this field, the disc can be played in the corresponding region. If a bit is Set in this field the disc can not be played in the corresponding region.

There are currently 6 regions defined. See the DVD Book for more information.

16.24.3 DISC KEY (Format Code = 02h)

Table 419 - READ DISC STRUCTURE Data format (With Format Code = 02h)

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB)			DISC STRUCTURE Data Length				
1								(LSB)
2				Reserved				
3				Reserved				
				Disk Key Structures				
0	(MSB)							
:				DISC KEY Data				
2047								(LSB)

The DISC STRUCTURE Data Length field indicates the length in bytes of the following DISC STRUCTURE data that is available to be transferred to the host. The DISC STRUCTURE Data Length value does not include the DISC STRUCTURE Data Length field itself.

The DISC KEY Data field returns the DISC KEY data for CSS and/or the Album Identifier for CPPM, which are obfuscated by a Bus Key. The length of the DISC KEY Data field is currently 2048 bytes only.

When neither the DISC KEY data nor the Album Identifier exist on DVD media, this command with Format Code = 02h ***shall*** be terminated with CHECK CONDITION status, 5/6F/01 COPY PROTECTION KEY EXCHANGE FAILURE - KEY NOT PRESENT.

When the DVD logical unit is not in the Bus Key Established state for CSS/CPPM, this command with Format Code = 02h ***shall*** be terminated with CHECK CONDITION status, 5/6F/02 COPY PROTECTION KEY EXCHANGE FAILURE - KEY NOT ESTABLISHED.

16.24.4 BCA (Format Code = 03h)

Table 420 - READ DISC STRUCTURE Data format (With Format Code = 03h)

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB)			DISC STRUCTURE Data Length				
1								(LSB)
2				Reserved				
3				Reserved				
				BCA Structures				
0	(MSB)			BCA Information				
:								
N								(LSB)

The DISC STRUCTURE Data Length field indicates the length in bytes of the following DISC STRUCTURE data that is available to be transferred to the host. The DISC STRUCTURE Data Length value does not include the DISC STRUCTURE Data Length field itself.

The BCA Information is returned from BCA recorded DVD/HD DVD media. The Length of BCA Information is in the range of 12 to 188 bytes for DVD. For HD DVD, the maximum Length of BCA Information is 76 bytes.

When a READ DISC STRUCTURE with a Format Code field value of 03h is presented for a DVD media without BCA, the command ***shall*** be terminated with CHECK CONDITION status, 5/24/00 INVALID FIELD IN CDB.

16.24.5 Disc Manufacturing Information (Format Code = 04h)

Table 421 - READ DISC STRUCTURE Data format (With Format Code = 04h)

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB)			DISC STRUCTURE Data Length				
1								(LSB)
2				Reserved				
3				Reserved				
Lead-in Structures								
0								
:				Disc Manufacturing Information				
2047								

The DISC STRUCTURE Data Length field indicates the length in bytes of the following DISC STRUCTURE data that is available to be transferred to the host. The DISC STRUCTURE Data Length value does not include the DISC STRUCTURE Data Length field itself.

The Disc Manufacturing Information is taken from the DVD/HD DVD media Lead-in. In the case of DVD-R/-RW/HD DVD-R multi-border disc, this information is taken from the last Border-in.

16.24.6 Copyright Management Information (Format Code = 05h)

Table 422 - READ DISC STRUCTURE Data format (With Format Code = 05h)

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB)			DISC STRUCTURE Data Length				
1								(LSB)
2				Reserved				
3				Reserved				
Copyright Management Information								
0				CPR_MAI				
1				Reserved				
2				Reserved				
3				Reserved				

The DISC STRUCTURE Data Length field indicates the length in bytes of the following DISC STRUCTURE data that is available to be transferred to the host. The DISC STRUCTURE Data Length value does not include the DISC STRUCTURE Data Length field itself.

The definition of the CPR_MAI field depends on the mounted media. The CPR_MAI field definition is shown in Table 423.

Table 423 - CPR_MAI field definition

Bit / Media	7	6	5	4	3	2	1	0
ROM	CPM	CP_SEC	CGMS		CP_MOD			
R Ver.1.0/ RW Ver.1.0	CPM	Reserved	CGMS		Reserved			
RAM Ver.1.0/2.1 / R for Authoring Ver.2.0	Reserved							
R for General Ver.2.1/ RW Ver.1.2	Reserved				ADP_TY		Reserved	

The CPM bit, if set to 0, indicates that this sector contains no copyrighted material. If the CPM bit is set to 1, indicates that this sector contains copyrighted material.

When the CPM bit is set to 0, the CP_SEC bit is set to 0. When the CPM bit is set to 1, the CP_SEC bit indicates whether this sector has a specific data structure for prerecorded media copyright protection system. A value of 0 indicates that no such data structure exists in this sector. A value of 1 indicates a specific data structure for CSS or CPPM exists in this sector.

When the CPM bit is set to 0, the CGMS field is set to 00b. When the CPM bit is set to 1, and if the CGMS field is set to 00b, indicates that copying is permitted without restriction, and if the CGMS field is set to 01b, indicates that the CGMS field is reserved, and if the CGMS field is set to 10b, indicates that one generation of copies may be made, and if the CGMS field is set to 11b, indicates that no copying is permitted.

When the CP_SEC bit is set to 0, the CP_MOD field is set to 0h. When the CP_SEC bit is set to 1, the CP_MOD field indicates the copyright protection mode of the specified sector. A value of 0h indicates the sector is scrambled by CSS. A value of 1h indicates the sector is encrypted by CPPM. Other values are reserved.

The ADP_TY field is defined only for DVD-RW Ver.1.2 and DVD-R for General Ver.2.1 media. The ADP_TY field, if set to 01b, indicates that this sector contains materials defined in DVD Specifications for Read-Only Disc Part 3 VIDEO SPECIFICATIONS. A value of 00b indicates that no such data exists in this sector. All other values of ADP_TY are reserved.

Note: For DVD-R/-RW media, a value of each field may not be correct at the first and last 16 sectors of each recording extent due to the nature of recording method for DVD-R/-RW media.

16.24.7 Media Identifier (Format Code = 06h)

Table 424 - READ DISC STRUCTURE Data format (With Format Code = 06h)

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB)	DISC STRUCTURE Data Length						
1								(LSB)
2	Reserved							
3	Reserved							
Media Identifier Structures								
0	(MSB)							
:	Media Identifier Data							
N								(LSB)

The DISC STRUCTURE Data Length field indicates the length in bytes of the following DISC STRUCTURE data that is available to be transferred to the host. The DISC STRUCTURE Data Length value does not include the DISC STRUCTURE Data Length field itself.

The Media Identifier Data field returns the Media Identifier, which is protected by a Bus Key.

When the DVD logical unit is not in the Bus Key Established state for CPRM, this command with Format Code = 06h ***shall*** be terminated with CHECK CONDITION status, 5/6F/02 COPY PROTECTION KEY EXCHANGE FAILURE - KEY NOT ESTABLISHED.

16.24.8 Media Key Block (Format Code = 07h)

Table 425 - READ DISC STRUCTURE Data format (With Format Code = 07h)

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB)	DISC STRUCTURE Data Length						
1								(LSB)
2	Reserved							
3	Total Packs							
Media Key Block Structures								
0	(MSB)							
:	Media Key Block Pack Data							
N								(LSB)

The DISC STRUCTURE Data Length field indicates the length in bytes of the following DISC STRUCTURE data that is available to be transferred to the host. The DISC STRUCTURE Data Length value does not include the DISC STRUCTURE Data Length field itself.

The Total Packs field reports the total number of Media Key Block Packs that are available for transfer to the host.

The Media Key Block Pack Data field returns the requested Media Key Block Pack, which is protected by a Bus Key only when the Address field set to 00000000h.

The Address field in the CDB specifies which of the available Media Key Block Packs ***shall*** be read. A valid AGID field value ***shall*** be supplied only when the Address field is set to 00000000h.

When the Address field value is 00000000h and the DVD logical unit is not in the Bus Key Established state for CPRM, this command with Format Code = 07h ***shall*** be terminated with CHECK CONDITION status, 5/6F/02 COPY PROTECTION KEY EXCHANGE FAILURE - KEY NOT ESTABLISHED.

16.24.9 Disc Definition Structure (DDS) (Format Code = 08h)

When a READ DISC STRUCTURE command with the Format Code field value of 08h is issued for other than DVD-RAM/HD DVD-Rewritable media, this command ***shall*** be terminated with CHECK CONDITION status, 5/24/00 INVALID FIELD IN CDB.

Table 426 - READ DISC STRUCTURE Data format (With Format Code = 08h)

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB) DISC STRUCTURE Data Length							
1								(LSB)
2	Reserved							
3	Reserved							
DVD-RAM/HD DVD-Rewritable Disc Definition Structure (DDS)								
0	(MSB) DDS Information							
:								
2047								(LSB)

The DISC STRUCTURE Data Length field indicates the length in bytes of the following DISC STRUCTURE data that is available to be transferred to the host. The DISC STRUCTURE Data Length value does not include the DISC STRUCTURE Data Length field itself.

The DDS Information is taken from the Defect Controls of the DVD-RAM/HD DVD-Rewritable media Lead-in. The length of the DDS Information is currently 2048 bytes only.

When a READ DISC STRUCTURE command with a Format Code field value of 08h is presented for a DVD media other than DVD-RAM media, the command ***shall*** be terminated with CHECK CONDITION status, 5/24/00 INVALID FIELD IN CDB.

16.24.10 DVD-RAM/HD DVD-RW Medium Status Information (Format Code = 09h)

When a READ DISC STRUCTURE command with the Format Code field value of 09h is issued for other than DVD-RAM/HD DVD-Rewritable media, this command ***shall*** be terminated with CHECK CONDITION status, 5/24/00 INVALID FIELD IN CDB.

Table 427 - READ DISC STRUCTURE Data format (With Format Code = 09h)

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB)	DISC STRUCTURE Data Length						
1								(LSB)
2	Reserved							
3	Reserved							
DVD-RAM/HD DVD-RW Medium Status Data								
0	Cartridge	Out	Reserved		MSWI[a]	CWP	PWP[a]	Reserved
1	Disc Type Identification							
2	Reserved							
3	RAM-SWI Information[a]							

a. For HD DVD-Rewritable, this field/bit is reserved.

The DISC STRUCTURE Data Length field indicates the length in bytes of the following DISC STRUCTURE data that is available to be transferred to the host. The DISC STRUCTURE Data Length value does not include the DISC STRUCTURE Data Length field itself.

The Cartridge bit of one indicates that a medium is in a cartridge. The Cartridge bit of zero indicates that a medium is not in a cartridge.

The Out bit of one indicates that a medium has been taken out from a cartridge or a medium is put into a cartridge. The Out bit of zero indicates that a medium has not been taken out from a cartridge. This field is valid only when the Cartridge bit is set to one. If the Cartridge bit is set to zero, the Out bit ***shall*** be set to zero.

The Media Specific Write Inhibition (MSWI) bit of one indicates that the writing is inhibited by the specific reason. The reason is indicated in the RAM-SWI Information[a] field. The MSWI bit of zero indicates that the writing is not inhibited by the specific reason. For HD DVD-Rewritable, this bit is reserved.

The Media Cartridge Write Protection (CWP) bit of one indicates that the write protect switch/tabs on a cartridge is set to write protected state. The CWP bit of zero indicates that the write protect switch/tabs on a cartridge is set to write permitted state. This field is valid only when the Cartridge bit is set to one. If the Cartridge bit is set to zero, the CWP bit ***shall*** be set to zero.

The Persistent Write Protection (PWP[a]) bit of one indicates that the media surface is set to write protected status. The PWP[a] bit of zero indicates that the media surface is set to write permitted status. For HD DVD-Rewritable, this bit is reserved.

The Disc Type Identification field indicates the Disc Type as defined in Table 428.

Table 428 - Disc Type Identification field definition

Value	Definition
00h	A Disc ***shall not*** be written without a cartridge.
01h-0Fh	Reserved
10h	A Disc may be written without a cartridge.
11h-FFh	Reserved

The DVD-RAM Specific Write Inhibition Information (RAM-SWI Information[a]) field indicates the reason of DVD-RAM specific write inhibition status. This field is valid only when the MSWI bit is set to one. For HD DVD-Rewritable, this field is reserved.

If MSWI bit is set to one, RAM-SWI Information[a] field ***shall*** be set according to Table 429.

Table 429 - RAM-SWI Information field definition

Value	Definition
00h	Reserved
01h	Bare Disc Write Inhibition (Disc Type Identification field of 00h and no cartridge)
02h-FEh	Reserved
FFh	Unspecified reason

16.24.11 Spare Area Information (Format Code = 0Ah)

Table 430 - READ DISC STRUCTURE Data format (With Format Code = 0Ah)

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB)	DISC STRUCTURE Data Length						
1								(LSB)
2	Reserved							
3	Reserved							
Spare Area Information								
0	(MSB)							
1		Number of Unused Primary Spare Blocks						
2								
3								(LSB)
4	(MSB)							
5		Number of Unused Supplementary Spare Blocks						
6								
7								(LSB)
8	(MSB)							
9		Number of Allocated Supplementary Spare Blocks						
10								
11								(LSB)

When a READ DISC STRUCTURE command with the Format Code field value of 0Ah is issued for other than DVD/HD DVD media which is capable of allocation of the Supplementary Spare area, this command ***shall*** be terminated with CHECK CONDITION status, 5/24/00 INVALID FIELD IN CDB.

The host can recognize whether the media is capable of allocation of the Supplementary Spare area or not, indicated in the Hardware Defect Management Feature Descriptor reported by the GET CONFIGURATION command.

The DISC STRUCTURE Data Length field indicates the length in bytes of the following DISC STRUCTURE data that is available to be transferred to the host. The DISC STRUCTURE Data Length value does not include the DISC STRUCTURE Data Length field itself.

The Number of Unused Primary Spare Blocks field indicates the number of unused spare blocks in the Primary Spare area.

The Number of Unused Supplementary Spare Blocks field indicates the number of unused spare blocks in the Supplementary Spare area.

The Number of Allocated Supplementary Spare Blocks field indicates the number of allocated spare blocks in the Supplementary Spare area.

16.24.12 Recording Type Information (Format Code = 0Bh)

Table 431 - READ DISC STRUCTURE Data format (With Format Code = 0Bh)

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB) DISC STRUCTURE Data Length							
1	DISC STRUCTURE Data Length (LSB)							
2	Reserved							
3	Reserved							
Recording Type Information								
0	Recording Type Information Data							
1	Reserved							
2	Reserved							
3	Reserved							

When a READ DISC STRUCTURE command with the Format Code field value of 0Bh is issued for other than DVD-RAM Ver.2.1 or HD DVD-Rewritable media, this command ***shall*** be terminated with CHECK CONDITION status, 5/24/00 INVALID FIELD IN CDB.

The DISC STRUCTURE Data Length field indicates the length in bytes of the following DISC STRUCTURE data that is available to be transferred to the host. The DISC STRUCTURE Data Length value does not include the DISC STRUCTURE Data Length field itself.

The definition of the Recording Type Information Data is shown in Table 432.

Table 432 - Recording Type Information Data field definition

Bit / Byte	7	6	5	4	3	2	1	0
0	Reserved			Recording Type	Reserved			

The Recording Type bit is defined only for DVD-RAM Ver.2.1 and HD DVD-Rewritable media. The Recording Type bit, if set to 1b, indicates that this sector contains a real-time data. A value of 0b indicates that this sector contains a general data. (see Table 11 - *Recording Type bit definition for DVD-RAM Ver.2.1 media* on page 80 or Table 112 - *Recording Type bit definition for HD DVD-Rewritable media* on page 252.)

*Note: Streaming bit of the WRITE (12) command **shall** be used to set/clear the Recording Type bit. (see 16.49, "WRITE (12) command" on page 713).*

16.24.13 RMD in the last Border-out (Format Code = 0Ch)

Table 433 - READ DISC STRUCTURE Data format (With Format Code = 0Ch)

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB)			DISC STRUCTURE Data Length				
1								(LSB)
2	Reserved							
3	Reserved							
RMD in last Border-out								
0	(MSB)							
:				RMD Bytes				
N								(LSB)

The DISC STRUCTURE Data Length field indicates the length in bytes of the following DISC STRUCTURE data that is available to be transferred to the host. The DISC STRUCTURE Data Length value does not include the DISC STRUCTURE Data Length field itself.

The RMD Bytes field returns the RMD which is written in the last recorded Border-out.

The Address field in the CDB specifies the starting RMD Field number where the read operation ***shall*** begin. The Allocation Length field in the CDB specifies the maximum number of RMD bytes that ***shall*** be returned. The largest RMD available is 30720 bytes (15 sectors) for DVD, 45056 (22 sectors) for HD DVD.

16.24.14 Recording Management Area Data (Format Code = 0Dh)

Table 434 - READ DISC STRUCTURE Data format (With Format Code = 0Dh)

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB)			DISC STRUCTURE Data Length				
1								(LSB)
2	Reserved							
3	Reserved							
DVD-R/-RW Recording Management Data Structure								
0	(MSB)							
:				Last Recorded RMA Sector Number / Start Sector Number of Valid Format 3 RMD Set				
3								(LSB)
4-N	(MSB)			RMD Bytes				(LSB)

This format is available only for DVD-R/-RW media. For other media, this format is reserved.

The DISC STRUCTURE Data Length field indicates the length in bytes of the following DISC STRUCTURE data that is available to be transferred to the host. The DISC STRUCTURE Data Length value does not include the DISC STRUCTURE Data Length field itself.

The Last Recorded RMA Sector Number / Start Sector Number of Valid Format 3 RMD Set field indicates the RMA sector number where the last RMD is recorded. On DVD-RW restricted overwritten media, this field indicates the start sector number of valid Format 3 RMD Set.

The RMD Bytes field returns the RMD which is written in RMA. The Address field in the CDB specifies the starting address of the RMA sector where the read operation ***shall*** begin. The Allocation Length field in the CDB specifies the maximum length of the descriptor returned to the host. The returned RMD data ***shall*** end at the next ECC boundary. The maximum number of RMD bytes that can be returned is 32768.

16.24.15 Pre-recorded Information in Lead-in (Format Code = 0Eh)

Table 435 - READ DISC STRUCTURE Data format (With Format Code = 0Eh)

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB) DISC STRUCTURE Data Length							
1								(LSB)
2	Reserved							
3	Reserved							
DVD-R Pre-recorded Information Structure								
0-63	Pre-recorded Information[a]							

a. See Table 50 - *Copy of Pre-pit Information* on page 140.

This format is available only for DVD-R/-RW media. For other media, this format is reserved.

The DISC STRUCTURE Data Length field indicates the length in bytes of the following DISC STRUCTURE data that is available to be transferred to the host. The DISC STRUCTURE Data Length value does not include the DISC STRUCTURE Data Length field itself.

The contents of Pre-recorded information are specified by the DVD Specifications for Recordable Disc, Part 1 or DVD Specifications for Re-Recordable Disc Part 1.

16.24.16 Unique Disc Identifier (Format Code = 0Fh)

Table 436 - READ DISC STRUCTURE Data format (With Format Code = 0Fh)

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB) DISC STRUCTURE Data Length							
1								(LSB)
2	Reserved							
3	Reserved							
Unique Disc Identifier								
0-17	Unique Disc Identifier[a]							

a. See Table 49 - *Unique Disc ID* on page 139 or Table 136 - *Unique Disc ID* on page 271.

This format is available only for DVD-R/-RW and HD DVD-R media. For other media, this format is invalid and reserved.

The DISC STRUCTURE Data Length field indicates the length in bytes of the following DISC STRUCTURE data that is available to be transferred to the host. The DISC STRUCTURE Data Length value does not include the DISC STRUCTURE Data Length field itself.

This format returns the Unique Disc Identifier which is recorded in RMD Field 0.

16.24.17 Physical Format Information of Control Data Zone in the Lead-in (Format Code = 10h)

This format is available only for DVD-R/-RW and HD DVD-R media. For other media, this format is invalid and reserved.

This DISC STRUCTURE data returns Physical format information of Control Data Zone in the Lead-in Area even if the disc is recorded with multi-Bordered Area.

Table 437 - READ DISC STRUCTURE Data format (With Format Code = 10h)

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB) DISC STRUCTURE Data Length							
1	DISC STRUCTURE Data Length (LSB)							
2	Reserved							
3	Reserved							
Physical format information in the Lead-in								
0	Book Type				Part Version			
1	Disc Size				Maximum Rate			
2	Reserved	Number of Layers		Track Path	Layer Type			
3	Linear Density				Track Density			
4	00h							
5	(MSB)							
6	Starting Physical Sector Number of Data Area							
7	(LSB)							
8	00h							
9	(MSB)							
10	End Physical Sector Number of Data Area							
11	(LSB)							
12	00h							
13	(MSB)							
14	End Sector Number in L0[a]							
15	(LSB)							
16	BCA Flag	Reserved						
17-2047	Media Specific							

a. For HD DVD-R, this field is reserved and ***shall*** be set to zero.

The Media Specific field ***shall*** return information as specified in the associated DVD/HD DVD specification.

The other field definitions are same as the definitions of Format code 00h.

16.24.18 HD DVD Copyright Protection Information (Format Code = 12h)

Table 438 - READ DISC STRUCTURE Data format (With Format Code = 12h)

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB) DISC STRUCTURE Data Length							
1	DISC STRUCTURE Data Length (LSB)							
2	Reserved							
3	Reserved							
HD DVD Copyright Protection Information								
0	(MSB) HD DVD Copyright Protection Information Data							
:	HD DVD Copyright Protection Information Data							
2047	HD DVD Copyright Protection Information Data (LSB)							

The DISC STRUCTURE Data Length field indicates the length in bytes of the following DISC STRUCTURE data that is available to be transferred to the host. The DISC STRUCTURE Data Length value does not include the DISC STRUCTURE Data Length field itself.

The HD DVD Copyright Protection Information is taken from the Copyright Protection Information recorded at the System Lead-in of the HD DVD discs. The length of the HD DVD Copyright Protection Information Data field is 2048 bytes only.

16.24.19 Volume Identifier of AACS (Format Code = 13h)

Table 439 - READ DISC STRUCTURE Data format (With Format Code = 13h)

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB) DISC STRUCTURE Data Length							
1	DISC STRUCTURE Data Length (LSB)							
2	Reserved							
3	Reserved							
Volume Identifier Structure								
0	(MSB) Volume Identifier Data							
:	Volume Identifier Data							
N	Volume Identifier Data (LSB)							

The DISC STRUCTURE Data Length field indicates the length in bytes of the following DISC STRUCTURE data that is available to be transferred to the host. The DISC STRUCTURE Data Length value does not include the DISC STRUCTURE Data Length field itself.

The Volume Identifier Data field returns the Volume Identifier of AACS, which integrity is ensured by the AACS Authentication.

When the logical unit is not in the Challenge Key in hold state of the AACS Authentication, this command with Format Code = 13h ***shall*** be terminated with CHECK CONDITION status, 5/6F/02 COPY PROTECTION KEY EXCHANGE FAILURE - KEY NOT ESTABLISHED.

16.24.20 Pre-recorded Media Serial Number of AACS (Format Code = 14h)

Table 440 - READ DISC STRUCTURE Data format (With Format Code = 14h)

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB)			DISC STRUCTURE Data Length				
1								(LSB)
2				Reserved				
3				Reserved				
				Pre-recorded Media Serial Number Structure				
0	(MSB)							
:				Pre-recorded Media Serial Number Data				
N								(LSB)

The DISC STRUCTURE Data Length field indicates the length in bytes of the following DISC STRUCTURE data that is available to be transferred to the host. The DISC STRUCTURE Data Length value does not include the DISC STRUCTURE Data Length field itself.

The Pre-recorded Media Serial Number Data field returns the Pre-recorded Media Serial Number of AACS, which integrity is ensured by the AACS Authentication.

When the logical unit is not in the Challenge Key in hold state of the AACS Authentication, this command with Format Code = 14h ***shall*** be terminated with CHECK CONDITION status, 5/6F/02 COPY PROTECTION KEY EXCHANGE FAILURE - KEY NOT ESTABLISHED.

16.24.21 Copyright data section (Format Code = 15h)

Table 441 - READ DISC STRUCTURE Data format (With Format Code = 15h)

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB)			DISC STRUCTURE Data Length				
1								(LSB)
2				Reserved				
3				Reserved				
				Copyright data section				
0								
:				Copyright data				
N								

The DISC STRUCTURE Data Length field indicates the length in bytes of the following DISC STRUCTURE data that is available to be transferred to the host. The DISC STRUCTURE Data Length value does not include the DISC STRUCTURE Data Length field itself.

The Copyright data field ***shall*** return information of the Copyright data section in the Control data zone.

For HD DVD, the Address field in the CDB specifies the starting address of the Copyright data section sector position from 0 to 31 where the read operation ***shall*** begin. The Allocation Length field in the CDB specifies the maximum length of the descriptor returned to the host. The maximum number of Copyright data that can be returned is 63488 that contains 31 sectors.

For DVD adapted to AACS, the Address field in the CDB specifies the starting address of the Copyright data section sector position from 2 to 15 where the read operation ***shall*** begin. The Allocation Length field in the CDB specifies the maximum length of the descriptor returned to the host. The maximum number of the Copyright data section that can be returned is 28672.

16.24.22 Media Identifier of AACS (Format Code = 16h)

Table 442 - READ DISC STRUCTURE Data format (With Format Code = 16h)

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB)			DISC STRUCTURE Data Length				
1								(LSB)
2				Reserved				
3				Reserved				
Media Identifier Structures								
0	(MSB)							
:				Media Identifier Data				
N								(LSB)

The DISC STRUCTURE Data Length field indicates the length in bytes of the following DISC STRUCTURE data that is available to be transferred to the host. The DISC STRUCTURE Data Length value does not include the DISC STRUCTURE Data Length field itself.

The Media Identifier Data field returns the Media Identifier of AACS, which integrity is ensured by the AACS Authentication.

When the logical unit is not in the Challenge Key in hold state of the AACS Authentication, this command with Format Code = 16h ***shall*** be terminated with CHECK CONDITION status, 5/6F/02 COPY PROTECTION KEY EXCHANGE FAILURE - KEY NOT ESTABLISHED.

16.24.23 Media Key Block of AACS (Format Code = 17h)

Table 443 - READ DISC STRUCTURE Data format (With Format Code = 17h)

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB)			DISC STRUCTURE Data Length				
1								(LSB)
2				Reserved				
3				Total Packs				
Media Key Block Structures								
0	(MSB)							
:				Media Key Block Pack Data				
N								(LSB)

The DISC STRUCTURE Data Length field indicates the length in bytes of the following DISC STRUCTURE data that is available to be transferred to the host. The DISC STRUCTURE Data Length value does not include the DISC STRUCTURE Data Length field itself.

The Total Packs field reports the total number of Media Key Block Packs that are available for transfer to the host.

The Media Key Block Pack Data field returns the requested Media Key Block Pack of Media Key Block in Lead-in specified by AACS. The size of Media Key Block Pack Data is 32 KB maximum.

The Address field in the CDB specifies which of the available Media Key Block Packs ***shall*** be read.

This command with Format Code = 17h does not require the AACS Authentication.

16.24.24 HD DVD-R Medium Status information (Format Code = 19h)

Table 444 - READ DISC STRUCTURE Data format (With Format Code = 19h)

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB) DISC STRUCTURE Data Length							
1	DISC STRUCTURE Data Length							(LSB)
2	Reserved							
3	Reserved							
HD DVD-R Medium Status								
0	Reserved							Extended Test zone
1	Number of remaining RMDs in RDZ							
2	Number of remaining RMDs in Current RMZ							
3	Number of remaining RMDs in Current RMZ							

The DISC STRUCTURE Data Length field indicates the length in bytes of the following DISC STRUCTURE data that is available to be transferred to the host. The DISC STRUCTURE Data Length value does not include the DISC STRUCTURE Data Length field itself.

The Extended Test zone bit of one indicates that Test zone has been extended.

The Number of remaining RMDs in RDZ field indicates the number of the unrecorded ECC blocks in the RDZ.

The Number of remaining RMDs in Current RMZ field indicates the number of the unrecorded ECC blocks in the current RMZ.

16.24.25 Last recorded RMD in the latest RMZ (Format Code = 1Ah)

Table 445 - READ DISC STRUCTURE Data format (With Format Code = 1Ah)

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB) DISC STRUCTURE Data Length							
1	DISC STRUCTURE Data Length							(LSB)
2	Reserved							
3	Reserved							
Last recorded RMD in the latest RMZ								
0	RMD Bytes							
:	RMD Bytes							
N	RMD Bytes							

The DISC STRUCTURE Data Length field indicates the length in bytes of the following DISC STRUCTURE data that is available to be transferred to the host. The DISC STRUCTURE Data Length value does not include the DISC STRUCTURE Data Length field itself.

For HD DVD, the RMD Bytes field returns the last recorded RMD which is written in the latest RMZ.

The Address field in the CDB specifies the starting RMD Field number where the read operation ***shall*** begin. The Allocation Length field in the CDB specifies the maximum number of RMD bytes that ***shall*** be returned. The largest RMD available is 45056 (22 sectors).

16.24.26 Layer Boundary Information (Format Code = 20h)

This format is available only for DVD-R Dual Layer / DVD+R Double Layer disc. For other media, this format is invalid and reserved.

This Format code returns the Layer boundary information. In the case of DVD -R Dual Layer disc, this value is fixed (= Start address of Fixed Middle Area) and is not changeable.

Table 446 - READ DISC STRUCTURE Data format (With Format Code = 20h)

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB)	DISC STRUCTURE Data Length						
1								(LSB)
2	Reserved							
3	Reserved							
Layer Boundary Information								
0	Init Status	Reserved						
1	Reserved							
2								
3								
4	(MSB)	L0 Data Area Capacity						
5								
6								
7								(LSB)

Init Status bit indicates whether the capacity of Data Area is changeable by the host or not. When Init Status is set to zero, L0 Data Area Capacity value has not been written into the Control Data Zone and the capacity of the medium ***shall*** be the default capacity. The host may specify a smaller capacity value by using the SEND DISC STRUCTURE command with Format Code = 20h. When Init Status is set to one, L0 Data Area Capacity value has been specified and may not be changed.

L0 Data Area Capacity is the number of Data Area sectors available for recording on L0. This value ***shall*** be an integral multiple of 16. The capacity of L0 is the number of sectors between the end of the Lead-in and the first sector of the Middle Area.

In the case of DVD+R Double Layer disc when no L0 Data Area Capacity has been selected, the default capacity ***shall*** be based upon the Lead-in ADIP. The disc provides exactly the same capacity in ECC blocks on each Layer. If the DVD+R Double Layer disc is completely blank, Init Status ***shall*** be set to zero and the default L0 Data Area Capacity ***shall*** be reported.

In the case of DVD-R Dual Layer Ver.3.0 disc, Init Status bit ***shall*** be set to 1 regardless of disc status. L0 Data Area Capacity is calcurated from the Fixed Middle Area start address.

16.24.27 Shifted Middle Area Start Address (Format Code = 21h)

This format is available only for DVD-R Dual Layer Ver.3.0 disc. For other media, this format is invalid and reserved.

This Format code returns the start logical block address of Shifted Middle Area on L0.

Table 447 - READ DISC STRUCTURE Data format (With Format Code = 21h)

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB)	DISC STRUCTURE Data Length						
1								(LSB)
2	Reserved							
3	Reserved							
Shifted Middle Area Information								
0	Init Status	Reserved						
1-3	Reserved							
4	(MSB)	Shifted Middle Area Start Address						
5								
6								
7								(LSB)

Init Status bit indicates whether the Shifted Middle Area start address is changeable by the host or not. When Init Status is set to zero, Shifted Middle Area start address is changeable. If this bit is set to 1, Shifted Middle Area start address is not changeable. The address of Shifted Middle Area has been registered in RMD on the disc.

Shifted Middle Area Start Address is the start logical block address of the Shifted Middle Area on L0. If this value is set to 0, the Shifted Middle Area is not specified on the medium.

16.24.28 Jump Interval size (Format Code = 22h)

This format is available only for DVD-R Dual Layer Ver.3.0 disc. For other media, this format is invalid and reserved.

This Format Code returns the Jump Interval size for the Regular Interval Layer Jump recording by number of blocks. The Jump Inteval size is specified by the SEND DISC STRUCTURE command with Format Code =22h.

Table 448 - READ DISC STRUCTURE Data format (With Format Code = 22h)

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB)	DISC STRUCTURE Data Length						
1								(LSB)
2	Reserved							
3	Reserved							
Jump Interval size Information								
0-3	Reserved							
4	(MSB)	Jump Interval size						
5								
6								
7								(LSB)

The Jump Interval size field shows the Jump Interval size for the Regular Interval Layer Jump recording. If the Jump Interval size is not specified to the Invisible/Incomoplete RZone, the Jump Interval size field *shall* be set to 0.

16.24.29 Manual Layer Jump Address (Format Code = 23h)

This format is available only for DVD-R Dual Layer Ver.3.0 disc. For other media, this format is invalid and reserved.

This Format code returns the Manual Layer Jump Address specified by Manual Layer Jump Address (Format Code = 23h) of SEND DISC STRUCTURE command on L0.

Table 449 - READ DISC STRUCTURE Data format (With Format Code = 23h)

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB) DISC STRUCTURE Data Length							
1	DISC STRUCTURE Data Length (LSB)							
2	Reserved							
3	Reserved							
Manual Layer Jump Address Information								
0-3	Reserved							
4	(MSB) Layer Jump Logical Block Address							
5	Layer Jump Logical Block Address							
6	Layer Jump Logical Block Address							
7	Layer Jump Logical Block Address (LSB)							

Layer Jump Logical Block Address is the Manual Layer Jump Address. After the specified Manual Layer Jump has happened or if no Layer jump is specified, Jump Interval size field *shall* be set to 0.

16.24.30 Remapping Address (Format Code = 24h)

This format is available only for DVD -R Dual Layer Ver.3.0 disc. For other media, this format is invalid and reserved.

This Format code returns the remapping address information of the specified Anchor Point.

Table 450 - READ DISC STRUCTURE Data format (With Format Code = 24h)

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB) DISC STRUCTURE Data Length							
1	DISC STRUCTURE Data Length (LSB)							
2	Reserved							
3	Reserved							
Remapping Information								
0-3	Reserved							
4	(MSB) Remapping Address							
5	Remapping Address							
6	Remapping Address							
7	Remapping Address (LSB)							

The Remapping Address field indicates the first logical block address of the ECC block that is used to reassign the Anchor Point block specified by Address field of CDB. If this value is set to 0, there is no valid remapped data of Anchor Point block.

The Address field of CDB is used to specify the Anchor Point Number. Single remapping information ***shall*** be reported.

16.24.31 Write Protection Status (Format Code = C0h)

Table 451 - READ DISC STRUCTURE Data format (With Format Code = C0h)

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB)	DISC STRUCTURE Data Length						
1								(LSB)
2	Reserved							
3	Reserved							
Write Protection Status								
0	Reserved				MSWI	CWP	PWP	SWPP
1	Reserved							
2	Reserved							
3	Reserved							

The Software Write Protection until Power down (SWPP) bit of one indicates that the software write protection is active. The SWPP bit of zero indicates that the software write protection is inactive. If the logical unit does not support SWPP, this bit ***shall*** be set to zero.

The Persistent Write Protection (PWP) bit of one indicates that the media surface is set to write protected status. The PWP bit of zero indicates that the media surface is set to write permitted status. If the mounted medium and logical unit do not support PWP, this bit ***shall*** be set to zero.

The Media Cartridge Write Protection (CWP) bit of one indicates that the write protect switch/tabs on a cartridge is set to write protected state. The CWP bit of zero indicates that the write protect switch/tabs on a cartridge is set to write permitted state. If the cartridge does not have CWP function or medium is mounted without cartridge, this bit ***shall*** be set to zero. Otherwise CWP bit ***shall*** indicate its actual status.

The Media Specific Write Inhibition (MSWI) bit of one indicates that any writing is inhibited by the media specific reason. The MSWI bit of zero indicates that writing is not inhibited by the media specific reason.

16.24.32 DISC Structure List (Format Code = FFh)

Table 452 - READ DISC STRUCTURE Data format (With Format Code = FFh)

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB)	DISC STRUCTURE Data Length						
1								(LSB)
2	Reserved							
3	Reserved							
DISC Structure List								
0	Structure List							
:								
N								

The Structure List is returned as a sequence of Structure List Entries as shown in Table 453.

Note: This DISC STRUCTURE is generated by the logical unit rather than read from the medium.

Table 453 - Structure List entry

Bit / Byte	7	6	5	4	3	2	1	0
0	Format Code							
1	SDS	RDS	Reserved					
2	(MSB)	Structure Length						
3								(LSB)

The Format Code field ***shall*** identify a DISC STRUCTURE data that is readable via the READ DISC STRUCTURE command.

The SDS bit, when set to zero, ***shall*** indicate that the DISC STRUCTURE data is not writable via the SEND DISC STRUCTURE command. When set to one, ***shall*** indicate that the DISC STRUCTURE data is writable via the SEND DISC STRUCTURE command.

The RDS bit, when set to zero, ***shall*** indicate that the DISC STRUCTURE data is not readable via the READ DISC STRUCTURE command. When set to one, ***shall*** indicate that the DISC STRUCTURE data is readable via the READ DISC STRUCTURE command.

The Structure Length field ***shall*** specify the length of the DISC STRUCTURE data that is identified by the Format Code.

Table 454 describes errors that may occur during the operation of the command or which may cause a CHECK CONDITION status to be reported.

Table 454 - READ DISC STRUCTURE command Errors

Error Description
A-1.1 "Deferred Error Reporting" on page 721
Table 630 - *Basic Error Codes* on page 730
Table 631 - *Media Access Error Codes* on page 733

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16.25 READ FORMAT CAPACITIES command

The READ FORMAT CAPACITIES command allows the host to request a list of the possible format capacities for an installed random-writable media. This command also has the capability to report the capacity for a media when it is installed. If this command is required by an implemented Feature, this command ***shall*** function independently of the state of that Feature's Current bit.

Table 455 - READ FORMAT CAPACITIES Command Descriptor Block

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation Code (23h)							
1	LUN (Obsolete)			Reserved				
2	Reserved							
3	Reserved							
4	Reserved							
5	Reserved							
6	Reserved							
7	(MSB)			Allocation Length				
8								(LSB)
9	Vendor-Specific		Reserved			NACA	Flag	Link
10	PAD							
11								

The Allocation Length field specifies the maximum number of bytes that a host has allocated for returned data. An Allocation Length of zero indicates that no data ***shall*** be transferred. This condition ***shall not*** be considered as an error. The logical unit ***shall*** terminate the data transfer when Allocation Length bytes have been transferred or when all available data have been transferred to the host, whichever is less.

Table 456 - Read Format Capacities Data Format

Bit / Byte	7	6	5	4	3	2	1	0
0-3	Capacity List Header							
4-11	Current/Maximum Capacity Descriptor							
	Formattable Capacity Descriptor(s)							
0	Formattable Capacity Descriptor 0							
7								
...								
n * 8	Formattable Capacity Descriptor n							
n * 8 + 7								

Table 457 - Capacity List Header

Bit / Byte	7	6	5	4	3	2	1	0
0	Reserved							
1								
2								
3	Capacity List Length							

The Capacity List Length specifies the length in bytes of the Capacity Descriptors that follow. Each Capacity Descriptor is eight bytes in length, making the Capacity List Length equal to eight times the number of descriptors. Values of n * 8 are valid, where 0 < n < 32.

Table 458 - Current/Maximum Capacity Descriptor

Bit / Byte	7	6	5	4	3	2	1	0
4	(MSB) Number of Blocks							
5								
6								
7								(LSB)
8	Reserved						Descriptor Type	
9	(MSB) Block Length							
10								
11								(LSB)

The Number of Blocks indicates the number of addressable blocks for the capacity defined by each Descriptor Type.

The Descriptor Type field indicates the type of information the descriptor contains. The values are shown in Table 459.

Table 459 - Descriptor Type field definition

Descriptor Type value	Definition	Description
00b	Reserved	Reserved
01b	Unformatted media	The reported value is for the Maximum formattable capacity for this media. The blank media ***shall*** be reported as “Unformatted media” with Descriptor Type = 01b.
10b	Formatted media	The reported value is the current media’s capacity. In the case of sequential recorded media, the number of blocks field indicates the number of addressable blocks between the first Lead-in and the last Lead-out or Border-out. When the sequential recorded media has no closed session or Border, it ***shall*** be reported as “Unknown capacity media” with Descriptor Type = 11b.
11b	No media present or Unknown capacity media	The reported value is for the maximum capacity of a media that the logical unit is capable of reading. The quick formatted DVD-RW media ***shall*** be reported as “Unknown capacity media” with Descriptor Type = 11b.

The Block Length specifies the length in bytes of each logical block.

Table 460 - Formattable Capacity Descriptor(s)

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB)							
1	Number of Blocks							
2								
3								(LSB)
4	Format Type						Reserved	
5	(MSB)							
6	Type Dependent Parameter							
7								(LSB)

The Format Type field indicates the type of information for formatting.

Table 461 - Format Types

Format Type	Description	Type Dependent Parameter
00h	The descriptor ***shall*** contain the number of addressable blocks and the block size used for formatting the whole media. If multiple formatting for the whole media is possible, each capacity/block size combination ***shall*** be reported as a separate descriptor.	Block Length in bytes
01h	The descriptor ***shall*** contain the number of addressable blocks and the block size used for formatting the whole media. If multiple formatting for the whole media is possible, each capacity/block size combination ***shall*** be reported as a separate descriptor. This Format Type is used to expand a Spare area.	Block Length in bytes
02h-03h	Reserved	
04h	The descriptor ***shall*** contain the number of addressable blocks in the zone and zone number used by zoned formatting for a zone of the media, where the size of zone is not constant for each zone. The information for each zone ***shall*** be reported as a separate descriptor.	Zone Number of the descriptor
05h	The descriptor ***shall*** contain the number of addressable blocks per zone and zone number of the highest numbered zone. This descriptor is used for zoned formatting of the media, where the size of zone is constant for each zone.	Zone Number of the last zone
06h-0Fh	Reserved	
10h	The descriptor ***shall*** contain the maximum number of addressable blocks and maximum packet size that can be used to fully format C/DVD-RW media. The packet size and number of addressable blocks may be adjusted downward by the host before sending this descriptor back via the FORMAT UNIT command.	Fixed Packet Size in sectors/ ECC block size in sectors
11h	The descriptor ***shall*** contain the maximum number of addressable blocks and the packet size which can be used to expand (grow) the last complete session/Border of C/DVD-RW media. The number of addressable blocks may be adjusted downward by the host before sending this descriptor back via the FORMAT UNIT command.	Fixed Packet Size in sectors/ ECC block size in sectors
12h	The descriptor ***shall*** contain the maximum number of addressable blocks and the maximum packet size which can be used to add a new session/Border to a C/DVD-RW media. The packet size and number of addressable blocks may be adjusted downward by the host before sending this descriptor back via the FORMAT UNIT command.	Fixed Packet Size in sectors/ ECC block size in sectors

Table 461 - Format Types (Continued)

Format Type	Description	Type Dependent Parameter
13h	The descriptor ***shall*** contain the maximum number of addressable blocks and the ECC block size which can be used to expand (grow) the last complete Border of DVD-RW media as an intermediate state. The number of addressable blocks may be adjusted downward by the host before sending this descriptor back via the FORMAT UNIT command.	ECC block Size in sectors
14h	The descriptor ***shall*** contain the maximum number of addressable blocks and the ECC block size which can be used to add a new intermediate state Border to a DVD-RW media. The number of addressable blocks may be adjusted downward by the host before sending this descriptor back via the FORMAT UNIT command.	ECC block Size in sectors
15h	The descriptor ***shall*** contain the maximum number of addressable blocks and ECC block size that can be used to fully format DVD-RW media as an intermediate state. The number of addressable blocks may be adjusted downward by the host before sending this descriptor back via the FORMAT UNIT command.	ECC block Size in sectors
16h	The descriptor ***shall not*** be reported. This Format type is used for extending Test zone in HD DVD-R media by using FORMAT UNIT command.	-
17h-1Fh	Reserved	
20h	The descriptor ***shall*** contain the maximum number of addressable blocks and the sparing parameters to be used.	M and N (sparing parameters)
21h-3Fh	Reserved	

The Number of Blocks field indicates the number of addressable blocks for the capacity defined by each Format Type.

The Type Dependent Parameter contents are as specified for each Format Type in Table 461. In the case of Format Type 20h, M specifies SL where $SL = 2^M$, $4 \le M \le 15$ or SL = 0 if M = 0 and N identifies SI where $SI = 2^N$, $4 \le N \le 24$. The Type Dependent Parameter ***shall*** be set to M * 10000h + N, effectively placing M in byte offset 5 and N in byte offset 7, and making byte 8 reserved. The device ***shall*** supply its default values for M and N.

The logical unit ***shall*** only return Formattable Capacity Descriptors that apply to the installed media. If there is no medium installed, the logical unit ***shall*** return only the Current/Maximum Capacity Descriptor, with the maximum capacity of a medium that the logical unit is capable of reading.

A Formattable Capacity Descriptor of Format Type 00h ***shall*** be reported if any other Formattable Capacity Descriptor is reported.

The descriptors ***shall*** be returned in ascending order of Format Type. For Format Types other than 04h and 05h, if multiple format descriptors exist, they ***shall*** be returned in logical unit preferred order. For Format Types 04h and 05h, the format descriptors ***shall*** be returned in ascending order of Zone number.

Formattable Capacity Descriptors for media that can be read, but cannot be formatted by the logical unit ***shall not*** be reported.

Table 462 - Returned Current/Maximum Descriptor for Combination of drive and media

<table>
<tr><th colspan="2" rowspan="2"></th><th colspan="4">Media</th></tr>
<tr><th>No Media</th><th>ROM Media</th><th>Sequential Writable Media</th><th>Random Writable Media</th></tr>
<tr><td rowspan="3">Drive</td><td>ROM</td><td rowspan="3">Descriptor Type = 11b</td><td rowspan="3">Descriptor Type = 10b</td><td>Descriptor Type = 10b or 11b</td><td>Descriptor Type = 10b</td></tr>
<tr><td>Sequential Writable</td><td>Descriptor Type = 10b</td><td>Descriptor Type = 10b</td></tr>
<tr><td>Random Writable</td><td>Descriptor Type = 10b or 11b</td><td>Descriptor Type = 01b or 10b plus Formattable Capacity Descriptor(s)</td></tr>
</table>

Note: This command is not mandatory for all drive types shown in Table 462; the table indicates the values returned if the command is implemented.

Table 463 describes errors that may occur during the operation of the command or which may cause a CHECK CONDITION status to be reported.

Table 463 - READ FORMAT CAPACITIES command errors

Error Description
A-1.1, "Deferred Error Reporting" on page 721
Table 630 - *Basic Error Codes* on page 730
Table 631 - *Media Access Error Codes* on page 733

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16.26 READ SUBCHANNEL command

The READ SUBCHANNEL command requests that the CD logical unit return the requested sub-channel data plus the state of play operations.

Table 464 - READ SUBCHANNEL Command Descriptor Block

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation code (42h)							
1	LUN (Obsolete)			Reserved			MSF	Reserved
2	Reserved	SubQ	Reserved					
3	Sub-channel Data Format							
4	Reserved							
5	Reserved							
6	Track Number							
7	(MSB)	Allocation Length						
8								(LSB)
9	Vendor-Specific		Reserved			NACA	Flag	Link
10	PAD							
11								

Sub-channel data returned by this command may be from the last appropriate sector encountered by a current or previous media accessing operation. When there is no current play operation, the CD logical unit may access the media to read the sub-channel data. The CD logical unit is responsible for ensuring that the data returned are current and consistent.

See *3.6, "CD address reporting formats (MSF bit)"* on page 64 for a description of the MSF bit. Support for the MSF bit is mandatory.

The SubQ bit set to one requests that the CD logical unit return the Q sub-channel data. The SubQ bit set to zero requests that no sub-channel data be returned. This ***shall not*** be considered an error. Support for the SubQ bit is mandatory. When the SubQ bit is Zero, only the Sub-Channel data header is returned. See Table 466.

The Sub-channel Data Format field specifies the returned sub channel data. If this field is 01h, 02h or 03h, the requested sub-Q data item is returned.

Table 465 - Sub-channel Data Format Codes

Format Code	Returned data	Support Requirement
00h	Reserved	Reserved
01h	CD current position	Mandatory
02h	Media catalogue number (UPC/bar code)	Mandatory
03h	Track international standard recording code (ISRC)	Mandatory
04h-EFh	Reserved	
F0h-FFh	Vendor-specific	Optional

The Track Number field specifies the track number from which the ISRC code is transferred. This field ***shall*** have a value from 01h to 63h (99d), and is valid only when the sub-channel data format is 03h. If this field is nonzero for any Sub-channel Data Formats other than 03h, the drive will terminate the command with a check condition (INVALID REQUEST / INVALID FIELD IN COMMAND PACKET).

The result data format is a Sub-Channel Data Header followed by data specified by the Sub-channel Data Format Code.

The Allocation Length field ***shall*** indicate the maximum number of bytes the drive ***shall*** return to the host. An Allocation Length field of zero ***shall not*** be considered an error.

Table 466 - Sub-channel Data Header format

Bit / Byte	7	6	5	4	3	2	1	0
0	Reserved							
1	Audio Status							
2	(MSB) Sub-channel Data Length							
3								(LSB)

16.26.1 CD Current Position Data Format

Table 467 describes the result data format if Format Code 01h is requested.

Table 467 - CD Current Position Data format (Format Code 01h)

Bit / Byte	7	6	5	4	3	2	1	0
Sub Channel Data Header								
0	Reserved							
1	Audio Status							
2	(MSB) Sub-channel Data Length							
3								(LSB)
CD Current Position Data Block								
0	Sub Channel Data Format Code (01h)							
1	ADR				Control			
2	Track Number							
3	Index Number							
4	(MSB) Absolute CD Address							
5								
6	See Table 4 - *MSF address format* on page 64							
7								(LSB)
8	(MSB) Track Relative CD Address							
9								
10	See Table 4 - *MSF address format* on page 64							
11								(LSB)

The Audio Status field indicates the status of play operations. The Audio Status values are defined inTable 468 - *Audio Status codes* on page 597. Audio Status values 13h and 14h return information on previous audio operations; they are returned only once after the condition has occurred. If another play operation is not requested, the Audio Status returned for subsequent READ SUBCHANNEL commands is 15h.

Table 468 - Audio Status codes

Status	Description
00h	Audio status byte not supported or not valid
11h	Play operation in progress
12h	Play operation paused
13h	Play operation successfully completed
14h	Play operation stopped due to error
15h	No current audio status to return

The Sub-channel Data Length specifies the length in bytes of the following sub-channel data block. A Sub-channel Data Length of zero indicates that no sub-channel data block is included in the returned data. Sub-channel Data Length does not include the sub channel header.

The Sub-Q Channel Data Block consists of control data (bytes 4 - 5), current position data (bytes 6 - 15) and identification data (bytes 16 - 47). The control data and current position data is obtained from the Q sub-channel information of the current block. Identification data may be reported that was obtained from a previous block. If identification data is reported, the data ***shall*** be valid for the sector addressed by the current position data.

1. If an play operation is proceeding in the background, position data for the last sector played ***shall*** be reported.
2. In other cases, for instance after a READ command, the CD logical unit may either report position data for the last sector processed for that operation or may report position data from the sector at the current read head position.

The ADR field gives the type of information encoded in the Q sub-channel of this block, as shown in the following table.

Table 469 - ADR Sub-channel Q Field

ADR code	Description
0h	Sub-channel Q mode information not supplied
1h	Sub-channel Q encodes current position data (i.e. track, index, absolute address, relative address)
2h	Sub-channel Q encodes media catalogue number
3h	Sub-channel Q encodes ISRC
4h-Fh	Reserved

For a description of the Sub-Q channel Control bits, see Table 487 - *Bit Definitions for the Control field in Sub-channel Q* on page 613.

The Track Number field ***shall*** indicate the Track number of the current track.

The Index Number specifies the index number in the current track.

The Absolute CD Address field gives the current location relative to the logical beginning of the media. If the MSF bit is zero, this field is a logical block address. If the MSF bit is one, this field is an absolute MSF address.

The Track Relative CD Address field gives the current location relative to the logical beginning of the current track. If the MSF bit is zero, this field is a track relative logical block address. (If the current block is in the pre-gap area of a track, this will be a negative value, expressed as a twos-complement number.) If the MSF bit is one, this field is the relative MSF address from the Q sub-channel.

16.26.2 Media Catalogue Number Data Format

The Media Catalogue Number Data Format is shown in Table 470.

Table 470 - Media Catalogue Number Data Format (Format Code 02h)

Bit / Byte	7	6	5	4	3	2	1	0
Sub Channel Data Header								
0	Reserved							
1	Audio Status							
2	MSB	Sub-channel Data Length						
3								LSB
Media Catalogue Number Data Block								
0	Sub Channel Data Format Code (02h)							
1	Reserved							
2	Reserved							
3	Reserved							
4 : 19	Media Catalogue Number (UPC/Bar Code) (See Table 471 - *UPC Format* on page 599)							

A Media Catalogue Valid (MCVal) bit of one indicates that the media catalogue number field is valid. A MCVal bit of zero indicates that the media catalogue number field is not valid.

The Media Catalogue Number field contains the identifying number of this media according to the universal product code values (UPC/EAN bar coding) expressed in ASCII. Non-zero values in this field are controlled by the Uniform Code Council, Inc.[1]) and the EAN International[2]. A value in this field of all ASCII zeros indicates that the media catalog number is not supplied.

If media catalogue number data is found, the MCVal bit is set to one. If MCN data is not detected, the MCVal bit is set to zero to indicate the Media Catalogue Number field is invalid.

