Blu-ray Disc (BD) Multi-Media Command Set Description

Draft version 0.55

23 May 2005

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1 Scope

Blu-ray Disc is a media type that requires special behavior by the Host and device. Blu-ray disc has three defined types: Read-only (BD-ROM), Recordable (BD-R), and rewritable (BD-RE).

This document describes the set of Multi-Media commands that allow a Host to utilize the capabilities of BD Drives. This document is created assuming MMC-4 as a basis. The ultimate destination for the content of this document is MMC-5.

This document is created to match the structure of MMC-4:

1. Scope — This section
2. References — A list of documents that may be needed by the reader for the correct understanding of this document.
3. Definitions, Symbols, Abbreviations, and Conventions – A glossary of terminology unique to this document
4. BD Models — Modeling for the various media oriented behaviors that the Host may witness from the device provides an overview of internal drive operation to the Host application developer.
5. Features and Profiles for BD Devices — Features describe Drive capability while profiles define a general device view.
6. Commands for BD Devices — Commands are described from the Host's point of view.
7. Mode Parameters for BD Devices — Inputs required by the drive are not always a part of a command. Inputs associated with mode of operation are readable and sometimes writable.

2 References

2.1 Normative References

2.1.1 Approved References

The following are approved ANSI, approved international and approved regional publications (ISO, IEC, CEN/CENELEC, and ITUT), and may be obtained from the international and regional organizations that control them.

ANSI INCITS 397-2005	AT Attachment with Packet Interface 7 (ATA/ATAPI-7) Volume 1: ATA Command Set Volume 2: Parallel ATA Volume 3: Serial ATA
ANSI NCITS.351:2001	SCSI-3 Primary Commands (SPC-2)
ANSI INCITS 360:2002	SCSI-3 MultiMedia Command Set 3 (MMC-3)
ANSI NCITS.306:1998	SCSI-3 Block Command Set (SBC)
ANSI NCITS.361:2002	AT Attachment with Packet Interface 6 (ATA/ATAPI-6)
ISO/IEC 646:1991	Information technology - ISO 7-bit coded character set for information interchange (third edition). See also: *ANSI INCITS 4-1986 (R2002) Information Systems - Coded Character Sets - 7-Bit American National Standard Code for Information Interchange (7-Bit ASCII)*
ECMA 167, 3rd Edition	Volume and File Structure for Write-Once and Write-Once Media using Non-Sequential Recording for Information Interchange

2.1.2 References Under Development

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

INCITS T10/1416D	SCSI Primary Command Set - 3 (SPC-3)
INCITS T10/1417D	SCSI Block Command Set - 2 (SBC-2)
INCITS T10/1545D	SCSI-3 MultiMedia Command Set 4 (MMC-4)

For more information on the current status of the above documents, contact INCITS Secretariat, 1250 Eye Street, NW Suite 200, Washington, DC 20005, Phone Number (202) 737-8888. To obtain copies of these documents, contact Global Engineering at (303) 792-2181 or INCITS Secretariat.

2.2 Other References

The following are published by Optical Storage Technology Association. For more information, see www.osta.org.

Universal Disk Format™ Specification, Revision 2.6

The following are published by the Blu-ray Disc Association (for availability, consult www.blu-raydisc.info.):

System Description Blu-ray Disc Read-only Format, Part 1: Basic Format Specifications, Version 1.0

System Description Blu-ray Disc Rewritable Format, Part 1: Basic Format Specifications, Version 2.0

System Description Blu-ray Disc Recordable Format, Part 1: Basic Format Specifications, Version 1.0

3 Definitions, Symbols, Abbreviations, and Conventions

3.1 General

The Definitions, Symbols, Abbreviations, and Conventions described in MMC-4 are valid within this document. The Definitions, Symbols, Abbreviations, and Conventions described in this clause are in addition to those found in MMC-4. In the event of duplication, this document shall rule.

3.2 Terms

3.2.1 ADIP (Address In Pre-groove)

Address and recording information encoded in the wobble pre-groove on BD-R, and BD-RE media is named the Address in pre-groove (ADIP).

3.2.2 BD

Blu-ray Disc (BD) is a high capacity system that defines media and includes devices capable of reading such media and optionally writing to writable types of that media. A 120 mm BD disc may contain one or two layers with defined layer capacities of 23.3 gB and 25.0 gB. An 80 mm BD disc may contain one or two layers with a defined layer capacity of 7.8 gB.

3.2.3 BD-ROM

A BD-ROM disc is a read-only BD disc.