The Media Catalogue Number data returned by this command with sub-channel data format field code 02h may be from any block that has UPC bar code Q sub-channel data. (This code is constant anywhere in every applicable disc.)

The CD logical unit may either return the UPC information that it has previously read (Cached data) or may scan for the information. As the UPC is only guaranteed to be contained in 1 out of 100 sectors and errors may be encountered, the time required to return the UPC data could be several seconds.

1. The Uniform Code Council, Inc. is located at 1009 Lenox Drive, Suite 202 Lawrenceville, NJ 08648.
2. The EAN International is located at 145 rue Royale B - 1000 Brussels, Belgium.

Table 471 - UPC Format

Bit / Byte	7	6	5	4	3	2	1	0
0	MCVal	Reserved						
1	N1 (Most significant)							
2	N2							
3	N3							
4	N4							
5	N5							
6	N6							
7	N7							
8	N8							
9	N9							
10	N10							
11	N11							
12	N12							
13	N13 (Least significant)							
14	Zero							
15	AFrame (Binary)							

N1 through N13 ***shall*** be retrieved from the Q channel in mode 2. The data ***shall*** be encoded as ASCII characters (i.e. if N1 of the UPC is 01bcd, then N1 of the above field ***shall*** be 49d or 31h).

16.26.3 Track International Standard Recording Code Data Format

The Track ISRC field contains the identifying number of this media according to the ISRC standards (DIN-31-621). The result data format is described in Table 472.

Table 472 - Track International Standard Recording Code Data Format

Bit / Byte	7	6	5	4	3	2	1	0
Sub Channel Data Header								
0	Reserved							
1	Audio Status							
2	(MSB)	Sub-channel Data Length						
3								(LSB)
Track ISRC Data Block								
0	Sub Channel Data Format Code (03h)							
1	ADR (03)				Control			
2	Track Number							
3	Reserved							
4 : 19	Track International Standard Recording Code (ISRC) See Table 474 - *ISRC Format of Data Returned to host* on page 600.							

If ISRC data is detected, the TCVal bit is set to one. If ISRC data is not detected, the TCVal bit is set to zero to indicate the Track ISRC field is invalid.

Track ISRC data returned by this command with Sub-channel Data Format field 03h may be from any block in the specified track that has ISRC data. When ADR field is 3 (0011), it is used to assign a unique number to an audio track. This is done by means of the ISRC which is 12 characters long (represented by I1 to I12.) The ISRC can only change immediately after the TNO has been changed.

Table 473 - Raw ISRC Format on the CD Disc

S0, S1	Control	ADR	I1 I2	I3 I4 I5	00	I6 I7 I8 I9 I10 I11 I12	zero	A Frame	CRC
		3	ISRC 60 bits						

00: These 2 bits are zero.

zero: These 4 bits are zero.

I1, I2 are the country code; I3, I4, I5 are the owner code; I6, I7 are the year of recording; I8, I9, I10, I11, I12 are the serial number of the recording. AFrame is the absolute frame number.

The information returned for the ISRC ***shall*** be converted to ASCII. The translation used will translate media codes from 00h - 09h to ASCII ‘0’ - ‘9’ and media codes from 10h - 3Fh to ASCII ‘@’ - ‘0’.

Table 474 - ISRC Format of Data Returned to host

Byte \ Bit	7	6	5	4	3	2	1	0
0	TCVal	Reserved						
1	I1 (Country Code) Valid codes are ASCII ‘A’ - ‘Z’							
2	I2							
3	I3 (Owner Code) Valid codes are ASCII ‘0’ - ‘9’ & ‘A’ - ‘Z’							
4	I4							
5	I5							
6	I6 (Year of Recording) Valid codes are ASCII ‘0’ - ‘9’							
7	I7							
8	I8 (Serial Number) Valid codes are ASCII ‘0’ - ‘9’							
9	I9							
10	I10							
11	I11							
12	I12							
13	Zero							
14	AFrame							
15	Reserved							

The following codes ***shall*** be valid for the above fields (Table 474):

1. Country Code: ‘A’ - ‘Z’ (41h - 5Ah)
2. Owner Code: ‘0’ - ‘9’ and ‘A’ - ‘Z’ (30h -39h, 41h - 5Ah)
3. Year of Recording: ‘0’ - ‘9’ (30h - 39h)
4. Serial Number: ‘0’ - ‘9’ (30h - 39h)

Zero field ***shall*** be set to 00h.

AFRAME may return the frame number in which the MCN was found. This ***shall*** be a value from 00h to 4Ah. All other values are reserved.

16.26.4 Caching of Sub-Channel Data

Sub-channel Q data ***shall*** be cached by the drive while playing audio. This is necessary so that the READ SUBCHANNEL or READ CD commands can access the Sub-Channel Q data while executing an immediate command. The device ***shall*** generate an error if the data is not in the cache.

READ SUBCHANNEL will return the “Current” data, while READ CD will return the specified data and remove any previous (older) data from the cache.

Using “FFFFFFFFh” on READ CD will work just like READ SUBCHANNEL.

Table 475 describes errors that may occur during the operation of the command or which may cause a CHECK CONDITION status to be reported.

Table 475 - READ SUBCHANNEL command errors

Error Description
A-1.1, "Deferred Error Reporting" on page 721
Table 630 - *Basic Error Codes* on page 730
Table 631 - *Media Access Error Codes* on page 733

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16.27 READ TOC/PMA/ATIP command

The READ TOC/PMA/ATIP command requests that the CD logical unit transfer data from the Table of Contents, the Program Memory Area (PMA), or the Absolute Time in Pre-Grove (ATIP) from CD media.

For DVD/HD DVD media, as there is no TOC, this command will return fabricated information that is similar to that of CD media for some formats. This fabrication is required for some legacy host environments. To retrieve correct information, host ***shall*** set MSF bit to 0. See *Section 16.27.9, "Fabrication of TOC information for DVD/HD DVD media"* on page 614.

Table 476 - READ TOC/PMA/ATIP Command Descriptor Block

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation code (43h)							
1	LUN (Obsolete)			Reserved			MSF	Reserved
2	Reserved				Format			
3	Reserved							
4	Reserved							
5	Reserved							
6	Track / Session Number							
7	(MSB) Allocation Length							
8	(LSB)							
9	Vendor-Specific		Reserved			NACA	Flag	Link
10	PAD							
11								

See *3.6, "CD address reporting formats (MSF bit)"* on page 64 for a description of the MSF bit. The Format field is defined in Table 477.

The Track / Session Number field specifies the starting track number for which the data ***shall*** be returned. The data is returned in contiguous ascending track number order. A value of AAh requests that the starting address of the Lead-out Area be returned. If this value is zero, the Table of Contents data ***shall*** begin with the first track or session on the medium.

If the Track / Session Number field is not valid for the currently installed medium, the command ***shall*** be terminated with CHECK CONDITION status, 5/24/00 INVALID FIELD IN CDB.

When a READ TOC/PMA/ATIP command is presented for a CD-R/RW media, where the first TOC has not been recorded (no complete session) and the Format codes 0000b, 0001b, or 0010b are specified, this command ***shall*** be rejected with CHECK CONDITION status, 5/24/00 INVALID FIELD IN CDB. Logical units that are not capable of reading an incomplete session on CD-R/RW media ***shall*** report CHECK CONDITION status, 2/30/02 CANNOT READ MEDIUM - INCOMPATIBLE FORMAT.

Table 477 - Format code definitions for READ TOC/PMA/ATIP command

Format field	Returned Data	Usage	Description	Use of Track/ Session Field
0h	TOC	CD Read Feature and Fabricated data for DVD/HD DVD media	The Track/Session Number field specifies starting track number for which the data will be returned. For multi-session discs, this command will return the TOC data for all sessions and for Track number AAh only the Lead-out Area of the last complete session. See Table 478 - *READ TOC/PMA/ATIP Data Format (With Format field = 0h)* on page 605	Contains the Track number
1h	Session Information	CD Read Feature and Fabricated data for DVD/HD DVD media	This format returns the first complete session number, last complete session number and last complete session starting address. In this format, the Track/Session Number field is reserved and should be set to 00h. NOTE: This format provides the initiator access to the last finalized session starting address quickly. See Table 479 - *READ TOC/PMA/ATIP Data Format (With Format field = 1h)* on page 606	Reserved
2h	Full TOC	CD Read Feature	This format returns all Q Sub-code data in the Lead-in (TOC) areas starting from a session number as specified in the Track/ Session Number field. In this format, the drive will support Q Sub-channel Point field value of A0h, A1h, A2h, Track numbers, B0h, B1h, B2h, B3h, B4h, C0h, and C1h. See Table 480 - *READ TOC/PMA/ATIP Data Format (With Format field = 2h)* on page 607	Contains the Session number
3h	PMA	Incremental Streaming Write Feature	This format returns all Q Sub-code data in the PMA area. In this format, the Track/Session Number field is reserved and ***shall*** be set to 00h. See Table 482 - *READ TOC/PMA/ATIP Data Format (With Format field = 3h)* on page 609	Reserved
4h	ATIP	Incremental Streaming Write Feature	This format returns ATIP data. In this format, the Track/Session Number field is reserved and ***shall*** be set to 00h. See Table 483 - *READ TOC/PMA/ATIP Data Format (With Format field = 4h)* on page 610	Reserved
5h	CD-Text	CD-Text	This format returns CD-Text information from the Lead-in	Contains the Session number
6h-0Fh	Reserved			

16.27.1 READ TOC/PMA/ATIP Format 0h

Table 478 - READ TOC/PMA/ATIP Data Format (With Format field = 0h)

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB) TOC Data Length							
1								(LSB)
2	First Track Number							
3	Last Track Number							
TOC Track Descriptors								
0	Reserved							
1	ADR				Control			
2	Track Number							
3	Reserved							
4	MSB Track Start Address							
5								
6								
7								LSB

The READ TOC/PMA/ATIP data consist of four header bytes and zero or more track descriptors. The READ TOC/PMA/ATIP data is dependent upon the format specified in the Format field of the COMMAND PACKET.

The TOC Data Length specifies the length in bytes of the following TOC data. The TOC Data Length value does not include the TOC Data Length field itself. This value is not modified when the allocation length is insufficient to return all of the TOC data available.

The First Track Number field indicates the first track number in the first complete session Table of Contents.

The Last Track Number field indicates the last track number in the last complete session Table of Contents before the Lead-out.

The ADR field gives the type of information encoded in the Q sub-channel of the block where this TOC entry was found. The possible ADR values are defined in Table 469 - *ADR Sub-channel Q Field* on page 597.

The Control field indicates the attributes of the track. The possible Control field values are defined in Table 487 - *Bit Definitions for the Control field in Sub-channel Q* on page 613

The Track Number field indicates the track number for which the data in the TOC track descriptor is valid. A track number of AAh indicates that the track descriptor is for the start of the Lead-out Area.

The Track Start Address contains the address of the first block with user information for that track number as read from the Table of Contents. An MSF bit of zero indicates that the Track Start Address field contains a Logical Block Address. An MSF bit of one indicates the Track Start Address field contains an MSF address.

16.27.2 READ TOC/PMA/ATIP Format 1h

Table 479 - READ TOC/PMA/ATIP Data Format (With Format field = 1h)

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB) TOC Data Length (0Ah)							
1								(LSB)
2	First Complete Session Number (Hex)							
3	Last Complete Session Number (Hex)							
TOC Track Descriptors								
0	Reserved							
1	ADR				Control			
2	First Track Number in Last Complete Session							
3	Reserved							
4	(MSB)							
5	Start Address of First Track in Last Session							
6								
7								(LSB)

The TOC Data Length specifies the length in bytes of the available session data. The TOC Data Length value does not include the TOC Data Length field itself. This value is not modified when the allocation length is insufficient to return all of the session data available.

The First Complete Session Number is set to one.

The Last Complete Session Number indicates the number of the last complete session on the disc. The Last Complete Session Number ***shall*** be set to one for a single session disc or if the logical unit does not support multi-session discs.

The ADR field gives the type of information encoded in the Q sub-channel of the block where this TOC entry was found. The possible ADR values are defined in Table 469 - *ADR Sub-channel Q Field* on page 597.

The Control field indicates the attributes of the track. The possible Control field values are defined in Table 487 - *Bit Definitions for the Control field in Sub-channel Q* on page 613.

First Track Number in Last Complete Session returns the first track number in the last complete session.

The Start Address of First Track in Last Session contains the address of the first block with user information for the first track of the last session, as read from the Table of Contents. An MSF bit of zero indicates that the Start Address of First Track in Last Session field contains a Logical Block Address. An MSF bit of one indicates the Start Address of First Track in Last Session field contains an MSF address.

16.27.3 READ TOC/PMA/ATIP Format 2h

None of the fields in the result data of Format 2h are affected by the MSF bit in the CDB.

Table 480 - READ TOC/PMA/ATIP Data Format (With Format field = 2h)

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB) TOC Data Length							
1								(LSB)
2	First Complete Session Number							
3	Last Complete Session Number							
TOC Track Descriptors								
0	Session Number							
1	ADR				Control			
2	Byte 1 or TNO							
3	Byte 2 or Point							
4	Byte 3 or Min							
5	Byte 4 or Sec							
6	Byte 5 or Frame							
7	Byte 6 or Zero							
8	Byte 7 or PMin							
9	Byte 8 or PSec							
10	Byte 9 or PFrame							

Multiple entries are recorded in the TOC area, but only one of each entry is reported.

For a Format field of 2h, the logical unit should return TOC data for Q sub-channel modes 1 and 5 (except mode 5, point 1 through 40) in the Lead-in Area.

The TOC Data Length specifies the length in bytes of the available TOC data. The TOC Data Length value does not include the TOC Data Length field itself. This value is not modified when the allocation length is insufficient to return all TOC data available.

The First Complete Session Number is set to one.

The Last Complete Session Number indicates the number of the last complete session on the disc. The Last Complete Session Number is set to one for a single session disc or if the logical unit does not support multi-session discs.

The ADR field gives the type of information encoded in the Q sub-channel of the block where this TOC entry was found. The possible ADR values are defined in Table 469 - *ADR Sub-channel Q Field* on page 597.

The Control field indicates the attributes of the track. The possible Control field values are defined in Table 487 - *Bit Definitions for the Control field in Sub-channel Q* on page 613.

Entries in bytes 2 through 10 of the descriptors ***shall*** be converted to hex by the logical unit if the media contains a value between 0 and 99bcd.

The returned TOC data of a multi-session disc is arranged in ascending order of the session number with duplicates removed. The TOC data within a session is arranged in the order of Q Sub-channel Point field value of A0h-AFh, Track Numbers, B0h-BFh, C0h-FFh. Only recorded Points ***shall*** be returned.

Q sub-channel formats in the Lead-in Area of the TOC is described in Table 486 - *Lead-in Area, Sub-channel Q formats* on page 612.

Table 481 - READ TOC/PMA/ATIP Track Descriptors

Byte	Point	Action	Description
Byte 0	-	Return a hex value	Session Number
Byte 1	-	No conversion, return as is	ADR / Control
Byte 2	-	0	Track (CD STRUCTURE = 0)
Byte 3	-	If 0-99bcd, then convert to hex	Point
Bytes 4 - 6 (MSF field)	00 - 99	Value should be 00h	
	A0h - AFh	Value should be 00h	
	B0h	Convert to hex	NRA
	B1h - BFh	Convert to hex	Skip Values
	C0	No Conversion	ORP / App Code
	C1	No Conversion	Copy of ATIP additional info 1
	C2 - FFh	No Conversion	Reserved
Byte 7	00h - AFh	Value should be 00h	
	B0h - BFh	Convert to Hex	# Pntrs / Skip
	C0h	No Conversion	Reserved
	C1h	Value should be 00h	
	C2h - FFh	No Conversion	Reserved
Bytes 8 - 10 (MSF field)	00 - 99	Convert to hex	Track Start
	A0h	Convert PMIN to hex, PSEC is returned as is	1st / Last / Start LO
	A1h - AFh	Convert to hex	1st / Last / Start LO
	B0h	Convert to hex	Lead Out Max
	B1h - BFh	Convert to hex	Skip Values
	C0h	Convert to hex	ORP / App Code
	C1h	Convert to hex	1st / Last / Start LO from ATIP
	C2h - FFh	No conversion	Reserved

16.27.4 READ TOC/PMA/ATIP Format 3h

None of the fields in the result data of Format 3h are affected by the MSF bit in the CDB.

Table 482 - READ TOC/PMA/ATIP Data Format (With Format field = 3h)

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB) PMA Data Length							
1	PMA Data Length							(LSB)
2	Reserved							
3	Reserved							
PMA Descriptors								
0	Reserved							
1	ADR				Control			
2	Byte 1 or TNO							
3	Byte 2 or Point							
4	Byte 3 or Min							
5	Byte 4 or Sec							
6	Byte 5 or Frame							
7	Byte 6 or Zero							
8	Byte 7 or PMin							
9	Byte 8 or PSec							
10	Byte 9 or PFrame							

Multiple entries are recorded in the PMA area.

The PMA Data Length specifies the length in bytes of the available PMA data. The PMA Data Length value does not include the PMA Data Length field itself. This value is not modified when the Allocation Length is insufficient to return all PMA data available. This value is set to 2 plus eleven times the number of descriptors read.

The returned PMA descriptors are arranged in the order found in the PMA, with duplicates removed.

Entries in bytes 2 through 10 of the descriptors ***shall*** be converted to hex by the logical unit if the media contains a value between 0 and 99bcd.

16.27.5 READ TOC/PMA/ATIP Format 4h

None of the fields in the result data of Format 4h are affected by the MSF bit in the CDB.

Table 483 - READ TOC/PMA/ATIP Data Format (With Format field = 4h)

Bit / Byte	7	6	5	4	3	2	1	0
0	MSB			ATIP Data Length				
1								LSB
2	Reserved							
3	Reserved							
ATIP Descriptors								
0	1	Indicative Device Writing Power			Reserved	Reference Speed		
1	0	URU	Reserved					
2	1	Disc Type	Disc Sub-Type			A1	A2	A3
3	Reserved							
4	ATIP Start Time of Lead-in (Min)							
5	ATIP Start Time of Lead-in (Sec)							
6	ATIP Start Time of Lead-in (Frame)							
7	Reserved							
8	ATIP Last Possible Start Time of Lead-out (Min)							
9	ATIP Last Possible Start Time of Lead-out (Sec)							
10	ATIP Last Possible Start Time of Lead-out (Frame)							
11	Reserved							
12-14	A1 Values							
15	Reserved							
16-18	A2 Values							
19	Reserved							
20-22	A3 Values							
23	Reserved							

ATIP Data Length specifies the number of bytes to be transferred in response to the command. The ATIP Data Length value does not include the data length field itself. This value is not modified when the Allocation Length is insufficient to return all of the ATIP data available.

Indicative Device Writing Power - encoded information indicating the media's recommended initial laser power setting. The meaning of these bits varies between CD-R and CD-RW media.

Reference Speed - encoded information indicating the recommended write speed for the media. 00h = reserved. 01h - 2× recording. Valid only for CD-RW media.

The Unrestricted Use Disc (URU) flag, when set to one, indicates that the mounted CD-R/RW disc is defined for unrestricted use. When the URU flag is set to zero, the mounted CD-R/RW disc is defined for restricted use. To record data to the mounted disc the appropriate Host Application code ***shall*** be set through the Write Parameters Mode Page. A Host Application Code of zero may be used to indicate a restricted use disc - general purpose.

Disc Type - zero indicates CD-R media; one indicates CD-RW media.

Disc Sub-Type - reports the following value according to the Orange Book Part 2 or Part 3 (B1,B2,B3).

Table 484 - Disc Type and Disc Sub Type field definition

Media	Disc Type	Disc Sub-Type	Field Definition
CD-R	0	See Orange Book	Media Type (Physical Characteristic)
CD-RW	1	000	Standard Speed CD-RW
		001	High Speed CD-RW

A1 - when set to one, indicates that the A1 Values field is valid. Otherwise, the A1 Values field is invalid.

A2 - when set to one, indicates that the A2 Values field is valid. Otherwise, the A2 Values field is invalid.

A3 - when set to one, indicates that the A3 Values field is valid. Otherwise, the A3 Values field is invalid.

ATIP Start time of Lead-in - the start time of the Lead-in. The value is read from ATIP and returned in hex format. Legal values for the M field are 50h through 63h.

ATIP Last Possible Start Time of Lead-out - the last possible start time of Lead-out. The value is read from ATIP and returned in hex format. Valid values for the M field are 0 through 4Fh.

A1 Values, A2 Values, and A3 Values field definitions depend on an applicable Orange Book.

16.27.6 READ TOC/PMA/ATIP Format 5h

None of the fields in the result data of Format 5h are affected by the MSF bit in the CDB.

Table 485 - READ TOC/PMA/ATIP Data Format (With Format field = 5h)

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB)			CD-Text Data Length				
1								(LSB)
2	Reserved							
3	Reserved							
CD-Text Descriptor								
0-17	CD-Text Descriptor							

CD-Text Data Length specifies the number of bytes available to be transferred in response to the command. The CD-Text Data Length value does not include the CD-Text Data Length field itself. This value is not modified when the Allocation Length is insufficient to return all of the CD-Text data available. This length is variable, and depends on the number of recorded Pack Data.

The CD-Text Descriptor field provides Pack Data available in the Lead-in Area of the medium. Each Pack Data consists of 18 bytes of CD-Text information. If Pack Data is recorded repeatedly on the medium, the logical unit should return it only once. CD-Text Pack Data is described in *Appendix G - "CD-Text Format in the Lead-in Area (Informative)"* on page 767.

16.27.7 Sub-channel Q information

Table 486 - Lead-in Area, Sub-channel Q formats

S0, S1	Control / ADR		TNO	Point	Min	Sec	Frame	Zero	Pmin	PSec	PFrame	CRC
	4/6	1	00	A0	00 (Absolute time is allowed)			00	First Track num	Disc Type	00	
	4/6	1	00	A1	00 (Absolute time is allowed)			00	Last Track num	00	00	
	4/6	1	00	A2	00 (Absolute time is allowed)			00	Start position of the Lead-out Area			
	4/6	1	00	01-99	00 (Absolute time is allowed)			00	Start position of track			
	4/6	5	00	B0	Start time of next possible program in the Recordable Area of the Hybrid Disc			# of pointers in Mode 5	Maximum start time of the outermost Lead Out area in the Recordable Area of the Hybrid Disc			
	4/6	5	00	B1	00	00	00	00	# of Skip Interval Pointers (N<=40)	# of Skip Track Pointers (N<=21)	00	$x^{16} + x^{12} + x^5 + 1$
	4/6	5	00	B2-B4	Skip #	Skip #	Skip #	Skip #	Skip #	Skip #	Skip #	
	4/6	5	00	01-40	Ending time for the interval that should be skipped			Reserved	Start time for interval that should be skipped on playback			
	4/6	5	00	C0	Optimum recording power	Application Code	Reserved	Reserved	Start time of the first Lead In Area of the Hybrid Disc			
	4/6	5	00	C1	Copy of information from A1 point in ATIP							

Point

The Point field defines various types of information:

01-99 Track number references
A0 First Track number in the program area
A1 Last Track number in the program area
A2 Start location of the Lead-out Area
B0 Used to identify a Hybrid Disc (Photo CD)
Contains start time of next possible program area
B1 Number of Skip Interval Pointers & Skip Track assignments
B2-B4 Skip Track Assignment Pointers
C0 Start time of first Lead In area of Hybrid Disc
This only exists in the first Lead In area
C1 Copy of information from additional area in ATIP

Disc Type Byte

This byte contains a definition of the type of disc

00h CD-DA or CD-ROM with first track in Mode 1
10h CD-I disc
20h CD-ROM XA disc with first track in Mode 2

The Control field is defined in Table 487.

Table 487 - Bit Definitions for the Control field in Sub-channel Q

Control Field	Definition
00x0b	2 Audio without Pre-emphasis
00x1b	2 Audio with Pre-emphasis of 50/15µs
10x0b	Audio channels without pre-emphasis (Reserved in CD-R/RW
10x1b	Audio channels with pre-emphasis of 50/15 µs (Reserved in CD-R/RW)
01x0b	Data track, recorded uninterrupted
01x1b	Data track, recorded incremental
11xxb	Reserved
xx0xb	Digital copy prohibited
xx1xb	Digital copy permitted

16.27.8 Example READ TOC/PMA/ATIP Operations

The following example is based on a 4-session, 12-track Photo CD disc. Data structure is shown as the data to host.

Command Packet: 43h 00 02h 00 00 00 00 10h 00 00 00 00

Table 488 - Example READ TOC/PMA/ATIP Operations

Ses[a]	A/C[b]	TNO[c]	Pnt[d]	Min Sec Frame	Zero	PMin PSec PFrame	Comments
01	14	00	A0	00 00 00	00	01 20 00	First track is 1. XA disc
01	14	00	A1	00 00 00	00	03 00 00	Last track is 3
01	14	00	A2	00 00 00	00	02 08 3F	Lead Out Area on 1st session
01	14	00	01	00 00 00	00	00 02 00	Start address of track 1
01	14	00	02	00 00 00	00	00 08 02	Start address of track 2
01	14	00	03	00 00 00	00	00 15 32	Start address of track 3
01	54	00	B0	04 26 3F	02	40 02 00	Next recordable area address
01	54	00	C0	C0 00 00	00	61 2C 00	Hybrid disc
02	14	00	A0	00 00 00	00	04 20 00	1st track on 2nd session is 4
02	14	00	A1	00 00 00	00	06 00 00	Last track on 2nd session is 6
02	14	00	A2	00 00 0	00	08 20 08	Lead Out Area on 2nd session
02	14	00	04	00 00 00	00	04 28 3F	Start address of track 4
02	14	00	05	00 00 00	00	04 2E 41	Start address of track 5
02	14	00	06	00 00 00	00	06 27 36	Start address of track 6
02	54	00	B0	09 2C 08	01	40 02 00	Next recordable area address
03	14	00	A0	00 00 00	00	07 20 00	1st track on 3rd session is 7
03	14	00	A1	00 00 00	00	09 00 00	Last track on 3rd session is 9
03	14	00	A2	00 00 00	00	0C 27 32	Lead Out Area on 3rd session
03	14	00	07	00 00 00	00	09 2E 08	Start address of track 7
03	14	00	08	00 00 00	00	09 34 10	Start address of track 8
03	14	00	09	00 00 00	00	0B 04 24	Start address of track 9
03	54	00	B0	0E 09 32	01	40 02 00	Next recordable area address
04	14	00	A0	00 00 00	00	0A 20 00	1st track on 4th session is 10
04	14	00	A1	00 00 00	00	0C 00 00	Last track on 4th session is12
04	14	00	A2	00 00 00	00	12 1B 1A	Lead Out Area on 4th session
04	14	00	0A	00 00 00	00	0E 0B 32	Start address of track 10

Table 488 - Example READ TOC/PMA/ATIP Operations (Continued)

Ses[a]	A/C[b]	TNO[c]	Pnt[d]	Min Sec Frame	Zero	PMin PSec PFrame	Comments
04	14	00	0B	00 00 0	00	0E 11 34	Start address of track 11
04	14	00	0C	00 00 00	00	11 08 22	Start address of track 12
04	54	00	B0	13 39 1A	01	40 02 00	Next recordable area address

a. Ses:session number
b. A/C:ADR/Control
c. TNO:00 for Lead In area
d. Pnt:Point

If you use the following command on this disc:

Command Packet: 43h 00 01h 00 00 00 00h 10h 00 00 00 00, return data would be as shown in Table 489.

Table 489 - Values for Control field in READ TOC/PMA/ATIP

Control Field value	Description
01h	First Session Number
04h	Last Session Number
00h	Reserved
14h	ADR/Control
0Ah (10d)	First Track Number in Last session
00h	Reserved
00h, 00h, F8h, EDh (In LBA format, 63725)	Absolute CD-ROM address of first track in last session -> 14M 9S 50F -> add 2 sec: 14M 11S 50F

16.27.9 Fabrication of TOC information for DVD/HD DVD media

When the READ TOC/PMA/ATIP command is used with DVD/HD DVD media the basic CD information required by some legacy host environments should be fabricated from the DVD/HD DVD Lead-in information. Although there are commands that report the needed information about DVD/HD DVD media to the host, these commands are not used by some BIOS and Legacy OS systems. Thus the need to report some basic information to the host using the READ TOC/PMA/ATIP command is allowed.

This section will give some guidelines to the developer that would like to fabricate information about DVD/HD DVD media to be reported to the READ TOC/PMA/ATIP command.

There are many types of structures that exist in CD media that have no corresponding DVD/HD DVD structure. For example CD media have multiple tracks but DVD/HD DVD data is contained in only one track. As CD media provides Audio and host Data as different types of information and DVD/HD DVD has only host Data, reporting of host data types only can be performed for DVD/HD DVD media.

When reporting the CD media ADR/Control fields for DVD/HD DVD media, the ADR field should contain 1h and the Control field should contain 4h.

16.27.9.1 Conversion of addresses on DVD/HD DVD media to CD MSF addressing

For some forms of the READ TOC/PMA/ATIP command the information that is reported to the host is formatted in a special address form called MSF. The largest address that can be reported using MSF addressing is only 1151849 blocks or about 2.35 Gigabytes. Thus addresses larger than this will be truncated. For LBA addressing the full four byte field may be used for the address and thus should not create any truncation.

16.27.9.2 Conversion of DVD/HD DVD track to CD track information

DVD/HD DVD media is different from CD media in that there is only one track and there is no logical track information as used for CD Audio tracks. Thus in providing information to the host using the READ TOC/PMA/ATIP command, there will be only two or three tracks reported to the host: the data tracks and the Lead-out track. If the media is DVD-ROM, DVD-RAM, DVD+RW, HD DVD-ROM or HD DVD-Rewritable there will only be two tracks reported that should cover the full recorded capacity. When DVD-R/HD DVD-R media that has been recorded using multiple borders is reported, all the border areas except the last one are reported as the first track and the last border is reported as the second track.

For reporting of the starting address for the Lead-out track, the address reported will be one more than the ending address of the last data track reported and less than MSF of 255/59/75.

16.27.9.3 Example Fabricated Data for DVD/HD DVD media

In the following example, the size of the recorded media is larger than the maximum that can be reported using MSF addressing, so the addresses have been truncated.

16.27.9.3.1 Sample 1

The following sample Command Packet requests Format 1 in LBA format.

Command Packet: 43h 00h 01h 00 00 00 00 00 30h 00 00 00

Table 490 - Example READ TOC/PMA/ATIP Operations for DVD/HD DVD media - Format 1

F_Ses[a]	L_Ses[b]	A/C[c]	TNO[d]	Address[e]	Comments
01	01	14	01	0	As if one session exists

a. F_Ses: First session number
b. L_Ses: Last session number
c. A/C: ADR/Control
d. TNO: First Track in Last Session
e. Address: Address of First Track in Last Session

16.27.9.3.2 Sample 2

In the following example, the sample Command Packet requests Format 0 in LBA format.

Command Packet: 43h 00 00 00 00 00 00 00 30h 00 00 00

Table 491 - Example READ TOC/PMA/ATIP Operations for DVD/HD DVD media - Format 0

A/C[a]	TNO[b]	Track Start Address	Comments
14	01	00000000h	Track 1
14	AA	00230000h	Lead Out Area

a. A/C: ADR/Control
b. TNO: Track Number

Table 492 describes errors that may occur during the operation of the command or which may cause a CHECK CONDITION status to be reported.

Table 492 - READ TOC/PMA/ATIP command errors

Error Description
A-1.1, "Deferred Error Reporting" on page 721
Table 630 - *Basic Error Codes* on page 730
Table 631 - *Media Access Error Codes* on page 733

16.28 READ TRACK/RZONE INFORMATION command

The READ TRACK/RZONE INFORMATION command provides information about a Track/RZone, regardless of its status. In case of DVD-RAM/ROM, HD DVD-Rewritable/ROM, the number of RZone and Border is considered one. If this command is required by an implemented Feature, this command ***shall*** function if any media is present.

For CD, if the PMA/TOC is unreadable, the command ***shall*** be terminated with CHECK CONDITION status, 3/57/00 UNABLE TO RECOVER TABLE-OF-CONTENTS.

For DVD, if the RMD is unreadable, the command ***shall*** be terminated with CHECK CONDITION status, 3/11/05 L-EC UNCORRECTABLE ERROR.

For HD DVD, if the RMZ/RMD in Border-out is unreadable, the command ***shall*** be terminated with CHECK CONDITION status, 3/11/05 L-EC UNCORRECTABLE ERROR.

If this command is issued during a long immediate operation, e.g., CLOSE TRACK/RZONE/SESSION/BORDER operation, the logical unit ***shall*** return NOT READY status with CHECK CONDITION status, 2/04/07 LOGICAL UNIT NOT READY, OPERATION IN PROGRESS.

Table 493 - READ TRACK/RZONE INFORMATION Command Descriptor Block

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation Code (52h)							
1	LUN (Obsolete)			Reserved		Appendable	Address/Number Type	
2	(MSB) Address/Number							
3								
4								
5								(LSB)
6	Reserved							
7	(MSB) Allocation Length							
8								(LSB)
9	Vendor-Specific		Reserved			NACA	Flag	Link
10	PAD							
11								

The Address/Number Type field in byte 1 is used to specify the contents of the Address/Number field.

The Appendable bit when set to zero, the Track/RZone Information of the Track/RZone specified by the Address/Number field is requested, when set to one the Track/RZone Information of the open Track/RZone that the Track/RZone has NWA and its Track/RZone number is the smallest but is greater than or equal to the specified address/number by the Address/Number field is requested. When no more open Track/RZone exist, logical unit ***shall*** transfer Track/RZone Information Block in that Session/Border Number (LSB), Session/Border Number (MSB), Track/RZone Number (LSB) and Track/RZone Number (MSB) are set to FFh, and all other fields are set to 0. When Address/Number Type is set to 2, or when Address/Number Type is set to 1, Address/Number field is set to FFh, and CD-R/RW disc is mounted, Appendable bit ***shall*** be set to 0. Otherwise the command ***shall*** be terminated with CHECK CONDITION status, 5/24/00 INVALID FIELD IN CDB.

Note: When Appendable bit is set to one, Track/RZone Number (MSB) field, Track/RZone Number (LSB) field and Free Blocks field of Track/RZone Information Block should be checked. If logical unit does not support Appendable bit and ignores the bit, the logical unit reports Track/RZone information of Track/RZone that is specified by Address/Number field to host. Host should set one larger Track/RZone number in Address/Number field to obtain the next open Track/RZone Information.

The Address/Number field is defined in Table 494.

Table 494 - Address/Number field definition

Address/ Number Type Value	Address/Number field	Description
0	Logical Block Address	T_{LBA}, where T_{LBA} is the number of the Track/RZone which contains the block associated with Logical Block Address.
1	00h	T_{TOC}, where T_{TOC} is the Lead-in Area of the disc
	Valid Track/RZone Number	T_{CDB}
	FFh	For CD, this value means T_{INV}, where T_{INV} is the Track number of the invisible or incomplete Track For DVD/HD DVD, this value means T_{CDB} (RZone number is 255)
2	Border Number	R_{BORDER}, where R_{BORDER} is the number of the first RZone which is in the Border Number.
3	Reserved	

Note: The Address/Number Type *2 is easy way to recognize UDF-Bridge file system that specified by DVD-ROM Book Part2.*

The number of Track/RZone Information Block bytes returned is limited by the Allocation Length parameter of the CDB. An Allocation Length of zero is not an error. Fields not used with the loaded media ***shall*** return 0.

The format and content of the Track/RZone Information Block is shown in Table 495.

Table 495 - Track/RZone Information Block

<table>
<tr><th>Bit
Byte</th><th>7</th><th>6</th><th>5</th><th>4</th><th>3</th><th>2</th><th>1</th><th>0</th></tr>
<tr><td>0</td><td colspan="8">(MSB)</td></tr>
<tr><td>1</td><td colspan="8">Track/RZone Information Length (LSB)</td></tr>
<tr><td>2</td><td colspan="8">Track/RZone Number (LSB)</td></tr>
<tr><td>3</td><td colspan="8">Session/Border Number (LSB)</td></tr>
<tr><td>4</td><td colspan="8">Reserved</td></tr>
<tr><td>5</td><td colspan="2">LJRS</td><td>Damage</td><td>Copy</td><td colspan="4">Track Mode</td></tr>
<tr><td>6</td><td>RT</td><td>Blank</td><td>Packet/Inc</td><td>FP</td><td colspan="4">Data Mode</td></tr>
<tr><td>7</td><td colspan="6">Reserved</td><td>LRA_V</td><td>NWA_V</td></tr>
<tr><td>8</td><td colspan="8">(MSB)</td></tr>
<tr><td>9</td><td colspan="8" rowspan="2">Track/RZone Start Address</td></tr>
<tr><td>10</td></tr>
<tr><td>11</td><td colspan="8">(LSB)</td></tr>
<tr><td>12</td><td colspan="8">(MSB)</td></tr>
<tr><td>13</td><td colspan="8" rowspan="2">Next Writable Address</td></tr>
<tr><td>14</td></tr>
<tr><td>15</td><td colspan="8">(LSB)</td></tr>
<tr><td>16</td><td colspan="8">(MSB)</td></tr>
<tr><td>17</td><td colspan="8" rowspan="2">Free Blocks</td></tr>
<tr><td>18</td></tr>
<tr><td>19</td><td colspan="8">(LSB)</td></tr>
<tr><td>20</td><td colspan="8">(MSB)</td></tr>
<tr><td>21</td><td colspan="8" rowspan="2">Fixed Packet Size/
Blocking Factor</td></tr>
<tr><td>22</td></tr>
<tr><td>23</td><td colspan="8">(LSB)</td></tr>
<tr><td>24</td><td colspan="8">(MSB)</td></tr>
<tr><td>25</td><td colspan="8" rowspan="2">Track/RZone Size / RZone End Address</td></tr>
<tr><td>26</td></tr>
<tr><td>27</td><td colspan="8">(LSB)</td></tr>
<tr><td>28</td><td colspan="8">(MSB)</td></tr>
<tr><td>29</td><td colspan="8" rowspan="2">Last Recorded Address</td></tr>
<tr><td>30</td></tr>
<tr><td>31</td><td colspan="8">(LSB)</td></tr>
<tr><td>32</td><td colspan="8">Track/RZone Number (MSB)</td></tr>
<tr><td>33</td><td colspan="8">Session/Border Number (MSB)</td></tr>
<tr><td>34-35</td><td colspan="8">Reserved</td></tr>
<tr><td>36</td><td colspan="8">(MSB)</td></tr>
<tr><td>37</td><td colspan="8" rowspan="2">Read Compatibility LBA</td></tr>
<tr><td>38</td></tr>
<tr><td>39</td><td colspan="8">(LSB)</td></tr>
</table>

Table 495 - Track/RZone Information Block

Byte \ Bit	7	6	5	4	3	2	1	0
40	(MSB)							
41				Next Layer Jump Address				
42								
43								(LSB)
44	(MSB)							
45				Last Layer Jump Address				
46								
47								(LSB)

The Track/RZone Information Length field specifies the length, in bytes, of the data available to be transferred given a sufficient Allocation Length. The Track/RZone Information Length value does not include the Track/RZone Information Length field itself. If the Allocation Length specified is less than the Track/RZone Information Length, the response *shall* be truncated at the Allocation Length specified. This truncation *shall* not cause a CHECK CONDITION status. The Track/RZone Information Length is not modified when the Allocation Length is insufficient to return all of the response data available.

Track/RZone Number is the Track number on CD media, the RZone number on DVD-R/HD DVD-R media, or 1 for media not containing logical tracks.

Session/Border Number is the Session number on CD media, the Border number on DVD/HD DVD media, or 1 for media not containing Sessions or Borders, that contains this Track/RZone.

The Layer Jump recording Status (LJRS) field indicates the status of Layer Jump recording mode of the disc. The definition of this field is shown in Table 496. This field may be valid when DVD-R Dual Layer Ver. 3.0 disc is mounted. For all other media, this field *shall* be set to zero. In case of Reserved RZone and Complete RZone on Layer Jump recording mode disc, the LJRS field *shall* be set to 01b.

Table 496 - LJRS field definition

Value	Recording mode		Definition
00b	DAO or Incremental		The disc is not in Layer Jump recording mode. The recording mode is either DAO or Incremental recording. Or the disc is blank and Write Type field is set to other than Layer Jump.
01b	Layer Jump	Unspecified	The disc is in Layer Jump recording mode. The RZone is Complete state, Reserved state or Invisible state. For the Invisible RZone, neither Manual Layer Jump Address nor Jump Interval size for Regular Interval Layer Jump recording is specified. Or the disc is blank and Write Type field is set to Layer Jump.
10b		Manual	The disc is in Layer Jump recording mode. The RZone is Invisible/Incomplete state and is in Manual Layer Jump recording mode.
11b		Regular Interval	The disc is in Layer Jump recording mode. The RZone is Invisible/Incomplete state and is in Regular Interval Layer Jump recording mode. The Jump Interval size field of the READ DISC STRUCTURE command with Format Code=22h S*shall* report the Jump Interval size in blocks.

When the LJRS field is set to other than zero, the Next Layer Jump Address field and the Last Layer Jump Address fields shall be present after the Read Compatibility LBA field in Track Information Block. The Packet/Inc bit *shall* be set to one, and FP bit *shall* be set to zero.

The Damage bit, when set to one, and the NWA_V is set to zero, the Track/RZone ***shall*** be considered "not closed due to an incomplete write". An automatic repair may be attempted by the logical unit when the CLOSE TRACK/RZONE/SESSION/BORDER command is issued. Further incremental writing in this Track/RZone is not possible.

The Damage bit, when set to one, and the NWA_V is set to one, indicates a Track/RZone that may be recorded further in an incremental manner. An automatic repair ***shall*** be attempted by the logical unit when the next command that requires writing to the Track/RZone is issued. If the repair is successful, the Damage bit ***shall*** be set to zero. Prior to the start of the repair, the Next Writable Address field ***shall*** contain the address of the Next Writable Sector assuming a successful repair. The Damage bit ***shall*** be set to zero for HD DVD-R.

The Copy bit indicates that this track is a second or higher generation copy (CD). For all other media, this bit ***shall*** be set to zero.

On CD media, the Track Mode is the control nibble as defined for mode 1 Q sub-channel for this track. For all other media, this field ***shall*** be set to 4 except when Session/Border Number (LSB), Session/Border Number (MSB), Track/RZone Number (LSB) and Track/RZone Number (MSB) are set to FFh.

For CD, if the RT bit is zero, then the Track is not reserved, otherwise the Track is reserved. The RT bit indicates that a PMA entry indicating the track's start and end addresses exists. If the logical unit is not capable of reading the PMA or RMA, this field ***shall*** be set to zero. For DVD/HD DVD, the RT bit of zero indicates that the RZone is Complete, Invisible, or Incomplete status. The RT bit of one indicates that the RZone is Empty Reserved or Partially Recorded Reserved status.

The Blank bit, when set to one, indicates that the Track/RZone contains no written data and Last Recorded Address field is invalid. For CD, tracks with the Track Descriptor Block recorded ***shall not*** be considered blank. In the case of media that does not have logical Tracks, this bit ***shall*** be set to zero.

The Packet/Inc bit, when set to one, indicates that this Track/RZone is to be written only with packets (CD) or incremental recording (DVD). For CD, the Packet/Inc bit is valid only when the RT bit is set to one or the track indicated is the incomplete track. For HD DVD-R, the Packet/Inc bit ***shall*** be set to one.

The Fixed Packet (FP) bit is valid only when the Packet/Inc bit is set to one. When the Packet/Inc bit is set to one and the FP bit is also set to one, then the track is to be written only with fixed packets on CD media, or the RZone is to be written with restricted overwrite method on DVD-RW media. When the Packet/Inc bit is set to one and the FP bit is set to zero, then the track is to be written only with variable packets on CD media, or the RZone is to be written with incremental recording on DVD-R media. Except for C/DVD-R/RW media, this field should be zero.

When writing, certain parameters may be set via the Write Parameters Mode Page. The state of the Track/RZone determines what parameters ***shall*** be set and which parameters in the mode page ***shall*** match. Required Write Parameters are defined in Table 497. All parameters common to READ TRACK/RZONE INFORMATION and the Write Parameters Mode Page ***shall*** match if the Write Parameters Mode Page is used.

Table 497 - Write Parameter Restrictions due to Track/RZone State

RT	Blank	Packet/ Inc	LJRS	DVD Write Parameter Restrictions	CD Write Parameter Restrictions
0	0	0	00b	Write type is set to DAO. RZone is Complete state. The logical unit cannot write to the disc.	Can’t write to stamped disc, or during track at once on invisible track, or writing session at once mode
X	X	0	01b	Invalid state	Invalid State
			10b		
			11b		
0	0	1	00b	Write type is set to Incremental. RZone is Complete or Incomplete state.	Write type is set to packet.
			01b	Write type is set to Layer Jump recording. RZone is Complete state.	Invalid State
			10b	Write type is set to Layer Jump recording. RZone is Incomplete state and is Manual Layer Jump recording mode.	
			11b	Write type is set to Layer Jump recording. RZone is Incomplete state and is Regular Interval Layer Jump recording[a] mode.	
0	1	0	00b	Write type is set to DAO. RZone is Invisible state The disc is empty. The logical unit cannot start DAO recording in this state. An RZone shall be reserved prior to start DAO recording.	Write type may be set to packet or TAO.
0	1	1	00b	Write type is set to Incremental. RZone is Invisible state and writable.	Invalid State
			01b	Write type is set to Layer Jump recording. RZone is Invisible state. Either Manual Layer Jump recording or Regular Interval recording can be specified.	
			10b	Write type is set to Layer Jump recording. RZone is Invisible state and is Manual Layer Jump recording mode.	
			11b	Write type is set to Layer Jump recording. RZone is Invisible state and is Regular Interval Layer Jump recording mode.	
1	0	0	00b	Write type is set to DAO. RZone is Partially recorded reserved state. The logical unit is performing DAO recording.	Can’t write to recorded track or during track at once on reserved track.
1	0	1	00b	Write type is set to Incremental. RZone is Partially recorded reserved state and is writable.	Write type is set to packet.
			01b	Write type is set to Layer Jump recording. RZone is Partially recorded reserved state.	Invalid State
			10b	Invalid State	
			11b		
1	1	0	00b	Write type is set to DAO. RZone is Empty reserved state and ready to start DAO recording.	Write type is set to TAO. Copy bit may be set only if copyright bit in track mode is clear.

Table 497 - Write Parameter Restrictions due to Track/RZone State

RT	Blank	Packet/Inc	LJRS	DVD Write Parameter Restrictions	CD Write Parameter Restrictions
1	1	1	00b	Write type is set to Incremental. RZone is Empty reserved and is writable.	Write type is set to Packet. Copy bit may be set only if copyright bit in track mode is clear. FP and packet size are changeable. *Note: It is not possible to create such a track using commands described in this specification.*
			01b	Write type is set to Layer Jump recording. RZone is Empty reserved state.	Invalid State
			10b	Invalid State	
			11b		

a. The READ DISC STRUCTURE command with Format Code = 22h ***shall*** report the Jump Interval size of the Regular Interval Layer Jump recording.

For CD, when RT, Blank and Packet/Inc bits are set to one, FP bit of a READ TRACK/RZONE INFORMATION result data is set to zero.

For DVD, when RT bit or Packet/Inc bit is set to one, FP bit of a READ TRACK/RZONE INFORMATION result data is set to zero.

Table 498 - Track/RZone Status Indications

RT	Blank	Packet/Inc	FP	LJRS	HD DVD		DVD		CD	
					Write Method	RZone Status	Write Method	RZone Status	Write Method	Track Status
0	0	0	-	00b	-	-	DAO	Complete	Uninterrupted/ TAO/SAO	Complete/ During TAO/SAO
0	0	1	0	00b	Incremental	Incomplete or Complete[a]	Incremental	Incomplete or Complete[b]	Variable	Incomplete
0	0	1	0	01b/ 10b/ 11b			Layer Jump	Incomplete or Complete[c]	-	(invalid)
0	0	1	1	00b	-	-	Restricted Overwrite	Complete or Incomplete[d]	Fixed	Incomplete
0	1	0	-	00b	-	-	DAO	Invisible	TAO/ Variable/ Fixed[e](*)	Invisible
0	1	1	0	00b	Incremental	Invisible	Incremental	Invisible	-	(invalid)
0	1	1	0	01b/ 10b/ 11b			Layer Jump	Invisible	-	(invalid)
0	1	1	1	00b	-	-	Restricted Overwrite	Invisible	-	(invalid)
1	0	0	-	00b	-	-	DAO	during DAO	TAO	Complete/ During TAO
1	0	1	0	00b	Incremental	Partially Recorded Reserved	Incremental	Partially Recorded Reserved	Variable	Complete/ Partially Recorded Reserved
1	0	1	0	01b/ 10b/ 11b			Layer Jump	Partially Recorded Reserved	-	(invalid)
1	0	1	1	00b	-	-	-	(invalid)	Fixed	Complete/ Partially Recorded Reserved
1	1	0	-	00b	-	-	DAO	Empty Reserved before start writing	TAO	Empty Reserved
1	1	1	0	00b	Incremental	Empty Reserved	Incremental	Empty Reserved	Variable/ Fixed	Empty Reserved
1	1	1	0	01b/ 10b/ 11b			Layer Jump	Empty Reserved	-	(invalid)
1	1	1	1	00b	-	-	-	(invalid)	-	(invalid)

a. If Free Blocks field is 0, the RZone is Complete state. Otherwise, the RZone is Incomplete state.
b. If Free Blocks field is 0, the RZone is Complete state. Otherwise, the RZone is Incomplete state.
c. If Free Blocks field is 0, the RZone is Complete state. Otherwise, the RZone is Incomplete state.
d. In the case of RZone that is in the intermediate state Bordered Area, the RZone is considered as Incomplete state.
e. In case last session is empty, SAO is also valid.

For CD, Data Mode defines the track content. Data Mode is defined in Table 499. For other media, this field should report 1 except when Session/Border Number (LSB), Session/Border Number (MSB), Track/RZone Number (LSB) and Track/RZone Number (MSB) are set to FFh.

Table 499 - Data Mode definition (CD)

Value	Definition
0h	Reserved
1h	Mode 1 (ISO/IEC 10149)
2h	Mode 2 (ISO/IEC 10149 or CD-ROM XA)
3h-Eh	Reserved
Fh	Data Block Type unknown (no track descriptor block)

The Next Writable Address Valid (NWA_V) bit validates the Next Writable Address. If NWA_V is zero, then the Next Writable Address field is not valid. Otherwise, the Next Writable Address field is valid. The NWA_V bit ***shall*** be set to zero if the Track/RZone is not writable for any reason.

The Last Recorded Address Valid (LRA_V) bit validates the last recorded address. If LRA_V is zero, then the Last Recorded Address field is not valid. Otherwise, the Last Recorded Address field is valid. The LRA_V bit ***shall*** be set to zero if the Track/RZone has damage for any reason and is repaired automatically.

The Track/RZone Start Address is the starting address for the specified Track/RZone.

The Next Writable Address, if valid, is the LBA of the next writable user block in the Track/RZone specified by the Address/Number field in the CDB. For CD media, the Next Writable Address ***shall*** be associated with the RT, Blank, and Packet/Inc bits as defined in Table 500. If the Write Type is Raw, the Next Writable Address may be a negative number as required to point to the start of the first Lead-in. When streaming in any Write Type, the Next Writable Address ***shall*** be the next user data block the logical unit expects to receive if no under-run occurs.

Table 500 - Next Writable Address definition (CD)

RT	Blank	Packet/ Inc	FP	NWA_V	Definition
0	0	0	x	1[a]	LBA that ***shall*** be specified by next write command[b]
0	0	1	0	1[c]	LBA that ***shall*** be specified by next write command[b]
0	0	1	1	1[c]	LBA that ***shall*** be specified by next write command[b,d]
0	1	0	0	1	LBA of the first data block after pre-gap[e]
0	1	1	0	x	Not Valid
0	1	1	1	x	Not Valid
1	0	0	x	0[a]	LBA that ***shall*** be specified by next write command[b]
1	0	1	0	1[c]	LBA that ***shall*** be specified by next write command[b]
1	0	1	1	1[c]	LBA that ***shall*** be specified by next write command[b,d]
1	1	0	x	1	LBA of the first data block after pre-gap
1	1	1	0	1	LBA of the first data block after pre-gap
1	1	1	1	-	-

a. During TAO (SAO), NWA_V is 1.

b. NWA ***shall*** be taken account of data blocks in buffer that has not yet been written to media. If the logical unit can write the data of next write command without interrupting of current data streaming (no underrun condition), NWA ***shall*** be contiguous to last address data in buffer. If WCE in Mode Cache Page is zero, NWA ***shall*** be taken account of Link Blocks (2 Run-out blocks, 1 Link block and 4 Run-out blocks) in case of Addressing Method-1.
c. When "Free Blocks" becomes 0 (data full), NWA_V becomes 0.
d. NWA ***shall*** follow the Addressing Method-2 if Method-2 bit in Mode CD Capabilities and Mechanical Status Page is set to one.
e. *In the case of SAO NWA ***shall*** be the first block after Lead-in for the first track of session.

The Free Blocks field represents the maximum number of user data blocks available for recording in the Track/RZone.

For CD media, this field ***shall*** be computed as follows: First, the Available Track Space (ATS) ***shall*** be computed. For the invisible track, *ATS = (StartTimeofLastPossibleLeadout) - NWA + 5.*

For DVD-R/-RW, this field value ***shall*** exclude the number of BSGA/LLA blocks that are located on the RZone boundary. In Layer Jump recording mode on DVD-R Dual Layer media, the number of BSGA/LLA blocks that are located on LJB boundary ***shall*** also be excluded to return actual available user data blocks in the RZone.