3.2.4 BD-R

BD-R disc is a BD disc that is write once in increments of 65 536 bytes.

3.2.5 BD-RE

BD-RE disc is a BD disc that is Rewritable.

3.2.6 Block (Logical Block)

A block (or logical block) consists of only the user data part of a sector.

3.2.7 Certification

Certification is a function defined for the Hardware Defect Management Feature. A Writable Unit is optionally written and then read. Vendor specific rules define a test for the read reliability of the writable unit. If the writable unit fails the test, the writable unit is registered into the hardware defect management system as defective. Otherwise, the writable unit is certified as good.

3.2.8 Cluster

A BD Cluster contains 32 logical sectors. The data of these 32 sectors are interleaved, scrambled, and EDC and ECC symbols are attached.

3.2.9 Defect List (DFL).

The Defect List exists to map defective Clusters to non-defective spare Clusters on BD-R and BD-RE discs. When a BD-R disc is formatted with the Pseudo-Overwrite capability, the DFL is also used to map replacement Clusters.

3.2.10 Disc/Defect Management Structure (DMS)

The DMS contains structures that define the disc format and that are necessary for defect management.

On BD-R there are two kinds of Disc Management Structures:

1. The Temporary Disc Management Structures (TDMS), recorded in the TDMA Areas as long as the disc has not been closed.
2. Disc Management Structures (DMS), recorded in the DMA Areas when a disc is closed (to preserve all Disc Management information contained in the last Temporary Disc Management Structure).

On BD-RE the Defect Management Structure is written and updated in the DMAs of the inner and outer zones.

3.2.11 Disc Definition Structure (DDS)

The DDS is contained within of sector of the DMS . The DDS contains basic format information about the disc: the physical location of LSN 0, the physical location of the last LSN, and the sizes of the spare areas.

On BD-R, the DDS also contains recording mode and TDMA information.

3.2.12 Drive

A Logical Unit that operates as a single MM disc accessing unit. e.g. a BD-R Drive.

3.2.13 Embossed Area

An Embossed Area is an area on the disc where information has been stored during the disc manufacturing process by means of either an High Frequency Modulated (HFM) Groove or by means of pits and space.
The recording in an embossed area cannot be modified by a recording device.

3.2.14 Full Certification

As a part of the execution of the FORMAT UNIT command on a rewritable disc, the Logical Unit may certify each writable unit in each of the Data Zones. This is Full Certification.

3.2.15 Host

A Host is a SCSI device with the characteristics of a primary computing device, typically a personal computer, workstation, minicomputer, mainframe computer, or auxiliary computing device or server. A Host includes one or more SCSI initiator devices.

3.2.16 Inner Spare Area (ISA0, ISA1)

When defect management is used on BD-R or BD-RE, a spare area may be allocated in the inner radius of each layer. Each of these areas is an Inner Spare Area (ISA). The ISA on layer 0 is referenced as ISA0, while the ISA on layer 1 is referenced as ISA1.

3.2.17 Logical Overwrite (LOW)

LOW is defined in *System Description Blu-ray Disc Recordable Format, Part 1: Basic Format Specifications* as the physical description of Pseudo-Overwrite. See the Pseudo-Overwrite definition.

3.2.18 Logical Sector Number (LSN)

A sector's LBA is referred to as LSN in some BD references.

3.2.19 Orphan LBA(s)

When a POW is executed, the relocation occurs at the NWA, N of some SRR, T. After the POW execution, the NWA is now N+32*K, where K is the number of POWed Clusters. LBAs N, N+1, ..., N+32*K-1 cannot be used in the next appending write to T. Consequently, these LBAs may be used only by additional POW operations. However, since there is not previous data to replace, these LBAs are Orphans.

3.2.20 Outer Spare Area (OSA0, OSA1)

When defect management is used on BD-R or BD-RE, a spare area may be allocated in the inner radius of each layer. Each of these areas is an Outer Spare Area (OSA). The OSA on layer 0 is referenced as OSA0, while the OSA on layer 1 is referenced as OSA1.

3.2.21 Permanent Information & Control data (PIC) Area

This zone contains general information about the disc. The PIC is embossed on all disc types.

3.2.22 Physical Sector Number (PSN)

When the total number of possible sectors on a media (even those not typically accessible) is N, physical sector numbering is a one-to-one mapping of the set 0, 1, 2, ...N-1 to the entire set of sectors. No device function (e.g. defect management) may change this mapping.

3.2.23 Pseudo-Overwrite (POW)

By using the Linear Replacement algorithm of the BD-R system, overwriting of a recorded Cluster is allowed. POW replacements are taken from the user data area and mapped using DFL. (POW is only defined for SRM formatted BD-R discs.)

3.2.24 Quick Certification

If a FORMAT UNIT command is issued by the Host for a BD-RE disc that was previously formatted, then the requested process is a reformat. Before starting the reformat, the DFL contains a list of Clusters that have been determined to be defective. As a part of the execution of the FORMAT UNIT command that is requesting a reformat, the Logical Unit may certify only Clusters registered in the DFL as defective. Since this process requires significantly less execution time than Full Certification, it is called Quick Certification.

3.2.25 Quick Reformat

If a FORMAT UNIT command is issued by the Host for a BD-RE disc that was previously formatted, then the requested process is a reformat. Before starting the reformat, the DFL contains a list of Clusters that have been determined to be defective.

If a FORMAT UNIT command requests a quick reformat, the Logical Unit shall convert each registered defective Cluster information on the disc to a re-usable Cluster status and perform no certification. The Logical Unit shall certify a Cluster that is registered as re-usable only when executing a non-streamed write. Since this process can make a reformat execute much faster than Quick Certification, this process is called Quick Reformat.

3.2.26 Random Recording Mode (RRM)

In the BD-R Random Recording Mode, data can be randomly written at every un-recorded Cluster.

3.2.27 Sector

A BD sector contains control information, one logical block, and logical block EDC.

3.2.28 Sequential Recording Mode (SRM)

Sequential Recording Mode is defined for BD-R to implement the generalized track/session model defined by MMC for implementation of the Incremental Streaming Writable Feature.

3.2.29 SRM+POW

A BD-R disc has the SRM+POW status when it has been formatted as SRM with the POW feature enabled.

3.2.30 SRM-POW

A BD-R disc has the SRM-POW status when it has been formatted as SRM with the POW feature disabled.

3.2.31 Sequential Recording Range (SRR)

Sequential Recording Range (SRR) is the physical definition of Logical Track for a BD-R in SRM.

3.2.32 Sequential Recording Range Information (SRRI)

Information about the location and status of all SRRs shall be stored in the Sequential Recording Range Information (SRRI) structures. While the disc is not finalized, the SRRI shall be recorded in the Temporary Disc Management Areas (TDMAs). At finalization, the most recent version of the SRRI is recorded in the Disc Management Area (DMA).

3.2.33 Space Bit Map (SBM)

A Space Bit Map specifies the recording status for a Recording Layer a BD-R disc formatted in Random Recording Mode (RRM).

3.2.34 Temporary Disc Management Area (TDMA)

On BD-R, the defect management and recording management information needs to be updated many times during use. For this purpose special areas are available in the Lead-in/Lead-out Area called the Temporary Disc Management Area. Additional TDMAs may be defined within spare areas.

3.2.35 Temporary Disc Management Structure (TDMS)

On BD-R, the Temporary Disc Management Structure (TDMS) is a version of the DMS recorded in a TDMA. The TDMS consists of the following three elements depending on the recording mode.

For sequential recording mode the TDMS consists of:

1. Temporary Disc Definition Structure (TDDS),
2. Temporary Defect List (TDFL),
3. Sequential Recording Range Information (SRRI).

For random recording mode the TDMS consists of:

1. Temporary Disc Definition Structure (TDDS),
2. Temporary Defect List (TDFL),
3. Space Bit Maps (SBM).

All of these elements shall be present in the TDMA currently in use. Whenever a disc leaves a recorder, the TDMS shall correctly reflect the current status of the disc.

3.2.36 Writable Unit

A writable media has a minimum physically writable amount of data. When expressed as an integral number of logical blocks, this is a writable unit. On BD media, the writable unit is a Cluster.

3.2.37 Zone

A zone is a physically contiguous region of the disc spiral. The Information Zone of a dual layer disc in OTP is considered physically contiguous.