For a reserved track, *ATS = (PMAStopTime) - NWA + 5.*

If the track is reserved for, or written with, fixed packets, or is the invisible track and the Write Parameters page specifies fixed packets:

FreeBlocks = IP(ATS / (PacketSize + 7)) • PacketSize. Otherwise, *FreeBlocks = ATS - 7*

Note: The StartTimeofLastPossibleLead-out is the last possible location of the link block at the start of the Lead-out.

Note: If a disc is fully recorded, the PMA entry for the last track will be equal to the StartTimeofLastPossibleLead-out.

Addressing within fixed packet written tracks is translated by the logical unit for reading and writing. The NWA ***shall*** also reflect this translation:

$$NWA_{Method2} = NWA_{Method1} - 7 \bullet IP((NWA_{Method1} - TrackStartAddress) / (PacketSize + 7))$$

Method 1 is the physical address. Method 2 is used on fixed packet written tracks to hide the link areas from the initiator. The *TrackStartAddress* is a physical address, even if prior tracks are recorded with Method 2. *IP( )* is the integer part of the value.

For CD, the Fixed Packet Size/ Blocking Factor field is valid only when the Packet/Inc and the FP bits are both set to one.

For DVD, if the FP bit is set to 0, the Fixed Packet Size/ Blocking Factor field specifies the number of sectors that is actual disc access unit. In case of DVD, this field is 16 and in case of HD DVD, this field is 32. For DVD-R, FP bit 1 is undefined.

If the disc is stamped, then Damage = 0, Blank = 0, RT = 0, and NWA_V = 0.

For CD, the Track/RZone Size / RZone End Address field reports the length in blocks of the user data in the specified track.

The track size ***shall*** be computed as follows:

First, compute the Complete Track Size (CTS).
For an incomplete track, *CTS = (StartTimeofLastPossibleLeadout) - PMATrackStart* + 5.
For a reserved track, *CTS = (PMAStopTime) - PMAStartTime* + 5.
If the track is reserved for, or written with, fixed packets, or is the invisible track and the Write Parameters page specifies fixed packets:

TrackSize = IP(CTS / (PacketSize + 7)) • PacketSize

Otherwise,

TrackSize =CTS - 7

For CD media, the Track/RZone Size / RZone End Address value may not be exact for the tracks that do not have a PMA entry. The track size of tracks that do not have PMA entries is calculated as follows:

TrackSizeofTrack_n = (StartofTrack_n+1) - (StartofTrack_n)
where n+1 is the Lead-out if n is the last track recorded in the TOC.

The track size from this calculation may include blocks from the following track and these blocks may not be readable.

For DVD, when LJRS field is set to 00b, the Track/RZone Size / RZone End Address field reports the number of sectors in the specified RZone.

The RZone size ***shall*** be reported as follows:

For a complete RZone, this field reports the number of sectors in the specified RZone including all padded sectors except the last 1 or 16 sectors of the RZone.
The RZone size is calculated as the following rule:

First, compute the following bit mask operation to get Linking Status of RZone (LSR):

LSR = NextRZoneStartAddress AND 0Fh
where the NextRZoneStartAddress[1] *is the start address of the RZone that is located immediately after the complete RZone to be calculated.*
The "AND" means the mathematical AND operation.

If the *LSR* = 0,

RZoneSize = NextRZoneStartAddress - RZoneStartAddress - 16 sectors;

Otherwise,

RZoneSize = NextRZoneStartAddress - RZoneStartAddress - 1 sector;
where the RZoneStartAddress is the start address of the complete RZone to be calculated.

For an incomplete RZone or invisible RZone, this field reports the number of sectors in the specified RZone including unrecorded sectors except the sectors to be used for the Border-out or truncated Border-out and its BSGA (16 sectors). As for truncated Border-out, see *4.16.11.6, "Disc final closure"* on page 152. The end address of the invisible/incomplete RZone is specified by the Outer limit of Data Recordable area field or the End PSN of Data Area field in Data Area Allocation field of Control Data Zone.
The RZone size is calculated as follows:

RZoneSize = EndPSNOfRZone - RZoneStartAddress - NumberOfSectorsInBorderOut - 16 sectors
where the EndPSNOfRZone is the end address of the invisible/incomplete RZone.
The NumberOfSectorsInBorderOut is the number of sectors to be recorded as Border-out or truncated Border-out just before the Lead-out.

For a reserved RZone, this field reports the number of sectors in the specified RZone including all unrecorded sectors except the last 16 sectors of the RZone to be used as a BSGA.
The RZone size is calculated as follows:

RZoneSize = NextRZoneStartAddress - RZoneStartAddress - 16 sectors

1. If the complete RZone to be calculated is the last RZone, the *NextRZoneStartAddress* is the start address of the last Border-out, or the start address of the Lead-out if the Border-out does not exist.

For DVD-R when the LJRS field is set to other than 00b, the Track/RZone Size / RZone End Address field reports the logical block address of the last sector that is avilable to record user data in the specified RZone.

For HD DVD, the Track/RZone Size field reports the number of sectors in the specified RZone.

The RZone size ***shall*** be reported as follows:

For a complete RZone, this field reports the number of sectors in the specified RZone.
The RZone size is calculated as the following rule:

RZoneSize = NextRZoneStartAddress - RZoneStartAddress

For an incomplete RZone or invisible RZone, this field reports the number of sectors in the specified RZone including unrecorded sectors except the sectors to be used for the Border-out. The end address of the invisible/incomplete RZone is specified by the Outer limit of Data Recordable area field in Data Area Allocation field of Control Data Zone.
The RZone size is calculated as follows:

RZoneSize = EndPSNOfRZone - RZoneStartAddress - NumberOfSectorsInBorderOut
where the EndPSNOfRZone is the end address of the Invisible/Incomplete RZone.
The NumberOfSectorsInBorderOut is the number of sectors to be recorded as Border-out just before the Lead-out.

For a reserved RZone, this field reports the number of sectors in the specified RZone including all unrecorded sectors.
The RZone size is calculated as follows:

RZoneSize = NextRZoneStartAddress - RZoneStartAddress

The Last Recorded Address is the address of last written user data sector of the specified RZone. The last written sector of padded sectors ***shall not*** be considered as the last written user data sector.

The Read Compatibility LBA is a padding recommendation logical block address of the current medium from the Logical Unit that the Initiator may use to ensure a minimal recorded radius. Some read-only logical units are constructed such that a minimal amount of a disc need to be recorded (typically to a radius of 28 ~ 30 mm) in order that it is acceptable as a valid, readable disc. If the disc is DVD+R and the track is the invisible track (i.e., RT=0), the Read Compatibility LBA field ***shall*** be present. For all other media, the Read Compatibility LBA is 00000000h.

The Next Layer Jump Address is the address of the future Layer Jump Address that will cause Layer jump from L0 to L1 or from L1 to L0 of the Reserved / Invisible / Incomplete RZone of DVD-R Dual Layer Ver.3.0 medium. The reported address is either the address on L0 or the address on L1. If no more Layer jump occurs in the RZone, this filed ***shall*** be set to 0. So when Layer jump of a Reserved RZone has happened, this field ***shall*** be set to 0. The default value of the blank DVD-R Dual Layer Ver.3.0 disc is the end sector address of the L0.

The Last Layer Jump Address is the address of the last Layer Jump Address on L0. In case of DVD-R Dual Layer Ver. 3.0 medium, only previous Layer Jump Address on L0 is reported. See *4.17.5.3, "LJB structure of Invisible/Incomplete RZone"* on page 168. If no Layer jump has happened in the RZone, this field ***shall*** be set to 0.

When the RZone is Invisible or Incomplete state, the Last Layer Jump Address field and the Next Layer Jump Address fields report the information about Layer Jump Block (LJB). See *4.17.5, "Recording unit of Layer Jump recording"* on page 167.

When the LJRS field is set to 00b and if the Next Layer Jump Address field and Last Layer Jump Address field present after Read Compatibility LBA field, these fields are 00000000h.

*Note: READ TRACK/RZONE INFORMATION **shall** provide certain valid fields for a disc with Unrecordable status: Track/RZone Number, Session/Border Number, Track Mode, Data Mode, Track/RZone Start Address.*

Table 501 describes errors that may occur during the operation of the command or which may cause a CHECK CONDITION status to be reported.

Table 501 - READ TRACK/RZONE INFORMATION command errors

Error Description
A-1.1, "Deferred Error Reporting" on page 721
Table 630 - *Basic Error Codes* on page 730
Table 631 - *Media Access Error Codes* on page 733

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16.29 REPAIR RZONE command

An RZone which has been defined for incremental writing may be damaged due to an incomplete ECC block at the end of written data. This may be caused by a RESET or a power-fail condition during a incremental write.

The REPAIR RZONE command will fill multiple of ECC block length data from beginning of damaged sector of the ECC block and ended with linking.

The recovery indicated here only allows the RZone to become writable again.

Table 502 - REPAIR RZONE Command Descriptor Block

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation code (58h)							
1	Reserved							Immed
2	Reserved							
3	Reserved							
4	(MSB)			RZone Number				
5								(LSB)
6	Reserved							
7	Reserved							
8	Reserved							
9	Vendor-Specific		Reserved			NACA	Flag	Link
10	PAD							
11								

The Immed bit allows execution of the REPAIR RZONE command function as an immediate operation. If Immed is set to 0, then the requested repair operation is performed to completion prior to returning status. If Immed is set to 1, then status is returned once the Command Packet has been validated.

The RZone Number specifies the RZone which requires repair.

Behavior of this command is the same as automatic repair. This command causes repair action without an explicit write of data.

For DVD-R, if the RZone Number field is set to 0, the RMA may be repaired.

Table 503 describes errors that may occur during the operation of the command or which may cause a CHECK CONDITION status to be reported.

Table 503 - REPAIR RZONE command errors

Error Description
A-1.1, "Deferred Error Reporting" on page 721
Table 630 - *Basic Error Codes* on page 730
Table 631 - *Media Access Error Codes* on page 733
Table 632 - *Write Error Codes* on page 736

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16.30 REPORT KEY command

The REPORT KEY command requests the start of authentication process, transfers data for the authentication process, transfers data protected by the authentication process and ends the authentication process. Different type of authentication process and key exchange may be classified by different Key Class. When the Key Class is different, definitions of the rest of Command Descriptor Block may be different. Currently the following Key Classes are assigned as shown in Table 504.

Table 504 - Key Class Definitions

Key Class	Authentication Type
00h	DVD CSS/CPPM or CPRM
01h	Rewritable Security Services-A
02h	AACS
03h-FFh	Reserved

16.30.1 REPORT KEY command for DVD CSS/CPPM or CPRM (Key Class = 00h)

The REPORT KEY command with Key Class = 00h is used for DVD CSS/CPPM authentication process and CPRM authentication process. The REPORT KEY command with Key Class = 00h requests the start of the authentication process and provides data necessary for authentication and for generating a Bus Key for the DVD logical unit. This command, in conjunction with SEND KEY command, is intended to perform authentication for logical units which conform to DVD content protection scheme and to generate a Bus Key as the result of authentication.

The REPORT KEY command also requests the DVD logical unit to transfer TITLE KEY data, obfuscated by a Bus Key, to the host.

Note: DVD CSS/CPPM and CPRM authentication use the same Key Class field value since they have the same Challenge KEY, KEY1, and KEY2 sizes, and since they are licensed through the same entity.

Table 505 - REPORT KEY Command Descriptor Block (Key Class = 00h)

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation code (A4h)							
1	LUN (Obsolete)			Reserved				
2	(MSB)							
3	Reserved/Logical Block Address							
4								
5								(LSB)
6	Reserved							
7	Key Class							
8	(MSB)							
9	Allocation Length							(LSB)
10	AGID		KEY Format					
11	Vendor-Specific		Reserved			NACA	Flag	Link

The KEY Format field specifies the type of information that is requested to be sent to the host.

The REPORT KEY command with KEY Format field of 000000b or 010001b begins the authentication process. The logical unit, when ready to begin the authentication process, ***shall*** grant the request by returning an Authentication Grant

ID (AGID). If there is no available Authentication Grant ID, the command ***shall*** be terminated with CHECK CONDITION status, 5/55/00 SYSTEM RESOURCE FAILURE.

The AGID field is used to control simultaneous key exchange sequences. The AGID specified in subsequent Key Exchange commands ***shall*** match a currently active AGID. An AGID becomes active by requesting one with KEY Format 000000b or 010001b. The AGID remains active until the authentication sequence completes or is invalidated. The AGID field ***shall*** be reserved when the KEY Format field contains 000000b, 000101b or 010001b.

Note: logical units that support more than one KEY Format for requesting an AGID do not necessarily support simultaneous key exchange sequences.

In case of KEY Format = 000100b, the Reserved/Logical Block Address field specifies the logical block address which contains the TITLE KEY to be sent to the host obfuscated by a Bus Key. In all other cases, this field ***shall*** be reserved.

The Allocation Length field specifies the maximum length in bytes of the REPORT KEY response data that ***shall*** be transferred from the logical unit to the host. An Allocation Length of zero indicates that no data ***shall*** be transferred. This condition ***shall not*** be considered as an error.

Table 506 - KEY Format code definitions for REPORT KEY command (Key Class = 00h)

Key Format	Returned Data	Description	AGID Use
000000b	AGID for CSS/ CPPM	Returns an AUTHENTICATION GRANT ID for Authentication for CSS/CPPM	Reserved & N/A
000001b	Challenge KEY	Returns a Challenge KEY	Valid AGID required
000010b	KEY1	Returns a KEY1	
000100b	TITLE KEY	Returns a TITLE KEY obfuscated by a Bus Key	
000101b	ASF	Returns the current state of the Authentication Success Flags for CSS/CPPM	Reserved & Ignored
001000b	RPC State	Report drive region settings	
010001b	AGID for CPRM	Returns an AUTHENTICATION GRANT ID for Authentication for CPRM	Reserved & N/A
111111b	None	Invalidate Specified AGID. Invalidating an invalid AGID ***shall not*** be considered an error. An AGID that has not been granted ***shall*** be considered invalid.	Valid AGID required
All other values	Reserved		

16.30.1.1 REPORT KEY data format for DVD CSS/CPPM, or CPRM (Key Class = 00h)

The following sections 16.30.1.1.1 through 16.30.1.1.7 specifies the data returned to the host for this command with Key Class = 00h.

With KEY Format Code of 111111b, no data ***shall*** be returned to the host.

16.30.1.1.1 Authentication Grant ID for CSS/CPPM (Key Format = 000000b)

Table 507 - REPORT KEY Data format (With KEY Format = 000000b, Key Class = 00h)

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB)	REPORT KEY Data Length (06h)						
1								(LSB)
2	Reserved							
3	Reserved							
AUTHENTICATION GRANT ID FOR CSS/CPPM								
0	Reserved							
1	Reserved							
2	Reserved							
3	AGID		Reserved					

This KEY Format requests the logical unit to return an Authentication Grant ID for CSS/CPPM. If the authentication process is started by the REPORT KEY command with a KEY Format of 000000b, the authentication ***shall*** be processed to exchange Key data only for CSS/CPPM protected contents.

Note: If the command with this KEY Format is required by an implemented Feature, the command should function, even when the current bit for that Feature is zero.

16.30.1.1.2 Challenge Key (Key Format = 000001b)

Table 508 - REPORT KEY Data format (With KEY Format = 000001b, Key Class = 00h)

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB)	REPORT KEY Data Length (0Eh)						
1								(LSB)
2	Reserved							
3	Reserved							
Challenge Key								
0	(MSB)							
:	Challenge Key Value							
9								(LSB)
10	Reserved							
11	Reserved							

The REPORT KEY Data Length field indicates the length in bytes of the following REPORT KEY Data that is available to be transferred to the host. The REPORT KEY Data Length value does not include the REPORT KEY Data Length field itself.

The Challenge Key Value field returns a value to be used to interrogate an external device to determine conformance with the DVD content protection scheme. The external device then generates the corresponding KEY2.

16.30.1.1.3 Key 1 (Key Format = 000010b)

Table 509 - REPORT KEY Data format (With KEY Format = 000010b, Key Class = 0)

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB)			REPORT KEY Data Length (0Ah)				
1								(LSB)
2	Reserved							
3	Reserved							
KEY 1								
0	(MSB)							
:				KEY1 Value				
4								(LSB)
5	Reserved							
6	Reserved							
7	Reserved							

The REPORT KEY Data Length field indicates the length in bytes of the following REPORT KEY Data that is available to be transferred to the host. The REPORT KEY Data Length value does not include the REPORT KEY Data Length field itself.

KEY1 Value field returns a value used to determine the logical unit's conformity with DVD Copy Protection scheme by an external device. The KEY1 Value will also be used as a parameter to generate a Bus Key in the logical unit.

When the logical unit is unable to produce a KEY1 Value, this command with KEY Format = 000010b ***shall*** be terminated with CHECK CONDITION status, 5/6F/01 COPY PROTECTION KEY EXCHANGE FAILURE - KEY NOT PRESENT.

16.30.1.1.4 Copyright Management Information and Title Key (Key Format = 000100b)

Table 510 - REPORT KEY Data format (With KEY Format = 000100b, Key Class = 0)

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB)			REPORT KEY Data Length (0Ah)				
1								(LSB)
2	Reserved							
3	Reserved							
Copyright Management Information								
0	CPM	CP_SEC	CGMS		CP_MOD			
TITLE KEY								
1	(MSB)							
2								
3				Title Key Value				
4								
5								(LSB)
6	Reserved							
7	Reserved							

The REPORT KEY Data Length field indicates the length in bytes of the following REPORT KEY Data that is available to be transferred to the host. The REPORT KEY Data Length value does not include the REPORT KEY Data Length field itself.

The CPM bit identifies the presence of copyrighted material in this sector. A value of 0 ***shall*** indicate material not copyrighted. A value of 1 ***shall*** indicate copyrighted material.

When the CPM bit is 1, the CP_SEC field indicates whether the specified sector has a specific data structure for copyright protection system. A value of 0 ***shall*** indicate that no such data structure exists in this sector. A value of 1 ***shall*** indicate a specific data structure for CSS or CPPM exists in this sector.

When the CPM bit is 1, the CGMS field indicates the restrictions on copying, as shown in

Table 511 - CGMS field definition

CGMS Value	Definition
00b	Copying is permitted without restriction
01b	Reserved
10b	One generation of copies may be made
11b	No copying is allowed

When the CP_SEC bit is 1, the CP_MOD field indicates the copyright protection mode of the specified sector. A value of 0h indicates the sector is scrambled by CSS. A value of 1h indicates the sector is encrypted by CPPM. Other values are reserved.

Title Key Value field returns the TITLE KEY which is obfuscated by a Bus Key. The length of Title Key Value is currently 5 bytes only.

Note: CPPM protected sectors do not contain a TITLE KEY.

When the specified sector does not contain TITLE KEY, this command with KEY Format = 000100b ***shall*** be terminated with CHECK CONDITION status, 5/6F/01 COPY PROTECTION KEY EXCHANGE FAILURE - KEY NOT PRESENT.

When the logical unit is not in the Bus Key Established state for CSS/CPPM, this command with KEY Format = 000100b ***shall*** be terminated with CHECK CONDITION status, 5/6F/02 COPY PROTECTION KEY EXCHANGE FAILURE - KEY NOT ESTABLISHED.

16.30.1.1.5 Authentication Success Flag (Key Format = 000101b)

Table 512 - REPORT KEY Data format (With KEY Format = 000101b, Key Class = 0)

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB) REPORT KEY Data Length							
1								(LSB)
2	Reserved							
3	Reserved							
AUTHENTICATION SUCCESS FLAG								
0	Reserved							
1	Reserved							
2	Reserved							
3	Reserved							ASF

The REPORT KEY Data Length field indicates the length in bytes of the following REPORT KEY Data that is available to be transferred to the host. The REPORT KEY Data Length value does not include the REPORT KEY Data Length field itself.

An ASF bit of one indicates that the authentication process for CSS/CPPM has completed successfully. Note, however, that the ASF value is not relevant to CPPM, since CPPM protected sectors do not contain a Title Key.

For more information on the contents of the ASF, see Figure 19 - *Authentication Flag Sequence* on page 94.

16.30.1.1.6 RPC status (Key Format = 001000b)

Table 513 - REPORT KEY Data format (With KEY Format = 001000b, Key Class = 0)

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB) REPORT KEY Data Length (06h)							
1	REPORT KEY Data Length (06h) (LSB)							
2	Reserved							
3	Reserved							
RPC State								
0	Type Code		# of Vendor Resets Available			# of User Controlled Changes Available		
1	Region Mask							
2	RPC Scheme							
3	Reserved							

The REPORT KEY Data Length field indicates the length in bytes of the following REPORT KEY Data that is available to be transferred to the host. The REPORT KEY Data Length value does not include the REPORT KEY Data Length field itself.

The logical unit ***shall not*** report an error concerning media to this KEY Format code. See *4.14.1, "Playback limitations by world region"* on page 97.

The Type Code field specifies the current state of the Regionalization Process. See Table 514.

Table 514 - Type Code field definition

Type Code	Name	Definition
00b	NONE	No drive region setting
01b	SET	Drive region is set
10b	LAST CHANCE	Drive region is set, with additional restrictions required to make a change.
11b	PERM	Drive region has been set permanently, but may be reset by the vendor if necessary.

# of Vendor Resets Available is a count down counter that indicates the number of times that the vendor can reset the region. This value is set to 4 by the drive manufacturer and decremented each time the vendor clears the drive's region. When this value is zero, the vendor can no longer clear the drive's region.

# of User Controlled Changes Available is a count down counter that indicates the number of times that the user can set the region. This value is initially 5.

The Region Mask returns a value that indicates the logical unit's specified region. Once the drive region has been set, exactly one bit ***shall*** be set to zero to indicate the region. Each bit represents one of eight regions. If a bit is set to zero in this field, the disc can be played in the corresponding region. If a bit is set to one in this field, the disc cannot be played in the corresponding region.

RPC Scheme specifies the type of Region Playback Controls being used by the logical unit. See Table 515.

Table 515 - RPC Scheme

RPC Scheme	RPC Name	Definition
00h	Unknown	The logical unit does not enforce Region Playback Controls (RPC).
01h	RPC Phase II	The logical unit ***shall*** adhere to this specification and all requirements of the CSS license agreement concerning RPC.
02h-FFh	Reserved	

16.30.1.1.7 Authentication Grant ID for CPRM (Key Format = 010001b)

Table 516 - REPORT KEY Data format (With KEY Format = 010001b, Key Class = 0)

Byte \ Bit	7	6	5	4	3	2	1	0
0	(MSB) REPORT KEY Data Length (06h)							
1	REPORT KEY Data Length (06h)							(LSB)
2	Reserved							
3	Reserved							
AUTHENTICATION GRANT ID FOR CPRM								
0	Reserved							
1	Reserved							
2	Reserved							
3	AGID		Reserved					

The REPORT KEY Data Length field indicates the length in bytes of the following REPORT KEY Data that is available to be transferred to the host. The REPORT KEY Data Length value does not include the REPORT KEY Data Length field itself.

This KEY Format requests the logical unit to return an Authentication Grant ID for CPRM. If the authentication process is started by the REPORT KEY command with a KEY Format of 010001b, the authentication ***shall*** be processed to exchange Key data only for CPRM protected contents.

Note: If the command with this KEY Format is required by an implemented Feature, the command should function, even when the current bit for that Feature is zero.

Table 522 describes errors that may occur during the operation of the command or which may cause a CHECK CONDITION status to be reported.

16.30.2 REPORT KEY command for AACS (Key Class = 02h)

The REPORT KEY command with Key Class = 02h is used for AACS authentication process. The REPORT KEY command with Key Class = 02h requests the start of the authentication process, generates and returns or just returns the Binding Nonce and ends the authentication process.

Table 517 - REPORT KEY Command Descriptor Block (Key Class = 02h)

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation code (A4h)							
1	LUN (Obsolete)			Reserved				
2	(MSB)							
3	Reserved/Address							
4								
5								(LSB)
6	Reserved/Block Count							
7	Key Class							
8	(MSB)							
9	Allocation Length							(LSB)
10	AGID		KEY Format					
11	Vendor-Specific		Reserved			NACA	Flag	Link

The KEY Format field specifies the type of information that is requested to be sent to the host.

The REPORT KEY command with KEY Format field of 000000b begins the authentication process. The logical unit, when ready to begin the authentication process, ***shall*** grant the request by returning an Authentication Grant ID for AACS (AGID for AACS). If there is no available Authentication Grant ID for AACS, the command ***shall*** be terminated with CHECK CONDITION status, 5/55/00 SYSTEM RESOURCE FAILURE.

The AGID field is used to control simultaneous authentication process. The AGID for AACS specified in subsequent commands for the given authentication process ***shall*** match a currently active AGID for AACS. An AGID for AACS becomes active by requesting one with KEY Format 000000b. The AGID for AACS remains active until the authentication sequence completes or is invalidated. The AGID field ***shall*** be reserved when the KEY Format field contains 000000b.

The Reserved/Address field contains a value which depends on the value in the KEY Format field.

For KEY Format field = 100000b (Generate Binding Nonce), the Reserved/Address field contains the starting address of the LBA Extent the Binding Nonce is to be recorded.

For KEY Format field = 100001b (Read Binding Nonce), the Reserved/Address field contains the starting address of the LBA Extent the Binding Nonce is to be read.

For other values - The Reserved/Address field ***shall*** be reserved.

The Reserved/Block Count field specifies a value which depends on the value in the KEY Format field.

For KEY Format field = 100000b (Generate Binding Nonce), the Block Count field contains the length of LBA Extent the Binding Nonce is to be recorded. The length of LBA Extent ***shall*** be no less than the value in the Block Count for Binding Nonce field in the AACS Feature Descriptor. If the length of LBA Extent designated by the REPORT KEY command is less than this value, the command ***shall*** be terminated with CHECK CONDITION status, 5/6F/06 INSUFFICIENT BLOCK COUNT FOR BINDING NONCE RECORDING. If the designated LBA Extent is overlapped with other LBA Extent being stored, the command ***shall*** be terminated with CHECK CONDITION status, 5/6F/07 CONFLICT IN BINDING NONCE RECORDING.

For KEY Format field = 100001b (Read Binding Nonce), the Block Count field contains the length of LBA Extent the Binding Nonce is to be read. The length of LBA Extent ***shall*** be no less than the value in the Block Count for Binding Nonce field in the AACS Feature Descriptor. If the length of LBA Extent designated by the REPORT KEY command is less than this value, the command ***shall*** be terminated with CHECK CONDITION status, 5/6F/06 INSUFFICIENT BLOCK COUNT FOR BINDING NONCE RECORDING.

The Allocation Length field specifies the maximum length in bytes of the REPORT KEY response data that ***shall*** be transferred from the logical unit to the host. An Allocation Length of zero indicates that no data ***shall*** be transferred. This condition ***shall not*** be considered as an error.

Table 518 - KEY Format code definitions for REPORT KEY command (Key Class = 02h)

Key Format	Returned Data	Description	AGID Use
000000b	AGID for AACS	Returns an AUTHENTICATION GRANT ID for Authentication for AACS	Reserved & N/A
100000b	Binding Nonce	Generates and stores a Binding Nonce and returns it	Valid AGID required
100001b	Binding Nonce	Returns a Binding Nonce	
111111b	None	Invalidate Specified AGID for AACS. Invalidating an invalid AGID for AACS ***shall not*** be considered an error. An AGID for AACS that has not been granted ***shall*** be considered invalid.	Valid AGID required
All other values	Reserved		

16.30.2.1 REPORT KEY data format for AACS (Key Class = 02h)

The following sections 16.30.2.1.1 through 16.30.2.1.3 specifies the data returned to the host for this command with Key Class = 02h. With KEY Format Code of 111111b, no data ***shall*** be returned to the host.

16.30.2.1.1 Authentication Grant ID for AACS (Key Format = 000000b)

Table 519 - REPORT KEY Data format (With KEY Format = 000000b, Key Class = 02h)

Byte \ Bit	7	6	5	4	3	2	1	0
0	(MSB)	REPORT KEY Data Length (06h)						
1								(LSB)
2	Reserved							
3	Reserved							
	AUTHENTICATION GRANT ID FOR AACS							
0	Reserved							
1	Reserved							
2	Reserved							
3	AGID		Reserved					

The REPORT KEY Data Length field indicates the length in bytes of the following REPORT KEY Data that is available to be transferred to the host. The REPORT KEY Data Length value does not include the REPORT KEY Data Length field itself.

This KEY Format requests the logical unit to return an Authentication Grant ID for AACS.

Note: If the command with this KEY Format is required by an implemented Feature, the command should function, even when the current bit for that Feature is zero.

16.30.2.1.2 Binding Nonce generated by the logical unit (Key Format = 100000b)

Table 520 - REPORT KEY Data format (With KEY Format = 100000b, Key Class = 02h)

Byte \ Bit	7	6	5	4	3	2	1	0
0	(MSB) REPORT KEY Data Length (A6h)							
1								(LSB)
2	Reserved							
3	Reserved							
Binding Nonce (generated by the logical unit)								
0	(MSB) Binding Nonce Data							
:								
163								(LSB)

The REPORT KEY Data Length field indicates the length in bytes of the following REPORT KEY Data that is available to be transferred to the host. The REPORT KEY Data Length value does not include the REPORT KEY Data Length field itself.

The Binding Nonce Data field returns a Binding Nonce that is generated by this command with KEY Format = 100000b and stored in the logical unit for later recording in a protected manner.

When the logical unit is not in the Challenge Key in hold state of the AACS Authentication, this command with KEY Format = 100000b ***shall*** be terminated with CHECK CONDITION status, 5/6F/02 COPY PROTECTION KEY EXCHANGE FAILURE - KEY NOT ESTABLISHED.

16.30.2.1.3 Binding Nonce (read from the medium) (Key Format = 100001b)

Table 521 - REPORT KEY Data format (With KEY Format = 100001b, Key Class = 02h)

Byte \ Bit	7	6	5	4	3	2	1	0
0	(MSB) REPORT KEY Data Length (A6h)							
1								(LSB)
2	Reserved							
3	Reserved							
Binding Nonce (read from the medium)								
0	(MSB) Binding Nonce Data							
:								
163								(LSB)

The REPORT KEY Data Length field indicates the length in bytes of the following REPORT KEY Data that is available to be transferred to the host. The REPORT KEY Data Length value does not include the REPORT KEY Data Length field itself.

The Binding Nonce Data field returns a Binding Nonce that is read from the designated LBA Extent by this command with KEY Format = 100001b in a protected manner.

When the logical unit is not in the Challenge Key in hold state of the AACS Authentication, this command with KEY Format = 100001b ***shall*** be terminated with CHECK CONDITION status, 5/6F/02 COPY PROTECTION KEY EXCHANGE FAILURE - KEY NOT ESTABLISHED.

Table 522 - REPORT KEY command errors

Error Description
A-1.1, "Deferred Error Reporting" on page 721
Table 630 - *Basic Error Codes* on page 730
Table 631 - *Media Access Error Codes* on page 733
Table 634 - *Authentication Error Codes* on page 737

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16.31 REQUEST SENSE command

The REQUEST SENSE command requests that the logical unit transfer sense data to the host.

Table 523 - REQUEST SENSE Command Descriptor Block

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation code (03h)							
1	LUN (Obsolete)			Reserved				
2	Reserved							
3	Reserved							
4	Allocation Length							
5	Vendor-Specific		Reserved				Flag	Link
6	PAD							
7								
8								
9								
10								
11								

The sense data:

1. ***shall*** be available if an error condition (CHECK CONDITION) had previously been reported to the host;
2. ***shall*** be available if other information (e.g., medium position) is available in any field.

If the logical unit has no other sense data available to return, it ***shall*** return a sense key of NO SENSE and an additional sense code of NO ADDITIONAL SENSE INFORMATION. No further CHECK CONDITION status ***shall*** be generated.

The sense data ***shall*** be preserved by the logical unit until retrieved by a REQUEST SENSE command or until the receipt of any other I/O command.

The logical unit ***shall*** return CHECK CONDITION status for a REQUEST SENSE command only to report exception conditions specific to the command itself. For example:

1. A logical unit malfunction prevents return of the sense data.

If a recovered error occurs during the execution of the REQUEST SENSE command, the logical unit ***shall*** return the sense data with GOOD status. If a logical unit returns CHECK CONDITION status for a REQUEST SENSE command, the sense data may be invalid.

Logical units ***shall*** be capable of returning at least 18 bytes of data in response to a REQUEST SENSE command. If the Allocation Length is 18 or greater, and a logical unit returns less than 18 bytes of data, the host should assume that the bytes not transferred would have been zeros had the logical unit returned those bytes. Hosts is able to determine how much sense data has been returned by examining the allocation length parameter in the Command Packet and the additional sense length in the sense data. Logical units ***shall not*** adjust the additional sense length to reflect truncation if the Allocation Length is less than the sense data available.

The sense data format for error codes 70h (current errors) and 71h (deferred errors) are defined in Table 524. Error code values of 72h to 7Eh are reserved. Error code 7Fh is for a vendor-specific sense data format. Logical units ***shall*** implement error code 70h; implementation of error code 71h is optional. Error code values of 00h to 6Fh are not defined by this Specification and their use is not recommended.

Table 524 - Request Sense Standard Data

Bit / Byte	7	6	5	4	3	2	1	0
0	Valid	Error Code (70h or 71h)						
1	Segment Number (Reserved)							
2	Reserved		ILI	Reserved	Sense Key			
3	Information							
6								
7	Additional Sense Length (n - 7)							
8	Command Specific Information							
9								
10								
11								
12	Additional Sense Code							
13	Additional Sense Code Qualifier (Optional)							
14	Field Replaceable Unit Code (Optional)							
15	SKSV	Sense Key Specific						
16								
17								
18	Additional Sense Bytes							
:								
n								

A Valid bit of zero indicates that the information field is not as defined in this Specification. A Valid bit of one indicates the information field contains valid information as defined in this Specification. Logical units ***shall*** implement the Valid bit.

The Segment Number field is reserved.

An Incorrect Length Indicator (ILI) bit of one indicates that the requested allocation length did not match the logical block length of the data on the medium.

The Sense Key, Additional Sense Code and Additional Sense Code Qualifier provide a hierarchy of information. The intention of the hierarchy is to provide a top-down approach for a host to determine information relating to the error and exception conditions. The Sense Key provides generic categories in which error and exception conditions can be reported. Hosts would typically use sense keys for high-level error recovery procedures. Additional Sense Codes provide further detail describing the sense key. Additional Sense Code Qualifiers add further detail to the additional sense code. The Additional Sense Code and Additional Sense Code Qualifier can be used by hosts where sophisticated error recovery procedures require detailed information describing the error and exception conditions.

The Sense Key field is mandatory and indicates generic information describing an error or exception condition. The sense keys are defined in Table 529 - *Sense Key descriptions* on page 650.

The contents of the Information field is command-specific and is defined within the appropriate section for the command of interest. Logical units ***shall*** implement the Information field. Unless specified otherwise, this field contains the unsigned logical block address associated with the sense key.

The Additional Sense Length field indicates the number of additional sense bytes to follow. If the Allocation Length of the Command Packet is too small to transfer all of the additional sense bytes, the Additional Sense Length is not adjusted to reflect the truncation.

The Command Specific Information field contains information that depends on the command that was performed. Further meaning for this field is defined within the command description. When this field is used to report a logical block address the data contained in this field ***shall*** be a logical address. Commands that make use of MSF addressing ***shall*** report the error location in LBA format.

The Additional Sense Code (ASC) field indicates further information related to the error or exception condition reported in the Sense Key field. Logical units ***shall*** support the Additional Sense Code field. Support of the additional sense codes not explicitly required by this Specification is optional. A list of additional sense codes is in Table 629 - *All Error Codes* on page 722. If the logical unit does not have further information related to the error or exception condition, the Additional Sense Code is set to NO ADDITIONAL SENSE INFORMATION.

The Additional Sense Code Qualifier (ASCQ) indicates detailed information related to the Additional Sense Code. The ASCQ is optional. If the error or exception condition is reportable by the logical unit, the value returned ***shall*** be as specified in Table 629 - *All Error Codes* on page 722. If the logical unit does not have detailed information related to the error or exception condition, the ASCQ is set to zero.

Non-zero values in the Field Replaceable Unit Code field are used to define a logical unit-specific mechanism or unit that has failed. A value of zero in this field ***shall*** indicate that no specific mechanism or unit has been identified to have failed or that the data is not available. The Field Replaceable Unit Code field is optional. The format of this information is not specified by this Specification. Additional information about the field replaceable unit may be available in the ASCII information page, if supported by the logical unit.

The Additional Sense Bytes field may contain command specific data, peripheral device specific data, or vendor-specific data that further defines the nature of the CHECK CONDITION status.

16.31.1 Sense-key Specific

The Sense Key Specific field is defined by this Specification when the value of the Sense-key Specific Valid (SKSV) bit is one. The SKSV bit and Sense Key Specific field are optional. The definition of this field is determined by the value of the Sense Key field. This field is reserved for sense keys not described below. An SKSV value of zero indicates that this field is not as defined by this Specification.

If the Sense Key field is set to ILLEGAL REQUEST and the SKSV bit is set to one, the Sense Key Specific field indicates which illegal parameters in the Command Packet or the data parameters are in error.

Table 525 - Field Pointer Bytes

Bit / Byte	7	6	5	4	3	2	1	0
15	SKSV	C/D	Reserved	Reserved	BPV	Bit Pointer		
16	(MSB)			Field Pointer				
17								(LSB)

A command Data (C/D) bit of one indicates that the illegal parameter is in the Command Packet. A C/D bit of zero indicates that the illegal parameter is in the data parameters sent by the host.

A Bit Pointer Valid (BPV) bit of zero indicates that the value in the Bit Pointer field is not valid. A BPV bit of one indicates that the Bit Pointer field specifies which bit of the byte designated by the Field Pointer field is in error. When a multiple-bit field is in error, the Bit Pointer field ***shall*** point to the most-significant (left-most) bit of the field.

The Field Pointer field indicates which byte of the Command Packet or of the parameter data was in error. Bytes are numbered starting from zero, as shown in the tables describing the commands and parameters. When a multiple-byte field is in error, the pointer ***shall*** point to the most significant (left-most) byte of the field.

If the sense key is RECOVERED ERROR, HARDWARE ERROR or MEDIUM ERROR and if the SKSV bit is one, the Sense Key Specific field ***shall*** be as shown in Table 526.

Table 526 - Actual Retry Count Bytes

Bit / Byte	7	6	5	4	3	2	1	0
15	SKSV	Reserved						
16	(MSB)	Actual Retry Count						
17								(LSB)

The Actual Retry Count field returns implementation-specific information on the actual number of retries of the recovery algorithm used in attempting to recover an error or exception condition. This field should relate to the Retry Count fields within the Read/Write Error Recovery Parameters Mode Page of the MODE SELECT (10) command.

If the sense key is MEDIUM ERROR and the additional sense code & qualifier set to ZONED FORMATTING FAILED DUE TO SPARE LINKING and if the SKSV bit is one, the Sense Key Specific field ***shall*** be as shown in Table 527.

Table 527 - Zone Number Bytes

Bit / Byte	7	6	5	4	3	2	1	0
15	SKSV	Reserved						
16	(MSB)	Zone Number						
17								(LSB)

The Zone Number field returns the zone number of the first zone which has a spare linking into the zone designated by a FORMAT UNIT command.

If the Sense Key field is set to NOT READY or NO SENSE and the SKSV bit is set to one, the Sense Key Specific field ***shall*** be as shown in Table 528.

Table 528 - Progress Indication

Bit / Byte	7	6	5	4	3	2	1	0
15	SKSV	Reserved						
16	(MSB)	Progress Indication						
17								(LSB)

The Progress Indication field is a percent complete indication in which the returned value is the numerator that has 65536 (10000h) as its denominator. The progress indication ***shall*** based upon the total operation time including any certification or initialization operations. *16.5.6, "Device Busy Class Events"* on page 461 describes progress indication in time unit.

16.31.2 Deferred Errors

Error Code field value of 70h indicates that the CHECK CONDITION status returned is the result of an error or exception condition on the I/O process that returned the CHECK CONDITION status. This includes errors generated during execution of the command by the actual execution process. It also includes errors not related to any command that are first observed during execution of a command. Examples of this latter type of error include disk servo-mechanism, off-track errors, and power-up test errors.

Error Code field value of 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, and with multiple command buffering. Logical units that implement these features are required to implement deferred error reporting.

The deferred error may be indicated by returning CHECK CONDITION status to the host 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 performed. After the logical unit detects a deferred error condition on a logical unit, it ***shall*** return a deferred error according to the rules described below:

1. 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 (10) command. The occurrence of the error may be logged if statistical or error logging is supported.
2. If a deferred error can be associated with a particular function or a particular subset of data, and the error is either unrecovered or required to be reported by the mode parameters, a deferred error indication ***shall*** be returned to the host.

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 host. This is necessary to be sure that recovery actions can be taken if deferred errors do occur in the storing of the data.

16.31.3 Sense-key and Sense Code Definitions

Table 529 - Sense Key descriptions

Sense key	Description
0h	NO SENSE. Indicates that there is no specific sense key information to be reported for the designated logical unit. This would be the case for a successful command.
1h	RECOVERED ERROR. Indicates that the last command completed successfully with some recovery action performed by the logical unit. Details may be determinable by examining the additional sense bytes and the information field. When multiple recovered errors occur during one command, the choice of which error to report (first, last, most severe, etc.) is logical unit specific.
2h	NOT READY. Indicates that the logical unit cannot be accessed. Operator intervention may be required to correct this condition.
3h	MEDIUM ERROR. Indicates that the command terminated with a non-recovered error condition that was probably caused by a flaw in the medium or an error in the recorded data. This sense key may also be returned if the logical unit is unable to distinguish between a flaw in the medium and a specific hardware failure (sense key 4h).
4h	HARDWARE ERROR. Indicates that the logical unit detected a non-recoverable hardware failure (e.g., controller failure, logical unit failure, parity error) while performing the command or during a self test.
5h	ILLEGAL REQUEST. Indicates that there was an illegal parameter in the Command Packet or in the additional parameters supplied as data for some commands. If the logical unit detects an invalid parameter in the Command Packet, then it ***shall*** terminate the command without altering the medium. If the logical unit detects an invalid parameter in the additional parameters supplied as data, then the logical unit may have already altered the medium.
6h	UNIT ATTENTION. Indicates that the removable medium may have been changed or the logical unit has been reset.
7h	DATA PROTECT. Indicates that a command that reads the medium was attempted on a block that is protected from this operation. The read operation is not performed.
8h	BLANK CHECK. Indicates that a write-once device or a sequential-access device encountered blank medium or format-defined end-of-data indication while reading or a write-once device encountered a non-blank medium while writing.
9h-Ah	Reserved
Bh	ABORTED COMMAND. Indicates that the logical unit has aborted the command. The host may be able to recover by trying the command again. This error is reported for conditions such as an overrun etc.
0Ch-0Dh	Reserved
Eh	MISCOMPARE. Indicates that the source data did not match the data read from the medium.
Fh	Reserved

16.31.4 Using the REQUEST SENSE command

Whenever an Error is reported, the host should issue a REQUEST SENSE command to receive the sense data describing what caused the Error condition. If the host issues some other command, the sense data is lost.

This command may be issued even if CHECK CONDITION status has not been reported to the host.

See *Appendix A - "Error Reporting and Sense Codes (Normative)"* on page 721 for a list of Sense Key, ASC, and ASCQ code values that may be reported to this command.

Table 530 - REQUEST SENSE command errors

Error Description	
5/24/00	INVALID FIELD IN CDB

16.32 RESERVE TRACK/RZONE/RMZ command

The RESERVE TRACK/RZONE/RMZ command allows reservation of disc space for a Track/RZone/RMZ. A PMA/RMA/RMZ entry for the Track/RZone/RMZ ***shall*** be either written or cached for writing prior to disc removal.

Table 531 - RESERVE TRACK/RZONE/RMZ Command Descriptor Block

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation code (53h)							
1	Reserved						RMZ	ARSV
2	(MSB) Track Reservation Parameter							
3								
4								
5								
6								
7								
8								(LSB)
9	Vendor-Specific		Reserved			NACA	Flag	Link
10	PAD							
11								

When ARSV (Address mode reservation) bit is set one, theTrack Reservation Parameter field is Logical Block Address mode. When this bit is set to zero, theTrack Reservation Parameter field is Reservation Size mode. Supporting of this mode is not mandatory for Incremental Streaming Writable Feature. When the Logical Block Address mode is availabe, the ARSV bit and the Current bit in Incremental Streaming Writable Feature Descriptor are set to one or the Current bit in Layer Jump recording Feature (0033h) Descriptor is set to one.The RMZ bit indicates the type of reservation and is shown in Table 532. The RMZ bit is valid only when the ARSV bit is set to 0b. For CD/DVD, the RMZ bit ***shall*** be set to 0b.

Table 532 - RMZ bit definition

Value	Definition
0b	Reserves Track/RZone
1b	Reserves U-RMZ

This command may work as immediate mode when the logical unit needs longer time to perform the track reservation.

The Track Reservation Parameter field contains the parameter to perform Track/RZone reservation as follows.

16.32.1 Address Mode Reservation

The Logical Block Address mode of Track Reservation Parameter is shown inTable 533.

Table 533 - Address Mode of the Track Reservation Parameter

Bit / Byte	7	6	5	4	3	2	1	0
2	(MSB) Logical Block Address							
3								
4								
5								(LSB)
6	Reserved							
7								
8								

The Logical Block Address field ***shall*** specify the start logical block address of new Invisible Logical Track. The logical unit ***shall*** reserve a reserved Logical Track to create the new Invisible Logical Track from specified logical block address. The reservation on Incomplete Track/RZone ***shall*** be allowed except Layer Jump recording mode of DVD-R Dual Layer disc and Fixed Packet mode (Method 2 Addressing) of CD. For thses cases, the incomplete logcial track ***shall*** be closed to perform Address Mode reservation. The Incomplete Track/RZone becomes an Reserved Track/RZone by the Logical Block Address mode reservation. The number of free blocks of the new reserved Track/RZone should be checked by READ TRACK/RZONE INFORMATION command. The address ***shall*** be the multiple of blocking factor shown by Blocking field of Random Readable Feature (0010h). When Blocking field is set to zero, Fixed Packet Size/ Blocking Factor field of Track/RZone Information Block ***shall*** be checked as blocking factor. If the specified address is not valid, the command ***shall*** be terminated with CHECK CONDITION status, 5/24/00 INVALID FIELD IN CDB.

16.32.2 Reservation Size Mode Reservation

The Reservation Size mode of Logical Track reservation parameter is shown inTable 534.

Table 534 - Reservation Size mode of the Track Reservation Parameter

Bit / Byte	7	6	5	4	3	2	1	0
2	Reserved							
3								
4								
5	(MSB) Reservation Size							
6								
7								
8								(LSB)

The Reservation Size field contains the number of user blocks desired for the Track/RZone reservation. The actual number of blocks allocated ***shall*** be according to the Write Parameters Mode Page. If size of the reserved Track/Rzone is larger than disc available space, the command ***shall*** be terminated with CHECK CONDITION status, 5/24/00 INVALID FIELD IN CDB.

Note: In case of logical unit that does not support Logical Block Address mode, when fourth byte of Logical Block Address field of Logical Track reservation parameter is set to non-zero value, the size of the reserved logical track becomes larger than available space. When the byte 3 is set to zero, the size of the reserved logical track becomes zero. Therefore legacy logical unit may not modify the disc information.

For both reservation mode, logical unit ***shall*** check following conditions.

For CD, the PMA start time ***shall*** reflect the appropriate pre-gap, as determined by the previous track's mode and the settings of the Write Parameters Mode Page.

For DVD, when the Write Type field of Write Parameters Mode Page is "Disc-at-once," the Reservation Size field is used to specify the actual size of user data to be transferred from host to the logical unit. When the Write Type field specifies "Incremental," the tail of reserved RZone is rounded up to ECC block unit and one ECC block length is added to the reserved RZone as a BSGA. Table 536 specifies the RZone reservation sizing.

For HD DVD, if the RMZ bit is set to 0b, the tail of reserved RZone is round up to ECC block unit. If the RMZ bit is set to 1b, the Reservation Size field ***shall*** be ignored and the logical unit ***shall*** reserve RMZ with 128 ECC blocks in size.

Table 535 - RZone/RMZ reservation sizing (HD DVD)

RMZ bit value	Reserved RZone/RMZ Size
0b	Reserves the number of user blocks specified. The Reserved RZone Size ***shall*** be *ReservedRZoneSize = 32 · Ceil(ReservationSize / 32)* where *ReservationSize* is the value specified in the CDB. Ceil (x) returns the least integer value greater than or equal to x.
1b	The *ReservedRMZSize = 1000h* (128 ECC blocks)

Table 536 - RZone reservation sizing (DVD)

Write Parameters Mode Page Write Type Value	Reserved RZone Size
Disc-at-once	Reserves the number of user blocks specified. The Reserved RZone Size ***shall*** be *ReservedRZoneSize = ReservationSize* where *ReservationSize* is the value specified in the CDB.
Incremental	Reserves the number of user blocks specified. The Reserved RZone Size ***shall*** be *ReservedRZoneSize = 16 · Ceil((ReservationSize + (NWA AND 0Fh)) / 16) - (NWA AND 0Fh) +16* [a] where *ReservationSize* is the value specified in the CDB. NWA is the Next Writable Address of the Invisible RZone, "AND" means mathematical AND, *+16* means BSGA. Ceil (x) returns the least integer value greater than or equal to x.

a. If the reservation size is equal to the remaining disc capacity, the BSGA ***shall not*** be added to the reserved RZone size.

Table 537 specifies the PMA stop time.

Table 537 - Track reservation sizing (CD)

Write Parameters Mode Page Write Type Value	PMA Stop Time
Session-at-once	Return CHECK CONDITION status, 5/2C/00 COMMAND SEQUENCE ERROR.
Track-at-once	Reserves the number of user blocks specified. The PMA stop time ***shall*** be *PMAStart* + *ReservationSize* + 2
Variable Packet	Reserve behaves as in track-at-once.
Fixed Packet	Set p = *ReservationSize/PacketSize* packets, where packet size is taken from the Write Parameters Mode Page. If p is an integer, then the reservation is performed and the PMA stop time ***shall*** be $PMAStart + (PacketSize + 7) \cdot p - 5$. Otherwise, the reservation is not performed and the logical unit returns CHECK CONDITION status, 5/24/00 INVALID FIELD IN CDB. Enough space for reservation size user data packets ***shall*** be reserved.

The Invisible Track/RZone is known to have Track/RZone number N+1 only because the Track/RZone number of the Track/RZone immediately preceding it has Track/RZone number N. Tracks/RZones ***shall*** only be reserved from the beginning of the invisible Track/RZone. Each Track/RZone prior to the invisible Track/RZone has a Track/RZone number defined in the RMA/PMA/RMZ. After the reservation is done, the Track/RZone number given to the new Track/RZone is the current Track/RZone number of the invisible Track/RZone. The number of the invisible Track/RZone is increased by one following a reservation.

For CD, if the Reservation Size or size of new Reserved Track of Address Mode is smaller than 298, excluding pre-gap length, the logical unit ***shall*** return CHECK CONDITION status, 5/24/00 INVALID FIELD IN CDB.

For DVD/HD DVD, if the Reservation Size field is set to 0, no reservation is done by logical unit and ***shall not*** be considered an error.

Reserving by the Reservation Size mode and reserving of Layer Jump recording mode by Address Mode ***shall*** be allowed when the last Track/RZone is Invisible. When the last Track/RZone is not Invisible, the logical unit ***shall*** generate CHECK CONDITION status, 5/2C/00 COMMAND SEQUENCE ERROR.

For CD, reserving a Track when the Write Type is set to Packet Writing ***shall*** cause the TDB (Track Descriptor Block) to be written.

For DVD/HD DVD, the maximum number of partially recorded reserved RZones is two[1]. Attempting to reserve RZone when two[1] RZones are already reserved but not fully recorded, the command ***shall*** be terminated with CHECK CONDITION status, 5/72/05 NO MORE RZONE RESERVATIONS ARE ALLOWED.

Because three RMD blocks are required for reservation, RZone closure and Border closure, attempting to reserve RZone when remaining ECC blocks in the RMA are less than three, the command ***shall*** be terminated with CHECK CONDITION status, 3/73/05 PROGRAM MEMORY AREA/RMA IS FULL.

For HD DVD, the Error reporting for the command with RMZ bit = 0 in each condition of the media is shown in Table 153 - *Error reporting for "RZone reservation" by using RESERVE TRACK/RZONE/RMZ command* on page 297.

For HD DVD, when the unrecorded ECC blocks in Current RMZ are equal to or less than 15 ECC blocks, a zone which consists of 128 ECC blocks can be reserved for the Extended RMZ in User data zone (U-RMZ). Attempting to extend U-RMZ when the unrecorded ECC blocks in Current RMZ are greater than 15 ECC blocks, the command with RMZ bit = 1 ***shall*** be terminated with CHECK CONDITION status, 5/72/06 RMZ EXTENSION IS NOT ALLOWED. See *5.13.12.5, "Error reporting for "RMZ extension by U-RMZ" by using RESERVE TRACK/RZONE/RMZ command"* on page 298.

1. For DVD-R Dual Layer disc, the maximum number of partially recorded reserved RZones is three.

Table 538 - RESERVE TRACK/RZONE/RMZ command errors

Error Description
A-1.1, "Deferred Error Reporting" on page 721
Table 630 - *Basic Error Codes* on page 730
Table 631 - *Media Access Error Codes* on page 733
Table 632 - *Write Error Codes* on page 736

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16.33 SCAN command

The SCAN command requests a fast-forward or fast-reverse scan operation starting from the Scan Starting Address. The command ***shall*** scan all the way to the end of the media (last audio track).