3.3 Abbreviations

ADIP	Address In Pre-groove
BCA	Burst Cutting Area
BD	Blu-ray Disc
BD-R	Blu-ray Disc Recordable
BD-RE	Blu-ray Disc Rewritable
BD-ROM	Blu-ray Disc Read-only
DDS	Disc Definition Structure
DFL(x)	Defect List (x=0..7)
DI	Disc Information
DL	Dual Layer
DMA(x)	Disc Management Area (x=1..4)
DMS	Disc Management Structure
EB	Emergency Brake
INFOx	Control Information (x=1..4)
ISA0	Inner Spare Area, layer 0
ISA1	Inner Spare Area, layer 1
L0	Layer 0
L1	Layer 1
LSN	Logical Sector Number
OSA0	Outer Spare Area, layer 0
OSA1	Outer Spare Area, layer 1
PAC	Physical Access Control
PIC	Permanent Information & Control data
POW	Pseudo-Overwrite
PSN	Physical Sector Number
RRM	Random Recording Mode
SBM	Space Bit Map
SL	Single Layer
SRM	Sequential Recording Mode
SRR	Sequential Recording Range
SRRI	Sequential Recording Range Information
TDDS	Temporary Disc Definition Structure
TDFL	Temporary Defect List
TDMA	Temporary Disc Management Area
TDMS	Temporary Disc Management Structure

4 BD Models

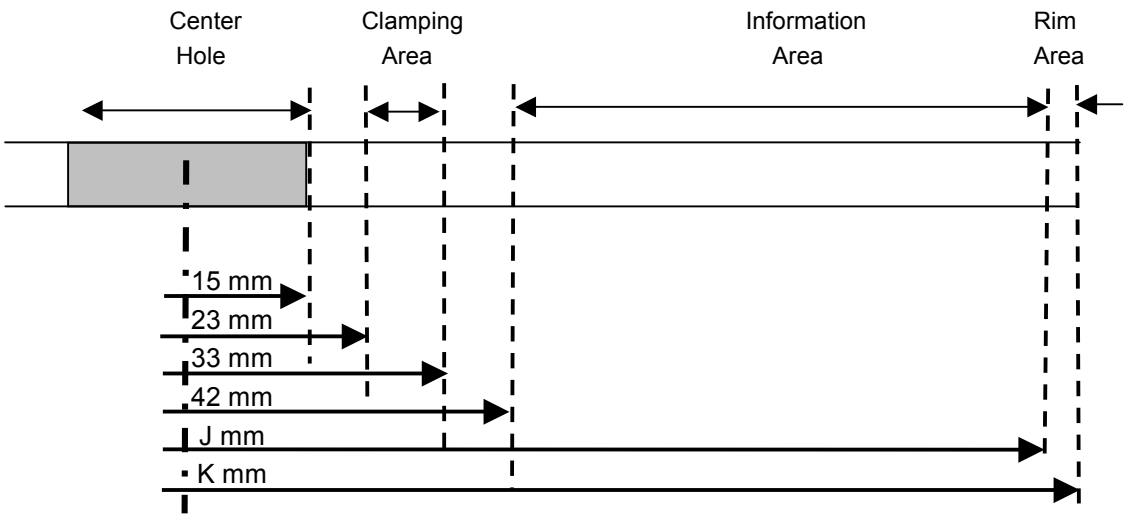
4.1 General

4.1.1 Physical Structure

Blu-ray Disc (BD) is a collection of high-density optical media: ROM (Read-Only Memory), R (write-once Recordable), and RE (Rewritable). The general characteristics of BD are:

- A BD disc may have a diameter of either 80 mm or 120 mm.
- A BD disc may be constructed as either one layer or two layers.
- Each layer has a continuous spiral track.
- In the case of two layers, the BD disc is constructed only as opposite track path (OTP).
- 120 mm BD media can have either 23.3 gB or 25.0 gB per layer.
- 80 mm BD media can have 7.8 gB per layer.
- The capacity of a dual layer disc is twice the single layer capacity.

A BD disc is separated into areas as shown in Figure 1.



For an 80 mm disc, J = 77 and K = 80. For a 120 mm disc, J = 117 and K = 120.

Figure 1 - The Areas of a BD

The Center Hole, Transition Areas and Clamping Area are all part of the alignment and clamping mechanisms. These areas have no direct involvement with the writable areas of the BD disc.

The Information Area is the area in which actual recording may occur. It contains the lead-in area, the data zone, and the lead-out area. The Information Area begins at a nominal diameter of 42 mm and proceeds to the outer diameter. For 120 mm media, the Information Area ends at a nominal diameter of 117 mm, whereas the 80 mm media Information Area ends at a nominal diameter of 77 mm. The Rim Area is simply the area beyond the data spiral. 120 mm media typically ends at a diameter of 120 mm. 80 mm media typically ends at a diameter of 80 mm.

4.1.2 Spiral Structure

The information area of the first layer (layer 0) of a Blu-ray disc is contained within a continuous spiral that begins near the inner radius and proceeds until the outer radius. The information area of the second layer (layer 1) of a Blu-ray disc is contained within a continuous spiral that begins near the outer radius and proceeds until the inner radius.

Each information zone of a recorded BD disc is a sequence of logical blocks. Logical blocks are collected into recordable units called Clusters:

- The logical block size is 2 048 bytes.
- A Cluster contains 32 logical blocks. The data of these 32 blocks are interleaved, scrambled, and EDC and ECC symbols are attached. The resulting structure is the physical Cluster.
- The error correction for user data within a BD sector is protected by the error correction coding in the Cluster that contains the sector.
- Logical Block Address (LBA) mapping to physical addresses (PSN) is dependent upon specific BD media type, i.e. ROM, R, RE.

4.1.2.1 Primary Zones

Each layer is separated into 3 primary areas: Inner, Data, and Outer.

On single layer discs, the Inner Zone is used as the disc Lead-in and the Outer Zone is used as the disc Lead-out. See Figure 2.

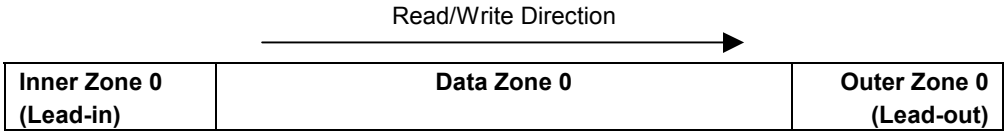


Figure 2 — Primary Zones of a Single Layer BD disc

On dual layer discs, the layer 0 Inner Zone is used as the disc Lead-in and the layer 1 Inner Zone is used as the disc Lead-out. The two Outer Zones are used as layer transition zones. See Figure 3.

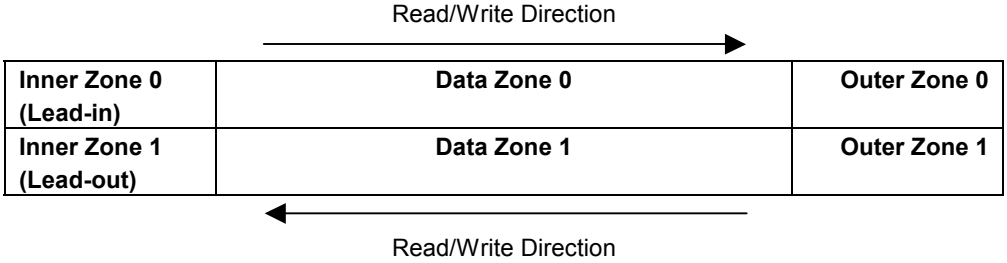


Figure 3 — Primary Zones of a Dual Layer BD disc

4.1.2.2 Capacity

BD capacity is determined by the size of the Data Zones. Possible BD disc capacities are shown in Table 1.

Table 1 — BD Disc Capacities

Diameter	Single Layer	Dual Layer
80 mm[1]	7.8 gB	15.6 gB
120 mm	23.3 gB	46.6 gB
	25.0 gB	50.0 gB
[1] 80 mm is not a defined size for BD-ROM		

4.1.2.3 ADIP

The spiral of each layer of a BD-R or BD-RE disc is defined with a fixed frequency wobbled groove. The wobble contains modulated location information called Address In Pre-groove (ADIP).

In the Inner Zones, the ADIP address information is interleaved with disc information called Disc Information (DI) frames. The collection of DI frames contains information about the logical disc structure as well as recording parameters.

The DI is repeated in embossed areas that occur prior to the Inner Zones.

4.1.2.4 Un-recorded Sector Addressing

In all recording modes, seek to any sector shall be supported by all BD Drives. Neither Lead-in Zone and/or Lead-out Zone needs to be completely written.

4.2 BD-ROM

4.2.1 Overview

BD-ROM disc is a read-only media with the general BD structure.

4.2.2 The Information Zone

The information zone of a dual layer BD-ROM disc (Figure 4) is the accessible spirals.