This command responds with immediate status, allowing overlapped commands. See also *B-9, "Immediate command processing considerations"* on page 744.

Table 539 - SCAN Command Descriptor Block

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation code (BAh)							
1	LUN (Obsolete)			DIRECT	Reserved			RelAdr
2	(MSB)							
3	Scan Starting Address							
4								
5								(LSB)
6	Reserved							
7	Reserved							
8	Reserved							
9	Type		Reserved					
10	Reserved							
11	Vendor-Specific		Reserved			NACA	Flag	Link

A Direction (DIRECT) bit of zero indicates a fast-forward. A DIRECT bit of one indicates a fast-reversed operation.

The Scan Starting Address specifies the address at which the Audio Fast Scan ***shall*** begin. The Type field determines the interpretation of the address.

Like the Audio Play commands, the SCAN command ***shall*** terminate the scan at the last audio track or upon receipt of the STOP PLAY/SCAN command. Upon receipt of the STOP PLAY/SCAN command the logical unit ***shall*** set the current address to the last address output during the SCAN command. Subsequent Audio Play commands ***shall*** cause the logical unit to begin playing at the location last output by the SCAN command. If the logical unit receives a PAUSE/RESUME command with the Resume bit clear, the logical unit ***shall*** pause. After that, if the logical unit receives a PAUSE/RESUME command with the Resume bit set, the logical unit ***shall*** resume audio play (note: not scan) from the address where the audio pause occurred. See Figure 172 - *Stop Play/Play Audio/Audio Scan/Pause/Resume Sequencing* on page 701 for additional information.

If the logical unit receives a SCAN command during play or pause, the logical unit ***shall*** stop play or pause and perform Scan.

Upon receipt of a READ SUBCHANNEL command during scan, the logical unit ***shall*** return an Audio Status of 11h (Audio Play operation in Progress).

If the logical unit receives a SCAN command during play or pause for which a valid stop address was specified, the logical unit will remember the stop address but ignore it during the SCAN command. The stop address becomes valid again when audio play resumes. Thus, upon resumption of audio play, if the current address is greater than the former stop address, the logical unit ***shall*** stop playing and return good status. After this, if the logical unit receives a READ SUBCHANNEL command, the logical unit ***shall*** return an Audio Status of 13h (Audio Play operation successfully completed).

If the logical unit reaches a data track, it ***shall*** stop scan.

Request to the implementer: *The following implementation of forward and reverse scan speed will provide good quality sound: Forward scan - [Play six CD-DA blocks and then jump 190* CD-DA blocks in the forward direction. Reverse*

scan - play six CD-DA blocks and then jump 150 CD-DA blocks (from the last block of the six) in the reverse direction.*
*This can be some fixed number between 150 and 200.

The Type field is defined in Table 540. This field specifies the "Type" of address contained in the Scan Starting Address field.

Table 540 - Type field

Type field	Definition
00b	Logical Block Address format
01b	AMIN, ASEC and AFRAME format
10b	Track Number (TNO) format
11b	Reserved

See *16.13.1, "PLAY AUDIO (10) with Immediate Packet commands"* on page 522 for information on overlapped commands during a SCAN operation.

Table 541 - Scan Starting Address in Logical Block Format

Bit / Byte	7	6	5	4	3	2	1	0
2	(MSB)							
3	Scan Starting Address							
4								
5								(LSB)

Table 542 - Scan Starting Address in AMIN, ASEC and AFRAME Format

Bit / Byte	7	6	5	4	3	2	1	0
2	Reserved							
3	CD-absolute time (AMIN)							
4	CD-absolute time (ASEC)							
5	CD-absolute time (AFRAME)							

The AMIN, ASEC and AFRAME fields specifies the relative running time from the beginning of the disc. The AMIN field has a range of 00 to 99d (63h). The ASEC ranges from 00 to 59d (3Bh). The AFRAME field has a range of 00 to 74d (4Ah). All MSF fields ***shall*** be Binary.

Table 543 - Scan Starting Address in Track Number (TNO) Format

Bit / Byte	7	6	5	4	3	2	1	0
2	Reserved							
3	Reserved							
4	Reserved							
5	Track Number (TNO)							

The Track Number field specifies the track in binary notation at which the scan operation will begin. This field has a range of 01h to 63h.

Table 544 - SCAN command errors

Error Description
A-1.1, "Deferred Error Reporting" on page 721
Table 630 - *Basic Error Codes* on page 730
Table 631 - *Media Access Error Codes* on page 733

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16.34 SEEK command

The SEEK command request that the logical unit seek to the specified logical block address. All Logical Block Addresses are valid targets for a seek operation, including a CD-DA audio sector. The content of the Sector at the specified LBA ***shall not*** affect the seek operation nor cause an error to be generated.

The SEEK command should be performed as an immediate command. The command should return completion status as soon as the seek operation has been started.

Table 545 - SEEK Command Descriptor Block

Byte \ Bit	7	6	5	4	3	2	1	0
0	Operation code (2Bh)							
1	LUN (Obsolete)			Reserved				
2	(MSB) Logical Block Address							
3								
4								
5								(LSB)
6	Reserved							
7	Reserved							
8	Reserved							
9	Vendor-Specific		Reserved			NACA	Flag	Link
10	PAD							
11								

The Logical Block Address field specifies the destination of the SEEK command.

Table 546 - SEEK command errors

Error Description
A-1.1, "Deferred Error Reporting" on page 721
Table 630 - *Basic Error Codes* on page 730
Table 631 - *Media Access Error Codes* on page 733

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16.35 SEND CUE SHEET command

A Session-at-once recording is written beginning with the Lead-in and continuing through the Lead-out. Only user data will be sent with the write commands, so a guide structure is required by the CD-R/RW logical unit in order to control the recording process. This guide structure is called the cue sheet. The cue sheet is constructed in the host and sent to the logical unit.

Table 547 - SEND CUE SHEET Command Descriptor Block

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation code (5Dh)							
1	LUN (Obsolete)			Reserved				
2	Reserved							
3	Reserved							
4	Reserved							
5	Reserved							
6	(MSB)							
7	Cue Sheet Size							
8								(LSB)
9	Vendor-Specific		Reserved			NACA	Flag	Link
10	PAD							
11								

The Cue Sheet Size parameter is the number of bytes in the cue sheet to be sent to the logical unit. The entire cue sheet ***shall*** be received by the logical unit prior to beginning the write process. If the logical unit cannot accept and buffer the entire cue sheet, then the logical unit ***shall*** return CHECK CONDITION Status, 5/24/00 INVALID FIELD IN CDB.

If the Write Parameters Mode Page does not have Write Type set to Session-at-once, then the logical unit ***shall*** return CHECK CONDITION Status, 5/2C/00 COMMAND SEQUENCE ERROR.

If the Write Type in the Write Parameters Mode Page is changed from session at once, the cue sheet may be lost.

16.35.1 CUE SHEET FORMAT

The Cue Sheet contains information required to specify the layout of a disc to be written, and ***shall*** be sent to the logical unit via the SEND CUE SHEET command before writing data to the disc.

Table 548 - Cue Sheet Format

Byte Number	Cue Sheet Data
0	Mixture of Information of absolute disc location, catalogue code and ISRC (Total M lines)
...	
(M-1) * 8	

If the Catalogue Code is to be recorded, it ***shall*** be described at the beginning of the Cue sheet.

If the ISRC is to be recorded, it ***shall*** be described immediately preceding each Track's information in the Cue Sheet.

For the Cue sheet, the Lead-out start time ***shall*** be the last entry.

16.35.2 Information of the absolute disc location

The logical unit writes a disc according to this information. This information defines the following parameters:

1. Generation of Sub-channel P and Q channel.
2. Format and block size of the data transferred by the WRITE (10) command

Table 549 - Sample Cue Sheet

Byte Number	Ctl/Adr	TNO	Index	Data Form	SCMS	Absolute Time		
(hex)	(hex)	(hex)	(hex)	(hex)	(hex)	Min	Sec	Frame
00 (Lead-in)	01[a]	00	00[b]	01[a]	00	00[b]	00[b]	00[b]
08 (TNO:01)[c]	01	01	00	01	00	00	02	00
18 (TNO:02)	01	02	00	C0	00	07	29	71
20 (TNO:02)	01	02	01	C0	00	07	31	71
28 (TNO:03)	01	03	01	C0	00	14	18	03
30 (TNO:04)[d]	41	04	00	10	00	19	06	62
38 (TNO:04)	41	04	01	10	00	19	09	62
40 (TNO:05)[d]	41	05	00	11	00	27	37	10
48 (TNO:05)	41	05	01	10	00	27	40	10
50 (TNO:06)	01	06	00	01	80[e]	38	53	23
58 (TNO:06)	01	06	01	00	80[e]	38	55	23
60 (Lead-out)	01[a]	AA	01[f]	01[a]	00	56	37	46

a. For the Lead-in and Lead-out Area the DATA FORM ***shall*** be one. For Lead-in, data form and control mode of the first track is specified. For Lead-out, data form and control mode of last track is specified automatically. All data for both Lead-in and Lead-out ***shall*** be generated by the logical unit.
b. Always zero for Lead-in.
c. The first information track on a disc is preceded by a pause encoding of 2-3 seconds. (If the first track is a Data track, this track does not contain pause encoding, but always contains a "pause" of 2 seconds of pre-gap).
d. Pre-gap
e. Copy
f. Always 01h for Lead-out

This information is composed of data units of 8 bytes (1 line). The information consists of three parts:

1. The Lead-in Area, which contains exactly one data unit.
2. The Program area, which contains one or more data units.
3. The Lead-out Area, which contains exactly one data unit.

The data units in Program Area and Lead-out Area are in Absolute Time order from the start time of index = 0 of the first track of the session.

Each data unit of Program area and Lead-out Area indicates that the value of each field (CONTROL, TNO, X, DATA FORM or ZERO) changes at the time shown in ABSOLUTE TIME field.

Table 550 - CUE Sheet Data

Ctl/Adr (hex)	TNO (hex)	Index (hex)	Data Form (hex)	SCMS (hex)	Absolute Time		
					Min	Sec	Frame
01	02	01	C0	00	07	31	71
01	03	01	C0	00	14	18	03

The above data unit indicates that the value of TNO changes from 02 to 03 when ABSOLUTE TIME is 14/18/03 MSF.

16.35.2.1 Control/Address Field

The CTL/ADR byte contains the Control field in the upper 4 bits and the ADR in the lower 4 bits. See Table 551.

Table 551 - CTL/ADR Byte

7	6	5	4	3	2	1	0
CTL Field				ADR Field			

16.35.2.2 CTL Field (upper 4 bits)

The CTL (Control) field contains 4 bits that define the kind of information in a track. See Table 552.

Table 552 - Control Field

Bit 7	Bit 6	Bit 5	Bit 4	Definition
0	0	x	0	2 audio channels without pre-emphasis
1	0	x	0	4 audio channels without pre-emphasis
0	0	x	1	2 audio channels with pre-emphasis of 50/15 µs.
1	0	x	1	4 audio channels with pre-emphasis of 50/15 µs.
0	1	x	0	Data track
x	x	0	x	digital copy prohibited
x	x	1	x	digital copy permitted

The bits of the Control field (except for the copy bit) ***shall*** only be changed during an actual pause (Index = 00) of at least 2 seconds and during Lead-in Area.

16.35.2.3 ADR Field (lower 4 bits)

Table 553 defines the codes found in the ADR Field.

Table 553 - ADR Field

Bit 3	Bit 2	Bit 1	Bit 0	Definition
0	0	0	1	start time at TNO/IDX
0	0	1	0	CATALOG CODE
0	0	1	1	ISRC CODE

All other codes are reserved for future use.

Control ***shall*** be the same for each entry associated with a particular track except for first part of pre-gap.

16.35.2.4 TNO

The TNO field indicates track number expressed in HEX. Each track has a minimum length of 4 seconds, not including the pause length preceding the track.

16.35.2.5 INDEX Field

The index number expressed in HEX. The logical unit supports only 00h - 63h.

16.35.2.6 DATA FORM

The following table defines the data form byte.

Table 554 - Data Form Byte

7	6	5	4	3	2	1	0
Data Form of Sub-channel		Data Form of Main Data					

16.35.2.7 SCMS (Serial Copy Management System)

Bit 7 of data form of 1 indicates that Copy bit of CONTROL field alternates for Serial Copy Management System (see Table 555). The other 7 bits (Reserved) are zero. This bit is effective if Copy bit of the Control Code is zero.

Table 555 - SCMS Byte

7	6	5	4	3	2	1	0
Alternate Copy bit	Reserved						

16.35.2.8 DATA FORM OF MAIN DATA

The DATA FORM OF MAIN DATA field specifies the format of the main data to be sent by a WRITE command to write on the disc. Currently available data formats are 1.) CD-DA, 2.) CD-ROM mode 1, 3.) CD-ROM XA and CD-I. For Lead-in and Lead-out Area data are generated automatically.

16.35.2.9 CD-DA Data Form

The Table 556 defines a CD-DA Data Form for one frame.

Table 556 - CD-DA Data Form

Data Form	Data of One Frame	Data Size
00h	2352	2352
01h	2352	0

The CD-DA data format, is as follows:

Table 557 - CD-DA Data format (1 Sample)

Bit / Byte	7	6	5	4	3	2	1	0
n*4+0 (L ch)	L7	L6	L5	L4	L3	L2	L1	L0
n*4+1 (L ch)	L15	L14	L13	L12	L11	L10	L9	L8
n*4+2 (R ch)	R7	R6	R5	R4	R3	R2	R1	R0
n*4+3 (R ch)	R15	R14	R13	R12	R11	R10	R9	R8

n = 0,1, .. ,587

1 Second = 75 Frames
1 Frame = 588 Samples
1 Sample = 4 bytes (16 bits L, R ch)

16.35.2.10 CD-ROM mode 1 Form

The Table 558 defines the form for CD-ROM mode 1.

Table 558 - CD-ROM Mode 1

Data Form	Sync/ Header	Data of One Frame	EDC/ECC Area	Data Size
10h	16 *2	2048 *1	288 *2	2048
11h	16 *3	2048 *1	288 *3	2352
12h	16 *2	2048 *3	288 *2	2048
13h	16 *3	2048 *3	288 *3	2352
14h	16 *2	2048 *2	288 *2	0

16.35.2.11 CD-ROM XA, CD-I Form

The Table 559 defines the form for CD-ROM XA, CD-I.

Table 559 - CD-ROM XA, CD-I

Data Form		Sync/ Header	Sub Header	Data of One Frame	EDC/ECC Area	Data Size
20h	Form 1	16 *2	8 *1	2048 *1	280 *3	2336
	Form 2	16 *2	8 *1	2324 *1	4 *3	2336
21h	Form 1	16 *3	8 *1	2048 *1	280 *3	2352
	Form 2	16 *3	8 *1	2324 *1	4 *3	2352
22h	Form 1	16 *2	8 *1	2048 *3	280 *3	2336
	Form 2	16 *2	8 *1	2324 *3	4 *3	2336
23h	Form 1	16 *3	8 *1	2048 *3	280 *3	2352
	Form 2	16 *3	8 *1	2324 *3	4 *3	2352
24h	Form 1	NA	NA	NA	NA	NA
	Form 2	16 *2	8 *2	2324 *2	4 *2	0

Reserved Area: The Reserved Area contains 4 bytes that are reserved for quality control during the disc production process. In case of Generate Zero, the logical unit generates zero data of 4 bytes for this area.

16.35.2.12 CD-ROM mode 2

The Table 560 defines the form for CD-ROM mode 2.

Table 560 - CD-ROM Mode 2

Data Form	Sync/ Header	Data of One Frame	Data Size
30h	16 *2	2336 *1	2336
31h	16 *3	2336 *1	2352
32h	16 *2	2336 *3	2336
33h	16 *3	2336 *3	2352
34h	16 *2	2336 *2	0

Notes for all forms:

1. Read Buffer: The data is sent by the initiator.
2. Generate Data: The logical unit generates the data in this area. The host ***shall not*** send the data for this area. All sectors in the program area ***shall*** have an associated write, even if all data for the sector is to be generated by the logical unit. Zero bytes ***shall*** be transferred for such sectors.
3. Ignore Buffer: The logical unit receives the data for this area from the initiator with WRITE (10) command. However, the logical unit ignores the data and generates data for this area.

16.35.3 Data Form of Sub-Channel

The DATA FORM OF SUB-CHANNEL (Table 561) field specifies the format of the sub-channel data stored in the inner buffer by WRITE (10) command to write on the disc.

Table 561 - Data Form of Sub-channel

Data Form		Data of One Frame				Data Size
Bit 7	Bit 6					
0	0	96[a]				0
0	1	96[b]				96
1	0	Reserved				
1	1	24 Pack[c]	24 Pack[c]	24 Pack[c]	24 Pack[c]	96

a. Generate zero data
b. RAW Data
c. PACK DATA, Initiator sends packed data. The logical unit writes R-W. The logical unit calculates and overwrites ECC, and performs Interleaving for each PACK.

The Sub-channel data is placed at the end of each Frame of main data. Figure 171 shows the relationship of Main Data and sub-channel data.

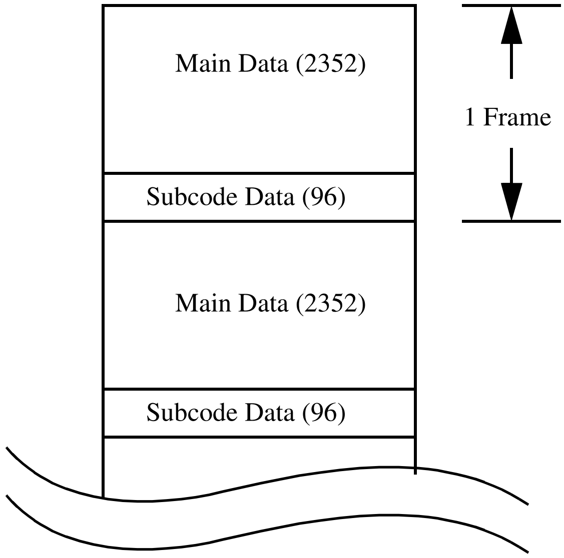

Figure 171 - Location of Sub-channel Data

The P and Q sub-channel information contained within the Subcode Data ***shall*** be ignored. The P and Q sub-channel information is generated by the logical unit and based on the content of the cue sheet.

16.35.4 Absolute Time

The time shown at Min, Sec, and Frame gives the changing point of the CONTROL, TNO, X, DATA FORM or SCMS field. These values are given in absolute time scale.

16.35.5 Session Format

The Session Format is used for the identification of the type of disc. See Table 362 - *Session Format codes* on page 517.

16.35.6 Pre-gap

If a Data track is preceded by a different mode of track (such as an audio track) or if the mode number of CD-ROM changes, this Data track starts with an extended pre-gap. A pre-gap is placed at the head of a Data track, also is belonging to the Data track. A pre-gap does not contain actual user data. The pre-gap is encoded as “pause.”

An extended pre-gap is divided into two parts. The first part of the extended pre-gap has a minimum 1 second of data, and it is encoded according to the data structure of previous track. The second part has a minimum 2 seconds data, and this data track is encoded according to the same data structure as the other parts.

16.35.7 Post-gap

If a Data track is followed by another kind of track (such as an audio track), this Data track ends with a post-gap. A post-gap is placed at the end of a Data track, and is part of the Data Track. A post-gap does not contain actual user data. The minimum length of post-gap is 2 seconds. The logical unit does not perform any action for a Post-gap.

16.35.8 Catalog Number

The Catalog Number, indicates the catalog number of a disc. The number uses UPC/EAN-code (BAR coding). If no catalog number is used, it ***shall*** be omitted. The format is as follows;

Table 562 - Catalog Number (N1..N13)

CTL/ ADR	Catalog Number						
Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
02h	N1	N2	N3	N4	N5	N6	N7
02h	N8	N9	N10	N11	N12	N13	00h

N1-N13: Catalog Number

CTL: 4 bits are zero.

ADR: 0010b

Catalog Number: ASCII 13 BYTES

16.35.9 ISRC

Table 563, ISRC (International Standard Recording Code), is a code that is given to CD-DA tracks. If no ISRC is used, it ***shall*** be omitted. If a track has no ISRC, it is not written in the Cue Sheet.

Table 563 - ISRC (I1..I12)

CTL/ ADR	ISRC (International Standard Recording Code)						
byte 0	byte 1	byte 2	byte 3	byte 4	byte 5	byte 6	byte 7
x3h	TNO	I1	I2	I3	I4	I5	I6
x3h	TNO	I7	I8	I9	I10	I11	I12

CTL: 4 bits of Control code are the same as that of disc location of the specified track

ADR: 0011b

TNO: Track number in HEX.

12 letters ISRC (On the Cue Sheet, I1-I12 ***shall*** be described by valid ASCII characters. See Table 474 - *ISRC Format of Data Returned to host* on page 600 for valid codes.
I1-I2: Country Code
I3-I5 Owner Code
I6-I7 Year of recording
I8-I12 Serial Number

Table 564 - SEND CUE SHEET command errors

Error Description
A-1.1, "Deferred Error Reporting" on page 721
Table 630 - *Basic Error Codes* on page 730
Table 631 - *Media Access Error Codes* on page 733
Table 632 - *Write Error Codes* on page 736

16.36 SEND DISC STRUCTURE command

The SEND DISC STRUCTURE command provides a means for the host to transfer disc structure data to the logical unit.

Table 565 - SEND DISC STRUCTURE Command Descriptor Block

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation code (BFh)							
1	LUN			Reserved	Sub-command (= 0000b)			
2	Reserved							
3	Reserved							
4	Reserved							
5	Reserved							
6	Reserved							
7	Format Code							
8	(MSB)			Parameter List Length				
9								(LSB)
10	Reserved							
11	Vendor-Specific		Reserved			NACA	Flag	Link

The Sub-command (= 0000b) field indicates the type of command definition to expand this command for other media type than DVD/HD DVD. This value ***shall*** be set to 0000b for DVD/HD DVD media.

Table 566 - Sub-command field definition

Sub-command	Media Type
0000b	DVD-ROM, DVD-RAM, DVD-R, DVD-RW, DVD+RW, DVD+R, HD DVD-ROM, HD DVD-R, and HD DVD-Rewritable media
0001b	BD-RE, BD-R, BD-ROM media (See MMC)
Others	Reserved

The Format Code field indicates the type of information that is requested to be sent to the logical unit. When a SEND DISC STRUCTURE command is issued for media that is not supported by the Sub-command field, with Format Code codes 00h - BFh, this command ***shall*** be terminated with CHECK CONDITION Status, 5/30/05 CANNOT WRITE MEDIUM - INCOMPATIBLE FORMAT. When the logical unit and medium combination does not support specified Format Code code, this command ***shall*** be terminated with CHECK CONDITION Status, 5/24/00 INVALID FIELD IN CDB.

Table 567 - Format Code definitions for SEND DISC STRUCTURE command

Format Code	Data to be sent to logical unit	Applicable media type	Description
00h-03h	Reserved	Reserved	
04h	User Specific Data	DVD-R/-RW/ HD DVD-R	Send User Specific Data to the RMD cache
05h	Copyright Management	DVD-R/-RW	Send data to CPR_MAI in Data Area cache. (CPM, CGMS, ADP_TY)

Table 567 - Format Code definitions for SEND DISC STRUCTURE command

Format Code	Data to be sent to logical unit	Applicable media type	Description
06h-0Eh	Reserved	Reserved	
0Fh	Timestamp	DVD-R/-RW/ HD DVD-R	Send Timestamp data to the RMD cache
10h-1Fh	Reserved	Reserved	
20h	Layer Boundary Information	DVD-R DL/ DVD+R DL	Send capacity of L0
21h	Shifted Middle Area Start Address	DVD-R DL	Send start logical block address of Shifted Middle Area on L0
22h	Jump Interval size	DVD-R DL	Send Jump Interval size of Regular Interval Layer Jump recording
23h	Manual Layer Jump Address	DVD-R DL	Send logical block address for Layer Jump on L0
24h	Remapping Address	DVD-R DL	Send logical block address for remapping Anchor Point
25h-2Fh	Reserved	Reserved	
30h	Disc Control Block	DVD+R/+RW	Send a Disc Control Block
31h-BFh	Reserved	Reserved	
C0h	Write Protection	DVD-RW	Send PWP status
C1h-FFh	Reserved	Reserved	

A DVD-R/HD DVD-R logical unit ***shall*** implement cache memory for the DISC STRUCTURE data defined in Section 16.36.1 through *Section 16.36.9, "Write Protection (Format Code = C0h)"* on page 678.

The cached RMD can be read by using the READ DISC STRUCTURE command.

The Parameter List Length field specifies the length in bytes of the DISC STRUCTURE data that ***shall*** be transferred from the host to the logical unit after the Command Packet is transferred. A Parameter List Length field of zero indicates that no data ***shall*** be transferred. This condition ***shall not*** be considered an error.

16.36.1 User Specific Data (Format Code = 04h)

Table 568 - SEND DISC STRUCTURE Data Format (With Format Code = 04h)

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB)			Structure Data Length				
1								(LSB)
2				Reserved				
3				Reserved				
DVD-R/HD DVD-R User Specific Data								
0-N	(MSB)			User Specific Data				(LSB)

The Structure Data Length field specifies the number of bytes that follow the Structure Data Length field.

The User Specific Data field contains user specific data. This data ***shall*** be used to specify the RMD Field 2, and when writing of Lead-in or Border-in occurs, the contents of this field ***shall*** also be written in Disc manufacturing information field of Lead-in or Border-in.

16.36.2 Copyright Management Information (Format Code = 05h)

Table 569 - SEND DISC STRUCTURE Data Format (With Format Code = 05h)

Byte \ Bit	7	6	5	4	3	2	1	0
0	(MSB)	Structure Data Length						
1								(LSB)
2	Reserved							
3	Reserved							
Copyright Management Information in Data Area								
0	CPR_MAI							
1	Reserved							
2								
3								

The Structure Data Length field specifies the number of bytes that follow the Structure Data Length field.

The sector written in the Data Area ***shall*** reflect the values in Table 569 for the copyright management information field of the sector.

The definition of the CPR_MAI field depends on the mounted media. The CPR_MAI field definition is shown in Table 570.

Table 570 - CPR_MAI field definition

Media \ Bit	7	6	5	4	3	2	1	0
R Ver.1.0/ RW Ver.1.0	CPM	Reserved	CGMS		Reserved			
R for Authoring Ver.2.0/ RAM Ver.2.1	Reserved							
R for General Ver.2.1/ RW Ver.1.2	Reserved				ADP_TY		Reserved	

If the CPM bit is set to 0, ***shall*** indicate that this sector contains no copyrighted material. If the CPM bit is set to 1, ***shall*** indicate that this sector contains copyrighted material. If this structure is not sent, the default value of the CPM bit ***shall*** be 0.

When the CPM bit is set to 0, the CGMS field ***shall*** be set to 00b. When the CPM bit is set to 1, the CGMS field ***shall*** be set as shown in Table 571.

Table 571 - CGMS field values

CGMS	Definition
00b	Copying is permitted without restriction
01b	Reserved
10b	One generation of copies may be made
11b	No copying is permitted

The identical CGMS value of CPR_MAI in Data Area ***shall*** match with this format following write operation.

The ADP_TY field is defined only for DVD-RW Ver.1.2 and DVD-R for General Ver. 2.1 media. If the sector contains materials defined in DVD Specifications for Read-Only Disc Part 3 VIDEO SPECIFICATIONS, the ADP_TY field ***shall*** be set to 01b. If the sector contains no such data, ADP_TY field ***shall*** be set to 00b. All other values of ADP_TY are reserved.

Note: A value of each field may not be stable at the first and last 16 sectors of each recording extent due to the nature of recording method for DVD-R/-RW media.

16.36.3 Timestamp (Format Code = 0Fh)

Table 572 - SEND DISC STRUCTURE Data Format (With Format Code = 0Fh)

Byte \ Bit	7	6	5	4	3	2	1	0
0	(MSB)			Structure Data Length				
1								(LSB)
2				Reserved				
3				Reserved				
DVD/HD DVD Timestamp Data								
0-1				Reserved				
2-3				Reserved				
4-7	(MSB)			Year				(LSB)
8-9	(MSB)			Month				(LSB)
10-11	(MSB)			Day				(LSB)
12-13	(MSB)			Hour				(LSB)
14-15	(MSB)			Minute				(LSB)
16-17	(MSB)			Second				(LSB)

The Structure Data Length field specifies the number of bytes that follow the Structure Data Length field.

The Timestamp data ***shall*** be used to specify the Structure Data Length field of the RMD Field 0.

The Timestamp data may also be used in the OPC related field in the RMD Field 1 and may help the judgement to do OPC.

The time value of the Timestamp data should be current UTC (Universal Coordinated Time) 24 hour clock.

The Year field ***shall*** specify the year which coded as ASCII in the range “0001” to “9999”.

The Month field ***shall*** specify the month of the year which coded as ASCII in the range “01” to “12”.

The Day field ***shall*** specify the day of the month which coded as ASCII in the range “01” to “31”.

The Hour field ***shall*** specify the hour of the day which coded as ASCII in the range “00” to “23”.

The Minute field ***shall*** specify the minute of the hour which coded as ASCII in the range “00” to “59”.

The Second field ***shall*** specify the second of the minute which coded as ASCII in the range “00” to “59”.

16.36.4 Layer Boundary Information (Format Code = 20h)

This format does not work for DVD-R Dual Layer disc Ver. 3.0. When the logical unit loads DVD-R Dual Layer disc Ver. 3.0, this command ***shall*** be terminated with CHECK CONDITION Status, 5/24/00 INVALID FIELD IN CDB.

Table 573 - SEND DISC STRUCTURE Data Format (With Format Code = 20h)

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB)			Structure Data Length				
1								(LSB)
2	Reserved							
3	Reserved							
Layer Boundary Information								
0-3	Reserved							
4-7	(MSB)			L0 Data Area Capacity				(LSB)

The Structure Data Length field specifies the number of bytes that follow the Structure Data Length field.

The L0 Data Area Capacity field ***shall*** specify the Data Area capacity on L0 in logical block. The value ***shall*** be greater than zero. The last LBA of Data Area on L0 is L0 Data Area Capacity - 1.

If the value of L0 Data Area Capacity field is not an integral multiple of 16, the value ***shall*** be rounded up to the next integral multiple of 16. If the rounded L0 Data Area Capacity value is greater than available capacity on L0, the command ***shall*** be terminated with CHECK CONDITION status and sense bytes SK/ASC/ASCQ ***shall*** be set to ILLEGAL REQUEST/INVALID FIELD IN PARAMETER BLOCK. If Data Area capacity has already been established by a previous SEND DISC STRUCTURE command with Format Code = 20h, the command ***shall*** be terminated with CHECK CONDITION status and sense bytes SK/ASC/ASCQ ***shall*** be set to ILLEGAL REQUEST/INVALID FIELD IN PARAMETER BLOCK.

16.36.5 Shifted Middle Area Start Address (Format Code = 21h)

Table 574 - SEND DISC STRUCTURE Data Format (With Format Code = 21h)

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB)			Structure Data Length				
1								(LSB)
2	Reserved							
3	Reserved							
Shifted Middle Area Information								
0-3	Reserved							
4-7	(MSB)			Shifted Middle Area Start Address				(LSB)

The Structure Data Length field specifies the number of bytes that follow the Structure Data Length field.

The Shifted Middle Area Start Address field ***shall*** specify the start Logical Block Address of the Shifted Middle Area on L0. This value ***shall*** be:

- multiple of the Blocking factor, and
- located in the unrecorded area of Invisible/Incomplete RZone, and
- larger than or equal to the LBA on L0 that is corresponding to the end LBA on L1, and
- less than or equal to the end LBA on L0 - AC10h only if the logical unit allocates the flexible ODTA (Outer Disc Testing Area).

Once this value has been set, the value is not changeable. The outer radius area beyond the Shifted Middle Area becomes unusable for user data. Therefore the number of free blocks is decreased. If the specified value is not correct or has been set, this command ***shall*** be terminated with CHECK CONDITION Status, 5/26/00 INVALID FIELD IN PARAMETER LIST. See *4.17.10.5, "Disc-at-Once like way"* on page 194.

16.36.6 Jump Interval size (Format Code = 22h)

Table 575 - SEND DISC STRUCTURE Data Format (With Format Code = 22h)

Byte \ Bit	7	6	5	4	3	2	1	0
0	(MSB)			Structure Data Length				
1								(LSB)
2				Reserved				
3				Reserved				
Jump Interval size Information								
0-3				Reserved				
4-7	(MSB)			Jump Interval size				(LSB)

The Structure Data Length field specifies the number of bytes that follow the Structure Data Length field.

The Jump Interval size field ***shall*** specify the Jump Interval size of the Regular Interval Layer Jump recording of Invisible RZone by number of sectors. The number of sectors ***shall*** be multiple of Blocking Factor specified by the Fixed Packet Size/ Blocking Factor field of Table 495 - *Track/RZone Information Block* on page 619. If the value is not multiple of Blocking Factor, the value is not correct value, the size has been set to the Invisible RZone, or Manual Layer Jump has been set to the Invisible RZone, this command ***shall*** be terminated with CHECK CONDITION Status, 5/26/00 INVALID FIELD IN PARAMETER LIST. See *4.17.7.3, "Regular Interval Layer Jump"* on page 179.

16.36.7 Manual Layer Jump Address (Format Code = 23h)

Table 576 - SEND DISC STRUCTURE Data Format (With Format Code = 23h)

Byte \ Bit	7	6	5	4	3	2	1	0
0	(MSB)			Structure Data Length				
1								(LSB)
2				Reserved				
3				Reserved				
Manual Layer Jump Address								
0-3				Reserved				
4-7	(MSB)			Layer Jump Logical Block Address				(LSB)

The Structure Data Length field specifies the number of bytes that follow the Structure Data Length field.

The Layer Jump Logical Block Address field ***shall*** specify the logical block address that cause Layer jump of NWA from L0 to Layer 1 after the sector of the logical block address is written. The logical block address ***shall*** be the last sector number of an ECC block.

If the corresponding address on Layer 1 of the Layer Jump Address on L0 is not available for recording (i.e., Out of range of the RZone) or has been set, this command ***shall*** be terminated with CHECK CONDITION Status, 5/26/00 INVALID FIELD IN PARAMETER LIST. See *4.17.7.2, "Manual Layer Jump"* on page 177.

16.36.8 Remapping Address (Format Code = 24h)

Table 577 - SEND DISC STRUCTURE Data Format (With Format Code = 24h)

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB)			Structure Data Length				
1								(LSB)
2				Reserved				
3				Reserved				
				Remapping Address				
0	(MSB)			Anchor Point Number				
1								(LSB)
2-3				Reserved				
4-7	(MSB)			Remapping Address				(LSB)

The Structure Data Length field specifies the number of bytes that follow the Structure Data Length field.

The Anchor Point Number field ***shall*** specify the number of Anchor Point that is reassigned. In the case of DVD-R Dual Layer Ver. 3.0 disc, the number ***shall*** be one of 1, 2, 3, and 4.

The Remapping Address field ***shall*** specify the logical block address that is used to reassign the Anchor Point block specified by Anchor Point Number field. The logical block address ***shall*** be multiple of Blocking Factor specified by the Fixed Packet Size/ Blocking Factor field of Table 495 - *Track/RZone Information Block* on page 619. If the value is not multiple of Blocking Factor or is not correct value, this command ***shall*** be terminated with CHECK CONDITION Status, 5/26/00 INVALID FIELD IN PARAMETER LIST. Logical unit ***shall*** check the ECC block that are specified by Anchor Point Number filed and Remapping Address field has been written. If the ECC block is not written, this command ***shall*** be terminated with CHECK CONDITION Status, 5/26/00 INVALID FIELD IN PARAMETER LIST. See *4.17.10.1, "AP remap operation"* on page 193.

Note: Logical unit needs not check the validity of Remapping Address. Even if the address specify Border Zone or Clearance, logical unit may not report any error.

16.36.9 Write Protection (Format Code = C0h)

Table 578 - SEND DISC STRUCTURE Data Format (With Format Code = C0h)

Byte \ Bit	7	6	5	4	3	2	1	0
0	(MSB) Structure Data Length							
1								(LSB)
2	Reserved							
3	Reserved							
Write Protection Data								
0	Reserved						PWP	Reserved
1	Reserved							
2	Reserved							
3	Reserved							

The Structure Data Length field ***shall*** indicate the number of bytes following this field.

The Persistent Write Protection (PWP) bit of one indicates that the medium surface ***shall*** be set to write protected status. The PWP bit of zero indicates that the medium surface ***shall*** be set to write permitted status.

Table 579 describes errors that may occur during the operation of the command or which may cause a CHECK CONDITION status to be reported.

Table 579 - SEND DISC STRUCTURE command errors

Error Description
A-1.1, "Deferred Error Reporting" on page 721
Table 630 - *Basic Error Codes* on page 730
Table 631 - *Media Access Error Codes* on page 733
Table 632 - *Write Error Codes* on page 736

16.37 SEND EVENT command

The SEND EVENT command requests the logical unit to process an event for the host. The Event should be one that the host had received from an earlier GET EVENT/STATUS NOTIFICATION command but not handled by the host.

If a logical unit has received a persistent prevent, it will report events via the GET EVENT/STATUS NOTIFICATION command instead of processing them directly. For example if a user pushes an independent play button on the front panel while the logical unit is in a Persistent Prevent state, the play would not be performed and instead the request ***shall*** be reported to the host by a GET EVENT/STATUS NOTIFICATION command. Such events may include front panel button presses, etc. When such a request is received by the host, it should complete any operations in progress and process the event by emulating the button's functionality via commands or sending the event back to the logical unit using the SEND EVENT command.

The Media Status Class Events reported to the host ***shall not*** be sent back to the logical unit using the SEND EVENT command. Only Events of Class External Request (Class 3) ***shall*** be sent via the SEND EVENT command.

Table 580 - SEND EVENT Command Descriptor Block

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation code (A2h)							
1	LUN (Obsolete)			Reserved				Immed
2	Reserved							
3	Reserved							
4	Reserved							
5	Reserved							
6	Reserved							
7	Reserved							
8	(MSB) Parameter List Length							
9								(LSB)
10	Reserved							
11	Vendor-Specific		Reserved			NACA	Flag	Link

An immediate (Immed) bit of zero ***shall*** indicate that the command ***shall not*** complete until the requested operation is complete. An Immed bit of one indicates that status ***shall*** be returned as soon as the Command Packet has been validated. The actual operation specified by the Event Parameter ***shall*** be processed after the status has been reported to the host. The Immed bit ***shall*** be set to 1 for ATAPI logical units.

The Parameter List Length field specifies the length in bytes of the Event parameter list that ***shall*** be transferred from the host to the logical unit after the Command Packet is transferred. A Parameter List Length of zero indicates that no data ***shall*** be transferred. This condition ***shall not*** be considered as an error.

If the Event parameter list length results in the truncation of Event parameter data, the logical unit ***shall*** terminate the command with CHECK CONDITION Status, 5/1A/00 PARAMETER LIST LENGTH ERROR.

The logical unit ***shall*** terminate the command with CHECK CONDITION Status, 5/26/00 INVALID FIELD IN PARAMETER LIST, and ***shall not*** take any action directed by the event specified for the following conditions:

1. If the host sets any unreserved field in the Event parameter header to an unsupported value.
2. If an host sends an Event parameter list with a Event Data Length not equal to the length returned by the GET EVENT/STATUS NOTIFICATION command for the specified event class.
3. If the host sends an invalid value for any Event parameter.

The Parameter List ***shall*** consist of an Event Parameter Header followed by an External Request Event Descriptor. See Table 272 - *Notification Status List* on page 454 for the Parameter List layout, Table 273 - *Event Header* on page 455 for the Event Status Header format, and *16.5.3, "External Request Class Events"* on page 457 for a description of the External Request Class Descriptor.

No more than one External Request Event Descriptor ***shall*** be sent by the host.

Table 581 - SEND EVENT command errors

Error Description
A-1.1, "Deferred Error Reporting" on page 721
Table 630 - *Basic Error Codes* on page 730

16.38 SEND KEY command

The SEND KEY command provides data necessary for authentication process. Different type of authentication process and key exchange may be classified by different Key Class. When the Key Class is different, definitions of the rest of Command Descriptor Block may be different. Currently the following Key Classes are assigned.

Table 582 - Key Class definitions

Key Class	Authentication Type
00h	DVD CSS/CPPM or CPRM
01h	Rewritable Security Services-A
02h	AACS
03h-1Fh	Reserved
20h	VCPS (See MMC)
21h-FFh	Reserved

16.38.1 SEND KEY command for DVD CSS/CPPM or CPRM (Key Class = 00h)

The SEND KEY command with Key Class = 00h is used for DVD CSS/CPPM authentication process and CPRM authentication process. The SEND KEY command with Key Class = 00h provides data necessary for authentication and for generating a Bus Key for the DVD logical unit.

This command, in conjunction with REPORT KEY command, is intended to perform authentication for logical units which conform to DVD content protection scheme and to generate a Bus Key as the result of authentication.

Note: DVD CSS/CPPM and CPRM authentication use the same Key Class field value since they have the same Challenge KEY, KEY1, and KEY2 sizes, and since they are licensed through the same entity.

Table 583 - SEND KEY Command Descriptor Block (Key Class = 00h)

<table>
<tr><th>Bit
Byte</th><th>7</th><th>6</th><th>5</th><th>4</th><th>3</th><th>2</th><th>1</th><th>0</th></tr>
<tr><td>0</td><td colspan="8">Operation code (A3h)</td></tr>
<tr><td>1</td><td colspan="3">LUN (Obsolete)</td><td colspan="5">Reserved</td></tr>
<tr><td>2</td><td colspan="8">Reserved</td></tr>
<tr><td>3</td><td colspan="8">Reserved</td></tr>
<tr><td>4</td><td colspan="8">Reserved</td></tr>
<tr><td>5</td><td colspan="8">Reserved</td></tr>
<tr><td>6</td><td colspan="8">Reserved</td></tr>
<tr><td>7</td><td colspan="8">Key Class</td></tr>
<tr><td>8</td><td colspan="8" rowspan="2">(MSB)
Parameter List Length
(LSB)</td></tr>
<tr><td>9</td></tr>
<tr><td>10</td><td colspan="2">AGID</td><td colspan="6">KEY Format</td></tr>
<tr><td>11</td><td colspan="2">Vendor-Specific</td><td colspan="3">Reserved</td><td>NACA</td><td>Flag</td><td>Link</td></tr>
</table>

The KEY Format field specifies the type of information that is sent to the logical unit.

The AGID field is used to control simultaneous key exchange sequences. The AGID specified in subsequent Key Exchange commands ***shall*** match a currently active AGID. The AGID field is further described in the REPORT KEY command. See *16.30,* on page 633.

The Parameter List Length field specifies the length in bytes of the SEND KEY parameter list that ***shall*** be transferred from the host to the logical unit after the Command Packet is transferred. A Parameter List Length of zero indicates that no data ***shall*** be transferred. This condition ***shall not*** be considered as an error.

If the Parameter List Length results in the truncation of any SEND KEY parameter list, the logical unit ***shall*** terminate the command with CHECK CONDITION status, 5/1A/00 PARAMETER LIST LENGTH ERROR.

Table 584 - Key Format code definitions for SEND KEY command (Key Class = 00h)

Key Format	Sent Data	Description	AGID Use
000001b	Challenge KEY	Accepts a Challenge KEY	Valid AGID required
000011b	KEY2	Accepts a KEY2	
000110b	RPC Structure	Set Region	Reserved & Ignored
111111b	None	Invalidate Specified AGID. Invalidating an invalid AGID ***shall not*** be considered an error. An AGID that has not been granted ***shall*** be considered invalid.	Valid AGID required
All other values	Reserved		

16.38.1.1 SEND KEY data format for DVD CSS/CPPM, or CPRM (Key Class = 00h)

The following sections 16.38.1.1.1 through 16.38.1.1.3 specifies the data sent to the logical unit by this command with Key Class = 00h.

16.38.1.1.1 Challenge Key (KEY Format = 000001b)

Table 585 - SEND KEY Parameter List (With KEY Format = 000001b, Key Class = 00h)

Byte \ Bit	7	6	5	4	3	2	1	0
0	(MSB)			SEND KEY Parameter List Length (0Eh)				
1								(LSB)
2	Reserved							
3	Reserved							
	Challenge Key							
0	(MSB)							
:				Challenge Key Value				
9								(LSB)
10	Reserved							
11	Reserved							

The SEND KEY Parameter List Length field specifies the length in bytes of the following SEND KEY parameter list to be transferred to the logical unit. The SEND KEY Parameter List Length value does not include the SEND KEY Parameter List Length field itself.

The Challenge Key Value is sent to the DVD logical unit to get corresponding KEY1 from the DVD logical unit to interrogate conformity with DVD Copy Protection scheme.

16.38.1.1.2 KEY 2 (KEY Format = 000011b)

Table 586 - SEND KEY Parameter List (With KEY Format = 000011b, Key Class = 00h)

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB)			SEND KEY Parameter List Length (0Ah)				
1								(LSB)
2	Reserved							
3	Reserved							
KEY 2								
0	(MSB)							
:				KEY2 Value				
4								(LSB)
5	Reserved							
6	Reserved							
7	Reserved							

The SEND KEY Parameter List Length field specifies the length in bytes of the following SEND KEY parameter list to be transferred to the logical unit. The SEND KEY Parameter List Length value does not include the SEND KEY Parameter List Length field itself.

The KEY2 Value, generated external to the DVD logical unit, is sent to the DVD logical unit to determine its conformity with DVD Copy Protection scheme. The KEY2 Value will be used for the second input to generate a Bus Key in the DVD logical unit.

When the KEY2 Value sent does not conform with the DVD Copy Protection scheme, this command ***shall*** be terminated with CHECK CONDITION status, 5/6F/00 COPY PROTECTION KEY EXCHANGE FAILURE - AUTHENTICATION FAILURE.

When the SEND KEY command with KEY Format = 000011b terminates with CHECK CONDITION status, the retry of authentication ***shall*** be performed from the beginning.

16.38.1.1.3 RPC Structure (KEY Format = 000110b)

Table 587 - SEND KEY Parameter List (With KEY Format = 000110b, Key Class = 00h)

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB)			SEND KEY Parameter List Length (06h)				
1								(LSB)
2	Reserved							
3	Reserved							
RPC Structure								
0	Preferred Drive Region Code							
1	Reserved							
2	Reserved							
3	Reserved							

The SEND KEY Parameter List Length field specifies the length in bytes of the following SEND KEY parameter list to be transferred to the logical unit. The SEND KEY Parameter List Length value does not include the SEND KEY Parameter List Length field itself.

Preferred Drive Region Code is sent to the DVD logical unit to make the logical unit regionalized. The Preferred Drive Region Code specifies a single region in which the disc can be played. Each bit represents one of eight regions. If a bit is Cleared in this field, the disc can be played in the corresponding region. If a bit is Set in this field, the disc cannot be played in the corresponding region. Exactly one bit of the Preferred Drive Region Code ***shall*** contain a zero.

If the logical unit does not support setting of the Region, or the Region is no longer changeable, then this command ***shall*** be terminated with CHECK CONDITION status, 5/6F/05 DRIVE REGION MUST BE PERMANENT/REGION RESET COUNT ERROR.

16.38.2 SEND KEY command for AACS (Key Class = 02h)

The SEND KEY command with Key Class = 02h is used for AACS authentication process. The SEND KEY command with Key Class = 02h provides data necessary for authentication process and ends the authentication process.

Table 588 - SEND KEY Command Descriptor Block (Key Class = 02h)

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation code (A3h)							
1	LUN (Obsolete)			Reserved				
2	Reserved							
3	Reserved							
4	Reserved							
5	Reserved							
6	Reserved							
7	Key Class							
8	(MSB) Parameter List Length							
9								(LSB)
10	AGID		KEY Format					
11	Vendor-Specific		Reserved			NACA	Flag	Link

The KEY Format field indicates the type of information that is sent to the logical unit.

The AGID field is used to control simultaneous key authentication process. The AGID for AACS specified in subsequent commands for the given authentication process ***shall*** match a currently active AGID for AACS. The AGID field is further described in the REPORT KEY command. See *Section 16.30, "REPORT KEY command"* on page 633.

The Parameter List Length field specifies the length in bytes of the SEND KEY parameter list that ***shall*** be transferred from the host to the logical unit after the Command Packet is transferred. A Parameter List Length of zero indicates that no data ***shall*** be transferred. This condition ***shall not*** be considered as an error.

If the Parameter List Length results in the truncation of any SEND KEY parameter list, the logical unit ***shall*** terminate the command with CHECK CONDITION status, 5/1A/00 PARAMETER LIST LENGTH ERROR.

Table 589 - Key Format code definitions for SEND KEY command (Key Class = 02h)

Key Format	Sent Data	Description	AGID Use
000001b	Challenge KEY	Accepts a Challenge KEY	Valid AGID required
111111b	None	Invalidate Specified AGID for AACS. Invalidating an invalid AGID for AACS ***shall not*** be considered an error. An AGID for AACS that has not been granted ***shall*** be considered invalid.	Valid AGID required
All other values	Reserved		

16.38.2.1 SEND KEY data format for AACS (Key Class = 02h)

The following section 16.38.2.1.1 specifies the data sent to the logical unit by this command with Key Class = 02h.

16.38.2.1.1 Challenge Key (KEY Format = 000001b)

Table 590 - SEND KEY Parameter List (With KEY Format = 000001b, Key Class = 02h)

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB)			SEND KEY Parameter List Length (12h)				
1								(LSB)
2	Reserved							
3	Reserved							
	Challenge Key							
0	(MSB)							
:				Challenge Key Value				
15								(LSB)

The SEND KEY Parameter List Length field specifies the length in bytes of the following SEND KEY parameter list to be transferred to the logical unit. The SEND KEY Parameter List Length value does not include the SEND KEY Parameter List Length field itself.

The Challenge Key Value is sent to the logical unit to be used to make subsequent transfer secure.

Table 591 describes errors that may occur during the operation of the command or which may cause a CHECK CONDITION status to be reported.

Table 591 - SEND KEY command errors

Error Description
A-1.1, "Deferred Error Reporting" on page 721
Table 630 - *Basic Error Codes* on page 730
Table 631 - *Media Access Error Codes* on page 733
Table 634 - *Authentication Error Codes* on page 737

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16.39 SEND OPC INFORMATION command

This command is used to restore the Optimum Power Calibration (OPC) values to the logical unit for a specific disc.

For CD, it is used in combination with the READ DISC INFORMATION command.

Table 592 - SEND OPC INFORMATION Command Descriptor Block

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation code (54h)							
1	Reserved			Reserved				DoOpc
2	Reserved							
3	Reserved							
4	Reserved							
5	Reserved							
6	Reserved							
7	(MSB) Parameter List Length (Obsolete)							
8								(LSB)
9	Vendor-Specific		Reserved			NACA	Flag	Link
10	PAD							
11								

The DoOpc bit, when set to one, indicates the logical unit ***shall*** perform an OPC operation to set the OPC values for the current speed. When this bit is set to zero, logical unit does not perform any operation. When Parameter List Length (Obsolete) field is not set to zero, the logical unit ***shall*** report CHECK CONDITION Status, 5/26/00 INVALID FIELD IN PARAMETER LIST.

If PCA is almost full, and the DoOpc bit is set to one, the command ***shall*** be performed normally and report CHECK CONDITION Status, 1/73/01 POWER CALIBRATION AREA ALMOST FULL.

If PCA is full, and the DoOpc bit is set to one, the command is not performed, and the logical unit ***shall*** report CHECK CONDITION Status, 3/73/02 POWER CALIBRATION AREA IS FULL.

For HD DVD, if current PCA is almost full, Test zone is not extended, and the DoOpc bit is set to one, then the command ***shall*** be performed normally and report CHECK CONDITION Status, 1/73/10 CURRENT POWER CALIBRATION AREA ALMOST FULL. If current PCA is full, Test zone is not extended, and the DoOpc bit is set to one, then the command is not performed, and the logical unit ***shall*** report CHECK CONDITION Status, 5/73/11 CURRENT POWER CALIBRATION AREA IS FULL.

For HD DVD, the Error reporting for the command in each condition of the media is shown in Table 162 - *Error reporting for SEND OPC INFORMATION command* on page 301.

For HD DVD, when the number of the unrecorded ECC blocks in Current RMZ is equal to or less than 8, the logical unit ***shall not*** write RMD on the disc.

Table 593 - SEND OPC INFORMATION Parameter List (Obsolete)

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB)	OPC Speed in kBytes per Second						
1								(LSB)
2	(MSB)							
3								
4		OPC Value						
5								
6								
7								(LSB)

Table 594 describes errors that may occur during the operation of the command or which may cause a CHECK CONDITION status to be reported.

Table 594 - SEND OPC INFORMATION command errors

Error Description
A-1.1, "Deferred Error Reporting" on page 721
Table 630 - *Basic Error Codes* on page 730
Table 631 - *Media Access Error Codes* on page 733
Table 632 - *Write Error Codes* on page 736

16.40 SET CD SPEED command

The SET CD SPEED command is used to set Read Speed and Write Speed and only applicable to CD-R/RW logical unit.

Note: PLAY commands will not use the speed that is set by this command.

Table 595 - SET CD SPEED Command Descriptor Block

Byte \ Bit	7	6	5	4	3	2	1	0
0	Operation Code (BBh)							
1	LUN (Obsolete)			Reserved			Rotational Control	
2	(MSB) Logical unit Read Speed (kBytes/sec)							
3								(LSB)
4	(MSB) Logical unit Write Speed (kBytes/sec)							
5								(LSB)
6	Reserved							
7	Reserved							
8	Reserved							
9	Reserved							
10	Reserved							
11	Vendor-Specific		Reserved			NACA	Flag	Link

The Logical unit Read Speed and Logical unit Write Speed parameters contain the requested Data rates the logical unit should use.