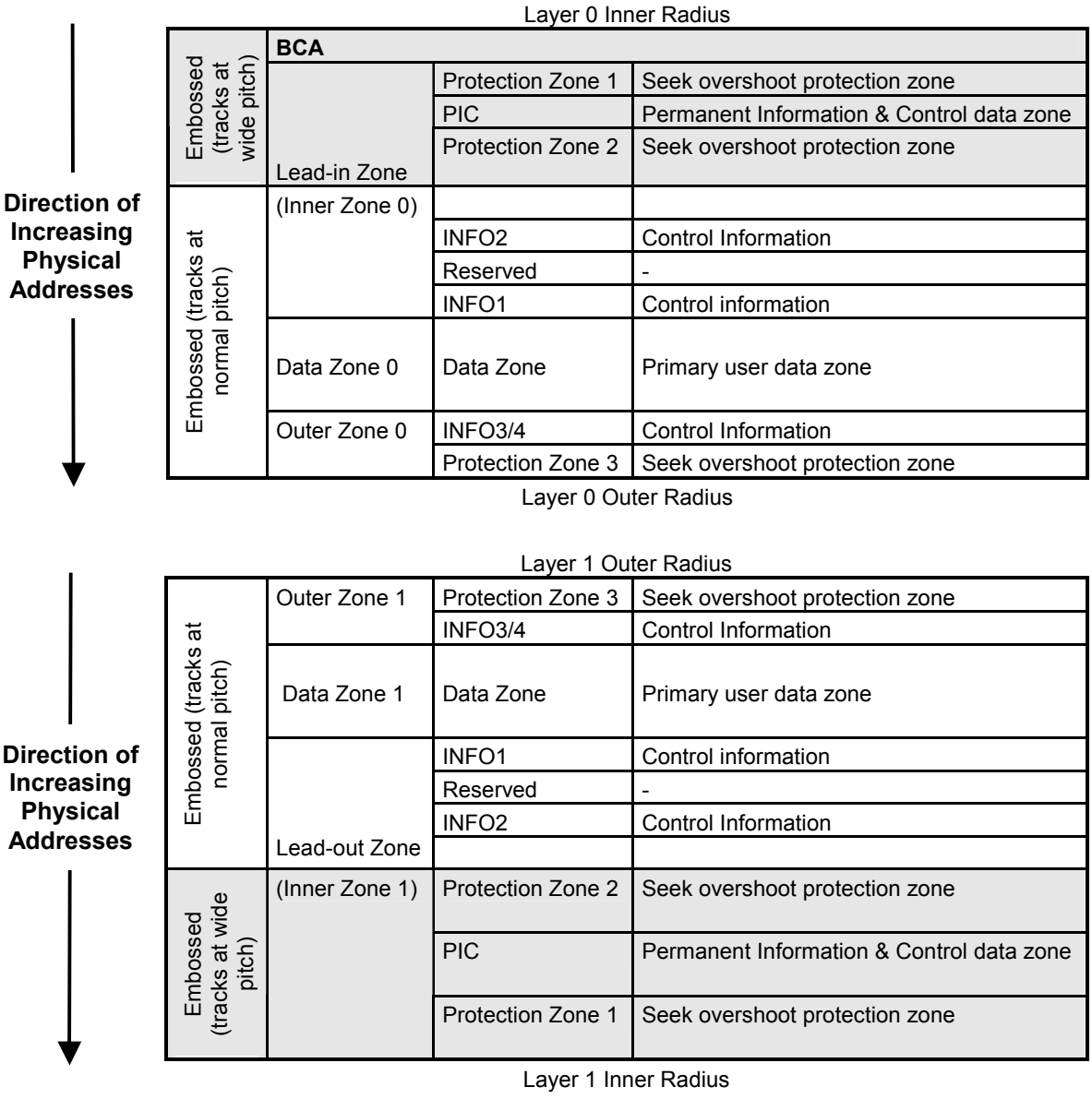


Figure 4 –BD-ROM Information Zone

4.2.2.1 Embossed Zone (tracks at wide pitch)

The Embossed area consists of:

BCA	The Burst Cutting Area (BCA), if present, contains application specific information.
Protection Zone 1	This zone exists for seek overshoot protection at the disc's inner radius.
Permanent Information & Control data zone (PIC)	On layer zero, this embossed zone contains disc information that includes, but is not restricted to: 1. Physical media class and version 2. Physical address of the start of the Data Zone 3. Physical address of the start of the outer zone (if this is a single layer media, this is the lead-out) 4. Number of layers 5. Recording Density 6. Write power information On layer 1 this embossed zone contains a copy of the layer 0 information, but the physical addresses refer to physical addresses on layer 1.
Protection Zone 2	This zone is a buffer area between the 2 track pitches. The first part of this zone has wide pitch.

4.2.2.2 Inner Zone 0 (Lead-in Zone)/Inner Zone 1 (Lead-out Zone)

An Inner Zone consists of:

Protection Zone 2	This zone is a buffer area between the 2 track pitches. The second part of this zone has normal pitch.
INFO2	This zone is intended to contain information specific to the application.
Reserved	This zone is reserved. Each Cluster shall contain only zeros.
INFO1	This zone is intended to contain control information.