Host ***shall*** set one of the values of logical unit Write Speed Performance Descriptor in *C/DVD Capabilities & Mechanical Status* Mode Page (2Ah) to Rotational Control field and Logical unit Write Speed field.

The logical unit is to select the Logical unit Read Speed specified or any higher rate. A value of FFFFh will set the Logical unit Read Speed or the Logical unit Write Speed to the best performance supported. If the logical unit is requested to write at the speed which is not listed in the logical unit Write Speed Performance Descriptor, the logical unit ***shall*** select any slower logical unit Write Speed. This condition is not regarded as an error condition. If the logical unit is requested to write at the lower speed than the logical unit's slowest speed, the logical unit may return CHECK CONDITION Status, 5/24/00 INVALID FIELD IN CDB or select an appropriate logical unit Write Speed.

Note: logical unit should return an error if current write mode is not packet write and buffer under-run free recording is not supported.

The Rotational Control field defines the operations that are defined in Table 596.

Table 596 - Rotational Control field definition

Value	Definition
0h	Non-pure CAV and CLV recording
1h	Pure CAV recording
Other values	Reserved

In the case of non-CLV rotational control, the logical unit Write Speed field value ***shall*** be assumed to reference the speed at 79:59:74 MSF, regardless of actual capacity or disc diameter.

The logical unit keeps the actual write speed setting till the current disc is ejected. When the disc is changed to another one and it does not support the write speed that was set for the previous media, the logical unit may select an appropriate write speed to the current medium. It is recommended that the host should set the write speed upon the media change.

Table 597 describes errors that may occur during the operation of the command or which may cause a CHECK CONDITION status to be reported.

Table 597 - SET CD SPEED command errors

Error Description
A-1.1, "Deferred Error Reporting" on page 721
Table 630 - *Basic Error Codes* on page 730
Table 631 - *Media Access Error Codes* on page 733
Table 632 - *Write Error Codes* on page 736

16.41 SET READ AHEAD command

The SET READ AHEAD command requests that the logical unit perform Read Ahead Caching operations from the Read Ahead Logical Block Address when the drive encounters the Trigger Logical Block Address during its internal Read Ahead Caching operation.

If this command is received by the logical unit when data after the Trigger Logical Block Address (Trigger LBA) and before the Read Ahead Logical Block Address (Read Ahead LBA) is contained in its cache, that data should be discarded and Read Ahead Caching restarted from the specified Read Ahead Logical Block Address.

Sectors after the Trigger LBA (Not including the Trigger LBA) should be skipped. The data for both the Trigger and Read Ahead LBAs will normally be read by the host. The sectors between these addresses (exclusive) are normally not read by the host.

Note: The host should expect seek delays if these sectors are read.

The Read-Ahead operation ***shall*** be performed in background, i.e. the logical unit ***shall*** accept a command during the Read-Ahead operation.

Table 598 - SET READ AHEAD Command Descriptor Block

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation code (A7h)							
1	LUN (Obsolete)			Reserved				
2	(MSB) Trigger Logical Block Address							
3								
4								
5								(LSB)
6	(MSB) Read Ahead Logical Block Address							
7								
8								
9								(LSB)
10	Reserved							
11	Vendor-Specific		Reserved			NACA	Flag	Link

Table 599 describes errors that may occur during the operation of the command or which may cause a CHECK CONDITION status to be reported.

Table 599 - SET READ AHEAD command errors

Error Description
A-1.1, "Deferred Error Reporting" on page 721
Table 630 - *Basic Error Codes* on page 730
Table 631 - *Media Access Error Codes* on page 733

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16.42 SET STREAMING command

The SET STREAMING command provides a way for the host to indicate to the logical unit that the application has specific request or requirements for logical unit performance.

Table 600 - SET STREAMING command Descriptor Block

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation code (B6h)							
1	LUN (Obsolete)			Reserved				
2	Reserved							
3	Reserved							
4	Reserved							
5	Reserved							
6	Reserved							
7	Reserved							
8	Type							
9	(MSB) Parameter List Length							
10								(LSB)
11	Vendor-Specific		Reserved			NACA	Flag	Link

The Type field specifies which type of data ***shall*** be transferred. If logical unit does not report Enhanced Defect Reporting Feature, host ***shall*** set the Type field to 0. If logical unit reports Enhanced Defect Reporting Feature, the logical unit ***shall*** support the Type field. The Type field is defined in Table 601.

If logical unit does not support *9.3.4.3, "Small DBI cache memory model"* on page 338 and Type field is set to other than 0, the logical unit ***shall*** terminate this command with CHECK CONDITION status, 5/24/00 INVALID FIELD IN CDB.

Table 601 - Type field values description

Type field value	Description	Reference
0	Performance descriptor	see 13.42.1
1-4	Reserved	
5	DBI cache zone descriptor	see 13.42.2
Others	Reserved	

The Parameter List Length field specifies the length in bytes of the Performance Descriptor that ***shall*** be transferred from the host to the logical unit after the Command Packet is transferred. A Parameter List Length of zero indicates that no data ***shall*** be transferred. This condition ***shall not*** be considered as an error.

If the Parameter List Length results in the truncation of Performance Descriptor, the logical unit ***shall*** terminate the command with CHECK CONDITION status, 5/1A/00 PARAMETER LIST LENGTH ERROR.

16.42.1 Performance descriptor

The Performance descriptor provides a way for the host to indicate to the logical unit that the application has specific request for logical unit performance. The logical unit may utilize the host supplied information to change mechanical or logical operation. For example, the spindle motor speed may be adjusted downward for lower data rates to help avoid buffer overrun (during reading) or buffer underrun (during writing) followed by a consequent rotational delay. The performance setting is persistent and remains until a new descriptor is sent. The setting only applies to the extent identified by the Start and End LBA field. Only zero or one performance extents ***shall*** be valid at any time.

If the SET STREAMING command is used to set performance, the logical unit may disable read and write reallocation in the specified region in order to meet the performance criteria. The host ***shall*** send a Performance Descriptor during the data phase of this command. The Performance Descriptor ***shall*** be sent in the format shown in Table 602.

Table 602 - Performance Descriptor

Bit / Byte	7	6	5	4	3	2	1	0
0	Reserved			WRC		RDD	Exact	MRW
1	Reserved							
2	Reserved							
3	Reserved							
4	(MSB)							
5				Start LBA				
6								
7								(LSB)
8	(MSB)							
9				End LBA				
10								
11								(LSB)
12	(MSB)							
13				Read Size				
14								
15								(LSB)
16	(MSB)							
17				Read Time				
18								
19								(LSB)
20	(MSB)							
21				Write Size				
22								
23								(LSB)
24	(MSB)							
25				Write Time				
26								
27								(LSB)

The Write Rotation Control (WRC) field specifies the type of the medium rotation control to write. See Table 312 - *Write Rotation Control values* on page 473. If logical unit does not support the write rotation control mode specified, the logical unit ***shall*** generate CHECK CONDITION status, 5/26/00 INVALID FIELD IN PARAMETER LIST.

The Restore Drive Defaults (RDD) bit, when set to zero, means that the remaining fields are valid. When set to one, ***shall*** indicate that the logical unit is to return to its default performance settings and the remaining fields in this descriptor ***shall*** be ignored. Read and Write reallocation ability ***shall*** be restored to operation specified by the *Read/Write Error Recovery Parameters* Mode Page (01h).

The Exact bit, when set to zero, ***shall*** indicate that the logical unit set its internal configuration to match the parameters as best as possible. No errors ***shall*** occur. When set to one, ***shall*** indicate that the logical unit set its internal configuration to support the requested parameters. If the logical unit cannot perform as requested, it ***shall*** generate CHECK CONDITION status, 5/26/00 INVALID FIELD IN PARAMETER LIST, and the Sense Key Specific bytes ***shall*** identify the Size or Time parameter that is not valid.

The Mixed Read/Write (MRW) bit, when set to zero, allows the logical unit to independently set the read and write speeds. When set to one, ***shall*** indicate to the logical unit that its performance settings should be optimized for random changes between reading and writing by the host. For example, a CD recorder that can record at 2× and read at 6× may choose to limit reading to 2× if the MRW bit was set to one.

The Start LBA field is the first logical block for which the performance request is being made.

The End LBA field is the last logical block for which the performance request is being made.

The data rate to be delivered for reading is $\frac{ReadSize}{ReadTime}$.

The Read Size field ***shall*** indicate the number of kilobytes the host expects to be delivered per period of Read Time when the host's requests for data occur sufficiently fast.

The Read Time field ***shall*** indicate the amount of time, in milliseconds, over which the Read Size is expected to be read.

The host may set these two fields by setting Read Size to the size of its application's buffer and the Read Time to the amount of time it takes to empty that buffer.

The Write Size field ***shall*** be set to the number of kilobytes to be written per Write Time.

The Write Time field ***shall*** indicate the amount of time, in milliseconds, over which the Write Size is expected to be written.

In many cases, the Write Size and Write Time fields should be set to match the corresponding Read fields. If not, the host may set the Write Size to the size of its application buffer and the Write Time to the time it takes to fill that buffer.

16.42.2 DBI cache zone Descriptor

The DBI cache zone descriptor provides a way for the host to indicate to the logical unit that the application has specific request for logical unit behavior of small DBI cache model in DRT-DM mode. Disc volume space is divided into a few DBI cache zones. RDBI and WDBI memory ***shall*** be allocated for each DBI cache zones. At least two DBI cache zones ***shall*** be supported. Number of supported DBI cache zone is shown in Number of DBI cache zones field of Table 246 - *Enhanced Defect Reporting Feature Descriptor* on page 433.

Table 603 - DBI cache zone Descriptor

Bit / Byte	7	6	5	4	3	2	1	0
0-7	DBI cache zone Header							
8-n	DBI cache zone Descriptor(s)							

Table 604 - DBI cache zone Header

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB)							
1				DBI cache zone Data Length				
2								
3								(LSB)
4-7				Reserved				

The DBI cache zone data length field specifies the length in bytes of the following data. The DBI cache zone data length value does not include the DBI cache zone data length field itself.

Table 605 - DBI cache zone Descriptor(s)

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB)							
1				Start LBA of DBI cache zone				
2								
3								(LSB)
4-7				Reserved				

Start LBA of DBI cache zone field specifies start LBA of a DBI cache zone. Logical unit ***shall*** adjust the start LBA to the packet start address that includes specified start LBA by Blocking factor for each media. The end address of a DBI cache zone is the end address of a packet that is preceded to the next DBI cache zone. The end address of the last DBI cache zone is the value of the last addressable LBA for the media. In case of C/DVD-RW media, the last readable address of the last track/RZone is the end address of the last DBI cache zone.

For C/DVD-RW media, the first DBI cache zone ***shall*** be started from 0 and host ***shall*** set the first cache zone start address to 0. In case of small DBI cache model, host should specify 2 descriptors minimally.

If logical unit received any invalid DBI cache zone descriptor and if number of DBI cache zone descriptors exceeded the value of Number of DBI cache zones field, the logical unit ***shall*** terminate this command with CHECK CONDITION status, 5/26/00 INVALID FIELD IN PARAMETER LIST.

Table 606 describes errors that may occur during the operation of the command or which may cause a CHECK CONDITION status to be reported.

Table 606 - SET STREAMING command errors

Error Description
A-1.1, "Deferred Error Reporting" on page 511
Table 480 - *Basic Error Codes* on page 519
Table 481 - *Media Access Error Codes* on page 523
Table 482 - *Write Error Codes* on page 526

16.43 START/STOP UNIT command

The START/STOP UNIT command requests that the logical unit enable or disable media access operations.

Table 607 - START/STOP UNIT Command Descriptor Block

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation code (1Bh)							
1	LUN (Obsolete)			Reserved				Immed
2	Reserved							
3	Reserved							
4	Power Condition				Reserved		LoEj	Start
5	Vendor-Specific		Reserved			NACA	Flag	Link
6	PAD							
7								
8								
9								
10								
11								

An immediate (Immed) bit of one indicates that status ***shall*** be returned as soon as the Command Packet has been validated. An Immed bit of zero indicates that status ***shall*** be returned after the operation is completed.

A Start bit of one requests the logical unit be made ready for use. The Idle and Standby timers are reloaded. A Start bit of zero requests that the logical unit be stopped (media cannot be accessed by the host). See Table 608.

Table 608 - Start/Stop and Eject Operations

LoEj	Start	Power Condition	Operation to be Performed
0	0	0	Stop the Disc
0	1	0	Start the Disc and read the TOC
1	0	0	Eject the Disc if possible (See Table 371 - *Actions for Lock/Unlock/Eject (Persistent bit = 0)* on page 528)
1	1	0	Load the Disc (Close Tray)
x	x	1h - Fh	Power Condition Change (Table 610)

Any attempt to Eject or Load a Disc when the logical unit does not support that capability ***shall*** result in CHECK CONDITION status, 5/24/00 INVALID FIELD IN CDB.

A load eject (LoEj) bit of zero requests that no action be taken regarding loading or ejecting the medium. A LoEj bit of one requests that the medium be unloaded if the start bit is zero. A LoEj bit of one requests that the medium be loaded if the start bit is one.

When the Loading Mechanism Type is a Changer utilizing individual disc change capability (4h), the Eject operation ***shall*** only eject the disc that is currently in the Play Position. If the Loading Mechanism is a changer utilizing a Cartridge (5h), then the Cartridge ***shall*** only be ejected when no media is in the play position.

Table 609 - Actions for Eject/Load Disc

Operation	Locked / Unlocked	If logical unit NOT READY (No Media)	If logical unit READY (Media Present)
Eject	Unlocked	No Error and Tray is opened	No Error: Media Ejects
	Locked	CHECK CONDITION status, 2/53/02 MEDIUM REMOVAL PREVENTED	CHECK CONDITION status, 5/53/02 MEDIUM REMOVAL PREVENTED
	Changer using Cartridge with Disc in Play Position	CHECK CONDITION status, 2/53/02 MEDIUM REMOVAL PREVENTED	CHECK CONDITION status, 5/53/02 MEDIUM REMOVAL PREVENTED
	Changer using Individual disc changeability with no Disc in the Play Position	CHECK CONDITION status, 2/53/02 MEDIUM REMOVAL PREVENTED	CHECK CONDITION status, 5/53/02 MEDIUM REMOVAL PREVENTED
Manual Eject	Unlocked	Tray opens (If tray exists)	Media is ejected
	Locked	No operation occurs	No operation, Media stays locked in logical unit

The Power Condition field requests the logical unit be placed into the power state defined in Table 610. If any bit is set in this field then the Start and the LoEj bits ***shall*** be ignored.

When the logical unit enters the sleep state, any queued GET EVENT/STATUS NOTIFICATION commands ***shall*** be removed from the command queue without command completion.

If any commands other then event status are in the queue upon receipt of the sleep command then the sleep command ***shall*** terminate with CHECK CONDITION status, 5/2C/00 COMMAND SEQUENCE ERROR.

The Immed bit ***shall*** be ignored if the Power Condition field contains 5h (Place logical unit into Sleep State).

Requests to enter the current power state ***shall*** complete without error.

If a request to go to a power state fails, the logical unit ***shall*** remain in the current power state and ***shall*** generate power management class event with the Power Event Field set to PwrChg-Fail.

All power state change requests, except sleep, that complete successfully ***shall*** generate power management class event with the Power Event field set to PwrChg-Succ.

Notification of power states ***shall*** occur upon entering a new power state.

Table 610 - Power Conditions

Code	Description
0h	No change in power conditions or in which logical unit is controlling power conditions
1h	Reserved
2h	Place logical unit into the Idle State, Standby Timer is reloaded
3h	Place logical unit into the Standby State
4h	Reserved
5h	Place logical unit into Sleep State. Before entering the sleep state, all buffers ***shall*** be successfully flushed by the logical unit. If the sleep command is successful, the host ***shall not*** issue new commands after receiving the successful completion status. The Device ***shall*** de-power and disable the interface only after all logical units have successful complete sleep commands.
6h-Fh	Reserved

In the Sleep condition the device ***shall*** only respond to a reset condition. When a device has multiple logical units attached it ***shall*** enter the Sleep condition only after all the logical units have been placed into a Sleep condition.

Table 611 describes errors that may occur during the operation of the command or which may cause a CHECK CONDITION status to be reported.

Table 611 - START/STOP UNIT command errors

Error Description
A-1.1, "Deferred Error Reporting" on page 721
Table 630 - *Basic Error Codes* on page 730
Table 631 - *Media Access Error Codes* on page 733

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16.44 STOP PLAY/SCAN command

The STOP PLAY/SCAN command stops playback of audio or scan commands.

Table 612 - STOP PLAY/SCAN Command Descriptor Block

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation code (4Eh)							
1	LUN (Obsolete)			Reserved				
2	Reserved							
3	Reserved							
4	Reserved							
5	Reserved							
6	Reserved							
7	Reserved							
8	Reserved							
9	Vendor-Specific		Reserved			NACA	Flag	Link
10	PAD							
11								

Issuing a STOP PLAY/SCAN command while the logical unit is scanning ***shall*** result in continuation of the play command. Issuing a STOP PLAY/SCAN command while the logical unit is paused ***shall*** stop the play command.

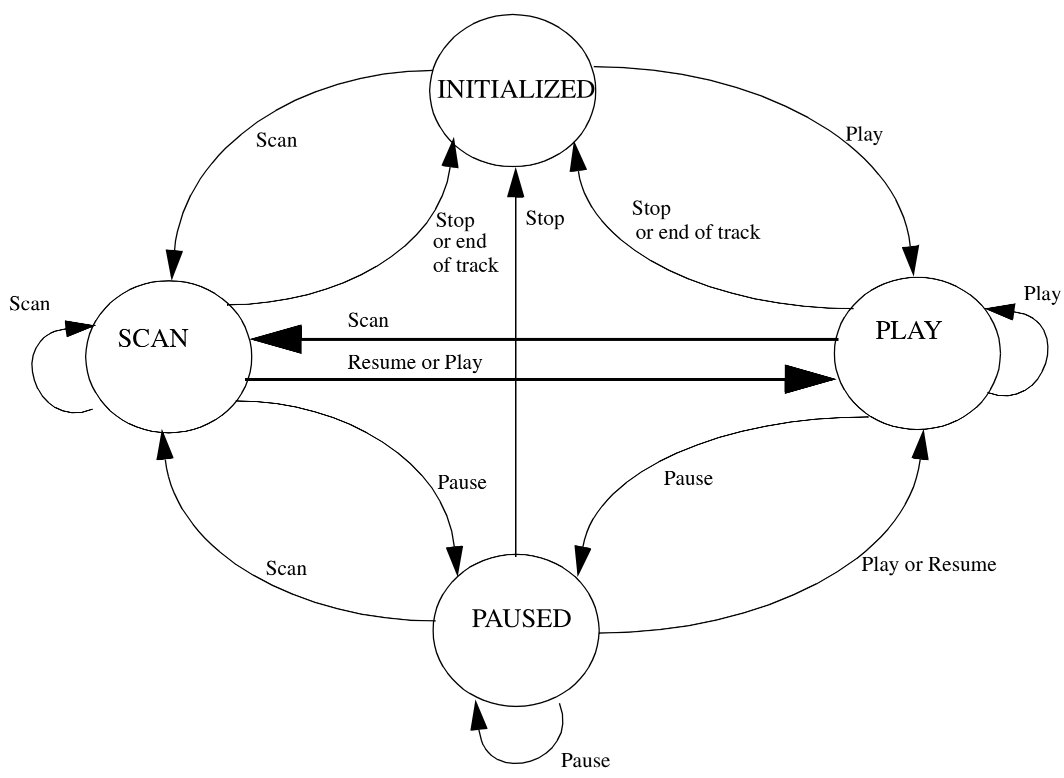

Figure 172 - Stop Play/Play Audio/Audio Scan/Pause/Resume Sequencing

Table 613 - STOP PLAY/SCAN command Errors

Error Description
A-1.1, "Deferred Error Reporting" on page 721
Table 630 - *Basic Error Codes* on page 730
Table 631 - *Media Access Error Codes* on page 733

16.45 SYNCHRONIZE CACHE command

The SYNCHRONIZE CACHE command ensures that logical blocks in the cache memory have their most recent data value recorded on the physical medium. If a more recent data value for a logical block exists in the cache memory than on the physical medium, then the logical blocks from the cache memory ***shall*** be written to the physical medium. Logical blocks are not necessarily removed from the cache memory as a result of the cache flush operation. Table 614 describes the Command Packet.

Note: This command does not make use of the range allowed in the SCSI version of this command. This definition replaces the definition in the SCSI Standard.

Table 614 - SYNCHRONIZE CACHE Command Descriptor Block

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation code (35h)							
1	LUN (Obsolete)			Reserved			Immediate	RelAdr (0)
2	(MSB) Logical Block Address							
3								
4								
5								(LSB)
6	Reserved							
7	Block Count							
8								
9	Vendor-Specific		Reserved			NACA	Flag	Link
10	PAD							
11								

The Immediate bit, when set to zero, indicates that the SYNCHRONIZE CACHE operation ***shall*** complete before completing the command. When set to one, ***shall*** indicate that the command ***shall*** return after the command parameters have been verified.

The Logical Block Address and the Block Count fields may be ignored by the logical unit.

For HD DVD, the Error reporting for the command in each condition of the media is shown in Table 152 - *Error reporting for SYNCHRONIZE CACHE command* on page 297.

For HD DVD, when the number of the unrecorded ECC blocks in Current RMZ is equal to or less than 8, the logical unit ***shall not*** write RMD on the disc.

Table 615 describes errors that may occur during the operation of the command or which may cause a CHECK CONDITION status to be reported.

Table 615 - SYNCHRONIZE CACHE command errors

Error Description
A-1.1, "Deferred Error Reporting" on page 721
Table 630 - *Basic Error Codes* on page 730
Table 631 - *Media Access Error Codes* on page 733
Table 632 - *Write Error Codes* on page 736
Table 633 - *Session/Border Error Codes* on page 737

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16.46 TEST UNIT READY command

The TEST UNIT READY command provides a means to check if the logical unit is ready. This is not a request for a self-test. If the logical unit would accept an appropriate medium-access command without returning CHECK CONDITION status, this command ***shall*** return a GOOD status. For unformatted media, the FORMAT UNIT command ***shall*** be considered an appropriate medium access command. If the logical unit cannot become operational or is in a state such that a host action (e.g., START/STOP UNIT command with Start = 1) is required to make the unit ready, the logical unit ***shall*** return CHECK CONDITION status with a Sense Key of NOT READY.

Table 616 - TEST UNIT READY Command Descriptor Block

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation code (00h)							
1	LUN (Obsolete)			Reserved				
2	Reserved							
3	Reserved							
4	Reserved							
5	Vendor-Specific		Reserved			NACA	Flag	Link
6	PAD							
7								
8								
9								
10								
11								

16.46.1 Using the TEST UNIT READY command

The TEST UNIT READY command is useful in that it allows a host to poll a logical unit until it is ready without the need to allocate space for returned data. It is especially useful to check cartridge status. Logical units are expected to respond promptly to indicate the current status of the logical unit. See Figure 173.

If TEST UNIT READY command is issued during a long immediate operation except BLANK command and FORMAT UNIT command, e.g., CLOSE TRACK/RZONE/SESSION/BORDER command with Immed bit set to one, the command ***shall*** be terminated with GOOD status. To detect the completion of the long immediate operation, REQUEST SENSE command or READ TRACK/RZONE INFORMATION command or READ DISC INFORMATION command should be used.

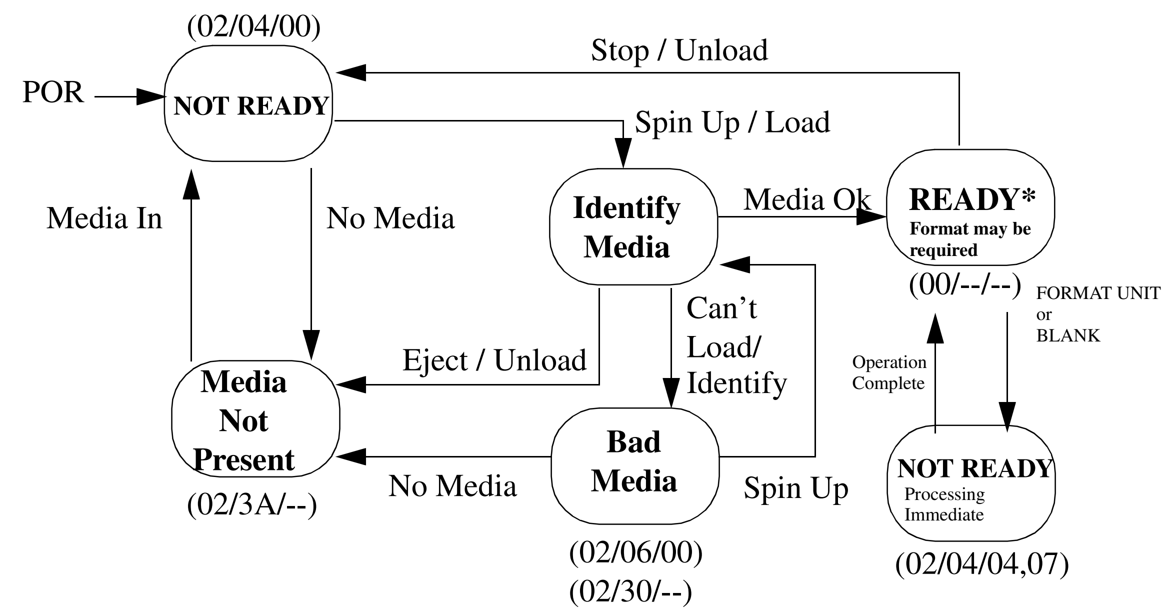

Figure 173 - TEST UNIT READY State Diagram

Table 617 describes errors that may occur during the operation of the command or which may cause a CHECK CONDITION status to be reported.

Table 617 - TEST UNIT READY command errors

Error Description
A-1.1, "Deferred Error Reporting" on page 721
Table 630 - *Basic Error Codes* on page 730
Table 631 - *Media Access Error Codes* on page 733

Note: Some logical units return ASC/ASCQ with Audio Status and Sense Key 0 when there is no error condition.

16.47 VERIFY (10) command

The VERIFY (10) command requests that the logical unit verify the data on the medium.

If Enhanced Defect Reporting Feature is current, the logical unit ***shall*** follow the setting of the PER bit and the EMCDR field in *Read/Write Error Recovery Parameters* Mode Page (01h). See *9.0, "Logical unit assisted software defect management model"* on page 333.

Table 618 - VERIFY (10) Command Descriptor Block

<table>
<tr><th>Bit
Byte</th><th>7</th><th>6</th><th>5</th><th>4</th><th>3</th><th>2</th><th>1</th><th>0</th></tr>
<tr><td>0</td><td colspan="8">Operation code (2Fh)</td></tr>
<tr><td>1</td><td colspan="3">LUN (Obsolete)</td><td>DPO (0)</td><td>Reserved</td><td>BlkVfy</td><td>BytChk (0)</td><td>RelAdr</td></tr>
<tr><td>2</td><td colspan="8">(MSB)</td></tr>
<tr><td>3</td><td colspan="8" rowspan="2">Logical Block Address</td></tr>
<tr><td>4</td></tr>
<tr><td>5</td><td colspan="8">(LSB)</td></tr>
<tr><td>6</td><td>G3tout</td><td colspan="7">Reserved</td></tr>
<tr><td>7</td><td colspan="8">(MSB) Verification Length</td></tr>
<tr><td>8</td><td colspan="8">(LSB)</td></tr>
<tr><td>9</td><td colspan="2">Vendor-Specific</td><td colspan="3">Reserved</td><td>NACA</td><td>Flag</td><td>Link</td></tr>
<tr><td>10</td><td colspan="8" rowspan="2">PAD</td></tr>
<tr><td>11</td></tr>
</table>

The VERIFY (10) command ***shall*** use stricter criteria for data recoverability than Read commands. The criteria is derived from the relevant media standard, with additional vendor specific criteria allowed. Automatic reallocation ***shall*** be controlled by the ARRE bit (see *16.11.3.1, "Read/Write Error Recovery Parameters Mode Page"* on page 495). The VERIFY (10) command may return an error for a sector that a Read command may not.

Verify Error Recovery Page parameters are not supported.

The RelAdr bit is only used for SCSI logical units. For information on this bit *C-3.1, "Use of the RelAdr bit"* on page 749

The byte check (BytChk) bit is not used and ***shall*** be set to zero, which causes a medium verification to be performed with no data comparison.

A blank verify (BlkVfy) bit of one causes a verification that the blocks are blank.

The Disable Page Out (DPO) bit is not used and ***shall*** be set to zero. A DPO bit of zero indicates the priority ***shall*** be determined by the retention priority fields in the cache page if supported. All other aspects of the algorithm implementing the cache memory replacement strategy are vender specific.

The Logical Block Address field specifies the logical block where the verify operation ***shall*** begin.

The Verification Length specifies the number of contiguous logical blocks of data or blanks that ***shall*** be verified. A Verification Length of zero indicates that no logical blocks ***shall*** be verified. This condition ***shall not*** be considered as an error. Any other value indicates the number of logical blocks that ***shall*** be verified.

If the G3tout bit is set to 1 and if the logical unit supports Group3 time-out and if Restricted Overwrite Feature or Rigid Restricted Overwrite Feature (e.g., CD-RW, DVD-RW) is current and if G3Enable bit in *Time-out & Protect* Mode Page (1Dh) is set to 1, the logical unit ***shall*** terminate this command within Group 3 time-out duration. In other cases, this command is categorized as Group 2 time-out.

Table 619 - VERIFY (10) command errors

Error Description
A-1.1, "Deferred Error Reporting" on page 721
Table 630 - *Basic Error Codes* on page 730
Table 631 - *Media Access Error Codes* on page 733

16.48 WRITE (10) command

The WRITE (10) command requests that the logical unit write the data transferred from the host to the medium.

If used with the Incremental Streaming Write Feature, the WRITE (10) command ***shall*** use the Write Parameters Mode Page to determine its operating behavior.

If Enhanced Defect Reporting Feature (0029h) is current, the logical unit ***shall*** follow the setting of the PER bit and the EMCDR field in *Read/Write Error Recovery Parameters* Mode Page (01h). See *9.0, "Logical unit assisted software defect management model"* on page 333.

Table 620 - WRITE (10) Command Descriptor Block

Byte \ Bit	7	6	5	4	3	2	1	0
0	Operation code (2Ah)							
1	LUN (Obsolete)			DPO	FUA	EBP	Reserved	RelAdr
2	(MSB)							
3	Logical Block Address							
4								
5								(LSB)
6	Reserved							
7	(MSB)							
8	Transfer Length							(LSB)
9	Vendor-Specific		Reserved			NACA	Flag	Link
10	PAD							
11								

The RelAdr bit is only used for SCSI logical units. For information on this bit see *C-3.1, "Use of the RelAdr bit"* on page 749.

The Erase By-pass (EBP) bit is not used by C/DVD/HD DVD logical units and ***shall*** be set to zero. An EBP bit of zero indicates that the logical unit will default to the normal write operation which does not by-pass the erase operation prior to writing the data.

The Disable Page Out (DPO) bit is not used by C/DVD/HD DVD logical units and ***shall*** be set to zero. A DPO bit of zero indicates the priority ***shall*** be determined by the retention priority fields in the cache page if supported. All other aspects of the algorithm implementing the cache memory replacement strategy are vender specific.

A Force Unit Access (FUA) bit of one indicates that the C/DVD/HD DVD logical unit ***shall*** access the media in performing the command. Write commands ***shall*** access the specified logical blocks on the media In the case where the cache contains a more recent version of a logical block than the media, the logical block ***shall*** first be written to the media. A FUA bit of zero indicates that the C/DVD/HD DVD logical unit may satisfy the command by writing to the cache memory.

The Transfer Length specifies the number of contiguous logical blocks of data that ***shall*** be transferred. A Transfer Length of zero indicates that no data ***shall*** be transferred. This condition ***shall not*** be considered an error and no data ***shall*** be written. Any other value indicates the number of logical blocks that ***shall*** be transferred.

The Logical Block Address field specifies the logical block where the write operation ***shall*** begin. For CD-R or DVD-R or HD DVD-R, and FUA=0 with incremental writing, and if the LBA is equal to the NWA in the same RZone as a previous write, then writing should continue without interruption of streaming. If the LBA is equal to the NWA in another Track/RZone, a SYNCHRONIZE CACHE may be performed before executing the write command. If the LBA is not any NWA, the logical unit ***shall*** return CHECK CONDITION status, 5/21/02 INVALID ADDRESS FOR WRITE.

For CD, LBA in the range of -45150 (FFFF4FA2h) to -1 (FFFFFFFFh) ***shall*** be encoded as a two's complement negative number. Values in the range 0 through ffff4fa1h ***shall*** be considered positive values. Values -45150 through 404849 are valid for CD media. Table 621 shows the MSF to LBA mapping.

Table 621 - LBA to MSF translation (CD)

Condition	Formulae
$-150 \le LBA \le 404849$	$M = IP((LBA + 150) / (60 \cdot 75))$ $S = IP((LBA + 150 - (M \cdot 60 \cdot 75)) / 75)$ $F = IP(LBA + 150 - (M \cdot 60 \cdot 75) - (S \cdot 75))$
$-45150 \le LBA \le -151$	$M = IP((LBA + 450150) / (60 \cdot 75))$ $S = IP((LBA + 450150 - (M \cdot 60 \cdot 75)) / 75)$ $F = IP(LBA + 450150 - (M \cdot 60 \cdot 75) - (S \cdot 75))$
$00/00/00 \le MSF \le 89/59/74$	$LBA = (M \cdot 60 + S) \cdot 75 + F - 150$
$90/00/00 \le MSF \le 99/59/74$	$LBA = (M \cdot 60 + S) \cdot 75 + F - 450150$

For CD-R or DVD-R, once actual writing to the media has started, the data stream ***shall*** be uninterrupted until the recording is done. Interruptions of data are called "underruns." The underrun condition may also be forced with the SYNCHRONIZE CACHE command. The CD-R or DVD-R logical unit ***shall*** behave as follows in an underrun condition.

1) Disc-at-Once: (DVD)
The logical unit ***shall*** generate and write a Lead-out (the Lead-in was generated and written before any data). The logical unit ***shall*** update the RMA.

2) Session at Once mode: (CD)
The logical unit ***shall*** generate and write a Lead-out (the Lead-in was generated and written before any data). The logical unit ***shall*** update the PMA to match the data actually recorded.

3) Track at Once mode: (CD)
The logical unit ***shall*** pad the track with all 00h main data if reserved or not minimum length and update the PMA.

4-1) Incremental mode: (DVD)
The logical unit ***shall*** perform linking.

4-2) Variable Packet: (CD)
If insufficient space exists for another variable packet within a reserved track, the logical unit ***shall*** pad the packet with all 00h data such that it fills the track. Otherwise, the logical unit ***shall*** write run-out and link blocks.

4-3) Fixed Packet: (CD)
The logical unit ***shall*** pad the packet with all 00h main data to the fixed packet size.

5) Raw mode: (CD)
The logical unit ***shall*** write run-out and link blocks. The logical unit ***shall*** read the TOC and track information from the session just written and update the PMA. It is assumed that the initiator has written the Lead-out.

6) Layer Jump recording mode: (DVD)
The logical unit ***shall*** perform linking.

Note: In Raw mode, it is possible for the host to send a TOC that is not valid, thus making a disc that cannot be read.

*Note: "Update the RMA/PMA" means to update the RMA/PMA on the disc or to update the RMA/PMA Cache, which **shall** be written to the RMA/PMA on the disc prior to removing the disc from the logical unit. PMA Caching is vendor specific.*

For HD DVD, when the number of the remaining ECC blocks in Current RMZ is less than or equal to 8, the logical unit ***shall not*** write RMD on the disc. The Error reporting for the command in each condition of the media is shown in Table 151 - *Error reporting for WRITE (10) command and WRITE (12) command* on page 296.

For CD, if the block number specified by the LBA field is already written on CD-R media, the logical unit ***shall*** return CHECK CONDITION status, 5/21/02 INVALID ADDRESS FOR WRITE. This error will indicate that an underrun may have occurred, as the run-out and link blocks occupy logical addresses. On CD-RW media, the LBA ***shall*** specify an address that is an appendable point (according to CD-R rules) or is the first user data block of an existing packet or track.

For DVD-RAM Ver.2.1 and HD DVD-Rewritable, the logical unit ***shall*** set all Recording Type bits to zero, which are in the Data ID fields of all sectors within the ECC block to be written.

While writing is occurring, the logical unit may not be able to process all SCSI/ATAPI commands. The following is a list of commands that ***shall*** function during writing without causing a flush cache.

1. TEST UNIT READY
2. REQUEST SENSE
3. INQUIRY
4. READ TRACK/RZONE INFORMATION (for current track). If the LBA or track number specified is not within the current track, the logical unit may return CHECK CONDITION status, 5/24/00 INVALID FIELD IN CDB.
5. READ BUFFER CAPACITY
6. GET CONFIGURATION
7. GET EVENT/STATUS NOTIFICATION

If Random Writable Feature (0020h) or Write Once Feature (0025h) is current, all other commands ***shall*** perform normally, but may force a SYNCHRONIZE CACHE before executing. The process of writing from the logical unit's cache to the medium ***shall not*** cause a NOT READY condition for any command.

If one of the following listed Features is current, commands that are allowed to report NOT READY error (See Table 183 - *NOT READY error & Time-out UNIT ATTENTION reporting (by command)* on page 362) may be terminated with CHECK CONDITION status, 2/04/08 LOGICAL UNIT NOT READY, LONG WRITE IN PROGRESS.

- Incremental Streaming Writable Feature (0021h)
- CD Track at Once Feature (002Dh)
- CD Mastering Feature (002Eh)
- DVD-R/-RW Write Feature (002Fh)
- Restricted Overwrite Feature (0026h)
- Rigid Restricted Overwrite Feature (002Ch)

While writing is occurring, if WRITE (10) command or WRITE (12) command cannot be terminated immediately due to insufficient buffer capacity, the logical unit may terminate the WRITE command with CHECK CONDITION status, 2/04/08 LOGICAL UNIT NOT READY, LONG WRITE IN PROGRESS and the host ***shall*** issue the same WRITE command again. After logical unit becomes ready due to sufficient buffer capacity for the WRITE command, the WRITE command ***shall*** be performed normally.

When Restricted Overwrite method is currently performed (Restricted Overwrite Feature (0026h) or Rigid Restricted Overwrite Feature (002Ch)), READ (10) command or READ (12) command ***shall*** be performed normally after data in buffer is written on the disc.

In case of DRT-DM mode, when Enhanced Defect Reporting Feature (0029h) is current and when the EMCDR field is set to 2 or 3, and if a Type 1, Type 2, or Type 3 defect level is found in DBI memory for any of the blocks being written, the logical unit ***shall*** terminate the command with CHECK CONDITION status, 1/18/05 RECOVERED DATA - RECOMMEND REASSIGNMENT at the completion of the command. Data in buffer ***shall*** be written on the medium normally.

Table 622 describes errors that may occur during the operation of the command or which may cause a CHECK CONDITION status to be reported.

Table 622 - WRITE (10) command errors

Error Description
A-1.1, "Deferred Error Reporting" on page 721
Table 630 - *Basic Error Codes* on page 730
Table 631 - *Media Access Error Codes* on page 733
Table 632 - *Write Error Codes* on page 736

16.49 WRITE (12) command

The WRITE (12) command requests that the logical unit write the data transferred from the host to the medium.

This command is mandatory to support the Real-Time Streaming Feature with SW bit is set to one.

If Enhanced Defect Reporting Feature (0029h) is current, the logical unit ***shall*** follow the setting of the PER bit and the EMCDR field in *Read/Write Error Recovery Parameters* Mode Page (01h). See *9.0, "Logical unit assisted software defect management model"* on page 333.

Table 623 - WRITE (12) Command Descriptor Block

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation code (AAh)							
1	LUN (Obsolete)			DPO (0)	FUA	EBP (0)	Reserved	RelAdr
2	(MSB) Logical Block Address							
3								
4								
5								(LSB)
6	(MSB) Transfer Length							
7								
8								
9								(LSB)
10	Streaming	Reserved						
11	Vendor-Specific		Reserved			NACA	Flag	Link

The Streaming bit of one specifies that the Stream recording operation ***shall*** be used for the command (see *8.0, "Real-Time Stream recording/playback model"* on page 327). The Streaming bit of zero specifies that the conventional write operation ***shall*** be used for the command. If the Streaming bit is set to one, the cache control Mode parameter may be ignored.

If Streaming bit is set to 1 and if the logical unit supports Group3 time-out and if G3Enable bit in *Time-out & Protect* Mode Page (1Dh) is set to 1, the logical unit ***shall*** terminate this command within Group 3 time-out duration. If G3Enable bit is set to 0, this command is categorized as Group 1 time-out.

When the Streaming bit is set to one, the FUA bit ***shall*** be set to zero. If both the Streaming bit and the FUA bit are set to one, the logical unit ***shall*** terminate the command with CHECK CONDITION status, 5/24/00 INVALID FIELD IN CDB.

The Logical Block Address field specifies the logical block where the write operation ***shall*** begin.

When the host issues the command with the Streaming bit set to one, the value of the Logical Block Address field and the Transfer Length field ***shall*** be the integral multiple of the Blocking factor. The Blocking factor of the media is described in the Feature description of each media, see *16.4.2, "Features"* on page 409. If the Logical Block Address field and the Transfer Length field values are not set to the integral multiple of the Blocking factor, the logical unit ***shall*** terminate the command with CHECK CONDITION status, 5/24/00 INVALID FIELD IN CDB.

For the DVD-RAM Ver.2.1 and HD DVD-Rewritable, the logical unit ***shall*** set all Recording Type bits to one, which are in the Data ID fields of all sectors within the ECC block to be written, when WRITE (12) command with the Streaming bit set to one is issued by the host. And the logical unit ***shall*** set all the Recording Type bits to zero when WRITE (12) command with the Streaming bit set to zero is issued by the host.

When Enhanced Defect Reporting Feature (0029h) is current and the PER bit and/or the EMCDR field is set to 2 or 3 and the Streaming bit is set to one, and if the logical unit could not write some data to the medium, the logical unit ***shall*** terminate the command with CHECK CONDITION status, 1/18/05 RECOVERED DATA - RECOMMEND

REASSIGNMENT at the completion of the command. Type 4 defect ***shall*** be stored in DBI memory. For other cases, see *16.48, "WRITE (10) command"* on page 709.

See *16.48, "WRITE (10) command"* on page 709 for a description of the other parameters for this command.

See Table 622 - *WRITE (10) command errors* on page 712 for information on the error conditions.

16.50 WRITE AND VERIFY (10) command

The WRITE AND VERIFY (10) command requests that the logical unit write the data transferred from the host to the medium and then verify that the data is correctly written.

If Enhanced Defect Reporting Feature (0029h) is current, the logical unit ***shall*** follow the setting of the PER bit and the EMCDR field in *Read/Write Error Recovery Parameters* Mode Page (01h). See *9.0, "Logical unit assisted software defect management model"* on page 333.

Table 624 - WRITE AND VERIFY (10) Command Descriptor Block

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation code (2Eh)							
1	LUN (Obsolete)			DPO (0)	Reserved		BytChk (0)	RelAdr
2	(MSB)							
3	Logical Block Address							
4								
5								(LSB)
6	Reserved							
7	(MSB)			Transfer Length				(LSB)
8								
9	Vendor-Specific		Reserved			NACA	Flag	Link
10	PAD							
11								

The verify operation of this command ***shall*** use stricter criteria for data recoverability than Read commands. The criteria is derived from the appropriate media standard, with additional vendor specific criteria allowed. Automatic reallocation ***shall*** be controlled by the ARRE bit (see *16.11.3.1, "Read/Write Error Recovery Parameters Mode Page"* on page 495). The VERIFY command may return an error for a sector that a READ command may not.

The RelAdr bit is only used for SCSI logical units. For information on this bit *C-3.1, "Use of the RelAdr bit"* on page 749.

The byte check (BytChk) bit is not used and ***shall*** be set to zero, which causes a medium verification to be performed with no data comparison.

The Disable Page Out (DPO) bit is not used by C/DVD/HD DVD logical units and ***shall*** be set to zero. A DPO bit of zero indicates the priority ***shall*** be determined by the retention priority fields in the cache page if supported. All other aspects of the algorithm implementing the cache memory replacement strategy are vender specific.

The Transfer Length field specifies the number of contiguous logical blocks of data or blanks that ***shall*** be written and verified. A Transfer Length of zero indicates that no logical blocks ***shall*** be verified. This condition ***shall not*** be considered as an error. Any other value indicates the number of logical blocks that ***shall*** be verified.

For DVD-RAM Ver.2.1 and HD DVD-Rewritable, the logical unit ***shall*** set the all Recording Type bits to zero, which are in the Data ID fields of all sectors within the ECC block to be written.

Table 625 - WRITE AND VERIFY (10) command errors

Error Description
A-1.1, "Deferred Error Reporting" on page 721
Table 630 - *Basic Error Codes* on page 730
Table 631 - *Media Access Error Codes* on page 733
Table 632 - *Write Error Codes* on page 736

16.51 WRITE BUFFER command

The WRITE BUFFER command is used in conjunction with the READ BUFFER command as a diagnostic function for testing logical unit memory in the target SCSI device and the integrity of the service delivery subsystem. Additional modes are provided for downloading microcode and for downloading and saving microcode.

Table 626 - WRITE BUFFER Command Descriptor Block

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation code (3Bh)							
1	LUN (Obsolete)			Reserved		Mode		
2	Buffer ID							
3	(MSB)							
4	Buffer offset							
5								(LSB)
6	(MSB)							
7	Parameter list length							
8								(LSB)
9	Vendor-Specific		Reserved			NACA	Flag	Link
10	PAD							
11								

If reservations are active, they ***shall*** affect the execution of the WRITE BUFFER command as follows. A reservation conflict ***shall*** occur when a WRITE BUFFER command is received from a host other than the one holding a logical unit or element reservation.

This command ***shall not*** alter any medium of the logical unit when the data mode or the combined header and data mode is specified.

The function of this command and the meaning of fields within the command descriptor block depend on the contents of the Mode field. The Mode field is defined in Table 627.

Table 627 - WRITE BUFFER Mode field definition

Mode	Description	Implementation requirements
000b[a]	Write combined header and data	Optional
001b[a]	Vendor-specific	Vendor-specific
010b	Write data	Optional
011b	Reserved	Reserved
100b	Download microcode	Optional
101b	Download microcode and save	Optional
110b[b]	Download microcode with offsets	Optional
111b[b]	Download microcode with offsets and save	Optional

a. Implementing this Mode is not recommended.
b. These are the only Modes recommended when Buffer offsets are used.

16.51.1 Combined header and data mode (000b)

In this mode, data to be transferred is preceded by a four-byte header. The four-byte header consists of all reserved bytes. The Buffer ID and the Buffer offset fields ***shall*** be zero. The Parameter list length field specifies the maximum number of bytes that ***shall*** be transferred from the Data-Out Buffer. This number includes four bytes of header, so the data length to be stored in the logical unit's buffer is Parameter list length minus four. The host should attempt to ensure that the Parameter list length is not greater than four plus the buffer capacity (see *16.18.4,* on page 534) that is returned in the header of the READ BUFFER command (Mode 00b). If the Parameter list length exceeds the buffer capacity the logical unit ***shall*** return CHECK CONDITION status, 5/1A/00 PARAMETER LIST LENGTH ERROR.

16.51.2 Vendor-specific mode (001b)

In this mode, the meaning of the Buffer ID, Buffer offset, and Parameter list length fields are not specified by this specification.

16.51.3 Data mode (010b)

In this mode, the Data-Out Buffer contains buffer data destined for the logical unit. The Buffer ID field identifies a specific buffer within the logical unit. The vendor assigns Buffer ID codes to buffers within the logical unit. Buffer ID zero ***shall*** be supported. If more than one buffer is supported, additional Buffer ID codes ***shall*** be assigned contiguously, beginning with one. If an unsupported Buffer ID code is selected, the logical unit ***shall*** return CHECK CONDITION status, 5/24/00 INVALID FIELD IN CDB. Data are written to the logical unit buffer starting at the location specified by the Buffer offset. The host should conform to the offset boundary requirements returned in the READ BUFFER descriptor. If the logical unit is unable to accept the specified Buffer offset, it ***shall*** return CHECK CONDITION status, 5/24/00 INVALID FIELD IN CDB.

The Parameter list length specifies the maximum number of bytes that ***shall*** be transferred from the Data-Out Buffer to be stored in the specified buffer beginning at the Buffer offset. The host should attempt to ensure that the Parameter list length plus the Buffer offset does not exceed the capacity of the specified buffer. (The capacity of the buffer may be determined by the Buffer Capacity field in the READ BUFFER descriptor.) If the Buffer offset and Parameter list length fields specify a transfer in excess of the buffer capacity, the logical unit ***shall*** return CHECK CONDITION status, 5/24/00 INVALID FIELD IN CDB.

16.51.4 Download microcode mode (100b)

If the logical unit cannot accept this command because of some device condition, the logical unit ***shall*** terminate each WRITE BUFFER command with this mode (100b) with CHECK CONDITION status, 5/2C/00 COMMAND SEQUENCE ERROR.

In this mode, vendor-specific microcode or control information ***shall*** be transferred to the control memory space of the logical unit. After a power-cycle or reset, the device operation ***shall*** revert to a vendor-specific condition. The meanings of the Buffer ID, Buffer offset, and Parameter list length fields are not specified by this specification and are not required to be zero-filled. When the microcode download has completed successfully the logical unit ***shall*** generate a UNIT ATTENTION condition for all hosts except the one that issued the WRITE BUFFER command. The additional sense code ***shall*** be set to MICROCODE HAS BEEN CHANGED.

16.51.5 Download microcode and save mode (101b)

If the logical unit cannot accept this command because of some device condition, the logical unit ***shall*** terminate each WRITE BUFFER command with this mode (101b) with CHECK CONDITION status, 5/2C/00 COMMAND SEQUENCE ERROR.

In this mode, vendor-specific microcode or control information ***shall*** be transferred to the logical unit and, if the WRITE BUFFER command is completed successfully, also ***shall*** be saved in a non-volatile memory space (semiconductor, disk, or other). The downloaded code ***shall*** then be effective after each power-cycle and reset until it is supplanted in another download microcode and save operation. The meanings of the Buffer ID, Buffer offset, and Parameter list length fields are not specified by this specification and are not required to be zero-filled. When the download microcode and save command has completed successfully the logical unit ***shall*** generate a UNIT ATTENTION condition for all hosts except the one that issued the WRITE BUFFER command. When reporting the UNIT ATTENTION condition, the logical unit ***shall*** set the additional sense code to MICROCODE HAS BEEN CHANGED.

16.51.6 Download microcode with offsets (110b)

In this mode, the host may split the transfer of the vendor-specific microcode or control information over two or more WRITE BUFFER commands. If the logical unit cannot accept this command because of some device condition, the logical unit ***shall*** terminate each WRITE BUFFER command with this mode (110b) with CHECK CONDITION status, 5/2C/00 COMMAND SEQUENCE ERROR.

If the last WRITE BUFFER command of a set of one or more commands completes successfully, the microcode or control information ***shall*** be transferred to the control memory space of the logical unit. After a power-cycle or reset, the device ***shall*** revert to a vendor-specific condition. In this mode, the Data-Out Buffer contains vendor-specific, self-describing microcode or control information.

Since the downloaded microcode or control information may be sent using several commands, when the logical unit detects the last download microcode with offsets and save mode WRITE BUFFER command has been received, the logical unit ***shall*** perform any logical unit required verification of the complete set of downloaded microcode or control information prior to returning GOOD status for the last command. After the last command completes successfully the logical unit ***shall*** generate a UNIT ATTENTION condition for all hosts except the one that issued the set of WRITE BUFFER commands. When reporting the UNIT ATTENTION condition, the logical unit ***shall*** set the additional sense code to MICROCODE HAS BEEN CHANGED.

If the complete set of WRITE BUFFER commands required to effect a microcode or control information change (one or more commands) are not received before a reset or power-on cycle occurs, the change ***shall not*** be effective and the new microcode or control information ***shall*** be discarded.

The Buffer ID field identifies a specific buffer within the logical unit. The vendor assigns Buffer ID codes to buffers within the logical unit. A Buffer ID value of zero ***shall*** be supported. If more than one buffer is supported, additional Buffer ID codes ***shall*** be assigned contiguously, beginning with one. If an unsupported Buffer ID code is identified, the logical unit ***shall*** return CHECK CONDITION status, 5/24/00 INVALID FIELD IN CDB.

The microcode or control information are written to the logical unit buffer starting at the location specified by the Buffer offset. The host ***shall*** send commands that conform to the offset boundary requirements (see *16.18.4,* on page 534). If the logical unit is unable to accept the specified Buffer offset, it ***shall*** return CHECK CONDITION status, 5/24/00 INVALID FIELD IN CDB.

The Parameter list length specifies the maximum number of bytes that ***shall*** be present in the Data-Out Buffer to be stored in the specified buffer beginning at the Buffer offset. The host should attempt to ensure that the Parameter list length plus the Buffer offset does not exceed the capacity of the specified buffer. (The capacity of the buffer may be determined by the Buffer Capacity field in the READ BUFFER descriptor.) If the Buffer offset and Parameter list length fields specify a transfer in excess of the buffer capacity, the logical unit ***shall*** return CHECK CONDITION status, 5/24/00 INVALID FIELD IN CDB.