4.2.2.3 Data Zone

The data zone contains application data that is readable by the Host as a sequence of sectors.

4.2.2.4 Outer Zone 0 (Lead-out Zone)/Outer Zone 1

On single layer media the Outer Zone has the function of the Lead-out Zone.

On dual layer media, the Outer Zone 0 and Outer Zone 1 are layer transition zones on layer 0 and layer 1, respectively.

The Outer Zone consists of:

INFO3/4	This zone is intended to store control information.
Protection Zone 3	This zone exists for seek overshoot protection at the disc's outer radius.

4.2.3 Access Model

BD-ROM discs may consist of one or two layers. In the case of two layers, the user area of each media appears to the Host as a single continuous address space.

The access model for BD-ROM is based upon the random access read-only device model:

- The user data space is organized in fixed size blocks (2 048 bytes/block) and addressed as logical blocks. LBA 0 is fixed at PSN = 00100000h.
- Blocks in this Logical Block Address space may be read using only the READ (10) and READ (12) commands.
- Logical Block Addresses are numbered from 0 through READ CAPACITY LBA. The value of READ CAPACITY LBA is the Logical Block Address returned by the READ CAPACITY command.
- The READ TOC/PMA/ATIP command is implemented to assure compatibility with existing applications. Only formats 0 and 1 are implemented. Some structures may be fabricated.
- Structures unique to BD may be read using the READ DISC STRUCTURES command.

4.3 BD-RE

4.3.1 Overview

BD-RE is a rewritable media with the general BD structure. The default format for BD-RE enables the Removable Disk Profile. The Removable Disk Profile includes the Hardware Defect Management feature, the Random Readable feature - with a 2 048 byte block size, and the Random Writable feature - with a 2 048 byte block size.

It is also possible to format a BD-RE disc without spare areas allocated for mastering applications.

4.3.2 The Information Zone

The information area of a dual layer BD-RE disc (Figure 5) is the accessible spirals.

Layer 0 Inner Radius

Embossed Zone	BCA		
	Inner Zone 0	Protection Zone 1	Seek overshoot protection zone
		PIC	Permanent Information & Control data zone
Rewritable Zone	(Lead-in Zone)	Protection Zone 2	Seek overshoot protection zone
		INFO2	Defect Management information
		OPC	Optimum Power Calibration zone
		Reserved	-
		INFO1	Drive information zone
	Data Zone 0	ISA0	Inner Spare area
		User Data Zone	Primary user data zone
		OSA0	Outer Spare Area
	Outer Zone 0	INFO3/4	Defect management and control info
		Protection Zone 3	Seek overshoot protection zone

Direction of Increasing Physical Addresses

Layer 0 Outer Radius

Layer 1 Outer Radius

Rewritable Zone	Outer Zone 1	Protection Zone 3	Seek overshoot protection zone
		INFO3/4	Defect management and control info
	Data Zone 1	OSA1	Outer Spare Area
		User Data Zone	Primary user data zone
		ISA1	Inner Spare Area
	Inner Zone 1	INFO1	Drive information zone
		OPC	Optimum Power Calibration zone
		Reserved	
		INFO2	Defect Management information
		Protection Zone 2	Seek overshoot protection zone
Embossed Zone	(Lead-out Zone)	PIC	Permanent Information & Control data zone
		Protection Zone 1	Seek overshoot protection zone

Direction of Increasing Physical Addresses

Layer 1 Inner Radius

Figure 5 –BD-RE Zones

Each layer of the Information Zone is divided into an embossed HFM area and a rewritable area. The rewritable area of layer 0 is divided into a lead-in zone, a data zone, and a Outer Zone. On single layer media, the outer area is the disc lead-out zone. On dual layer media the outer area is a layer transition area.

4.3.2.1 Embossed HFM Zone

The Embossed HFM zone consists of:

Burst Cutting Area (BCA)	The BCA is used to add information to the disc after completion of the manufacturing process. The BCA-code can be written by a high-power laser system in case of Recordable discs.
Permanent Information & Control data zone (PIC)	On layer zero, this embossed zone contains disc information that includes, but is not restricted to: 1. Physical media class and version 2. Physical address of the start of the Data Zone 3. Physical address of the start of the outer zone (if this is a single layer media, this is the lead-out) 4. Number of layers 5. Recording Density 6. Write power information On layer 1 this embossed zone contains a copy of the layer 0 information, but the physical addresses refer to physical addresses on layer 1.