16.51.7 Download microcode with offsets and save mode (111b)

In this mode, the host may split the transfer of the vendor-specific microcode or control information over two or more WRITE BUFFER commands. If the logical unit cannot accept this command because of some device condition, the logical unit ***shall*** terminate each mode 111b WRITE BUFFER command with CHECK CONDITION status, 5/2C/00 COMMAND SEQUENCE ERROR.

If the last WRITE BUFFER command of a set of one or more commands completes successfully, the microcode or control information ***shall*** be saved in a non-volatile memory space (semiconductor, disk, or other). The saved downloaded microcode or control information ***shall*** then be effective after each power-cycle and reset until it is supplanted by another download microcode with save operation or download microcode with offsets and save operation. In this mode, the Data-Out Buffer contains vendor-specific, self-describing microcode or control information.

Since the downloaded microcode or control information may be sent using several commands, when the logical unit detects the last download microcode with offsets and save mode WRITE BUFFER command has been received, the logical unit ***shall*** perform any logical unit required verification of the complete set of downloaded microcode or control information prior to returning GOOD status for the last command. After the last command completes successfully the logical unit ***shall*** generate a UNIT ATTENTION condition for all hosts except the one that issued the set of WRITE BUFFER commands. When reporting the UNIT ATTENTION condition, the logical unit ***shall*** set the additional sense code to MICROCODE HAS BEEN CHANGED.

If the complete set of WRITE BUFFER commands required to effect a microcode or control information change (one or more commands) are not received before a reset or power-on cycle occurs, the change ***shall not*** be effective and the new microcode or control information ***shall*** be discarded. The Buffer ID field identifies a specific buffer within the logical unit. The vendor assigns Buffer ID codes to buffers within the logical unit. A Buffer ID value of zero ***shall*** be supported. If more than one buffer is supported, additional Buffer ID codes ***shall*** be assigned contiguously, beginning with one. If an unsupported Buffer ID code is identified, the logical unit ***shall*** return CHECK CONDITION status, 5/24/00 INVALID FIELD IN CDB.

The microcode or control information are written to the logical unit buffer starting at the location specified by the Buffer offset. The host ***shall*** conform to the offset boundary requirements. If the logical unit is unable to accept the specified Buffer offset, it ***shall*** return CHECK CONDITION status, 5/24/00 INVALID FIELD IN CDB.

The Parameter list length specifies the maximum number of bytes that ***shall*** be present in the Data-Out Buffer to be stored in the specified buffer beginning at the Buffer offset. The host should attempt to ensure that the Parameter list length plus the Buffer offset does not exceed the capacity of the specified buffer. (The capacity of the buffer may be determined by the Buffer Capacity field in the READ BUFFER descriptor.) If the Buffer offset and Parameter list length fields specify a transfer in excess of the buffer capacity, the logical unit ***shall*** return CHECK CONDITION status, 5/24/00 INVALID FIELD IN CDB.

Table 628 describes errors that may occur during the operation of the command or which may cause a CHECK CONDITION status to be reported.

Table 628 - WRITE BUFFER command errors

Error Description
A-1.1, "Deferred Error Reporting" on page 721
Table 630 - *Basic Error Codes* on page 730

Appendix A - Error Reporting and Sense Codes (Normative)

A-1 Error Reporting

This annex lists error codes that may be generated by logical units. Specific commands specify that certain errors occur in response to certain conditions, but each command does not contain a comprehensive list of possible error conditions. Although a particular command lists a set of errors, some of those errors may be typically reported to a subsequent command due to deferred error reporting.

A-1.1 Deferred Error Reporting

Any error may be reported in response to any command due to the occurrence of a deferred error. For example, a write error may occur due to data cached from a WRITE (10) command and that error ***shall*** be reported in response to the next command (with some exceptions). Errors listed in Table 630 are not caused by any specific commands but by actions outside the control of the Initiator.

A-1.2 Error Tables

Table 629 lists all errors that may be generated by logical units. Not all errors are applicable to all devices.

Table 630 lists errors that may occur at any time, typically in response to a protocol or hardware error or user intervention.

Table 631 lists errors that may occur when accessing the medium. The access may be implicit or explicit, and may be a read or write.

Table 632 lists errors that may occur when writing to the medium. The write may be to the user Data Area or to a control area on the medium.

Table 633 lists errors that may occur when operating on Sessions or Borders.

Table 634 lists errors that may occur when performing a key exchange operation.

Table 629 - All Error Codes (Sheet 1 of 8)

Sense Key	ASC	ASC Q	Description	Type
8	--	--	BLANK CHECK	Write Once, Incremental Streaming Write
0	00	00	NO ADDITIONAL SENSE INFORMATION	General
0	00	01	FILEMARK DETECTED	N/A
0	00	02	END-OF-PARTITION/MEDIUM DETECTED	N/A
0	00	03	SETMARK DETECTED	N/A
0	00	04	BEGINNING-OF-PARTITION/MEDIUM DETECTED	N/A
0	00	05	END-OF-DATA DETECTED	N/A
B	00	06	I/O PROCESS TERMINATED, PLAY OPERATION ABORTED	General
0	00	11	AUDIO PLAY OPERATION IN PROGRESS	Audio Play
0	00	12	AUDIO PLAY OPERATION PAUSED	Audio Play
0	00	13	AUDIO PLAY OPERATION SUCCESSFULLY COMPLETED	Audio Play
0	00	14	AUDIO PLAY OPERATION STOPPED DUE TO ERROR	Audio Play
0	00	15	NO CURRENT AUDIO STATUS TO RETURN	Audio Play
0	00	16	OPERATION IN PROGRESS	Sequential Write
4	00	17	CLEANING REQUESTED	Read
4	01	00	NO INDEX/SECTOR SIGNAL	Read
3	02	00	NO SEEK COMPLETE	Read
3	03	00	PERIPHERAL DEVICE WRITE FAULT	Random Write
3	03	01	NO WRITE CURRENT	N/A
3	03	02	EXCESSIVE WRITE ERRORS	N/A
2	04	00	LOGICAL UNIT NOT READY, CAUSE NOT REPORTABLE	General
2	04	01	LOGICAL UNIT IS IN PROCESS OF BECOMING READY	Read
2	04	02	LOGICAL UNIT NOT READY, INITIALIZING CMD. REQUIRED	Read
2	04	03	LOGICAL UNIT NOT READY, MANUAL INTERVENTION REQUIRED	General
2	04	04	LOGICAL UNIT NOT READY, FORMAT IN PROGRESS	Random Write
2	04	05	LOGICAL UNIT NOT READY, REBUILD IN PROGRESS	N/A
2	04	06	LOGICAL UNIT NOT READY, RECALCULATION IN PROGRESS	N/A
2	04	07	LOGICAL UNIT NOT READY, OPERATION IN PROGRESS	Read
2	04	08	LOGICAL UNIT NOT READY, LONG WRITE IN PROGRESS	Write
4	05	00	LOGICAL UNIT DOES NOT RESPOND TO SELECTION	General
2	06	00	NO REFERENCE POSITION FOUND (medium may be upside down)	Read
5	07	00	MULTIPLE PERIPHERAL DEVICES SELECTED	N/A
4	08	00	LOGICAL UNIT COMMUNICATION FAILURE	General
4	08	01	LOGICAL UNIT COMMUNICATION TIME-OUT	General
4	08	02	LOGICAL UNIT COMMUNICATION PARITY ERROR	General
4	08	03	LOGICAL UNIT COMMUNICATION CRC ERROR (ULTRA-DMA/32)	General
4	09	00	TRACK FOLLOWING ERROR	Read
4	09	01	TRACKING SERVO FAILURE	Read
4	09	02	FOCUS SERVO FAILURE	Read
4	09	03	SPINDLE SERVO FAILURE	Read
4	09	04	HEAD SELECT FAULT	N/A
6	0A	00	ERROR LOG OVERFLOW	General

Table 629 - All Error Codes (Sheet 2 of 8)

Sense Key	ASC	ASC Q	Description	Type
1	0B	00	WARNING	General
1	0B	01	WARNING - SPECIFIED TEMPERATURE EXCEEDED	General
1	0B	02	WARNING - ENCLOSURE DEGRADED	General
3	0C	00	WRITE ERROR	Write
3	0C	01	WRITE ERROR - RECOVERED WITH AUTO REALLOCATION	N/A
3	0C	02	WRITE ERROR - AUTO REALLOCATION FAILED	Random Write
3	0C	03	WRITE ERROR - RECOMMEND REASSIGNMENT	Random Write
3	0C	04	COMPRESSION CHECK MISCOMPARE ERROR	N/A
3	0C	05	DATA EXPANSION OCCURRED DURING COMPRESSION	N/A
3	0C	06	BLOCK NOT COMPRESSIBLE	N/A
3	0C	07	WRITE ERROR - RECOVERY NEEDED	Write
3	0C	08	WRITE ERROR - RECOVERY FAILED	Write
3	0C	09	WRITE ERROR - LOSS OF STREAMING	Sequential Write
1	0C	0A	WRITE ERROR - PADDING BLOCKS ADDED	Sequential Write
	0D	00	Reserved	
	0E	00	Reserved	
	0F	00	Reserved	
3	10	00	ID CRC OR ECC ERROR	Read
3	11	00	UNRECOVERED READ ERROR	Read
3	11	01	READ RETRIES EXHAUSTED	Read
3	11	02	ERROR TOO LONG TO CORRECT	Read
3	11	03	MULTIPLE READ ERRORS	N/A
3	11	04	UNRECOVERED READ ERROR - AUTO REALLOCATE FAILED	N/A
3	11	05	L-EC UNCORRECTABLE ERROR	Read
3	11	06	CIRC UNRECOVERED ERROR	CD Read
3	11	07	RE-SYNCHRONIZATION ERROR	N/A
3	11	08	INCOMPLETE BLOCK READ	N/A
3	11	09	NO GAP FOUND	N/A
3	11	0A	MISCORRECTED ERROR	N/A
3	11	0B	UNRECOVERED READ ERROR - RECOMMEND REASSIGNMENT	N/A
3	11	0C	UNRECOVERED READ ERROR - RECOMMEND REWRITE THE DATA	N/A
3	11	0D	DE-COMPRESSION CRC ERROR	N/A
3	11	0E	CANNOT DECOMPRESS USING DECLARED ALGORITHM	N/A
3	11	0F	ERROR READING UPC/EAN NUMBER	CD Read
3	11	10	ERROR READING ISRC NUMBER	CD Read
B	11	11	READ ERROR - LOSS OF STREAMING	Read
3	12	00	ADDRESS MARK NOT FOUND FOR ID FIELD	Read
3	13	00	ADDRESS MARK NOT FOUND FOR DATA FIELD	Read
3	14	00	RECORDED ENTITY NOT FOUND	Write
3	14	01	RECORD NOT FOUND	Read
3	14	02	FILEMARK OR SETMARK NOT FOUND	N/A
3	14	03	END-OF-DATA NOT FOUND	N/A
3	14	04	BLOCK SEQUENCE ERROR	N/A
3	14	05	RECORD NOT FOUND - RECOMMEND REASSIGNMENT	Read
3	14	06	RECORD NOT FOUND - DATA AUTO-REALLOCATED	Read
3	15	00	RANDOM POSITIONING ERROR	Read

Table 629 - All Error Codes (Sheet 3 of 8)

Sense Key	ASC	ASC Q	Description	Type
3	15	01	MECHANICAL POSITIONING ERROR	Read
3	15	02	POSITIONING ERROR DETECTED BY READ OF MEDIUM	Read
3	16	00	DATA SYNCHRONIZATION MARK ERROR	Random Write
3	16	01	DATA SYNC ERROR - DATA REWRITTEN	Random Write
3	16	02	DATA SYNC ERROR - RECOMMEND REWRITE	Random Write
3	16	03	DATA SYNC ERROR - DATA AUTO-REALLOCATED	Random Write
3	16	04	DATA SYNC ERROR - RECOMMEND REASSIGNMENT	Random Write
1	17	00	RECOVERED DATA WITH NO ERROR CORRECTION APPLIED	Read
1	17	01	RECOVERED DATA WITH RETRIES	Read
1	17	02	RECOVERED DATA WITH POSITIVE HEAD OFFSET	Read
1	17	03	RECOVERED DATA WITH NEGATIVE HEAD OFFSET	Read
1	17	04	RECOVERED DATA WITH RETRIES AND/OR CIRC APPLIED	Read
1	17	05	RECOVERED DATA USING PREVIOUS SECTOR ID	Read
1	17	06	RECOVERED DATA WITHOUT ECC - DATA AUTO-REALLOCATED	Random Write
1	17	07	RECOVERED DATA WITHOUT ECC - RECOMMEND REASSIGNMENT	Random Write
1	17	08	RECOVERED DATA WITHOUT ECC - RECOMMEND REWRITE	Random Write
1	17	09	RECOVERED DATA WITHOUT ECC - DATA REWRITTEN	Random Write
1	18	00	RECOVERED DATA WITH ERROR CORRECTION APPLIED	Read
1	18	01	RECOVERED DATA WITH ERROR CORR. & RETRIES APPLIED	Read
1	18	02	RECOVERED DATA - DATA AUTO-REALLOCATED	Random Write
1	18	03	RECOVERED DATA WITH CIRC	CD Read
1	18	04	RECOVERED DATA WITH L-EC	Read
1	18	05	RECOVERED DATA - RECOMMEND REASSIGNMENT	Random Write
1	18	06	RECOVERED DATA - RECOMMEND REWRITE	Random Write
1	18	07	RECOVERED DATA WITH ECC - DATA REWRITTEN	Random Write
1	18	08	RECOVERED DATA WITH LINKING	N/A
3	19	00	DEFECT LIST ERROR	Random Write
3	19	01	DEFECT LIST NOT AVAILABLE	Random Write
3	19	02	DEFECT LIST ERROR IN PRIMARY LIST	Random Write
3	19	03	DEFECT LIST ERROR IN GROWN LIST	Random Write
5	1A	00	PARAMETER LIST LENGTH ERROR	General
4	1B	00	SYNCHRONOUS DATA TRANSFER ERROR	General
4	1C	00	DEFECT LIST NOT FOUND	Random Write
4	1C	01	PRIMARY DEFECT LIST NOT FOUND	Random Write
4	1C	02	GROWN DEFECT LIST NOT FOUND	Random Write
E	1D	00	MISCOMPARE DURING VERIFY OPERATION	Write
1	1E	00	RECOVERED ID WITH ECC CORRECTION	Read
3	1F	00	PARTIAL DEFECT LIST TRANSFER	N/A
5	20	00	INVALID COMMAND OPERATION CODE	General
5	21	00	LOGICAL BLOCK ADDRESS OUT OF RANGE	Read
5	21	01	INVALID ELEMENT ADDRESS	N/A
5	21	02	INVALID ADDRESS FOR WRITE	Incremental Streaming Write
5	21	03	INVALID WRITE CROSSING LAYER JUMP	Layer Jump
5	22	00	ILLEGAL FUNCTION (USE 20 00, 24 00, OR 26 00)	N/A
	23	00	Reserved	

Table 629 - All Error Codes (Sheet 4 of 8)

Sense Key	ASC	ASC Q	Description	Type
5	24	00	INVALID FIELD IN CDB	General
5	25	00	LOGICAL UNIT NOT SUPPORTED	General
5	26	00	INVALID FIELD IN PARAMETER LIST	General
5	26	01	PARAMETER NOT SUPPORTED	General
5	26	02	PARAMETER VALUE INVALID	General
5	26	03	THRESHOLD PARAMETERS NOT SUPPORTED	General
5	26	04	INVALID RELEASE OF ACTIVE PERSISTENT RESERVATION	General
7	27	00	WRITE PROTECTED	Write
7	27	01	HARDWARE WRITE PROTECTED	Write
7	27	02	LOGICAL UNIT SOFTWARE WRITE PROTECTED	Write
7	27	03	ASSOCIATED WRITE PROTECT	Write
7	27	04	PERSISTENT WRITE PROTECT	Write
7	27	05	PERMANENT WRITE PROTECT	Write
7	27	06	CONDITIONAL WRITE PROTECT	Write
6	28	00	NOT READY TO READY CHANGE, MEDIUM MAY HAVE CHANGED	General
6	28	01	IMPORT OR EXPORT ELEMENT ACCESSED	N/A
6	29	00	POWER ON, RESET, OR BUS DEVICE RESET OCCURRED	General
6	29	01	POWER ON OCCURRED	General
6	29	02	SCSI BUS RESET OCCURRED	General
6	29	03	BUS DEVICE RESET FUNCTION OCCURRED	General
6	29	04	DEVICE INTERNAL RESET	General
6	2A	00	PARAMETERS CHANGED	General
6	2A	01	MODE PARAMETERS CHANGED	General
6	2A	02	LOG PARAMETERS CHANGED	General
6	2A	03	RESERVATIONS PREEMPTED	General
5	2B	00	COPY CANNOT EXECUTE SINCE HOST CANNOT DISCONNECT	General
5	2C	00	COMMAND SEQUENCE ERROR	General
5	2C	01	TOO MANY WINDOWS SPECIFIED	N/A
5	2C	02	INVALID COMBINATION OF WINDOWS SPECIFIED	N/A
5	2C	03	CURRENT PROGRAM AREA IS NOT EMPTY	CD Write
5	2C	04	CURRENT PROGRAM AREA IS EMPTY	CD Write
5	2C	05	PERSISTENT PREVENT CONFLICT	Morphing
3	2D	00	OVERWRITE ERROR ON UPDATE IN PLACE	N/A
6	2E	00	INSUFFICIENT TIME FOR OPERATION	Timeout
6	2F	00	COMMANDS CLEARED BY ANOTHER INITIATOR	General
2	30	00	INCOMPATIBLE MEDIUM INSTALLED	Read
2	30	01	CANNOT READ MEDIUM - UNKNOWN FORMAT	Read
2	30	02	CANNOT READ MEDIUM - INCOMPATIBLE FORMAT	Read
5	30	02	CANNOT READ MEDIUM - INCOMPATIBLE FORMAT	Read
2	30	03	CLEANING CARTRIDGE INSTALLED	Read
5	30	04	CANNOT WRITE MEDIUM - UNKNOWN FORMAT	Write
5	30	05	CANNOT WRITE MEDIUM - INCOMPATIBLE FORMAT	Write
5	30	06	CANNOT FORMAT MEDIUM - INCOMPATIBLE MEDIUM	Random Write
2	30	07	CLEANING FAILURE	N/A
5	30	08	CANNOT WRITE - APPLICATION CODE MISMATCH	Sequential Write
5	30	09	CURRENT SESSION NOT FIXATED FOR APPEND	Sequential Write

Table 629 - All Error Codes (Sheet 5 of 8)

Sense Key	ASC	ASC Q	Description	Type
3	31	00	MEDIUM FORMAT CORRUPTED	Random Write
3	31	01	FORMAT COMMAND FAILED	Formattable
3	31	02	ZONED FORMATTING FAILED DUE TO SPARE LINKING	Formattable
3	32	00	NO DEFECT SPARE LOCATION AVAILABLE	Random Write
3	32	01	DEFECT LIST UPDATE FAILURE	Random Write
3	33	00	TAPE LENGTH ERROR	N/A
4	34	00	ENCLOSURE FAILURE	General
4	35	00	ENCLOSURE SERVICES FAILURE	General
5	35	01	UNSUPPORTED ENCLOSURE FUNCTION	General
2	35	02	ENCLOSURE SERVICES UNAVAILABLE	General
4	35	03	ENCLOSURE SERVICES TRANSFER FAILURE	General
5	35	04	ENCLOSURE SERVICES TRANSFER REFUSED	General
3	36	00	RIBBON, INK, OR TONER FAILURE	N/A
1	37	00	ROUNDED PARAMETER	N/A
5	38	00	Reserved	Sequential Write
5	39	00	SAVING PARAMETERS NOT SUPPORTED	General
2	3A	00	MEDIUM NOT PRESENT	General
2	3A	01	MEDIUM NOT PRESENT - TRAY CLOSED	General
2	3A	02	MEDIUM NOT PRESENT - TRAY OPEN	General
3	3B	00	SEQUENTIAL POSITIONING ERROR	N/A
3	3B	01	TAPE POSITION ERROR AT BEGINNING-OF-MEDIUM	N/A
3	3B	02	TAPE POSITION ERROR AT END-OF-MEDIUM	N/A
3	3B	03	TAPE OR ELECTRONIC VERTICAL FORMS UNIT NOT READY	N/A
4	3B	04	SLEW FAILURE	N/A
4	3B	05	PAPER JAM	N/A
3	3B	06	FAILED TO SENSE TOP-OF-FORM	N/A
3	3B	07	FAILED TO SENSE BOTTOM-OF-FORM	N/A
3	3B	08	REPOSITION ERROR	N/A
3	3B	09	READ PAST END OF MEDIUM	N/A
3	3B	0A	READ PAST BEGINNING OF MEDIUM	N/A
3	3B	0B	POSITION PAST END OF MEDIUM	N/A
3	3B	0C	POSITION PAST BEGINNING OF MEDIUM	N/A
5	3B	0D	MEDIUM DESTINATION ELEMENT FULL	N/A
5	3B	0E	MEDIUM SOURCE ELEMENT EMPTY	N/A
6	3B	0F	END OF MEDIUM REACHED	Read
2	3B	11	MEDIUM MAGAZINE NOT ACCESSIBLE	Load
6	3B	12	MEDIUM MAGAZINE REMOVED	Load
6	3B	13	MEDIUM MAGAZINE INSERTED	Load
6	3B	14	MEDIUM MAGAZINE LOCKED	Load
6	3B	15	MEDIUM MAGAZINE UNLOCKED	Load
4	3B	16	MECHANICAL POSITIONING OR CHANGER ERROR	Load
	3C	00	Reserved	N/A
5	3D	00	INVALID BITS IN IDENTIFY MESSAGE	General
2	3E	00	LOGICAL UNIT HAS NOT SELF-CONFIGURED YET	General
4	3E	01	LOGICAL UNIT FAILURE	General
4	3E	02	TIMEOUT ON LOGICAL UNIT	General

Table 629 - All Error Codes (Sheet 6 of 8)

Sense Key	ASC	ASC Q	Description	Type
6	3F	00	TARGET OPERATING CONDITIONS HAVE CHANGED	General
6	3F	01	MICROCODE HAS BEEN CHANGED	General
6	3F	02	CHANGED OPERATING DEFINITION	General
6	3F	03	INQUIRY DATA HAS CHANGED	General
4	40	00	RAM FAILURE (SHOULD USE 40 NN)	N/A
4	40	NN	DIAGNOSTIC FAILURE ON COMPONENT NN (80H-FFH)	General
4	41	00	DATA PATH FAILURE (SHOULD USE 40 NN)	N/A
4	42	00	POWER-ON OR SELF-TEST FAILURE (SHOULD USE 40 NN)	N/A
5	43	00	MESSAGE ERROR	General
4	44	00	INTERNAL TARGET FAILURE	General
b	45	00	SELECT OR RESELECT FAILURE	General
4	46	00	UNSUCCESSFUL SOFT RESET	General
4	47	00	SCSI PARITY ERROR	General
b	48	00	INITIATOR DETECTED ERROR MESSAGE RECEIVED	General
b	49	00	INVALID MESSAGE ERROR	General
4	4A	00	COMMAND PHASE ERROR	General
4	4B	00	DATA PHASE ERROR	General
4	4C	00	LOGICAL UNIT FAILED SELF-CONFIGURATION	General
b	4D	NN	TAGGED OVERLAPPED COMMANDS (NN = QUEUE TAG)	General
B	4E	00	OVERLAPPED COMMANDS ATTEMPTED	General
	4F	00	Reserved	N/A
	50	00	WRITE APPEND ERROR	N/A
	50	01	WRITE APPEND POSITION ERROR	N/A
	50	02	POSITION ERROR RELATED TO TIMING	N/A
3	51	00	ERASE FAILURE	Random Write
3	51	01	ERASE FAILURE - Incomplete erase operation detected	Sequential Write
3	52	00	CARTRIDGE FAULT	N/A
4	53	00	MEDIA LOAD OR EJECT FAILED	Load
	53	01	UNLOAD TAPE FAILURE	N/A
2	53	02	MEDIUM REMOVAL PREVENTED	General
5	53	02	MEDIUM REMOVAL PREVENTED	General
	54	00	SCSI TO HOST SYSTEM INTERFACE FAILURE	N/A
5	55	00	SYSTEM RESOURCE FAILURE	General
	55	01	SYSTEM BUFFER FULL	N/A
	56	00	Reserved	N/A
3	57	00	UNABLE TO RECOVER TABLE-OF-CONTENTS	Read
	58	00	GENERATION DOES NOT EXIST	N/A
	59	00	UPDATED BLOCK READ	N/A
6	5A	00	OPERATOR REQUEST OR STATE CHANGE INPUT	General
6	5A	01	OPERATOR MEDIUM REMOVAL REQUEST	General
6	5A	02	OPERATOR SELECTED WRITE PROTECT	Write
6	5A	03	OPERATOR SELECTED WRITE PERMIT	Write
6	5B	00	LOG EXCEPTION	General
6	5B	01	THRESHOLD CONDITION MET	General
6	5B	02	LOG COUNTER AT MAXIMUM	General
6	5B	03	LOG LIST CODES EXHAUSTED	General

Table 629 - All Error Codes (Sheet 7 of 8)

Sense Key	ASC	ASC Q	Description	Type
6	5C	00	RPL STATUS CHANGE	N/A
6	5C	01	SPINDLES SYNCHRONIZED	N/A
3	5C	02	SPINDLES NOT SYNCHRONIZED	N/A
1	5D	00	FAILURE PREDICTION THRESHOLD EXCEEDED - Predicted logical unit Failure	General
1	5D	01	FAILURE PREDICTION THRESHOLD EXCEEDED - Predicted Media Failure	General
1	5D	03	FAILURE PREDICTION THRESHOLD EXCEEDED - Predicted Spare Area Exhaustion	Random Write
1	5D	FF	FAILURE PREDICTION THRESHOLD EXCEEDED (FALSE)	General
6	5E	00	LOW POWER CONDITION ON	General
6	5E	01	IDLE CONDITION ACTIVATED BY TIMER	General
6	5E	02	STANDBY CONDITION ACTIVATED BY TIMER	General
6	5E	03	IDLE CONDITION ACTIVATED BY COMMAND	General
6	5E	04	STANDBY CONDITION ACTIVATED BY COMMAND	General
	5F	00	Reserved	N/A
4	60	00	LAMP FAILURE	N/A
3	61	00	VIDEO ACQUISITION ERROR	N/A
3	61	01	UNABLE TO ACQUIRE VIDEO	N/A
3	61	02	OUT OF FOCUS	N/A
4	62	00	SCAN HEAD POSITIONING ERROR	N/A
5	63	00	END OF USER AREA ENCOUNTERED ON THIS TRACK	CD Read
5	63	01	PACKET DOES NOT FIT IN AVAILABLE SPACE	CD Read
5	64	00	ILLEGAL MODE FOR THIS TRACK	CD Read
5	64	01	INVALID PACKET SIZE	CD Write
4	65	00	VOLTAGE FAULT	General
4	66	00	AUTOMATIC DOCUMENT FEEDER COVER UP	N/A
4	66	01	AUTOMATIC DOCUMENT FEEDER LIFT UP	N/A
4	66	02	DOCUMENT JAM IN AUTOMATIC DOCUMENT FEEDER	N/A
4	66	03	DOCUMENT MISS FEED AUTOMATIC IN DOCUMENT FEEDER	N/A
4	67	00	CONFIGURATION FAILURE	N/A
4	67	01	CONFIGURATION OF INCAPABLE LOGICAL UNITS FAILED	N/A
4	67	02	ADD LOGICAL UNIT FAILED	N/A
4	67	03	MODIFICATION OF LOGICAL UNIT FAILED	N/A
4	67	04	EXCHANGE OF LOGICAL UNIT FAILED	N/A
4	67	05	REMOVE OF LOGICAL UNIT FAILED	N/A
4	67	06	ATTACHMENT OF LOGICAL UNIT FAILED	N/A
4	67	07	CREATION OF LOGICAL UNIT FAILED	N/A
2	68	00	LOGICAL UNIT NOT CONFIGURED	N/A
4	69	00	DATA LOSS ON LOGICAL UNIT	N/A
4	69	01	MULTIPLE LOGICAL UNIT FAILURES	N/A
4	69	02	A PARITY/DATA MISMATCH	N/A
1	6A	00	INFORMATIONAL, REFER TO LOG	N/A
6	6B	00	STATE CHANGE HAS OCCURRED	N/A
6	6B	01	REDUNDANCY LEVEL GOT BETTER	N/A
6	6B	02	REDUNDANCY LEVEL GOT WORSE	N/A

Table 629 - All Error Codes (Sheet 8 of 8)

Sense Key	ASC	ASC Q	Description	Type
3	6C	00	REBUILD FAILURE OCCURRED	N/A
3	6D	00	RECALCULATE FAILURE OCCURRED	N/A
4	6E	00	COMMAND TO LOGICAL UNIT FAILED	N/A
5	6F	00	COPY PROTECTION KEY EXCHANGE FAILURE - AUTHENTICATION FAILURE	CPP
5	6F	01	COPY PROTECTION KEY EXCHANGE FAILURE - KEY NOT PRESENT	CPP
5	6F	02	COPY PROTECTION KEY EXCHANGE FAILURE - KEY NOT ESTAB-LISHED	CPP
5	6F	03	READ OF SCRAMBLED SECTOR WITHOUT AUTHENTICATION	CPP
5	6F	04	MEDIA REGION CODE IS MISMATCHED TO LOGICAL UNIT REGION	CPP
5	6F	05	DRIVE REGION MUST BE PERMANENT/REGION RESET COUNT ERROR	CPP
5	6F	06	INSUFFICIENT BLOCK COUNT FOR BINDING NONCE RECORDING	AACS
5	6F	07	CONFLICT IN BINDING NONCE RECORDING	AACS
3	70	NN	DECOMPRESSION EXCEPTION SHORT ALGORITHM ID OF NN	N/A
3	71	00	DECOMPRESSION EXCEPTION LONG ALGORITHM ID	N/A
3	72	00	SESSION FIXATION ERROR	Sequential Write
3	72	01	SESSION FIXATION ERROR WRITING Lead-in	Sequential Write
3	72	02	SESSION FIXATION ERROR WRITING Lead-out	Sequential Write
5	72	03	SESSION FIXATION ERROR - INCOMPLETE TRACK IN SESSION	Sequential Write
5	72	04	EMPTY OR PARTIALLY WRITTEN RESERVED TRACK	Sequential Write
5	72	05	NO MORE RZONE RESERVATIONS ARE ALLOWED	Sequential Write
5	72	06	RMZ EXTENSION IS NOT ALLOWED	Sequential Write
5	72	07	NO MORE TEST ZONE EXTENSIONS ARE ALLOWED	Sequential Write
3	73	00	CD CONTROL ERROR	CD Read
1	73	01	POWER CALIBRATION AREA ALMOST FULL	Sequential Write
3	73	02	POWER CALIBRATION AREA IS FULL	Sequential Write
3	73	03	POWER CALIBRATION AREA ERROR	Sequential Write
3	73	04	PROGRAM MEMORY AREA/RMA UPDATE FAILURE	Sequential Write
3	73	05	PROGRAM MEMORY AREA/RMA IS FULL	Sequential Write
1	73	06	PROGRAM MEMORY AREA/RMA IS (almost) FULL	Sequential Write
1	73	10	CURRENT POWER CALIBRATION AREA ALMOST FULL	Sequential Write
5	73	11	CURRENT POWER CALIBRATION AREA IS FULL	Sequential Write
5	73	15	CURRENT PROGRAM MEMORY AREA/RMZ IS FULL	Sequential Write
1	73	16	CURRENT PROGRAM MEMORY AREA/RMZ IS (almost) FULL	Sequential Write
5	73	17	RDZ IS FULL	Sequential Write
	80 through FF	xx through xx	VENDOR SPECIFIC	

ALL CODES NOT SHOWN ARE RESERVED.

Table 630 - Basic Error Codes (Sheet 1 of 3)

Sense Key	ASC	ASC Q	Description
0	00	00	NO ADDITIONAL SENSE INFORMATION
B	00	06	I/O PROCESS TERMINATED, PLAY OPERATION ABORTED
2	05	00	LOGICAL UNIT DOES NOT RESPOND TO SELECTION
5	07	00	MULTIPLE PERIPHERAL DEVICES SELECTED
4	08	00	LOGICAL UNIT COMMUNICATION FAILURE
4	08	01	LOGICAL UNIT COMMUNICATION TIME-OUT
4	08	02	LOGICAL UNIT COMMUNICATION PARITY ERROR
4	08	03	LOGICAL UNIT COMMUNICATION CRC ERROR (ULTRA-DMA/32)
6	0A	00	ERROR LOG OVERFLOW
1	0B	00	WARNING
1	0B	01	WARNING - SPECIFIED TEMPERATURE EXCEEDED
1	0B	02	WARNING - ENCLOSURE DEGRADED
5	1A	00	PARAMETER LIST LENGTH ERROR
4	1B	00	SYNCHRONOUS DATA TRANSFER ERROR
5	20	00	INVALID COMMAND OPERATION CODE
5	24	00	INVALID FIELD IN CDB
5	25	00	LOGICAL UNIT NOT SUPPORTED
5	26	00	INVALID FIELD IN PARAMETER LIST
5	26	01	PARAMETER NOT SUPPORTED
5	26	02	PARAMETER VALUE INVALID
5	26	03	THRESHOLD PARAMETERS NOT SUPPORTED
5	26	04	INVALID RELEASE OF ACTIVE PERSISTENT RESERVATION
6	28	00	NOT READY TO READY CHANGE, MEDIUM MAY HAVE CHANGED
6	28	01	IMPORT OR EXPORT ELEMENT ACCESSED
6	29	00	POWER ON, RESET, OR BUS DEVICE RESET OCCURRED
6	29	01	POWER ON OCCURRED
6	29	02	SCSI BUS RESET OCCURRED
6	29	03	BUS DEVICE RESET FUNCTION OCCURRED
6	29	04	DEVICE INTERNAL RESET
6	2A	00	PARAMETERS CHANGED
6	2A	01	MODE PARAMETERS CHANGED
6	2A	02	LOG PARAMETERS CHANGED
6	2A	03	RESERVATIONS PREEMPTED
5	2C	00	COMMAND SEQUENCE ERROR
6	2F	00	COMMANDS CLEARED BY ANOTHER INITIATOR
4	34	00	ENCLOSURE FAILURE
4	35	00	ENCLOSURE SERVICES FAILURE
5	35	01	UNSUPPORTED ENCLOSURE FUNCTION
2	35	02	ENCLOSURE SERVICES UNAVAILABLE
4	35	03	ENCLOSURE SERVICES TRANSFER FAILURE
5	35	04	ENCLOSURE SERVICES TRANSFER REFUSED
5	3D	00	INVALID BITS IN IDENTIFY MESSAGE
2	3E	00	LOGICAL UNIT HAS NOT SELF-CONFIGURED YET
4	3E	01	LOGICAL UNIT FAILURE

Table 630 - Basic Error Codes (Sheet 2 of 3)

Sense Key	ASC	ASC Q	Description
4	3E	02	TIMEOUT ON LOGICAL UNIT
6	3F	00	TARGET OPERATING CONDITIONS HAVE CHANGED
6	3F	01	MICROCODE HAS BEEN CHANGED
6	3F	02	CHANGED OPERATING DEFINITION
6	3F	03	INQUIRY DATA HAS CHANGED
4	40	00	RAM FAILURE (SHOULD USE 40 NN)
4	40	NN	DIAGNOSTIC FAILURE ON COMPONENT NN (80H-FFH)
4	41	00	DATA PATH FAILURE (SHOULD USE 40 NN)
4	42	00	POWER-ON OR SELF-TEST FAILURE (SHOULD USE 40 NN)
5	43	00	MESSAGE ERROR
4	44	00	INTERNAL TARGET FAILURE
b	45	00	SELECT OR RESELECT FAILURE
4	46	00	UNSUCCESSFUL SOFT RESET
4	47	00	SCSI PARITY ERROR
b	48	00	INITIATOR DETECTED ERROR MESSAGE RECEIVED
b	49	00	INVALID MESSAGE ERROR
4	4A	00	COMMAND PHASE ERROR
4	4B	00	DATA PHASE ERROR
4	4C	00	LOGICAL UNIT FAILED SELF-CONFIGURATION
b	4D	NN	TAGGED OVERLAPPED COMMANDS (NN = QUEUE TAG)
B	4E	00	OVERLAPPED COMMANDS ATTEMPTED
4	54	00	SCSI TO HOST SYSTEM INTERFACE FAILURE
5	55	00	SYSTEM RESOURCE FAILURE
6	55	01	SYSTEM BUFFER FULL
6	5A	00	OPERATOR REQUEST OR STATE CHANGE INPUT
6	5A	01	OPERATOR MEDIUM REMOVAL REQUEST
6	5A	02	OPERATOR SELECTED WRITE PROTECT
6	5A	03	OPERATOR SELECTED WRITE PERMIT
6	5B	00	LOG EXCEPTION
6	5B	01	THRESHOLD CONDITION MET
6	5B	02	LOG COUNTER AT MAXIMUM
6	5B	03	LOG LIST CODES EXHAUSTED
1	5D	00	FAILURE PREDICTION THRESHOLD EXCEEDED - Predicted logical unit Failure
1	5D	01	FAILURE PREDICTION THRESHOLD EXCEEDED - Predicted Media Failure
1	5D	03	FAILURE PREDICTION THRESHOLD EXCEEDED - Predicted Spare Area Exhaustion
1	5D	FF	FAILURE PREDICTION THRESHOLD EXCEEDED (FALSE)
6	5E	00	LOW POWER CONDITION ON
6	5E	01	IDLE CONDITION ACTIVATED BY TIMER
6	5E	02	STANDBY CONDITION ACTIVATED BY TIMER
6	5E	03	IDLE CONDITION ACTIVATED BY COMMAND
6	5E	04	STANDBY CONDITION ACTIVATED BY COMMAND
4	65	00	VOLTAGE FAULT
4	67	00	CONFIGURATION FAILURE
4	67	01	CONFIGURATION OF INCAPABLE LOGICAL UNITS FAILED
4	67	02	ADD LOGICAL UNIT FAILED
4	67	03	MODIFICATION OF LOGICAL UNIT FAILED

Table 630 - Basic Error Codes (Sheet 3 of 3)

Sense Key	ASC	ASC Q	Description
4	67	04	EXCHANGE OF LOGICAL UNIT FAILED
4	67	05	REMOVE OF LOGICAL UNIT FAILED
4	67	06	ATTACHMENT OF LOGICAL UNIT FAILED
4	67	07	CREATION OF LOGICAL UNIT FAILED
2	68	00	LOGICAL UNIT NOT CONFIGURED
6	6A	00	INFORMATIONAL, REFER TO LOG
6	6B	00	STATE CHANGE HAS OCCURRED
6	6B	01	REDUNDANCY LEVEL GOT BETTER
6	6B	02	REDUNDANCY LEVEL GOT WORSE
3	6C	00	REBUILD FAILURE OCCURRED
3	6D	00	RECALCULATE FAILURE OCCURRED
4	6E	00	COMMAND TO LOGICAL UNIT FAILED
	80	xx	VENDOR SPECIFIC
	through		
	FF	xx	

Table 631 - Media Access Error Codes (Sheet 1 of 3)

Sense Key	ASC	ASC Q	Description
4	00	17	CLEANING REQUESTED
4	01	00	NO INDEX/SECTOR SIGNAL
3	02	00	NO SEEK COMPLETE
2	04	00	LOGICAL UNIT NOT READY, CAUSE NOT REPORTABLE
2	04	01	LOGICAL UNIT IS IN PROCESS OF BECOMING READY
2	04	02	LOGICAL UNIT NOT READY, INITIALIZING CMD. REQUIRED
2	04	03	LOGICAL UNIT NOT READY, MANUAL INTERVENTION REQUIRED
2	04	04	LOGICAL UNIT NOT READY, FORMAT IN PROGRESS
2	04	05	LOGICAL UNIT NOT READY, REBUILD IN PROGRESS
2	04	06	LOGICAL UNIT NOT READY, RECALCULATION IN PROGRESS
2	04	07	LOGICAL UNIT NOT READY, OPERATION IN PROGRESS
2	04	08	LOGICAL UNIT NOT READY, LONG WRITE IN PROGRESS
2	06	00	NO REFERENCE POSITION FOUND (medium may be upside down)
4	09	00	TRACK FOLLOWING ERROR
4	09	01	TRACKING SERVO FAILURE
4	09	02	FOCUS SERVO FAILURE
4	09	03	SPINDLE SERVO FAILURE
4	09	04	HEAD SELECT FAULT
3	10	00	ID CRC OR ECC ERROR
3	11	00	UNRECOVERED READ ERROR
3	11	01	READ RETRIES EXHAUSTED
3	11	02	ERROR TOO LONG TO CORRECT
3	11	03	MULTIPLE READ ERRORS
3	11	04	UNRECOVERED READ ERROR - AUTO REALLOCATE FAILED
3	11	05	L-EC UNCORRECTABLE ERROR
3	11	06	CIRC UNRECOVERED ERROR
3	11	07	RE-SYNCHRONIZATION ERROR
3	11	08	INCOMPLETE BLOCK READ
3	11	09	NO GAP FOUND
3	11	0A	MISCORRECTED ERROR
3	11	0B	UNRECOVERED READ ERROR - RECOMMEND REASSIGNMENT
3	11	0C	UNRECOVERED READ ERROR - RECOMMEND REWRITE THE DATA
3	11	0D	DE-COMPRESSION CRC ERROR
3	11	0E	CANNOT DECOMPRESS USING DECLARED ALGORITHM
3	11	0F	ERROR READING UPC/EAN NUMBER
3	11	10	ERROR READING ISRC NUMBER
B	11	11	READ ERROR - LOSS OF STREAMING
3	12	00	ADDRESS MARK NOT FOUND FOR ID FIELD
3	13	00	ADDRESS MARK NOT FOUND FOR DATA FIELD
3	15	00	RANDOM POSITIONING ERROR
3	15	01	MECHANICAL POSITIONING ERROR
3	15	02	POSITIONING ERROR DETECTED BY READ OF MEDIUM
1	17	00	RECOVERED DATA WITH NO ERROR CORRECTION APPLIED
1	17	01	RECOVERED DATA WITH RETRIES

Table 631 - Media Access Error Codes (Sheet 2 of 3)

Sense Key	ASC	ASC Q	Description
1	17	02	RECOVERED DATA WITH POSITIVE HEAD OFFSET
1	17	03	RECOVERED DATA WITH NEGATIVE HEAD OFFSET
1	17	04	RECOVERED DATA WITH RETRIES AND/OR CIRC APPLIED
1	17	05	RECOVERED DATA USING PREVIOUS SECTOR ID
1	17	06	RECOVERED DATA WITHOUT ECC - DATA AUTO-REALLOCATED
1	17	07	RECOVERED DATA WITHOUT ECC - RECOMMEND REASSIGNMENT
1	17	08	RECOVERED DATA WITHOUT ECC - RECOMMEND REWRITE
1	17	09	RECOVERED DATA WITHOUT ECC - DATA REWRITTEN
1	18	00	RECOVERED DATA WITH ERROR CORRECTION APPLIED
1	18	01	RECOVERED DATA WITH ERROR CORR. & RETRIES APPLIED
1	18	02	RECOVERED DATA - DATA AUTO-REALLOCATED
1	18	03	RECOVERED DATA WITH CIRC
1	18	04	RECOVERED DATA WITH L-EC
1	18	05	RECOVERED DATA - RECOMMEND REASSIGNMENT
1	18	06	RECOVERED DATA - RECOMMEND REWRITE
1	18	07	RECOVERED DATA WITH ECC - DATA REWRITTEN
1	18	08	RECOVERED DATA WITH LINKING
3	19	00	DEFECT LIST ERROR
3	19	01	DEFECT LIST NOT AVAILABLE
3	19	02	DEFECT LIST ERROR IN PRIMARY LIST
3	19	03	DEFECT LIST ERROR IN GROWN LIST
4	1C	00	DEFECT LIST NOT FOUND
4	1C	01	PRIMARY DEFECT LIST NOT FOUND
4	1C	02	GROWN DEFECT LIST NOT FOUND
1	1E	00	RECOVERED ID WITH ECC CORRECTION
3	1F	00	PARTIAL DEFECT LIST TRANSFER
5	21	00	LOGICAL BLOCK ADDRESS OUT OF RANGE
5	21	01	INVALID ELEMENT ADDRESS
2	30	00	INCOMPATIBLE MEDIUM INSTALLED
2	30	01	CANNOT READ MEDIUM - UNKNOWN FORMAT
2	30	02	CANNOT READ MEDIUM - INCOMPATIBLE FORMAT
5	30	02	CANNOT READ MEDIUM - INCOMPATIBLE FORMAT
2	30	03	CLEANING CARTRIDGE INSTALLED
5	30	04	CANNOT WRITE MEDIUM - UNKNOWN FORMAT
5	30	05	CANNOT WRITE MEDIUM - INCOMPATIBLE FORMAT
5	30	06	CANNOT FORMAT MEDIUM - INCOMPATIBLE MEDIUM
2	30	07	CLEANING FAILURE
5	30	08	CANNOT WRITE - APPLICATION CODE MISMATCH
5	30	09	CURRENT SESSION NOT FIXATED FOR APPEND
2	3A	00	MEDIUM NOT PRESENT
2	3A	01	MEDIUM NOT PRESENT - TRAY CLOSED
2	3A	02	MEDIUM NOT PRESENT - TRAY OPEN
3	57	00	UNABLE TO RECOVER TABLE-OF-CONTENTS
6	59	00	UPDATED BLOCK READ

Table 631 - Media Access Error Codes (Sheet 3 of 3)

Sense Key	ASC	ASC Q	Description
5	63	00	END OF USER AREA ENCOUNTERED ON THIS TRACK
5	63	01	PACKET DOES NOT FIT IN AVAILABLE SPACE
5	64	00	ILLEGAL MODE FOR THIS TRACK
5	6F	03	READ OF SCRAMBLED SECTOR WITHOUT AUTHENTICATION
3	73	00	CD CONTROL ERROR
	80	xx	VENDOR SPECIFIC
	through		
	FF	xx	

Table 632 - Write Error Codes (Sheet 1 of 2)

Sense Key	ASC	ASC Q	Description
8	--	--	BLANK CHECK
3	03	00	PERIPHERAL DEVICE WRITE FAULT
3	03	01	NO WRITE CURRENT
3	03	02	EXCESSIVE WRITE ERRORS
3	0C	00	WRITE ERROR
3	0C	01	WRITE ERROR - RECOVERED WITH AUTO REALLOCATION
3	0C	02	WRITE ERROR - AUTO REALLOCATION FAILED
3	0C	03	WRITE ERROR - RECOMMEND REASSIGNMENT
3	0C	04	COMPRESSION CHECK MISCOMPARE ERROR
3	0C	05	DATA EXPANSION OCCURRED DURING COMPRESSION
3	0C	06	BLOCK NOT COMPRESSIBLE
3	0C	07	WRITE ERROR - RECOVERY NEEDED
3	0C	08	WRITE ERROR - RECOVERY FAILED
3	0C	09	WRITE ERROR - LOSS OF STREAMING
1	0C	0A	WRITE ERROR - PADDING BLOCKS ADDED
E	1D	00	MISCOMPARE DURING VERIFY OPERATION
5	21	02	INVALID ADDRESS FOR WRITE
5	21	03	INVALID WRITE CROSSING LAYER JUMP
7	27	01	HARDWARE WRITE PROTECTED
7	27	02	LOGICAL UNIT SOFTWARE WRITE PROTECTED
7	27	03	ASSOCIATED WRITE PROTECT
7	27	04	PERSISTENT WRITE PROTECT
7	27	05	PERMANENT WRITE PROTECT
7	27	06	CONDITIONAL WRITE PROTECT
5	30	04	CANNOT WRITE MEDIUM - UNKNOWN FORMAT
5	30	05	CANNOT WRITE MEDIUM - INCOMPATIBLE FORMAT
5	30	06	CANNOT FORMAT MEDIUM - INCOMPATIBLE MEDIUM
2	30	07	CLEANING FAILURE
5	30	08	CANNOT WRITE - APPLICATION CODE MISMATCH
5	30	09	CURRENT SESSION NOT FIXATED FOR APPEND
3	32	00	NO DEFECT SPARE LOCATION AVAILABLE
3	32	01	DEFECT LIST UPDATE FAILURE
5	38	00	Reserved
4	50	00	WRITE APPEND ERROR
4	50	01	WRITE APPEND POSITION ERROR
4	50	02	POSITION ERROR RELATED TO TIMING
3	51	00	ERASE FAILURE
3	51	01	ERASE FAILURE - Incomplete erase operation detected
5	64	01	INVALID PACKET SIZE
3	73	00	CD CONTROL ERROR
1	73	01	POWER CALIBRATION AREA ALMOST FULL
3	73	02	POWER CALIBRATION AREA IS FULL
3	73	03	POWER CALIBRATION AREA ERROR
3	73	04	PROGRAM MEMORY AREA/RMA UPDATE FAILURE

Table 632 - Write Error Codes (Sheet 2 of 2)

Sense Key	ASC	ASC Q	Description
3	73	05	PROGRAM MEMORY AREA/RMA IS FULL
1	73	06	PROGRAM MEMORY AREA/RMA IS (almost) FULL
1	73	10	CURRENT POWER CALIBRATION AREA ALMOST FULL
5	73	11	CURRENT POWER CALIBRATION AREA IS FULL
5	73	15	CURRENT PROGRAM MEMORY AREA/RMZ IS FULL
1	73	16	CURRENT PROGRAM MEMORY AREA/RMZ IS (almost) FULL
5	73	17	RDZ IS FULL
	80 through FF	xx xx	VENDOR SPECIFIC

Table 633 - Session/Border Error Codes

Sense Key	ASC	ASC Q	Description
5	2C	03	CURRENT PROGRAM AREA IS NOT EMPTY
5	2C	04	CURRENT PROGRAM AREA IS EMPTY
3	72	00	SESSION FIXATION ERROR
3	72	01	SESSION FIXATION ERROR WRITING Lead-in
3	72	02	SESSION FIXATION ERROR WRITING Lead-out
5	72	03	SESSION FIXATION ERROR - INCOMPLETE TRACK IN SESSION
5	72	04	EMPTY OR PARTIALLY WRITTEN RESERVED TRACK
5	72	05	NO MORE RZONE RESERVATIONS ARE ALLOWED
5	72	06	RMZ EXTENSION IS NOT ALLOWED
5	72	07	NO MORE TEST ZONE EXTENSIONS ARE ALLOWED
	80 through FF	xx xx	VENDOR SPECIFIC

Table 634 - Authentication Error Codes

Sense Key	ASC	ASC Q	Description
5	6F	00	COPY PROTECTION KEY EXCHANGE FAILURE - AUTHENTICATION FAILURE
5	6F	01	COPY PROTECTION KEY EXCHANGE FAILURE - KEY NOT PRESENT
5	6F	02	COPY PROTECTION KEY EXCHANGE FAILURE - KEY NOT ESTABLISHED
5	6F	04	MEDIA REGION CODE IS MISMATCHED TO LOGICAL UNIT REGION
5	6F	05	DRIVE REGION MUST BE PERMANENT/REGION RESET COUNT ERROR
5	6F	06	INSUFFICIENT BLOCK COUNT FOR BINDING NONCE RECORDING
5	6F	07	CONFLICT IN BINDING NONCE RECORDING

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Appendix B - ATAPI Implementation Notes (Normative)

B-1 Introduction

See the INCITS T13 ATA/ATAPI-4 Specification for information on the connection and protocol to be use for ATAPI C/DVD device.

The ATA/IDE interface has become a de facto industry standard for connection of disk drives in PC's. In the interest of simplicity and cost, the ATA/IDE interface was originally designed to support only a small subset of computer peripherals. The expanding use of multimedia, inexpensive program distribution on CD & DVD, and faster and more powerful systems has created the need for enhancements to ATA. This specification is one of those enhancements and provides a simple and inexpensive C/DVD interface through a superset of ATA.

B-2 ATA Signal Utilization

ATAPI Devices will utilize the same signals and timing from the ATA Standard and Extensions.

B-3 ATA command Utilization

The ATA Task File concept does not contain enough bytes to support some of the command structures, so a command called "ATAPI Packet command" has been added to allow a Packet to be sent to the Device. The Packet will be transferred by writing multiple times to the Data Register. No random access to the register file in the Peripheral can be done. This technique reduces the number of register addresses needed, but not the actual space needed. Although all the commands for the CD-ROM Device could be sent via this packet mode, some of the existing ATA commands and the full ATA command protocol ***shall*** be provided for the existing drivers to operate correctly. The C/DVD Device will therefore support some existing ATA commands in addition to the new "ATAPI Packet command," so that there will be minimal changes to the existing drivers. This minimal set of ATA commands is different than the minimum as defined in the ATA standard, but should be sufficient for normal operation.

B-4 ATA Compatibility

There are several legacy issues with the existing ATA commands, and therefore the Device will respond to the existing ATA Reset Master/Slave Diagnostic Sequence, but not the Identify Drive or Read commands. This will allow the BIOS and older drivers to ignore the Device and not confuse ATAPI data with normal ATA Drive format data. All unsupported ATA commands ***shall*** be Aborted, and not performed. As with aborted commands in ATA, an interrupt will be generated to signal the completion with an "aborted" error status.

B-5 Packet Types

To allow for generic packet transfer and the connection of SCSI like peripherals, there ***shall*** exist a minimum set of information that is exchanged. This information ***shall*** generically support the following:

- Command Packet (Always padded to number of bytes identified in byte 0 of the identify drive data. 00 = 12 bytes, 01 = 16 bytes)
- Command Parameter Data (e.g., Write Data)
- Command Response Data (e.g., Read Data)
- Status. The Status will not take the form of a packet of information. The status will be presented using the ATAPI Status Register (redefinitions of the ATA Status Register).

B-6 How SCSI is Used by ATAPI

Although the ATAPI Device will utilize many of the actual packet definitions from the SCSI standard, it will NOT use most other features of the normal SCSI Protocol. Thus there are no Phases, no Messages, no sharable bus, (only one host Computer) and no SCSI Hardware. For those who are familiar with the current SCSI-3 effort, this specification will not conform with that Packetized Standard.

B-6.1 Differences from the SCSI Standard

Some of the major differences from the SCSI Standard:

- Status will use the ATAPI description, rather than a Data Byte passed at the end of the command.
- ATAPI Device is slave during operation rather than the master view of a SCSI Peripheral.
- No messages are supported.
- No disconnect/reconnect or any of the SCSI Pointers.
- No linking.
- All CD Command Packets (CP) are 12 bytes in length, rather than the 6, 8, 10 or 12-byte packets of the SCSI Standard; however, 16-byte ATAPI command packets are defined for SAM compatibility for future Devices. The size of the command packet required by a Device is defined in word 0 of the ATAPI Identify Device command, allowing host System Device Drivers to determine the size of the Command Packets before issuing an ATAPI command packet.
- No allegiance conditions are used.

This specification will make use of many of the Standard SCSI Command Block definitions and commands, but some of the commands that would normally be supported by a SCSI Device will not be supported for various reasons. These commands are:

- Reserve and release; as there is only one host allowed, this is not needed.
- Send and receive diagnostics; the ATA EXECUTE DRIVE DIAGS command replaces these commands.
- Change definitions; as there is no SCSI, this command is nonsensical.
- Copy / Copy and Verify; no shared bus so this command can’t be implemented.
- Compare; no shared bus, so this command can’t be implemented.
- Read and Write Buffer; simplification.
- Log Sense and Select; simplification.
- Search Data; simplification.
- Verify; simplification.

B-6.2 Reset Usage

This section describes the three types of resets and how they are used in an ATAPI environment.

Table 635 - Reset Function Mapping

Reset Type	ATAPI
Power-On Reset	Same as Power-On Reset in the proposed ATA/ATAPI-4 INCITS T13/1153D Standard
Hard Reset	Hard Reset, RESET- bus signal
	ATA SRST. This is a channel reset and as such is treated as a Hard Reset. However the SRST ***shall not*** reset any mode parameters to the default state.
Device Reset	Device Reset in proposed ATA/ATAPI-4 INCITS T13/1153D Standard
	ATAPI Soft Reset in SFF8020i (expired)

B-6.3 Power On Reset

The Power On Reset ***shall*** operate as specified in the proposed ATA/ATAPI-4 INCITS T13/1153D Standard.

B-6.4 Hard Reset

The Hard Reset corresponds to the Hard Reset (RESET- signal line) and the SRST (ATA/ATAPI Software Reset).

The ATAPI Hard Reset, being different from SCSI, can not reset just one device. In ATAPI all the devices on the same cable are reset.

The effect of these two resets are the same, but usage of the SRST will be restricted.

B-6.4.1 SRST

The SRST was defined for use in an ATA environment and **should not be used in an ATAPI environment**. However there are some specific requirements of the SRST that are specified in the ATA/ATAPI-4 INCITS T13/1153D Proposed Standard. These ***shall*** be followed. These are requirements caused because the SRST is a Channel Reset and not a specific device reset.

B-6.5 Device Reset

The Device Reset corresponds to the DEVICE RESET command in the proposed ATA/ATAPI-4 INCITS T13/1153D Standard. In an earlier standard (SFF8020i - expired) the Device Reset was called ATAPI SOFT RESET. The functions of DEVICE RESET and ATAPI SOFT RESET are the same.

The Device Reset is capable of resetting an individual device.

The Device Reset should keep the media-based information such as disc TOC. It it expected that the Device Reset will operate quickly. Host drivers expect that the device will be ready to perform other commands quickly after the Device Reset. It is recommended that all information about a previously installed media be maintained across a Device Reset.

The ATAPI version of Device Reset is different from SCSI. Known differences include:

- Device Reset will immediately reset ATAPI logical protocol sequence. SCSI protocols are not affected by the Device Reset.
- Time constraints on the processing of the reset exist in ATAPI but not the SCSI environments.

B-6.6 Function Comparison Table

Table 636 - Reset Function Comparison

Function	Power-On / Hard Reset	ATA/ATAPI-4 Device Reset	SRST
Initialization sequence required	Yes	No	No
Immediate Bus Release	Yes	Yes	Yes
Mode parameters	Reset to default or saved parameters	No change allowed	No change allowed
Cached Lead-in information	Discarded	Should not re-read Lead-in	Should not re-read Lead-in
Persistent Prevent Flag	Unlocked	No change allowed	No change allowed
Key Management	Reset to Default state	Reset to Default state	No change allowed

B-6.7 Redundant command functionality (Task File vs. Packet)

The SCSI Standard has provided some commands that the ATA Standard also provides. It is the intent of this specification to allow all the functionality to exist, by utilizing only Command Packets. This will allow existing SCSI like drivers to continue to issue packets for all operation, and have some lower level driver convert them to the ATAPI protocol. Unfortunately there are existing low level drivers that would like to continue to use some non data transfer ATA Task File commands. As such both these “Task File” and “Packet” commands will be supported.

B-6.7.1 Door Lock and Door Unlock vs. Prevent / Allow Medium Removal

There exists both an ATA and a Packet method to control the insertion and removal of media. Both of these methods do not provide necessary functionality for the host operating system. It is therefor recommended that both the ATA Lock/ Unlock and the Packet Prevent/Allow functions not be implemented by a C/DVD device. There now exist a new set of commands, both for ATA and for Packet Commands. These commands control a capability called Media Status Notification. As the functionality for the packet and the register based commands are similar, only the Packet versions of the MSN commands ***shall*** be implemented by C/DVD devices.

B-6.7.2 ATAPI Identify Drive vs. Inquiry

The ATAPI IDENTIFY DRIVE command has information that the low level drivers use to perform ATA interface hardware configuration. Information in the Identify Drive ***shall*** continue to look exactly as the ATA Identify Drive does for compatibility reasons. As the information in the Inquiry command cannot be returned by the ATAPI Identify Drive command, the Inquiry command will be supported for use by higher level drivers.

B-6.7.3 Initialize Drive Parameters & Set Features vs. Mode Sense and Mode Select

The INITIALIZE DRIVE PARAMETERS command does not contain a method to provide non ATA device configuration information, and will not be used. As such the Mode Select and Mode Sense from the SCSI standard ***shall*** be supported. The combination of Mode Select and Set Features commands contain all the necessary functionality and is most compatible with the existing BIOSes and OS Drivers.

B-6.8 ATAPI Device Reset

Note: For performance reasons, a Device reset may not force reading of TOC.

B-6.9 Execute Drive Diagnostics

This command ***shall*** perform the internal diagnostic tests implemented by the drive. The DRV bit is ignored. Both drives, if present, ***shall*** perform this command. See the ATA Standard (INCITS T9.2/791D) for more information.

Note: ATAPI device drivers issuing the Execute Diagnostics command will cause all ATA and ATAPI devices to perform a diagnostic command resulting in a device reset. To prevent unwanted resets and or driver compatibility issues, ATAPI drivers should not issue the Execute Diagnostics command. The command is implemented by ATAPI devices for ATA compatibility only.

B-6.10 ATAPI Identify Device

The ATAPI IDENTIFY DEVICE command enables the host to receive parameter information from the drive. For more information see ATA/ATAPI-4 Standard.

B-7 Command Packet Description

An ATAPI command is communicated by sending a Command Packet to the Device. For several commands, the Command Packet is accompanied by a list of parameters sent upon receiving an interrupt following the Command Packet being sent. See the specific commands for detailed information.

The Command Packet always has an operation code as its first byte.

For all commands, if there is an invalid parameter in the Command Packet, then the ATAPI Device ***shall*** abort the command without altering the medium.

Table 637 - Typical Command Packet for Most commands

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation Code							
1	Reserved			Reserved				
2	(MSB)							
3	Logical Block Address (if required)							
4								
5								(LSB)
6	Reserved							
7	(MSB)	Transfer Length (if required) or Parameter List Length (if required) or						
8	Allocation Length (if required)							(LSB)
9	Reserved							
10	Pad							
11								

Table 638 - Typical Command Packet for Some Extended commands

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation Code							
1	Reserved			Reserved				
2	(MSB)							
3	Logical Block Address (if required)							
4								
5								(LSB)
6	(MSB)							
7	Transfer Length (if required) or							
8	Parameter List Length (if required) or							
9	Allocation Length (if required)							(LSB)
10	Reserved							
11	Reserved							

B-7.1 Operation Code

The operation code of the Command Packet has a group code field and a command code field. The three-bit group code field provides for eight groups of command codes. The five-bit command code field provides for thirty-two command codes in each group. Thus, a total of 256 possible operation codes exist. Operation codes are defined in the subsequent sections.

Table 639 - Operation Code

Bit	7	6	5	4	3	2	1	0
	Group Code			Command Code				

Note: The Group / Command code fields have been kept for backward compatibility and are not used by ATAPI.

B-7.2 Logical Block Address

The logical block address ***shall*** begin with block zero and be contiguous up to the last logical block.

B-7.3 Transfer Length

The Transfer Length Field specifies the amount of data to be transferred, usually the number of blocks. For several commands the transfer length indicates the requested number of bytes to be sent as defined in the command description. For these commands the Transfer Length Field may be identified by a different name. See the following descriptions and the individual command descriptions for further information.

In commands that use multiple bytes for the transfer length, a transfer length of zero indicates that no data transfer ***shall*** take place. A value of one or greater indicates the number of blocks that ***shall*** be transferred.

B-7.4 Parameter List Length

The Parameter List Length is used to specify the number of bytes to be sent to the Drive. This field is typically used in Command Packets for parameters that are sent to a Drive (e.g., mode parameters, diagnostic parameters). A parameter length of zero indicates that no data ***shall*** be transferred.

B-7.5 Allocation Length

The Allocation Length Field specifies the maximum number of bytes that a host Computer has allocated for returned data. An allocation length of zero indicates that no data ***shall*** be transferred. The Drive ***shall*** terminate the data transfer when allocation length bytes have been transferred or when all available data have been transferred to the host Computer, whichever is less. The allocation length is used to limit the maximum amount of data (e.g., sense data, mode data) returned to a host Computer. When data is truncated, no error is generated, except for the Mechanism Status command that ***shall*** generate a Parameter List Length Error.

B-8 Status

A Status byte ***shall*** be sent from the Drive to the host Computer at the completion of each command unless the command is terminated by one of the following events:

1. A hard reset condition.
2. An unexpected event.

Status is normally presented at the end of a command, but in some cases may occur prior to transferring the Command Packet.

ILI bit and EOM bit in the error register are not used in this specification. These bits ***shall*** be set to zero at the PACKET command completion. Host ***shall*** take out all error information via sense data.

For a description of the Status Byte see ATA/ATAPI-4.

B-9 Immediate command processing considerations

Immediate commands are a class of commands which return completion status to the host system before they are finished executing the command. The purpose of immediate commands is to allow the host to perform more than one command at a time on the same IDE cable.

In earlier specification (SFF8002i (expired), INF-8090i rev. 3.6) DSC bit was defined to indicate the completion status of the seek operation of immediate commands. But currently DSC bit is replaced by SERV bit for PACKET command overlap feature. About progress indication, refer to each command description and *Section 16.31.1, "Sense-key Specific"* on page 647 and *16.5.6, "Device Busy Class Events"* on page 461.

For C/DVD logical unit, at the completion of Power-on reset sequence DSC bit is set to zero. When a command is issued this bit ***shall*** be set to one and remain in this state unless the logical unit supports overlap or command queuing as defined in ATA/ATAPI-4.

B-10 Command processing considerations and exception conditions

The following sections describe some exception conditions and errors associated with command processing and the sequencing of commands.

B-10.1 Selection of an invalid logical unit

The CD-ROM Drive's response to selection of a logical unit that is not valid is described in the following paragraphs. The logical unit may not be valid because:

1. The ATAPI CD-ROM Drive does not support the logical unit. In response to an INQUIRY command, the ATAPI CD-ROM Drive ***shall*** return the INQUIRY data with the peripheral qualifier set to the value required in *16.7.1, "Standard INQUIRY Data"* on page 477 In response to any other command except REQUEST SENSE, the ATAPI CD-ROM Drive ***shall*** terminate the command with CHECK CONDITION status. In response to a REQUEST SENSE command, the ATAPI CD-ROM Drive ***shall*** return sense data. The sense key ***shall*** be set to ILLEGAL REQUEST and the additional sense code ***shall*** be set to LOGICAL UNIT NOT SUPPORTED.
2. The ATAPI CD-ROM Drive supports the logical unit, but the peripheral device is not currently attached to the ATAPI CD-ROM Drive. In response to an INQUIRY command, the ATAPI CD-ROM Drive ***shall*** return the INQUIRY data with the peripheral qualifier set to the value required in *16.7.1, "Standard INQUIRY Data"* on page 477. In response to any other command except REQUEST SENSE, the ATAPI CD-ROM Drive ***shall*** terminate the command with CHECK CONDITION status. In response to a REQUEST SENSE command, the ATAPI CD-ROM Drive ***shall*** return sense data. The sense key ***shall*** be set to ILLEGAL REQUEST and the additional sense code ***shall*** be set to LOGICAL UNIT NOT SUPPORTED.
3. The ATAPI CD-ROM Drive supports the logical unit and the peripheral device is attached, but not operational. In response to an INQUIRY command, the ATAPI CD-ROM Drive ***shall*** return the INQUIRY data with the peripheral qualifier set to the value required in *16.7.1, "Standard INQUIRY Data"* on page 477. The ATAPI CD-ROM Drive's response to any command other than INQUIRY and REQUEST SENSE is vendor-specific.

B-10.2 Parameter Rounding

Certain parameters sent to an ATAPI Device with various commands contain a range of values. ATAPI devices may choose to implement only selected values from this range. When the ATAPI Device receives a value that it does not support, it either rejects the command (CHECK CONDITION status with ILLEGAL REQUEST sense key) or it rounds the value received to a supported value. The ATAPI device ***shall*** reject unsupported values unless rounding is permitted in the description of the parameter.

Rounding of parameter values, when permitted[1], ***shall*** be performed as follows - An ATAPI device that receives a parameter value that is not an exact supported value ***shall*** adjust the value to one that it supports and ***shall*** return CHECK CONDITION status with a sense key of RECOVERED ERROR. The additional sense code ***shall*** be set to ROUNDED PARAMETER. The host Computer is responsible for issuing an appropriate command to learn what value the ATAPI device has selected.

1. Generally, the ATAPI device should adjust maximum-value fields down to the next lower supported value than the one specified by the host Computer. Minimum-value fields should be rounded up to the next higher supported value than the one specified by the host Computer. In some cases, the type of rounding (up or down) is explicitly specified in the description of the parameter.

B-11 UNIT ATTENTION condition

The ATAPI device ***shall*** generate a UNIT ATTENTION on each valid logical unit whenever the ATAPI device has been reset by a hard reset condition, or by a power-on reset. The ATAPI device ***shall*** also generate a UNIT ATTENTION condition on the affected logical unit(s) whenever one of the following events occurs:

1. A removable Disc or Cartridge may have been changed.
2. The version or level of microcode has been changed.
3. INQUIRY or Packet Identify Drive Data has been changed.
4. The mode parameters in effect for the host Computer have been restored from non-volatile memory.
5. Any other event occurs that requires the attention of the host Computer.
6. Any Disc or Cartridge has been manually moved within a Changer.

The ATAPI device may queue UNIT ATTENTION conditions on logical units. After the first UNIT ATTENTION condition is cleared, another UNIT ATTENTION condition may exist (e.g., a power on condition followed by a microcode change condition).

The UNIT ATTENTION condition ***shall*** persist on the logical unit, until the host Computer clears the condition as described in the following paragraphs.

If an INQUIRY command is received from an host Computer to a logical unit with a pending UNIT ATTENTION condition, the ATAPI device ***shall*** perform the INQUIRY command and ***shall not*** clear the UNIT ATTENTION condition.

If a REQUEST SENSE command is received from a host Computer with a pending UNIT ATTENTION condition, then the ATAPI device ***shall*** either:

1. report any pending sense data and preserve the UNIT ATTENTION condition on the logical unit, or,
2. report the UNIT ATTENTION condition, may discard any pending sense data, and clear the UNIT ATTENTION condition on the logical unit.

If an host Computer issues a command other than GET CONFIGURATION, GET EVENT/STATUS NOTIFICATION, INQUIRY or REQUEST SENSE while a UNIT ATTENTION condition exists for that host, the ATAPI device ***shall not*** perform the command and ***shall*** report CHECK CONDITION status unless a higher priority status as defined by the ATAPI device is also pending (e.g., BUSY).

B-12 Commands and Parameters

The ATAPI commands were derived from the SCSI command set.

With the exception of the CD-ROM MSF addressing technique, the interface uses logical rather than physical addressing for all data blocks. Each Device may be interrogated to determine how many blocks it contains. A logical unit may coincide with all or part of a peripheral device.

Commands often implemented on CD/DVD logical units are listed in Table 640.

Table 640 - Packet Commands for ATAPI C/DVD Devices

Command Description	Opcode	Reference
BLANK	A1h	*16.1,* on page 391
CLOSE TRACK/RZONE/SESSION/BORDER	5Bh	*16.2,* on page 395
FORMAT UNIT	04h	*16.3,* on page 399
GET CONFIGURATION	46h	*16.4,* on page 407
GET EVENT/STATUS NOTIFICATION	4Ah	*16.5,* on page 453
GET PERFORMANCE	ACh	*16.6,* on page 465
INQUIRY	12h	*16.7,* on page 477
LOAD/UNLOAD MEDIUM	A6h	*16.8,* on page 483
MECHANISM STATUS	BDh	*16.9,* on page 485
MODE SELECT (10)	55h	*16.10,* on page 489
MODE SENSE (10)	5Ah	*16.11,* on page 491
PAUSE/RESUME	4Bh	*16.12,* on page 519
PLAY AUDIO (10)	45h	*16.13,* on page 521
PLAY AUDIO MSF	47h	*16.14,* on page 525
PLAY CD	BCh	Obsolete
PREVENT/ALLOW MEDIUM REMOVAL	1Eh	*16.15,* on page 527
READ (10)	28h	*16.16,* on page 529
READ (12)	A8h	*16.17,* on page 531
READ CAPACITY	25h	*16.20,* on page 539
READ CD	BEh	*16.21,* on page 541
READ CD MSF	B9h	*16.22,* on page 551
READ DISC INFORMATION	51h	*16.23,* on page 553
READ DISC STRUCTURE	ADh	*16.24,* on page 559
READ FORMAT CAPACITIES	23h	*16.25,* on page 589
READ HEADER	44h	Obsolete
READ SUBCHANNEL	42h	*16.26,* on page 595
READ TOC/PMA/ATIP	43h	*16.27,* on page 603
READ TRACK/RZONE INFORMATION	52h	*16.28,* on page 617
REPAIR RZONE	58h	*16.29,* on page 631
REPORT KEY	A4h	*16.30,* on page 633
REQUEST SENSE	03h	*16.31,* on page 645
RESERVE TRACK/RZONE/RMZ	53h	*16.32,* on page 651
SCAN	BAh	*16.33,* on page 657
SEEK	2Bh	*16.34,* on page 661
SEND CUE SHEET	5Dh	*16.35,* on page 663
SEND DISC STRUCTURE	BFh	*16.36,* on page 671
SEND EVENT	A2h	*16.37,* on page 679
SEND KEY	A3h	*16.38,* on page 681
SEND OPC INFORMATION	54h	*16.39,* on page 687
SET CD SPEED	BBh	*16.40,* on page 689
SET READ AHEAD	A7h	*16.41,* on page 691
SET STREAMING	B6h	*16.42,* on page 693
START/STOP UNIT	1Bh	*16.43,* on page 697
STOP PLAY/SCAN	4Eh	*16.44,* on page 701
SYNCHRONIZE CACHE	35h	*16.45,* on page 703

Table 640 - Packet Commands for ATAPI C/DVD Devices (Continued)

Command Description	Opcode	Reference
TEST UNIT READY	00h	*16.46,* on page 705
VERIFY (10)	2Fh	*16.47,* on page 707
WRITE (10)	2Ah	*16.48,* on page 709
WRITE (12)	AAh	*16.49,* on page 713
WRITE AND VERIFY (10)	2Eh	*16.50,* on page 715

Appendix C - SCSI Implementation Notes (Normative)

C-1 Introduction

This section will describe where possible the use of the contents for SCSI C/DVD devices. This specification is intended to be used in conjunction with the SCSI-3 Architecture Model (SAM-2), the SCSI-3 Primary Command Set (SPC-2) standard and the SCSI-3 Block Command Set (SBC).

See the INCITS T10 SCSI-3 Specifications for information on the connection and protocol to be use for a SCSI C/DVD device.

C-2 SCSI Signal Utilization

C/DVD Devices will utilize the same signals and timing from the SCSI Standard and Extensions.

C-3 SCSI Compatibility

C-3.1 Use of the RelAdr bit

A relative address (RelAdr) bit of one indicates that the logical block address field is a two's complement displacement. This negative or positive displacement ***shall*** be added to the logical block address last accessed on the logical unit to form the logical block address for this command. This feature is only available when linking commands. The feature requires that a previous command in the linked group have accessed a block of data on the logical unit.

A RelAdr bit of zero indicates that the logical block address field specifies the first logical block of the range of logical blocks to be operated on by this command. This bit is only supported for logical units that make use of a SCSI interface. The command field shows that this bit exists, but is only applicable to SCSI.

C-3.2 Differences from the SCSI Standard

Some of the major differences from the SCSI Standard:

- LUN field of command packets (CDB) is used by this specification.
- SYNCHRONIZE CACHE command does not make use of the Logical Block or Number of Blocks fields.
- EVENT STATUS NOTIFICATION replaces the AEN capability in SCSI.
- CHANGE DEFINITION is not used.
- INQUIRY command does not use EVPD or CmdDt CDB bits.
- UNIT ATTENTION with INQUIRY DATA HAS CHANGED is not used.
- Peripheral qualifier in the INQUIRY data is not used.
- The AERC, TrmTsk and NormACA are in conflict with the current definition of the INQUIRY data. This specification specifies the ATAPI Transport version in place of these bits.
- EncServ, MultiP, MChngr, ACKREQQ, Addr32, Addr16, RelAdr, WBus32, WBus16, Sync, Linked, TranDis, CmdQue bits in the INQUIRY data is defined as Reserved in this specification.
- Byte 56 and 57 of the INQUIRY data are used to specify the Major and Minor version the logical unit is compliant with.
- The Mechanism State in this specification uses a value of 3h for the data port in use and not 1h as is specified in the SCSI Standard.
- The PF bit in the MODE SELECT command is specified as always set to 1.
- The DBD bit in the MODE SENSE is specified as being set to one. This bit is allowed to be set to zero only when the logical unit is a legacy SCSI device.
- EER bit of the Read-Write recovery page is not supported by this specification.
- Correction Span, Head offset count, Data strobe offset count, Recovery Time Limit fields of the Read-Write recovery page are not supported by this specification.
- The power model for this specification is different from that described for SCSI.
- The Information Exceptions Mode Page is called the Fault / Failure Reporting page in this specification.
- LogErr bit in the Information Exceptions mode page is not supported.
- Disconnect/Reconnect, Write Parameter, Verify Error Recovery, Caching, Peripheral Device, Control Mode and Medium Types pages are not supported by this specification.
- DPO bit in the READ command is not supported by this specification.
- Only the READ(12) is supported by this specification.
- The PMI bit of the READ CAPACITY command is not supported by this specification.
- READ CAPACITY command is recommended not to be used by this specification.

C-4 Reset Functionality

This section describes the functionality of the various resets in SCSI.

C-4.1 Power On Reset

The Power On Reset is an event that causes the Power On condition in SCSI. See “Task and Command Lifetimes” in the SCSI Architecture Model standard (SAM-2).

C-4.2 Hard Reset

In SCSI, Hard Reset is mapped as Hard Reset in the SCSI Architecture Model. See “Hard Reset” in SAM-2.

Devices that comply with this specification follow a simple model and the initiator is mapped to the host and a target is mapped to the device. Hard Reset for a SCSI Device will:

- Abort all tasks in all task sets;
- Clear all auto contingent allegiance conditions;
- Release all SCSI device reservations;
- Return any device operating modes to their appropriate initial conditions, similar to those conditions that would be found following device power-on. The MODE SELECT conditions ***shall*** be restored to their last saved values if saved values have been established. MODE SELECT conditions for which no saved values have been established ***shall*** be returned to their default values;
- UNIT ATTENTION condition ***shall*** be set.

C-4.2.1 TARGET RESET task management function

A response to a TARGET RESET task management request, issued by an initiator.

Different from ATA/ATAPI, in SCSI, the TARGET RESET can reset a devices individually. When a SCSI initiator is wishes to reset all the devices connected on one cable with TARGET RESET request, the initiator ***shall*** issue the TARGET RESET task management request to every device.

Note: The TARGET RESET task management function was called a "Bus Device Reset" in SCSI-2.

*Note: The LOGICAL UNIT RESET function is gone from SCSI-3 SAM revision 18. If this function is issued by the host to this a C/DVD device, the reaction of the device **shall** be same as the TARGET RSET task management function.*

C-4.2.2 Reset Events

A protocol specific event which may trigger a Hard Reset response from a SCSI device.

For example, SIP SCSI-3 Parallel Interface, there's a Reset Service generated by assertion of the RST- (reset) bus signal. This is one of the reset events and is a kind of Task Management Service defined in SIP SCSI-3 Interlocked Protocol specification, as a ULP, upper layer protocol.

SIP: SCSI Interlocked Protocol specification (INCITS T10/856D)

SPI: SCSI Parallel Interface specification (INCITS T10/855D)

Table 641 - Example Hard Reset Implementation

Mt Fuji	Generic SCSI-3 SAM	Example SCSI-3 SIP,SPI
Hard Reset	TARGET RESET task management function	TARGET RESET message
	Reset events	RST bus signal activated

C-4.3 Device Reset

In SCSI, Device Reset is not equivalent with the ATA/ATAPI Device Reset. For SCSI devices there are two possible Device Reset alternatives, ABORT TASK SET or CLEAR TASK SET. The ABORT TASK SET is mandatory for all SCSI devices, but the function is a little different from the ATA/ATAPI Device Reset. The CLEAR TASK SET is not always supported by the SCSI devices that don't support tagged tasks. CLEAR TASK SET is different from ABORT TASK SET in that CLEAR TASK SET clears all the queued tasks for all initiators. If the device is in a single initiator SCSI environment, ABORT and CLEAR TASK SET are the same.

As in ATAPI Device Reset, these "resets" in SCSI don't set to defaults the Mode Parameters, or SCAM functions and does not flush the contents of any cached Lead-in data.

The ABORT/CLEAR TASK SET:

- Does not immediately reset SCSI bus protocol.
- Does not reset parameters in mode page to default values
- Always keep the disc information such as disc TOC information
- Does not change the Persistent Prevent state

Although the host may use the ABORT/CLEAR TASK SET functions to provide a Device Reset, when something is wrong with the SCSI communications it may be necessary for the host to use stronger means, such as Hard Reset (a TARGET RESET or a Reset Event).

Table 642 - Reset Function Comparison

Function	Power-On / Hard Reset	SCSI-3 ABORT/CLEAR TASK SET
Initialization sequence required	Yes	No
Immediate Bus Release	Yes	No
Mode parameters	Reset to default or saved parameters	No change allowed
Cached Lead-in information	Discarded	Not Specified
Persistent Prevent Flag	Unlocked	No change allowed
Key Management	Reset to Default state	Reset to Default state

C-4.3.1 Device Reset Issues for SCSI Devices

The host may generate a Device Reset to bring the hung-up (something wrong or the communication is broken) device back to operation. For this purpose, this will work well in ATAPI. But in SCSI, this may not work well. Even the Hard Reset (a TARGET RESET or a Reset Event) may not work well in SCSI system because these Hard Resets are not always HARDWARE based resets, and it depends on the device design. Thus the application should consider the differences between ATAPI and SCSI environment.

Note: In the SCSI-3 standard, the term "Soft Reset" is no longer defined.

C-4.4 Power management and Device Reset in SCSI

When a SCSI Device is in the Power Managed Sleep state, the SCSI Target Reset ***shall*** be used to wake the device.

C-5 Command Utilization for a SCSI logical unit

Commands often implemented on CD/DVD logical units are listed in Table 643.

Table 643 - Packet Commands for SCSI C/DVD Devices

Command Description	Opcode	Reference
BLANK	A1h	*16.1,* on page 391
CLOSE TRACK/RZONE/SESSION/BORDER	5Bh	*16.2,* on page 395
FORMAT UNIT	04h	*16.3,* on page 399
GET CONFIGURATION	46h	*16.4,* on page 407
GET EVENT/STATUS NOTIFICATION	4Ah	*16.5,* on page 453
GET PERFORMANCE	ACh	*16.6,* on page 465
INQUIRY	12h	*16.7,* on page 477
LOAD/UNLOAD MEDIUM	A6h	*16.8,* on page 483
MECHANISM STATUS	BDh	*16.9,* on page 485

Table 643 - Packet Commands for SCSI C/DVD Devices (Continued)

Command Description	Opcode	Reference
MODE SELECT (10)	55h	*16.10,* on page 489
MODE SELECT (6)		SPC
MODE SENSE (10)	5Ah	*16.11,* on page 491
MODE SENSE (6)		SPC
PAUSE/RESUME	4Bh	*16.12,* on page 519
PLAY AUDIO (10)	45h	*16.13,* on page 521
PLAY AUDIO (12)		MMC
PLAY AUDIO MSF	47h	*16.14,* on page 525
PLAY CD	BCh	Obsolete
PREVENT/ALLOW MEDIUM REMOVAL	1Eh	*16.15,* on page 527
READ (10)	28h	*16.16,* on page 529
READ (12)	A8h	*16.17,* on page 531
READ (6)	08h	SBC
READ CAPACITY	25h	*16.20,* on page 539
READ CD	BEh	*16.21,* on page 541
READ CD MSF	B9h	*16.22,* on page 551
READ DISC INFORMATION	51h	*16.23,* on page 553
READ DISC STRUCTURE	ADh	*16.24,* on page 559
READ FORMAT CAPACITIES	23h	*16.25,* on page 589
READ HEADER	44h	Obsolete
READ SUBCHANNEL	42h	*16.26,* on page 595
READ TOC/PMA/ATIP	43h	*16.27,* on page 603
READ TRACK/RZONE INFORMATION	52h	*16.28,* on page 617
RELEASE		SPC
REPAIR RZONE	58h	*16.29,* on page 631
REPORT KEY	A4h	*16.30,* on page 633
REQUEST SENSE	03h	*16.31,* on page 645
RESERVE		SPC
RESERVE TRACK/RZONE/RMZ	53h	*16.32,* on page 651
SCAN	BAh	*16.33,* on page 657
SEEK	2Bh	*16.34,* on page 661
SEND CUE SHEET	5Dh	*16.35,* on page 663
SEND DIAGNOSTIC		SPC
SEND DISC STRUCTURE	BFh	*16.36,* on page 671
SEND EVENT	A2h	*16.37,* on page 679
SEND KEY	A3h	*16.38,* on page 681
SEND OPC INFORMATION	54h	*16.39,* on page 687
SET CD SPEED	BBh	*16.40,* on page 689
SET READ AHEAD	A7h	*16.41,* on page 691
SET STREAMING	B6h	*16.42,* on page 693

Table 643 - Packet Commands for SCSI C/DVD Devices (Continued)

Command Description	Opcode	Reference
START/STOP UNIT	1Bh	*16.43,* on page 697
STOP PLAY/SCAN	4Eh	*16.44,* on page 701
SYNCHRONIZE CACHE	35h	*16.45,* on page 703
TEST UNIT READY	00h	*16.46,* on page 705
VERIFY (10)	2Fh	*16.47,* on page 707
WRITE (10)	2Ah	*16.48,* on page 709
WRITE (12)	AAh	*16.49,* on page 713
WRITE AND VERIFY (10)	2Eh	*16.50,* on page 715

Appendix D - IEEE 1394 Implementation Notes (Normative)

D-1 Introduction

This section will describe where possible the use of the contents for IEEE 1394 devices. This specification is intended to be used in conjunction with IEEE 1394, the SCSI-3 Architecture Model (SAM-2), the Serial Bus Protocol (SBP-2), the SCSI-3 Primary Command Set (SPC-2) standard and the SCSI-3 Block Command Set.

See the INCITS T10 SCSI-3 Specifications for information on the connection and protocol to be use for a SCSI C/DVD device.

D-2 IEEE 1394 Signal Utilization

logical units ***shall*** utilize the signals and timing defined in IEEE 1394.

D-3 Compatibility

D-3.1 Use of the RelAdr bit

A relative address (RelAdr) bit of one indicates that the logical block address field is a two's complement displacement. This negative or positive displacement ***shall*** be added to the logical block address last accessed on the logical unit to form the logical block address for this command. This feature is only available when linking commands. The feature requires that a previous command in the linked group have accessed a block of data on the logical unit.

A RelAdr bit of zero indicates that the logical block address field specifies the first logical block of the range of logical blocks to be operated on by this command. This bit is supported for logical units that make use of a IEEE 1394 interface.

D-3.2 Comparison of SBP-2 and MMC-2

Some of the major differences between MMC-2 and SCSI or SBC-2:

- EVENT STATUS NOTIFICATION replaces unsolicited status.
- CHANGE DEFINITION is not used.
- INQUIRY command does not use EVPD or CmdDt CDB bits.
- UNIT ATTENTION with INQUIRY DATA HAS CHANGED is not used.
- Peripheral qualifier in the INQUIRY data is not used.
- The PF bit in the MODE SELECT (10) command is specified as always set to 1.
- The power model for this specification is different from that described for IEEE 1394.

D-4 Reset Functionality

This section describes the functionality of the various resets in IEEE 1394.

D-4.1 Power On Reset

The Power On Reset is an event that causes the Power On condition in IEEE 1394. See “Task and Command Lifetimes” in the SCSI Architecture Model standard (SAM-2).

D-4.2 Hard Reset

In IEEE 1394, Hard Reset is mapped as Hard Reset in the SCSI Architecture Model. See “Hard Reset” in SAM-2.

Devices that comply with this specification follow a simple model and the initiator is mapped to the host and a target is mapped to the logical unit. Hard Reset for a IEEE 1394 logical unit will:

- Abort all tasks in all task sets;
- Clear all auto contingent allegiance conditions;
- Release all device reservations;
- Return any device operating modes to their appropriate initial conditions, similar to those conditions that would be found following device power-on. The MODE SELECT (10) conditions ***shall*** be restored to their last saved values if saved values have been established. MODE SELECT (10) conditions for which no saved values have been established ***shall*** be returned to their default values;
- UNIT ATTENTION condition ***shall*** be set.

D-4.2.1 TARGET RESET task management function

A response to a TARGET RESET task management request, issued by an initiator.

Different from ATA/ATAPI, in IEEE 1394, the TARGET RESET can reset a devices individually. When a host wishes to reset all the devices connected on one cable with TARGET RESET request, the host ***shall*** issue the TARGET RESET task management request to every device.

Note: The TARGET RESET task management function was called a "Bus Device Reset" in SCSI-2.

Note: The LOGICAL UNIT RESET function is gone from SCSI-3 SAM revision 18. If this function is issued by the host to this a C/DVD device, the reaction of the device ***shall*** *be same as the TARGET RSET task management function.*

D-4.3 Device Reset

In IEEE 1394, Device Reset is not equivalent with the ATA/ATAPI Device Reset. For IEEE 1394 devices there are two possible Device Reset alternatives, ABORT TASK SET or CLEAR TASK SET. The ABORT TASK SET is mandatory for all IEEE 1394 devices, but the function is a little different from the ATA/ATAPI Device Reset. The CLEAR TASK SET is not always supported by the IEEE 1394 devices that don't support tagged tasks. CLEAR TASK SET is different from ABORT TASK SET in that CLEAR TASK SET clears all the queued tasks for all initiators. If the device is in a single initiator IEEE 1394 environment, ABORT and CLEAR TASK SET are the same.

As in ATAPI Device Reset, these "resets" in IEEE 1394 don't set to defaults the Mode Parameters and does not flush the contents of any cached Lead-in data.

The ABORT/CLEAR TASK SET:

- Does not immediately reset IEEE 1394 bus protocol.
- Does not reset parameters in mode page to default values
- Always keep the disc information such as disc TOC information
- Does not change the Persistent Prevent state

Although the host may use the ABORT/CLEAR TASK SET functions to provide a Device Reset, when something is wrong with the IEEE 1394 communications it may be necessary for the host to use stronger means, such as Hard Reset (a TARGET RESET or a Reset Event).

Table 644 - Reset Function Comparison

Function	Power-On / Hard Reset	IEEE 1394 ABORT/CLEAR TASK SET
Initialization sequence required	Yes	No
Immediate Bus Release	Yes	No
Mode parameters	Reset to default or saved parameters	No change allowed
Cached Lead-in information	Discarded	Not Specified
Persistent Prevent Flag	Unlocked	No change allowed
Key Management	Reset to Default state	Reset to Default state

D-4.3.1 Device Reset Issues for IEEE 1394 Devices

The host may generate a Device Reset to bring the hung-up (something wrong or the communication is broken) device back to operation. For this purpose, this will work well in ATAPI. But in IEEE 1394, this may not work well. Even the Hard Reset (a TARGET RESET or a Reset Event) may not work well in IEEE 1394 system because these Hard Resets are not always HARDWARE based resets, and it depends on the device design. Thus the application should consider the differences between ATAPI and IEEE 1394 environment.

Note: In the SCSI-3 standard, the term "Soft Reset" is no longer defined.

D-4.4 Power management and Device Reset in IEEE 1394

When a IEEE 1394 Device is in the Power Managed Sleep state, a Target Reset ***shall*** be used to wake the device.

D-5 Command Utilization for a IEEE 1394 logical unit

Table 645 - Packet Commands for IEEE 1394 C/DVD Devices

Command Description	Opcode	Reference
BLANK	A1h	*16.1,* on page 391
CLOSE TRACK/RZONE/SESSION/BORDER	5Bh	*16.2,* on page 395
FORMAT UNIT	04h	*16.3,* on page 399
GET CONFIGURATION	46h	*16.4,* on page 407
GET EVENT/STATUS NOTIFICATION	4Ah	*16.5,* on page 453
GET PERFORMANCE	ACh	*16.6,* on page 465
INQUIRY	12h	*16.7,* on page 477
LOAD/UNLOAD MEDIUM	A6h	*16.8,* on page 483
MECHANISM STATUS	BDh	*16.9,* on page 485
MODE SELECT (10)	55h	*16.10,* on page 489
MODE SELECT (6)		SPC
MODE SENSE (10)	5Ah	*16.11,* on page 491
MODE SENSE (6)		SPC
PAUSE/RESUME	4Bh	*16.12,* on page 519
PLAY AUDIO (10)	45h	*16.13,* on page 521
PLAY AUDIO (12)		MMC
PLAY AUDIO MSF	47h	*16.14,* on page 525
PLAY CD	BCh	Obsolete
PREVENT/ALLOW MEDIUM REMOVAL	1Eh	*16.15,* on page 527

Table 645 - Packet Commands for IEEE 1394 C/DVD Devices

Command Description	Opcode	Reference
READ (10)	28h	*16.16,* on page 529
READ (12)	A8h	*16.17,* on page 531
READ (6)	08h	SBC
READ CAPACITY	25h	*16.20,* on page 539
READ CD	BEh	*16.21,* on page 541
READ CD MSF	B9h	*16.22,* on page 551
READ DISC INFORMATION	51h	*16.23,* on page 553
READ DISC STRUCTURE	ADh	*16.24,* on page 559
READ FORMAT CAPACITIES	23h	*16.25,* on page 589
READ HEADER	44h	Obsolete
READ SUBCHANNEL	42h	*16.26,* on page 595
READ TOC/PMA/ATIP	43h	*16.27,* on page 603
READ TRACK/RZONE INFORMATION	52h	*16.28,* on page 617
RELEASE		SPC
REPAIR RZONE	58h	*16.29,* on page 631
REPORT KEY	A4h	*16.30,* on page 633
REQUEST SENSE	03h	*16.31,* on page 645
RESERVE		SPC
RESERVE TRACK/RZONE/RMZ	53h	*16.32,* on page 651
SCAN	BAh	*16.33,* on page 657
SEEK	2Bh	*16.34,* on page 661
SEND CUE SHEET	5Dh	*16.35,* on page 663
SEND DIAGNOSTIC		SPC
SEND DISC STRUCTURE	BFh	*16.36,* on page 671
SEND EVENT	A2h	*16.37,* on page 679
SEND KEY	A3h	*16.38,* on page 681
SEND OPC INFORMATION	54h	*16.39,* on page 687
SET CD SPEED command	BBh	*16.40,* on page 689
SET READ AHEAD	A7h	*16.41,* on page 691
SET STREAMING	B6h	*16.42,* on page 693
START/STOP UNIT	1Bh	*16.43,* on page 697
STOP PLAY/SCAN	4Eh	*16.44,* on page 701
SYNCHRONIZE CACHE	35h	*16.45,* on page 703
TEST UNIT READY	00h	*16.46,* on page 705
VERIFY (10)	2Fh	*16.47,* on page 707
WRITE (10)	2Ah	*16.48,* on page 709
WRITE (12)	AAh	*16.49,* on page 713
WRITE AND VERIFY (10)	2Eh	*16.50,* on page 715

Appendix E - Example Event Implementation Notes (Informative)

E-1 Design Intent

E-1.1 Goals

The set of commands used with Morphing was designed to eliminate the use of errors for the communication of errors and normal device events to the host. The use of event reporting allows errors to be used to communicate true errors - i.e. illegal usage or medium defects. The use of events may help reduce the amount of error handling code in host software.

The implementation described here replaces the Asynchronous Event Notification defined in SCSI. AEN was not widely supported, as it would require a change in architecture of most OS to allow unsolicited messages from the peripheral. In particular, the OS would have to decide to which process an unsolicited message belonged. There were other inhibiting factors also. For example, there is no low level protocol for a peripheral to send an unsolicited message.

E-1.2 Command Use

The GET EVENT/STATUS NOTIFICATION command has two modes of operation. The first is the non-immediate mode. This is the preferred method of operation. Non-immediate mode means that the command will complete as soon as an event occurs. Effectively, a message can be sent at any time to the host because it has been solicited. However, this method of operation is not feasible if command queuing and overlap are not possible. Current ATAPI implementations do not support queuing nor overlap, so the immediate mode must be used.

The Immediate mode allows the host to periodically poll the device to find events and examine status. This technique should be used only in environments where queuing is not possible.

E-1.3 Implementation Hints

Events are not required to be queued, nor is generation of events blocked due to the occurrence of a new event. What this means is that an implementation can set aside an event variable and a status variable for each event class it supports. Each section of code that needs to generate an event can simply overwrite any event that exists in the same class.

E-1.4 Interactions with UNIT ATTENTION

The GET EVENT/STATUS NOTIFICATION command specifies that any associated UNIT ATTENTION not be cleared when an Event is reported to the host. Therefore, no changes to sense generation or reporting are required.

E-1.5 Sample Implementation of Events

The following code shows how events might be implemented in C.

```
typedef struct _sEventData {
      UInt8       Event;
      UInt8       Status;
      Uint16      EventData;
} sEventData;

sEventData EventData[8];                  /* One per event class */

Set_Event(EventClass, Event, Status, EventData)
{
      EventData[EventClass].Event = Event
      EventData[EventClass].Status = Status;
      EventData[EventClass].EventData = EventData;
      Do_Synchronous_Event_Notification(EventClass);        /*This completes any
            pending GET EVENT/STATUS NOTIFICATION commands in the queue    */
}
```

None of these routines checks for existing Events. Any old Event is simply replaced with the new one.

The GET EVENT/STATUS NOTIFICATION command would report the EventData structure for the highest priority (lowest number) requested event and then clear that Event.

Appendix F - Command Implementation Notes (Informative)

F-1 Overview

This section explains what information ***shall*** return when READ DISC INFORMATION or READ TRACK/RZONE INFORMATION commandis issued for C/DVD media to a Read Only logical unit.

The READ DISC INFORMATION and READ TRACK/RZONE INFORMATION commands are originally designed for writable logical unit. A Read Only logical unit ***shall*** also return the information of C/DVD media appropriately when READ DISC INFORMATION and READ TRACK/RZONE INFORMATION command is issued.

F-1.1 Returned data for CD media

For Read Only logical unit, the interpretation of the status of CD media which has one or more complete session is based on followings:

- Disc Status is always treated as “Complete” even if there is incomplete session on the disc.
- Last Session is considered to be the Complete Session closed at the end even if there is an incomplete session exists following the complete session. The incomplete session which has not been closed by writable logical unit is not considered to return disc/track status. Only the information on Complete Session(s) on the disc ***shall*** be returned.
- Number of Session is the total of closed Complete Sessions.
- All the values of PMA are invalid because Read Only logical unit does not have capability to read PMA.

If the disc of which 1st session is not complete is inserted into Read Only logical unit, appropriate error ***shall*** be returned. And media access commands ***shall*** report BLANK CHECK when a Blank disc is loaded.

The Figure 174 shows an example of CD recorded/stamped media. (Session 1 and session 2 are both completed. Session 3 is incomplete status. Each session has some tracks.)

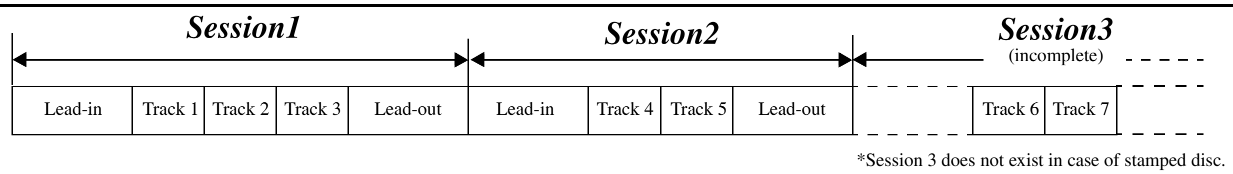

Figure 174 - Example of CD Multisession recorded/stamped* disc

Table 646 shows the example of data returned, when the READ DISC INFORMATION command is issued for the above media.

Table 646 - Example of READ DISC Information returned for CD media

Inserted media Disc Information field	CD-ROM/R/RW disc
Erasable	0 or 1[a]
Status of Last Session	11b (Complete Session)
Disc Status	10b (Complete Disc)
Number of First track on Disc	1[b]
Number of Sessions	2[b]
First Track Number in Last Session	4[b]
Last Track Number in Last Session	5[b]
DID_V	0
DBC_V	0
URU	invalid
Disc Type	from A0/PSEC field in the TOC of the first Session in which there is at least one data track
Disc Identification	invalid
Lead-in Start Time for Last Session (MSF)	FF:FF:FF
Last Possible Start Time for Start of Lead-out (MSF)	FF:FF:FF
Disc Bar Code	invalid

a. If logical unit can detect the Erasable media, this field may be set to 1, otherwise the field is set to 0.
b. In the case of *"Figure 174 - Example of CD Multisession recorded/stamped* disc"* on page 761.

There are some kinds of writing method of recording data in CD media. Disc At Once, Session At Once, Track At Once, and Packet Writing are used as the method of recording CD media. The Packet Writing can be classified into Variable Packet Writing and Fixed Packet Writing.

The Packet layout for CD media is shown in Figure 3 - *Packet Layout* on page 65. Each packet starts with Link block followed by four Run-in blocks. The User data blocks are placed directly after the Run-in blocks. Finally two Run-out blocks are located following the User data blocks. In the case of Fixed packet writing, the size of User Data blocks is always constant in length.

For CD media, there are two kinds of addressing method. Except for the space within a Fixed Packet written track, the logical block number has a one-to-one relationship to the physical block number. Such kind of addressing method is called “Method 1 Addressing” and logical block numbers are also assigned to Link, Run-in, and Run-out blocks. On the other hand, in the Fixed Packet written track, the logical block number has a linear relationship to the physical block number using the special addressing method called “Method 2 Addressing”. In this case, Logical Block numbers are not assigned to Link, Run-in, and Run-out blocks.

When the READ TRACK/RZONE INFORMATION command is issued for CD media, *"Table 647* - Example of READ TRACK/RZONE Information returned for CD media" shows the example of data returned for the command.

Table 647 - Example of READ TRACK/RZONE Information returned for CD media

Track type Track Information field	Stamped track/ DAO written track/ Audio track	TAO[a] written data track	Variable Packet written data track	Fixed Packet written data track
Damage	0	0	0	0
Copy	0	0	0	0
Track Mode	from Q sub-channel of this track			
RT	0 or 1[b]	0 or 1	0 or 1	0 or 1
Blank	0	0	0	0
Packet	0	0	1	1
FP	0	0	0	1
Data Mode	Fh	1h or 2h	1h or 2h	1h or 2h
NWA_V	0	0	0	0
Track Start Address	from TOC	from TOC	from TOC	from TOC
Next Writable Address	0	0	0	0
Free Blocks	0	0	0	0
Fixed Packet Size	0	0	0	from TDB[c]
Track Size	See below			

a. TAO: Track At Once recording
b. If it can be considered the disc as stamped disc, this field is set to 0.
c. TDB: Track Descriptor Block

Note: In order to distinguish if the medium is Disc At Once recorded/Stamped, the logical unit should read the pre-gap of the first data track. If a TDB is written, the media is Track At Once or Packet written media. If no TDB is written, the media is Disc At Once recorded or Stamped media.

The track size is different according to the difference of the writing method. The Track Size ***shall*** be computed as follows:

First, compute the Complete Track Size (*CTS*). For Read Only logical unit, *CTS* for the track which has a track number n is computed as follows.

$$CTS(n) = TrackStartAddress(n + 1) - TrackStartAddress(n)$$

Where *TrackStartAddress(n)* means Track Start address of the track which has a track number n. The value is encoded in the TOC. If the track number n is the last track number of the session, *TrackStartAddress(n+1)* means the Lead-out start address.

For Disc At Once written media, $TrackSize(n) = CTS(n)$

Where *TrackSize(n)* means track size of the track which has a track number n.

For Track At Once written track or Variable packet written track, $TrackSize(n) = CTS(n) - PreGapLength(n + 1) - 2$

Where *PreGapLength(n)* means the Pre-gap length of the track which has track number n. When the Pre-gap has no TDB or the logical unit does not read the TDB, *PreGapLength(n)* is treated as always 150 even if the actual *PreGapLength(n)* is not 150[1]. If the track number n is the last track, *PreGapLength(n+1)* is 0.

For Fixed Packet written track,

$$TrackSize(n) = \frac{CTS(n) - PreGapLength(n + 1) + 5}{PacketSize(n) + 7} \bullet PacketSize(n)$$

1. This may cause an incorrectly computed result.

If *TrackStartAddress(n)* is the last track start address of the session, then *TrackStartAddress(n+1)* is start address of the Lead-out and *PreGapLength(n+1)* is zero. *PacketSize(n)* is the number of User Data Blocks in the fixed packet and is encoded in the Pre-gap as required by the Orange Book Part-II & Part-III[1]. Figure 4 - *Example of Packet written Track layout* on page 66 shows example of the layout of packet written track.

F-1.2 Returned data for DVD media

The READ DISC INFORMATION and READ TRACK/RZONE INFORMATION returned data includes the RZone/Border information for DVD media. However, there is no concept of RZone/Border in DVD-ROM/RAM media. For DVD-ROM or formatted DVD-RAM media, to respond to this command appropriately, the Data Area is considered to be one RZone which has RZone number one and the number of Border is considered to be one.

For Read Only logical unit, the interpretation of the status of DVD media which has one or more complete Border is based on followings:

- Disc Status is always treated as “Complete” even if there is incomplete Border on the disc.
- Last Border is considered to be the Complete Border closed at the end even if there is an incomplete Border exists following the complete Border. The incomplete Border which has not been closed by writable logical unit is not considered to return disc/RZone status. Only the information on Complete Border(s) on the disc ***shall*** be returned.
- The RZone number of the first RZone is one.
- Number of Border is the total of closed Complete Borders.

If the blank disc or the disc which has no complete Border is inserted into Read Only logical unit, appropriate error ***shall*** be returned. And media access commands ***shall*** report BLANK CHECK when a Blank disc is loaded.

The Figure 175 shows one example of DVD-R recorded media. (Border 1 and Border 2 are both completed. Border 3 is incomplete status. Each Border has some RZones.)

.

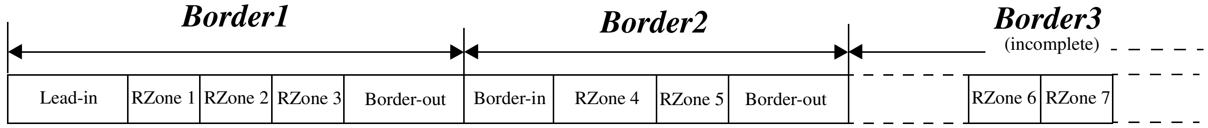

Figure 175 - Example of DVD-R Multi-Border disc

"Table 648 - Example of READ DISC Information returned for DVD media" on page 765 shows the example of data returned, when the READ DISC INFORMATION command is issued for the above media. The Returned data for DVD-ROM/RAM disc are also shown in same figure.

1. Specifications developed by Philips & Sony Corp.

Table 648 - Example of READ DISC Information returned for DVD media

Media Type Disc Information field	DVD-R disc	DVD-ROM disc	DVD-RAM disc
Erasable	0	0	1
Status of Last Session/Border	11b (Complete)	11b (Complete)	11b (Complete)
Disc Status	10b (Complete Disc)	10b (Complete Disc)	10b (Complete Disc)
Number of First RZone on Disc	1	1	1
Number of Borders	2[a]	1	1
First RZone Number in Last Border	4[a]	1	1
Last RZone Number in Last Border	5[a]	1	1
DID_V	0	0	0
DBC_V	0	0	0
URU	invalid	invalid	invalid
Disc Type	invalid	invalid	invalid
Disc Identification	invalid	invalid	invalid
Lead-in Start Time for Last Session (MSF)	invalid	invalid	invalid
Last Possible Start Time for Start of Lead-out (MSF)	invalid	invalid	invalid
Disc Bar Code	invalid	invalid	invalid

a. In the case of *"Figure 175 - Example of DVD-R Multi-Border disc"* on page 764.

To get the RZone status of DVD media, the READ TRACK/RZONE INFORMATION command ***shall*** be used. There are two kinds of writing method of recording data in DVD-R media. Disc At Once and Incremental recording are used as the method of recording DVD media.

For Read Only logical unit, the interpretation of the RZone status is shown in *"Table 649 - Example of READ TRACK/ RZONE Information returned for DVD media"* on page 765.

Table 649 - Example of READ TRACK/RZONE Information returned for DVD media

RZone type Track Information Field	DVD-ROM/DVD-RAM/ DAO written RZone	Incremental written RZone
Damage	0	0
Copy	invalid	invalid
Track Mode	invalid	invalid
RT	0 or 1[a]	1
Blank	0	0
Packet/Inc	0	1
FP	invalid	invalid
Data Mode	invalid	invalid
NWA_V	0	0
RZone Start Address	0	from RMD in Border-out
Next Writable Address	invalid	invalid
Free Blocks	0	0
Blocking Factor	16	16
RZone Size	from Lead-in	from RMD in Border-out

a. If it can be considered the disc as ROM or RAM disc, this field is set to 0.

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Appendix G - CD-Text Format in the Lead-in Area (Informative)

This annex explains the CD-Text information that is stored in the Lead-in Area as raw R-W Sub-channel data. The information here is stored in a memory and can be retrieved to the Initiator immediately.

G-1 General

The CD-Text information in the Lead-in Area is retrieved from raw R-W Sub-Channel data. The data format of RAW Sub-channel is explained in Table 397 - *P-W Raw* on page 549. 6 bits of each byte are R-W Raw data and are converted from 6 bits to 8 bits from the 1st bytes, thus making 4 chunks of 18 bytes of data each. Each 18 byte data block is called CD-Text Pack Data as shown in Table 650. CD-Text information is recorded repeatedly in the Lead-in Area and this one repeated data is called the Text Group. Each Text Group consists of up to 8 types of language Blocks. Each Block represents one language and consists of a maximum of 255 sets of Pack Data. Table 650 shows the contents of one Pack Data.

Table 650 - CD-Text Pack Data format for the Lead-in Area

Bit / Byte	7	6	5	4	3	2	1	0
0	Pack Type Indicator							
1	EF	Track Number Indicator						
2	Sequence Number Indicator							
3	DBCC	Block Number			Character Position			
4	Text Data Field byte 0							
5	Text Data Field byte 1							
6	Text Data Field byte 2							
7	Text Data Field byte 3							
8	Text Data Field byte 4							
9	Text Data Field byte 5							
10	Text Data Field byte 6							
11	Text Data Field byte 7							
12	Text Data Field byte 8							
13	Text Data Field byte 9							
14	Text Data Field byte 10							
15	Text Data Field byte 11							
16	CRC Field byte 0 or Reserved							
17	CRC Field byte 1 or Reserved							

Each Data Pack consists of a four byte Header Field, twelve bytes of Text Data and a CRC Field.

The Pack Type Indicator has the value and descriptions defined in Table 651. Packs ***shall*** be encoded in the order of the items listed in the Table.

Table 651 - Pack Type Indicator Definitions

Pack Type	Description
80h	Title of Album name(ID2=00h) or Track Titles (ID2=01h...63h)
81h	Name(s) of the performer(s) (in ASCII)
82h	Name(s) of the songwriter(s) (in ASCII)
83h	Name(s) of the composer(s) (in ASCII)
84h	Name(s) of the arranger(s) (in ASCII)
85h	Message(s) from content provider and/or artist (in ASCII)
86h	Disc Identification information
87h	Genre Identification and Genre information
88h	Table of Content information
89h	Second Table of Content information
8Ah	Reserved
8Bh	Reserved
8Ch	Reserved
8Dh	Reserved for content provider only
8Eh	UPC/EAN code of the album and ISRC code of each track
8Fh	Size information of the Block

The Extension Flag (EF) bit is normally set to 0b. If it is set to 1b, the Pack is used for an extended application.

The Track Number Indicator field contains the Track Number or Pack Element Number. A Track Number is used when the Text Data Fields belongs to a track. If the Pack is independent of Tracks, this field indicates Pack Element Number which depends on the type of the Pack.

The Sequence Number Indicator is the number incrementally increased from the first Pack to the end in each Block. It starts from 00h to FFh.

The DBCC (Double Byte Character Code) bit, when set to one, indicates that the Text Data Field contains a Double Byte Character Code. When set to 0b, the Single Byte Character Code is used.

The Block Number field indicates the Block Number of the Block to which the Pack belongs. A Block is used to indicate a set of text information representing one particular language. Up to 8 can be used at the same time.

The Character Position field is the number of characters in the strings that belong to the Text Data Field in the previous Pack. The Character Position starts from 0 to 15, and 15 indicates that the first character belongs to the one before the previous Pack. When the character code is double byte code, a set of 2 bytes in the Text Data Field is counted at one.

A null code is also counted as a character, which indicates termination of each string.

Character Position is not used in Packs with ID1=88h, 89h and 8Fh. 00h ***shall*** be used in all these Packs.

A Text Data Field consists of 12 bytes. It contains either character strings or binary information depending on the type of Pack. All data in this field ***shall*** be transferred as recorded on the disc.

Packs except Pack Types 88h, 89h and 8Fh ***shall*** contain character strings in the Text Data Field. If Packs with Pack Type 80h to 85h, and 8Eh are used, a character string for each track ***shall*** be provided.

A character string consists of series of characters and a terminator (One null code for single byte, two null codes for double byte)

The size of a character string is recommended to be less than 160 bytes. If a character string does not fit in a Text Data Field of a Pack, it is continued onto the succeeding Packs. The succeeding character string will be encoded starting at the next byte in the Text Data Field after the terminator of the current string. Unused bytes in the Text Data Field ***shall*** be filled with null codes.

In case the same character stings is used for consecutive tracks, the Tab Indicator may be used to indicate the same as previous track. It is a single tab code (09h) for single byte codes, and two tab codes for double bytes character codes. It ***shall not*** used for the first track.

Packs with ID1=86h, 87h, 88h, 89h and 8Fh contains binary information in the Text Data Field.

The CRC Field consists of 2 bytes. The host may use these bytes to check for errors in the Pack. The polynomial is $X^{16} + X^{12} + X^5 + 1$. All bits ***shall*** be inverted before recording. This field is not mandatory for supporting CD-Text data. This field ***shall*** be valid or set to 0000h.

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Appendix H - Mt. Fuji revision history (Informative)

H-1 Changes from Mt. Fuji 1 to Mt. Fuji 2

1. Added support for DVD-RAM devices.
2. Numerous spelling, grammatical, and convention errors fixed. (Changed most occurrences of CD-E to CD-RW, Used "logical unit" in place of "C/DVD logical unit," "drive," "target,", and "device.")
3. Added Feature Descriptors.
4. Added Profiles.
5. Added Regional Playback Control model and command support.
6. Added a DVD-RAM model section.
7. Added a DVD-R model section.
8. Added the SYNCHRONIZE CACHE command.
9. Added the FORMAT UNIT command.
10. Added the GET CONFIGURATION command.
11. Removed the Feature Set Support & Version Page.
12. The GET EVENT/STATUS NOTIFICATION command ***shall not*** clear the UNIT ATTENTION condition.
13. Changed the definition of the NEA bit from "No Event available in the requested Class(es)" to "None of the requested Event Classes is supported."
14. The "MediaChange" Event was added.
15. Added the GET PERFORMANCE command.
16. Allowed use of the EVPD bit in the INQUIRY command.
17. Updated the Audio Attenuation Levels in the CD Audio Control Mode Page.
18. Added the READ (10) command.
19. Added the READ BUFFER command.
20. Added READ DISC STRUCTURE Format 8h.
21. Added the READ FORMAT CAPACITIES command.
22. Added fabrication of data for DVD media to the READ TOC/PMA/ATIP command.
23. Added the Last Recorded Address, Track/RZone Number (MSB), Session/Border Number (MSB), and two reserved bytes to the READ TRACK/RZONE INFORMATION command result data.
24. Added REPORT KEY Format 1000b for RPC state.
25. Added SEND KEY Format 110b for RPC.
26. Added the SET STREAMING command.
27. Added the VERIFY (10) command.
28. Added the WRITE (10) command.
29. Added the WRITE AND VERIFY (10) command.
30. Added the WRITE BUFFER command.

H-2 Changes from Mt. Fuji 2 to Mt. Fuji 3

1. Added support for CD-R, CD-RW, DVD-R, DVD+RW, and AS-MO logical units.
2. Added terms to *2.2, "Definitions"* on page 43 for the added logical unit support.
3. Added parameters for new devices to Table 9 - *General Parameters of DVD discs* on page 70.
4. Added parameters for the Physical Information descriptor (Table 14 - *Physical format information in Control Data Block* on page 82) for the new logical units.
5. Added *4.16, "Recording/reading for DVD+RW media"* on page 113.
6. Added material to *4.16, "Recording for DVD-R Single Layer media"* on page 121 to describe writing to DVD-R.
7. Added *6.0, "AS-MO model"* on page 317.
8. Obsoleted the *C/DVD Capabilities & Mechanical Status* Mode Page (2Ah) and adjusted references to it to point to the appropriate Feature Descriptor instead.
9. Added Profiles for Non-removable disk, MO Erasable, MO Write Once, AS-MO, CD-R, CD-RW, and DVD-R Sequential recording to *Section 15.0, "Profiles"* on page 379.
10. Modified the DVD-RAM Feature (0012h) to include DVD+RW (description only).
11. Added the BLANK command.
12. Added the COMPARE command.
13. Added the ERASE (10) command.
14. Added the CLOSE TRACK/RZONE/SESSION/BORDER command.
15. Added descriptors 10h, 11h, 12h, and 20h to the FORMAT UNIT command for CD-RW and DVD+RW.
16. Added Incremental Streaming Writable, Sector Erasable, Write Once, Restricted Overwrite, CD Track at Once, CD Mastering, DVD-R Write, Logical unit serial number, and Disc Control Blocks Features.
17. Modified the Morphing Feature to describe the case of Class 3 Events.
18. Modified the Random Writable Feature to remove dependency on the Random Readable Feature (added bytes 8-15).
19. Added the Operational Change Request/Notification, External Request, and Multi-Initiator Event Classes to the GET EVENT/STATUS NOTIFICATION command.
20. Added the *Write Parameters* Mode Page (05h).
21. Added the Address field to the READ DISC STRUCTURE command.
22. Added structures 05h, 0Ch-0Fh, 30h, and FFh to the READ DISC STRUCTURE command.
23. Added result codes to the READ DISC STRUCTURE command for some fields for new media support.
24. Added format codes 10h-12h and 20h to the READ FORMAT CAPACITIES command.
25. Added format 5h for CD-Text to the READ TOC/PMA/ATIP command.
26. Added the REPAIR RZONE command.
27. Added the Key Class field to the REPORT KEY and SEND KEY commands.
28. Added the BLANK CHECK Sense Key to the REQUEST SENSE command.
29. Added the RESERVE TRACK/RZONE/RMZ command.
30. Added the SEND CUE SHEET command.
31. Added the SEND DISC STRUCTURE command.

32. Added the SEND EVENT command.
33. Added the SEND OPC INFORMATION command.
34. Obsoleted the SET C/DVD SPEED command.
35. Added use of the BlkVfy bit in the VERIFY (10) command.
36. Added descriptions on the use of the WRITE (10) command with sequentially written media.
37. Added *Appendix D - "IEEE 1394 Implementation Notes (Normative)"* on page 755.
38. Added *Appendix E - "Example Event Implementation Notes (Informative)"* on page 759
39. Added *Appendix F - "Command Implementation Notes (Informative)"* on page 761 for a description of using the READ DISC INFORMATION and READ TRACK/RZONE INFORMATION commands.
40. Added *Appendix G - "CD-Text Format in the Lead-in Area (Informative)"* on page 767.
41. Added this Appendix.
42. Added *Appendix I - "Sample Applications of Events (Informative)"* on page 779.
43. Added *Appendix J - "UDF Key Structure (Informative)"* on page 789 describing the use of the Mt. Fuji commands to enable reading UDF discs.

H-3 Changes from Mt. Fuji 3 to Mt. Fuji 4

1. Added support for DVD-RW devices.
2. READ BUFFER CAPACITY command is added.
3. The name of FLUSH CACHE command is changed to SYNCHRONIZE CACHE command
4. Physical Interface Standard code for Fibre Channel is added in the Core Feature descriptor.
5. Data Block Type Supported field and description are added to Incremental Streaming Writable Feature Descriptor.
6. Data Block Type Supported field and description are added to CD Track at Once Feature Descriptor.
7. Descriptions for CD media are removed from REPAIR RZONE command.
8. Section 8.0 “Real-Time Stream recording/playback Model” is added.
9. Format Type = 01h (Spare Area Expansion) is added to FORMAT UNIT and READ FORMAT CAPACITIES commands.
10. Partial Certification for DVD-RAM is obsolete.
11. Hardware Defect Management Feature Descriptor is expanded and SSA bit is added.
12. Streaming Writing (SW) bit is defined in the Real-Time Streaming Feature Descriptor to support Stream recording operation.
13. GET PERFORMANCE command data is expanded to return Unusable Area data besides Performance data.
14. Definition in the Fault / Failure Reporting Mode Page is changed.
15. Streaming bit is added to READ (12) command to support Stream playback operation.
16. Format codes for Spare Area Information (0Ah) is added to READ DISC STRUCTURE command.
17. WRITE (12) command with Streaming bit is added to support Streaming recording operation.
18. ASC/ASCQ = 5D/03 (FAILURE PREDICTION THRESHOLD EXCEEDED - Predicted Spare Area Exhaustion) is added.
19. Section 4.16.4.4 Silent Linking and Section 4.16.4.5 Buffer Under-run Free Recording are added to the DVD-R Model section.
20. Section 4.19 Recording/Reading for DVD-RW media is added.
21. DVD-RW Restricted Overwrite Profile (13h) is added.
22. Blanking Types for DVD-RW media are added to the BLANK command.
23. Close operation for DVD-RW intermediate state Bordered Area is defined to the CLOSE TRACK/RZONE/SESSION/BORDER command.
24. New Format Types for DVD-RW media are added to the FORMAT UNIT command and READ FORMAT CAPACITIES command.
25. DVD-RW Restricted Overwrite Feature (002Ch) is added.
26. New status of DVD-RW media is defined for the Status of Last Session/Border field of READ DISC INFORMATION command.
27. Definition of the Last Recorded RMA Sector Number field of DVD Structure data (RMA) is changed to Start Sector Number of Valid Format 3 RMD Set field when restricted overwritten DVD-RW medium is loaded.
28. ASC = 51, ASCQ = 01, ’ERASE FAILURE - Incomplete erase operation detected’ is added.
29. Section 11.0 Write Protection Model is added.

30. Write Protect Feature (04h) is added.
31. MECHANISM STATUS command is added to Embedded Changer Feature command.
32. The Type field value of 02h (GET PERFORMANCE command) is assigned for Defect Status data and Defect Status Header and Descriptor are defined.
33. CWP_V and CWP bits are added to Slot Table Response data format of MECHANISM STATUS command.
34. Format code = C0h (Write Protection status) and related descriptor are added to READ DISC STRUCTURE command.
35. Format code = C0h (Write Protection status) and related descriptor are added to SEND DISC STRUCTURE command.
36. DVD-RAM Medium status data is added to READ DISC STRUCTURE returned data (Format Code 09h).
37. ASC/ASCQ returned value is changed when a READ DISC STRUCTURE command with a Format Code field value of 08h is presented for a DVD media without the DDS Information.
38. ASC = 27, ASCQ = 06, 'CONDITIONAL WRITE PROTECT' is added.
39. ASCIIButton event codes of External Request are moved to 200h through 2FFh to avoid confliction. (GET EVENT/STATUS NOTIFICATION command)
40. DSC bit description is deleted from PLAY AUDIO (10), PLAY AUDIO MSF and SCAN commands.
41. When SEND DISC STRUCTURE command with Format code of 0h-BFh is issued on non-DVD media, ASC = 30, ASCQ = 05 'CANNOT WRITE MEDIUM - INCOMPATIBLE FORMAT' will be returned.
42. Appendix B-12.1 Operation Code Types is deleted.

H-4 Feature Descriptor version history

A Feature Descriptor has Version field to identify different version of the Feature Descriptor. If some changes are required to a Feature, and if they are backward compatible, the changes will be included in the Feature Descriptor and the Version field will be incremented.

Table 652 shows the current version of each Feature and references for old Feature Descriptor versions.

Table 652 - Feature Descriptor Version

Feature Number	Feature Name	Current Version	References for old Feature Descriptor versions
0000h	Profile List	0	-
0001h	Core	1	See INF-8090i Rev.5.5 for version 0 descriptor
0002h	Morphing	1	See INF-8090i Rev.5.5 for version 0 descriptor
0003h	Removable Medium	0	-
0004h	Write Protect	0	-
0005h-000Fh	Reserved	Reserved	-
0010h	Random Readable	0	-
0011h-001Ch	Reserved	Reserved	-
001Dh	MultiRead	0	-
001Eh	CD Read	1	See Mt.Fuji Ver.2 Revision 1.0 for version 0 descriptor
001Fh	DVD Read	1	See INF-8090i Rev.5.5 for version 0 descriptor
0020h	Random Writable	1	See Mt.Fuji Ver.2 Revision 1.0 for version 0 descriptor
0021h	Incremental Streaming Writable	3	See INF-8090i Rev.3.6[a] for version 0 descriptor See INF-8090i Rev.5.1 for version 1 descriptor See INF-8090i Rev.5.5 for version 2 descriptor
0022h	Sector Erasable	0	-
0023h	Formattable	0	-
0024h	Hardware Defect Management	1	See INF-8090i Rev.3.6 for version 0 descriptor
0025h	Write Once	0	-
0026h	Restricted Overwrite	0	-
0027h	CD-RW CAV Write	0	-
0028h	MRW	See MMC4	See MMC
0029h	Enhanced Defect Reporting	0	-
002Ah	DVD+RW	See MMC	See MMC
002Bh	DVD+R	See MMC	See MMC
002Ch	Rigid Restricted Overwrite	0	-
002Dh	CD Track at Once	2	See INF-8090i Rev.3.6 for version 0 descriptor See INF-8090i Rev.5.1 for version 1 descriptor
002Eh	CD Mastering	1	See INF-8090i Rev.5.1 for version 0 descriptor
002Fh	DVD-R/-RW Write	2	See INF-8090i Rev.4.0[b] for version 0 descriptor See INF-8090i Rev.5.5 for version 1 descriptor
0030h-00FFh	Reserved	Reserved	-
0033h	Layer Jump recording	0	-
0034h-0036h	Reserved	Reserved	-
0037h	CD-RW Media Write Support	See MMC	See MMC
0038h-0039h	Reserved	Reserved	-

Table 652 - Feature Descriptor Version (Continued)

Feature Number	Feature Name	Current Version	References for old Feature Descriptor versions
0040h	BD Read	See MMC	See MMC
0041h-004Fh	Reserved	Reserved	-
0050h	HD DVD Read	0	-
0051h	HD DVD Write	0	-
0052h-00FFh	Reserved	Reserved	-
0100h	Power Management	0	-
0101h	S.M.A.R.T.	0	-
0102h	Embedded Changer	0	-
0103h	CD Audio analog play	0	-
0104h	Microcode Upgrade	0	-
0105h	Time-out	1	See INF-8090i Rev.5.4 for version 0 descriptor
0106h	DVD CSS	0	-
0107h	Real-Time Streaming	3	See INF-8090i Rev.5.0[c] for version 2 descriptor See INF-8090i Rev.4.0 for version 1 descriptor See INF-8090i Rev.3.6 for version 0 descriptor
0108h	logical unit serial number	0	-
0109h	Reserved	Reserved	-
010Ah	Disc Control Blocks	0	-
010Bh	DVD CPRM	0	-
010Ch	Firmware Information	0	
010Dh	AACS	0	-
010Eh-FEFFh	Reserved	Reserved	-
FF00h-FFFFh	Vendor Unique	-	-

a. INF-8090i Rev.3.6 corresponds to Mt.Fuji Ver.3 Revision 1.0.
b. INF-8090i Rev.4.0 corresponds to Mt.Fuji Ver.4 Revision 1.0.
c. INF-8090i Rev.5.0 corresponds to Mt.Fuji Ver.5 Revision 1.0.

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Appendix I - Sample Applications of Events (Informative)

I-1 Overview

Events were designed to be a one-way pipe of information from the logical unit to the host. The original design intent for this functionality was to use Asynchronous Event Notification, where the logical unit would issue commands to the host to notify the host about asynchronous events. This behavior cannot be implemented on ATAPI busses. In addition, the software driver stack on most operating systems does not allow for “target mode” operation. Changing the stacks to allow this behavior would require a large effort.

The GET EVENT/STATUS NOTIFICATION command simply provides for asynchronous event notification through the traditional command path. It is the “output” of the pipe.

Input to the pipe is generated by the logical unit in response to asynchronous events within the logical unit. Operation of user controls (buttons, trays, magazines, etc.), resets, requests from other hosts, and power state changes due to timers are examples of events that cause an Event Descriptor to be placed into the Event Queue (pipe).

An Event is generated when it is placed into the Event Queue. An Event is reported when the GET EVENT/STATUS NOTIFICATION command is used to read it from the Queue. Unless a GET EVENT/STATUS NOTIFICATION command was queued because an Event was requested for an empty Queue and the Immed bit was set to zero, there is no timing requirement between generating and reporting events. For example, a new logical unit in a legacy system would generate Events and never report them.

The Multi-host behavior described here is for a co-operative type of shared use. This model is best suited for an occasionally shared environment, particularly use by a single user across multiple machines. It is not suited for frequent intermixed access.

I-2 Example logical unit implementation

Several commands are used by the host when utilizing Events. Examples given here show only a few of the possible sequences in which commands could be received. A logical unit should not need any state information for the implementation of Events and Morphing other than that explicitly described here. The following represents one basic model for implementation; it is not intended to be the only possible implementation.

The following is a list of state information that can be modified by a host. The list does not include commands that have secondary effects such as ejecting the medium. Some of the state information can be modified by the logical unit in addition to the host. The type of the state information is given in brackets.

1. Persistent Prevented [Boolean]
2. Persistent Prevented Owner [ID]
3. Prevented (one per host) [Boolean]
4. Event Queue (one queue per Event Class per host) [Event Data]
5. Sense Data (one per host) [SK/ASC/ASCQ]

I-2.1 Operation of the PREVENT/ALLOW MEDIUM REMOVAL command

I-2.1.1 Persistent Prevent

Normally, the logical unit performs each command as received, regardless of the source of each command. The PREVENT/ALLOW MEDIUM REMOVAL command is used to modify the state of the Persistent Prevented, Persistent Prevented Owner, and Prevented variables. These bits are checked by most commands to determine if and how that command operates.

While in the Persistent Prevented state, commands from other hosts that would affect the host owning the Persistent Prevent will fail. In addition to failing the command with CHECK CONDITION Status, 5/2C/05 PERSISTENT

PREVENT CONFLICT, the logical unit may send an External Request Event to the host owning the Persistent Prevent. Such Events ***shall not*** be generated for commands that require data transfer.

If a PREVENT/ALLOW MEDIUM REMOVAL command with the Persistent and Prevent bits set is received from the host that originally set the Persistent Prevented state, or the Persistent Prevented state is False, the logical unit ***shall*** set the Persistent Prevented state and the Persistent Prevented Owner ***shall*** be set to the ID of the issuing host. The logical unit ***shall*** generate Multi-host Event, Control Grant Events for all other hosts.

If a PREVENT/ALLOW MEDIUM REMOVAL command with the Persistent and Prevent bits set is received from a host other than the one that set the Persistent Prevent state, the logical unit ***shall*** fail the command with CHECK CONDITION Status, 5/2C/05 PERSISTENT PREVENT CONFLICT. The logical unit ***shall*** generate a Multi-host Event, Control Request Event for the host owning the Persistent Prevent.

If a PREVENT/ALLOW MEDIUM REMOVAL command with the Persistent bit set and the Prevent bit cleared is received from the host owning the Persistent Prevented state, or the logical unit is not in the Persistent Prevented state, the Persistent Prevented state ***shall*** be cleared. The logical unit ***shall*** generate a Multi-host Event, Control Release Event for all other hosts.

If a PREVENT/ALLOW MEDIUM REMOVAL command with the Persistent bit set and the Prevent bit cleared is received from a host other than the one that originally set the Persistent Prevent state, the logical unit ***shall*** fail the command with CHECK CONDITION Status, 5/2C/05 PERSISTENT PREVENT CONFLICT. The logical unit ***shall*** generate a Multi-host Event, Control Request Event for the logical unit owning the Persistent Prevent.

I-2.1.2 Legacy Prevent

The logical unit is in the Prevented state if any host has a Prevent in place.

If a PREVENT/ALLOW MEDIUM REMOVAL command with the Persistent bit cleared and the Prevent bit set is received from the host that originally set the Persistent Prevented state, or the Persistent Prevented state is False, the logical unit ***shall*** set the Prevented state for the issuing host.

If a PREVENT/ALLOW MEDIUM REMOVAL command with the Persistent bit cleared and the Prevent bit set is received from a host other than the one that set the Persistent Prevent state, the logical unit ***shall*** fail the command with CHECK CONDITION Status, 5/2C/05 PERSISTENT PREVENT CONFLICT.

If a PREVENT/ALLOW MEDIUM REMOVAL command with the Persistent bit cleared and the Prevent bit set is received, the logical unit ***shall*** clear the Prevent state for that host.

I-2.2 Operation of the GET CONFIGURATION command

The GET CONFIGURATION command result data is determined primarily by state information derived from the medium. This includes media type, presence of certain data types, write protect state, and many other variables not controllable directly through the interface.

The GET CONFIGURATION command result data may be affected by the Persistent Prevented state. For example, Features that would interfere with logical unit operation as seen by the host owning the Persistent Prevented state might be marked as not Current. Determination of interfering Features is vendor unique. For example, a CD-R drive vendor might determine that reading interferes with the owning host's operation, but a CD-ROM drive vendor may not.

I-2.3 Operation of the GET EVENT/STATUS NOTIFICATION command

In some implementations, the sole job of the GET EVENT/STATUS NOTIFICATION command is to pop the next Event from the Event Queue (if any) and return it to the host. If no Event is in any of the requested Queues, the command either completes with the result data indicating No Event (Immed = 1) or is kept in the command Queue (Immed = 0) until an Event in one of the requested classes occurs.

An implementation that locks the tray when the New Media Event is reported rather than when it is generated must either maintain a state variable to indicate reporting of the New Media Event or provide a function to peek into the Event Queue to see if a New Media Event is present in the Media Event Class Queue.

I-2.4 Operation of the START/STOP UNIT command

If a Prevent is in place for any host, all Eject requests ***shall*** fail.

If a Persistent Prevent is in place, all Eject requests from hosts other than the Persistent Prevent owner ***shall*** fail.

An Eject request from the host that owns the Persistent Prevent or if no Persistent Prevent is in place ***shall*** succeed.

I-2.5 Operation of the SEND EVENT command

The SEND EVENT command simply performs the requested function, if possible. The function will typically correspond to a function that can be requested from the front panel.

The logical unit ***shall not*** check to see if a corresponding Event had been reported. The logical unit simply determines if the requested function can be performed, and if so, performs the requested function.

If a host owns a Persistent Prevent, SEND EVENT commands from other hosts ***shall*** fail.

I-2.6 Internal functions

A Generate Event function is called in many different situations, including from within commands and external event monitors. It should take Class, Event, Status, Event Data, and host information as data. Host information includes the ID of a host and whether the Event is for that host, all hosts, or all hosts but the one identified. The routine that mounts new media would call this function with Media Event Class, New Media, Media Status 2, Slots 1 - 1, all hosts. The PREVENT/ALLOW MEDIUM REMOVAL command may call this function with Multi-host Event Class, Control Release Event, Multi-host Status Ready, Event Data 0, all hosts but the one issuing the command as parameters.

If a logical unit locks the tray when Persistent Prevented and the New Media Event is generated, the START/STOP UNIT command can simply check for the media mounted state and the Persistent Prevented state, since the media mounted state is entered at the same time that the Event is generated (by definition of the New Media Event).

If a logical unit locks the tray when Persistent Prevented and the New Media Event is reported, either a separate state variable is needed to track the Event reporting, or a Peek at Event Queue function is needed to determine if a New Media Event is still present (not yet reported). In this model, if a New Media Event is in the Queue, and the eject button is pressed, the logical unit ***shall*** remove the New Media Event from the Queue before ejecting the medium.

I-2.7 Summary

Table 653 represents drive behavior upon receipt of various commands. The Persistent Prevented state represents the state of the logical unit before receipt of the command. The Same host column identifies commands that were received from the same host that owns the Persistent Prevent.

Table 653 - Persistent Prevent Behavior

Command	Persistent Prevented	Same host	Action
PREVENT/ALLOW MEDIUM REMOVAL, Persistent = 1, Prevent = 0 (Persistent Allow)	N	X	Generate Control Release Event for all other hosts.
	Y	N	Fail the command
		Y	Leave the Persistent Prevented state. Generate Control Release Event for all other hosts.
PREVENT/ALLOW MEDIUM REMOVAL, Persistent = 1, Prevent = 1	N	X	Enter the Persistent Prevented state (for that host). Generate Control Grant for all other hosts.
	Y	N	Fail the command, generate Control Request Event for the host that owns the Persistent Prevent.
		Y	Generate Control Grant for all other hosts.
Any command that requires data transfer but doesn't affect logical unit operation (e.g., INQUIRY)	N	X	Perform the command
	Y	N	Perform the command
		Y	Perform the command
Any command that requires data transfer and affects logical unit operation (e.g., MODE SELECT (10))	N	X	Perform the command
	Y	N	Fail the command
		Y	Perform the command
Any command that does not require data transfer and does not affect logical unit operation (e.g., TEST UNIT READY)	N	X	Perform the command
	Y	N	Perform the command
		Y	Perform the command
Any command that does not require data transfer but affects logical unit operation (e.g., START/STOP UNIT)	N	X	Perform the command
	Y	N	Fail the command. May generate an External Request Notification Event.
		Y	Perform the command

I-3 Example host implementations

The following examples are not meant to describe all applications and possibilities. They represent just a few possible implementations.

I-3.1 Host use of the Multi-host Event Class

In this model, a single host requests control of the logical unit via the Persistent Prevent command. If successful, the host can operate as if it were the only host. If not successful, most commands may fail. If the host requires use of the logical unit, the host should wait for a Control Release Event. After a reasonable time-out (user intervention is probably required on the owning host), the host may attempt another Persistent Prevent command (to trigger another Control Request Event to the owning host).

Note: The Control Release Event may never occur, especially if the owning host does not implement this protocol.

If a host owns the Persistent Prevent, it ***shall*** expect to receive Control Request Events. If a Control Request Event is received, the host should flush its buffers and unmount any file systems on that logical unit. If the unmounting is successful, the host should issue a PREVENT/ALLOW MEDIUM REMOVAL command, Persistent = 1, Prevent = 0. If the unmounting is unsuccessful, the host should notify the user about the attempted operation and the possible reason or reasons for its failure.

A host will generally not issue a PREVENT/ALLOW MEDIUM REMOVAL command, Persistent = 1, Prevent = 0 unless:

1. The user explicitly unmounts the logical unit.
2. The system is shut down.
3. It is responding to a Control Request Event.

In this model, it is not necessary to do a Persistent Allow when immediate needs are met; it is sufficient to do it when a request comes from another host.

This results in a ping-pong type behavior that is suited to a single user on several machines, or where a single resource is shared among co-operating users. This model is similar to that of a printer, where the “owner” can only change between “jobs.” The granularity is very coarse. This is necessary because mounting and unmounting file systems is a time consuming process, and should be performed only as often as required.

I-3.2 Host use of the Operational Event Class

The Operational Event Class was designed for “intelligent” peripherals that have front panel buttons and the ability to perform operations based on those buttons. For example, a logical unit that acts as both a CD-R and a standalone CD-R audio component may have “Record” and “Finalize” buttons, among others. Some buttons may have behavior that interferes with operations that the host may attempt. If the logical unit is in the Persistent Prevented state, such interference is not allowed.

However, it is desired that the front panel buttons continue to function. To allow this, the host is “put in the loop.” That is, instead of acting directly on the button, the logical unit generates Events to be reported to the host.

One implementation possibility is to not look for such Events, or to discard them as received. If a Persistent Prevent is issued, the controls on the front panel essentially are deactivated. If only selected Events are discarded, the corresponding buttons are deactivated.

An implementation that acts on Events may use the SEND EVENT command to request that the logical unit handle the Event as it would if the Persistent Prevent were not in place. If the Event is one that is not known to the host, it should flush buffers and unmount the media before issuing the SEND EVENT command because the operation to be performed is unknown. The same rule applies for known Events that depend on or modify the state of the medium.

Finally, an implementation may act upon the button presses itself. For example, if a software application is being used to play DVD-Video, it may act on a “Fast Forward” button press by sending a code to the application to perform a “Fast Forward” operation.

I-4 Example Device Busy Class Events implementations

The Immed bit of Command descriptor block specifies that the command should be terminated immediately before completion of the long time operation. The progress indication that shows the progress display of the long time operation in a device has the inaccuracy to some degree. This cannot be avoided. Here is an example that shows the reason of the inaccuracy.

Sometimes device takes very long time till the termination of the immediate command with Immed=1. Here is an example that shows the reason of the long time till the immediate command termination.

I-4.1 Example of Device Busy Class Events reporting

16.5.6, "Device Busy Class Events" on page 461 reports the condition change of *3.5, "Logical Unit Not Busy condition/ Busy condition"* on page 63 and the predicted amount of time remaining for the logical unit to become not busy. This example explains the GET EVENT/STATUS NOTIFICATION command of Device Busy Class Events behavior using disc format process.

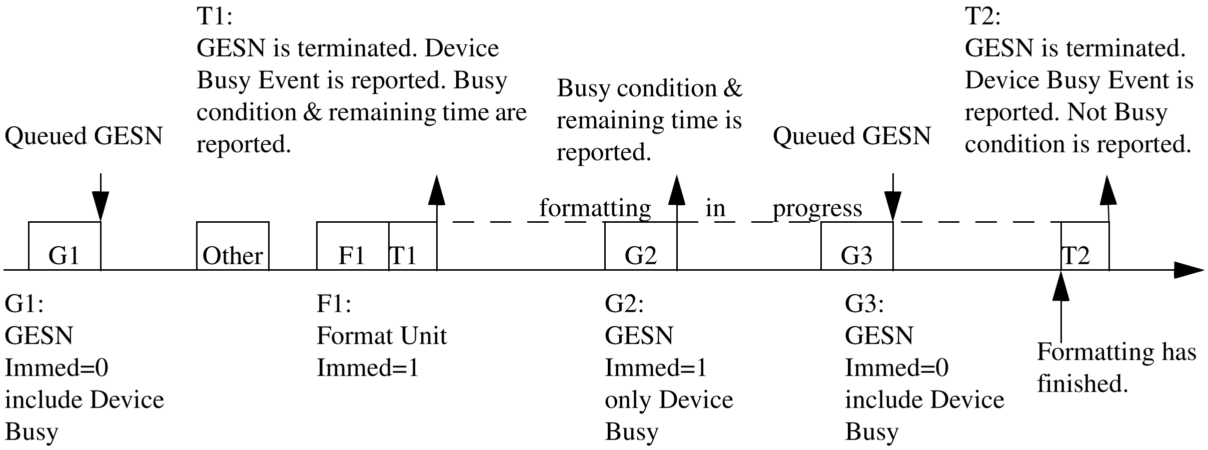

Figure 176 - Execution of a command that may cause Logical Unit Busy condition

I-4.2 Time-unit progress indication implementation example

The time base progress indication may not show accurate information. It is because there are a lot of events that break the forecast. Here is a sample list that should reduce the accuracy of the information.

- Seek, Seek retry
- OPC, OPC retry
- Disc rotation speed control, disc spin-up time

These operations are affected by some mechanical randomness. Additional retry action may take additional time adding to the original assumed time. If some retry operations are taken, twice or three times longer time will be necessary. There are no way other than to accept this inaccuracy.

Device may assume a fixed time length for the above mechanical operation. Device may report the integrated time length of all operations in a Command at the beginning. For example, a Close Session Command to a CD- R consists of disc spin-up, OPC, (PMA write,) Lead-in write and Lead-out write. Also, the time of the initial OPC may be different with the time of the additional OPC. The initial OPC may take very longer time than the additional OPC. In case of ZCLV, one or more OPC operations may be performed between Lead-in writing and Lead-out writing. The time of additional OPC may be included in "Delay of seek operation" and "Adjustment".

Here are two typical implementation types. One is stairs type. When an operation is done the assigned time of the operation is subtracted from the remaining time of the command. The progress indication may be discontinuous like stairs. Other is clock type. The remaining time of the command is started from the initial integrated time length. Then the remaining time is decreased by real time till the command end.

I-4.2.1 Example of stair type

The progress indication may be discontinuous like stairs. If an operation e.g., OPC is finished, the corresponded time is decreased from the remaining time.

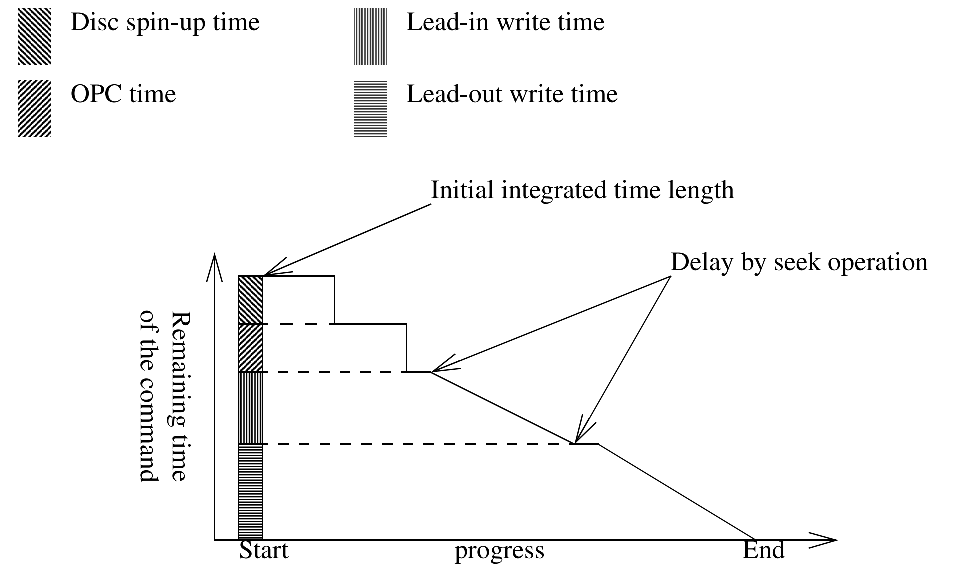

Figure 176 - Execution of Stair type implementation of CD-R session closing

It is recommended to report not with the single step but with two or more steps for OPC or disc rotation speed control. For example, if OPC consists from two parts, each end of a part is regarded as a step for reducing the remaining time.

I-4.2.2 Example of clock type

The progress indication is linear with real-time clock.

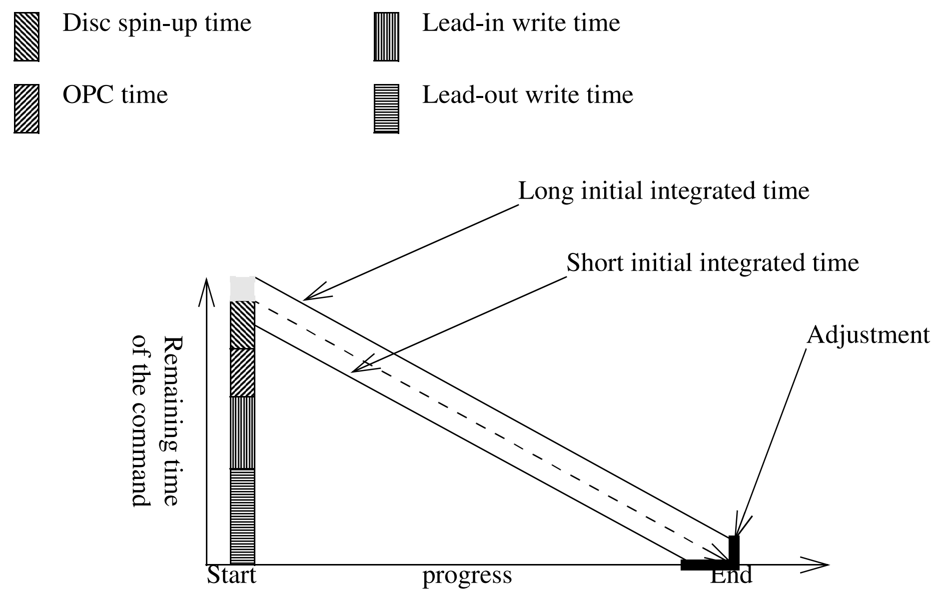

Figure 177 - Execution of clock type implementation of CD-R session closing

Some adjustment of value may happen. The value of the time field ***shall not*** be negative.

It is recommended that the remaining time decrease monotonously unless a significant retry or change of operation happens.

I-4.3 Intermediate steps of long operation

When host issued an immediate command that has Immed=1 device may not start the operation immediately. Usually an immediate command is terminated immediately. But sometimes the immediate command takes long time till the command termination. Device keeps its interface active. Or, sometimes long time operation of the immediate command takes several intermediate steps till the operation completion. The host needs to handle these status transactions of the device till the operation ending.

I-4.3.1 Long time of an immediate command till its termination

Some immediate commands need very long time till the command termination to check the command validity. During validity check, the immediate command should not be terminated, and then logical unit should occupy its interface bus. To eliminate this long time till the command termination, host should do an appropriate preparation before doing the operation.

For example, CLOSE TRACK/RZONE/SESSION/BORDER command with Immed=1, Session=1 that will close a CD-R session may take very long time to terminate the command. If a CD-R disc has 99 tracks in an open session, when device received a Session Close request (CLOSE TRACK/RZONE/SESSION/BORDER command with Immed=1, Session=1), logical unit checks that all of the tracks are closed. If any open tracks exist in the open session, logical unit terminates the CLOSE TRACK/RZONE/SESSION/BORDER command with CHECK CONDITION Status, 5/72/04 EMPTY OR PARTIALLY WRITTEN RESERVED TRACK.

To check this command validity, logical unit may take 45 - 90 seconds. Even if Immed bit is set to one, logical unit may not terminate the command for this check. To eliminate this issue, host should check the status of the all tracks using READ TRACK INFORMATION command by itself. Logical unit can detect all tracks status, then the time of the command validity becomes short.

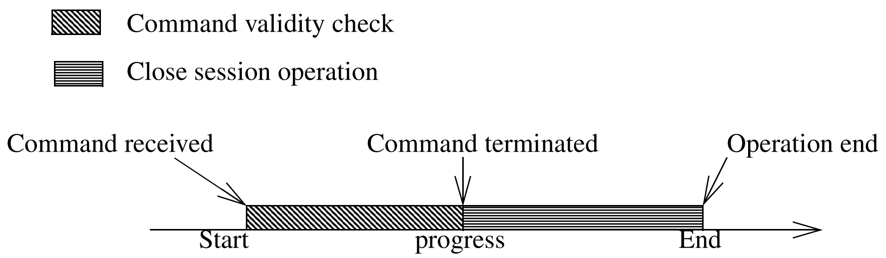

Figure 178 - Command validity check of CD-R session closing

I-4.3.2 Multiple steps immediate operation

Some immediate commands cause several intermediate steps of the logical unit. Logical unit may report different error code to show the operation progress to READ DISC INFORMATION command. Host should wait the completion of the operation.

For example, START/STOP UNIT command with Immed=1, Start=0, LoEj=1 that will eject a media may cause data writing before ejection. If logical unit has writable C/DVD media, and logical unit has data in its buffer, the logical unit needs to write the data on the medium before disc ejection. Sometimes logical unit needs to update media specific information (e.g., PMA, RMA, FDCB) before disc ejection. In these cases, the logical unit may report 2/04/07 LOGICAL UNIT NOT READY, OPERATION IN PROGRESS or 2/04/08 LOGICAL UNIT NOT READY, LONG WRITE IN PROGRESS in response to later media access commands. After data writing completion, logical unit will start disc eject operation, and then logical unit will report no media error (e.g., 2/3A/00 MEDIUM NOT PRESENT or 2/3A/02 MEDIUM NOT PRESENT - TRAY OPEN).

Further, if START/STOP UNIT command with Immed=0/1, Start=1, LoEj=1 that will close the tray is issued during the above described data writing operation of the disc ejection, the above immediate disc eject operation may be canceled. In this case, logical unit may not report Media Class Events and Unit Attention Condition of 6/28/00 NOT READY TO READY CHANGE, MEDIUM MAY HAVE CHANGED.

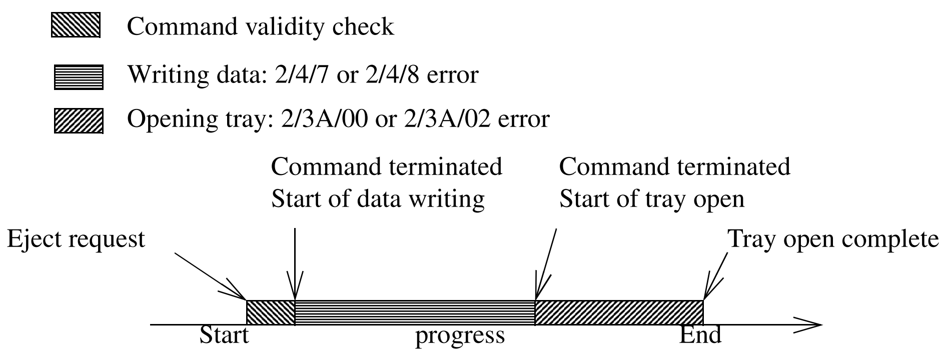

Figure 179 - Disc ejection with data writing of tray type

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Appendix J - UDF Key Structure (Informative)

J-1 Introduction

OSTA Universal Disk Format (UDF) is the file system that is adopted as the standard DVD file system. OSTA UDF is a subset of the standard ECMA 167 3rd edition. The command set described in this document was designed to allow easy access to information required by a UDF implementation.

To read UDF written disc, following descriptors and sequences are used to get file structure.

- Volume Recognition Sequence (VRS)
- Anchor Volume Descriptor Pointer (AVDP)
- Volume Descriptor Sequence (VDS)
- File Set Descriptor (FSD)
- Root Directory ICB
- Root Directory file

.

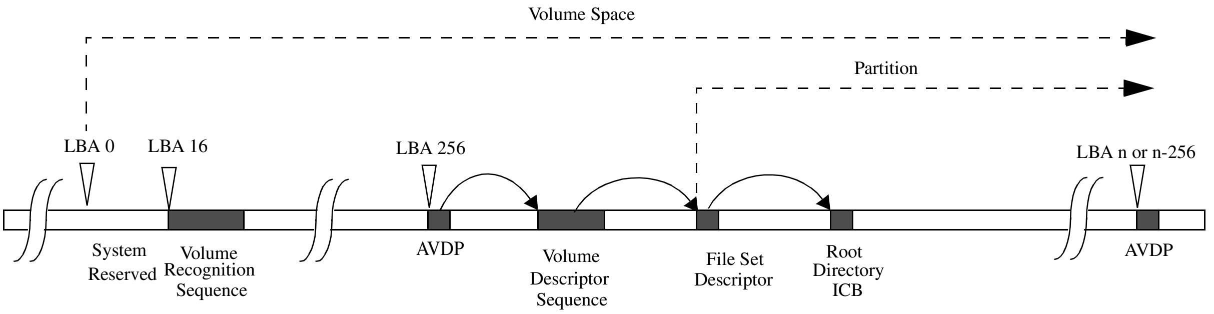

Figure 180 - Basic UDF Structure

For UDF sequential recording, following are also used.

- Virtual Allocation Table ICB (VAT ICB)
- Virtual Allocation Table (VAT)

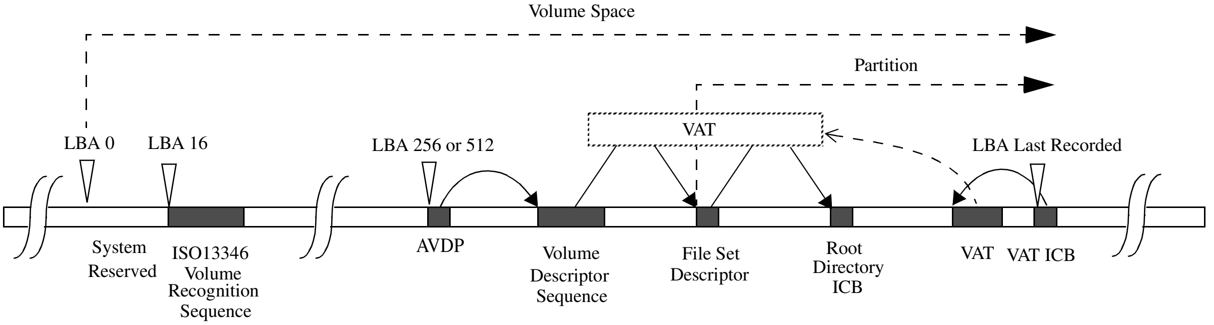

Figure 181 - Basic UDF Structure used on sequentially written media

VRS ***shall*** start at LBA 16. VRS contains information on whether the volume complies with ECMA 167. This sequence may contain ISO 9660 descriptors also. When Random access mode is used, a duplicate VRS may be recorded at sector n-16.

When the volume is sequentially written, a Virtual Allocation Table (VAT) is recorded to translate Virtual Addresses to Logical Addresses. To find the Virtual Allocation Table, the VAT ICB ***shall*** be written in the last user data sector.

AVDP ***shall*** be recorded at LBA 256, and LBA n or n-256, where n is the last LBA. For sequentially written media, AVDP can be located only at LBA 512 until closing the volume. AVDP contains pointer to the VDS.

The Volume Descriptor Sequence (VDS) is made up of several Volume Descriptors such as a Primary Volume Descriptor, a Logical Volume Descriptor, and a Partition Descriptor. The Logical Volume Descriptor contains pointer to the File Set Descriptor.

The File Set Descriptor contains pointer to the Root Directory ICB.

The Root Directory ICB contains either the Root Directory file or pointers to the Root Directory file.

For further information on UDF, refer to OSTA UDF specification, available from http://www.osta.org/

J-2 Read compatibility issue of AVDP and VAT ICB at end LBA

When DVD-R for General Ver.2.1 or DVD-RW Ver.1.2 medium is mounted, the host may not obtain correct disc capacity via READ CAPACITY command and READ TOC/PMA/ATIP command (LBA mode). Because DVD logical units that does not support these media format may read Outer limit of Data Recordable area field on DVD-R for General Ver.2.1 or DVD-RW Ver.1.2 media in reading the position End PSN of Data Area field of DVD-ROM media. The value reported by such DVD logical unit does not represent the END LBA. See Table 21 - *Data Area Allocation field definition* on page 85. The reported End LBA sector may be out of Lead-out Area and may be un-recorded. When a host fail to read the END LBA, the host should not attempt to retry reading to avoid repetitive Pick-up overrun error.

Implementation note:

To detect DVD-R for General Ver.2.1/RW Ver.1.2 media compatibility of DVD logical unit, the following sequence is recommended:

1. Check READ CAPACITY Data returned by READ CAPACITY command and address of the End Physical Sector Number of Data Area field returned by READ DISC STRUCTURE command with Format Code 00h.

If the READ CAPCITY Data and End Physical Sector Number of Data Area - 30000h are the same value, there is possibility that the DVD read-only logical unit does not support reading of DVD-R for General Ver.2.1/RW Ver.1.2 media format correctly.

2. Check if Format Code 0Ch of READ DISC STRUCTURE command is supported. To examine the supported DVD Structures, the READ DISC STRUCTURE command with Format Code FFh is used.

If a DVD read-only logical unit supports Format Code 0Ch of READ DISC STRUCTURE command, the logical unit supports multi-border reading and is able to read DVD-R for General Ver.2.1/RW Ver.1.2 media format correctly.

J-3 Retrieval method of end LBA for read-only logical unit

For CD-R/RW media, when READ CAPACITY command is issued, read-only logical unit calculates capacity from Lead-out Track Start Address that is recorded in the last addressable TOC. This value is correct for CD-R/RW disc which is recorded by SAO/DAO. But for Packet/TAO recording method, this value may not be correct because Link sector and Run-out sectors may exist before Lead-out Track. In the case of Packet recorded disc, END LBA may be Lead-out Track Start Address - 3.

For DVD-R/RW media, the last sector address of user data is registered in Lead-in/Border-in. Then read-only logical unit can report correct address of END LBA via READ CAPACITY command. In the case of READ TOC/PMA/ATIP command, END LBA is Lead-out Track Start Address - 1.

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