4.3.2.2 Inner Zone 0/Inner Zone 1 (Lead-in Zone/Lead-out Zone)

An Inner Zone consists of:

Protection Zone 2	On both layers, this zone buffers the rewritable area from the embossed zone.
INFO2	On both layers, INFO2 is reserved for defect management information and PAC storage.
Optimum Power Calibration (OPC) Zone	On both layers, the OPC Zone is reserved for testing and calibration.
INFO1	On both layers, this zone is reserved for drive specific information and PAC storage.

4.3.2.3 Data Zone

The Data Zone consists of:

Inner Spare Areas (ISA0, ISA1)	If spare Clusters are allocated for defect management, then ISA0 is allocated with 4 096 Clusters. If spare Clusters are allocated for defect management, ISA1 is an area available for spare area allocation in 256 Cluster increments. Any part of the data zone that is not allocated for spare Clusters is part of the User Data Zone.
User Data Zone	The User Data Zone is the logically addressed area of the disc.
Outer Spare Areas (OSA0, OSA1)	If spare Clusters are allocated for defect management, OSA0 is an area available for spare area allocation in 256 Cluster increments. OSA1 is the same size as OSA0.

4.3.2.4 Lead-out Zone/Outer Zone 0/Outer Zone 1

On single layer media the Outer Zone has the function of the Lead-out Zone.

On dual layer media, the Outer Zone 0 and Outer Zone 1 are layer transition zones on layer 0 and layer 1, respectively.

The Outer Zone consists of:

INFO3/4	On both layers, INFO3/4 is reserved for defect management and control information.
Protection Zone 3	On both layers, this zone exists for seek overshoot protection at the disc's outer radius.

4.3.3 Physical Track Structure

BD-RE physical track structure has the general BD disc structure with additional format entities defined uniquely for BD-RE.

Spare Areas are allocated from the Data Zone, creating three areas within the Data Zone: Inner Spare Area (ISA0), User Data Zone, and Outer Spare Area (OSA0).

If ISA0 is present, it has a fixed size of 4096 Clusters. OSA0 has a variable size from 0 to 16384 Clusters, allocated in increments of 256 Clusters. Consequently, OSA0 size in Clusters = N*256 Clusters, where 0 ≤ N ≤ 64. See Figure 6.

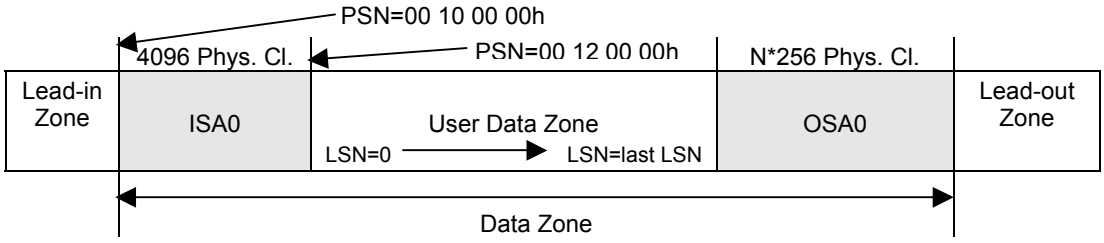


Figure 6 – Layout of Single Layer BD-RE Disc

The layer 0 information zone of a dual layer BD-RE disc is contained within a continuous spiral that begins near the inner radius and proceeds until the outer radius. The layer 1 information zone of a dual layer disc is contained within a continuous spiral that begins near the outer radius and proceeds until the inner radius. The layer 0 information zone is divided into three areas: the Lead-in Zone, Data Zone 0, and the Outer Zone 0. The layer 1 information zone is divided into three areas: the Outer zone 1, Data Zone 1, and the Lead-out zone.

Spare Areas are allocated from the Data Zones, creating three areas within each data zone: Inner Spare Areas (ISA0 and ISA1), User Data Zone, and Outer Spare Areas (OSA0 and OSA1).

If ISA0 is present, it has a fixed size of 4096 Clusters. OSA0 has a variable size from 0 to 8192 Clusters in increments of 256 Clusters. OSA0 size in Clusters = N*256 Clusters, where 0 ≤ N ≤ 32. OSA1 has the same size as OSA0. ISA1 has a variable size from 0 to 16 384 Clusters, in increments of 256 Clusters. Consequently, ISA1 size in Clusters = L*256 Clusters, where 0 ≤ L ≤ 64. See Figure 7.

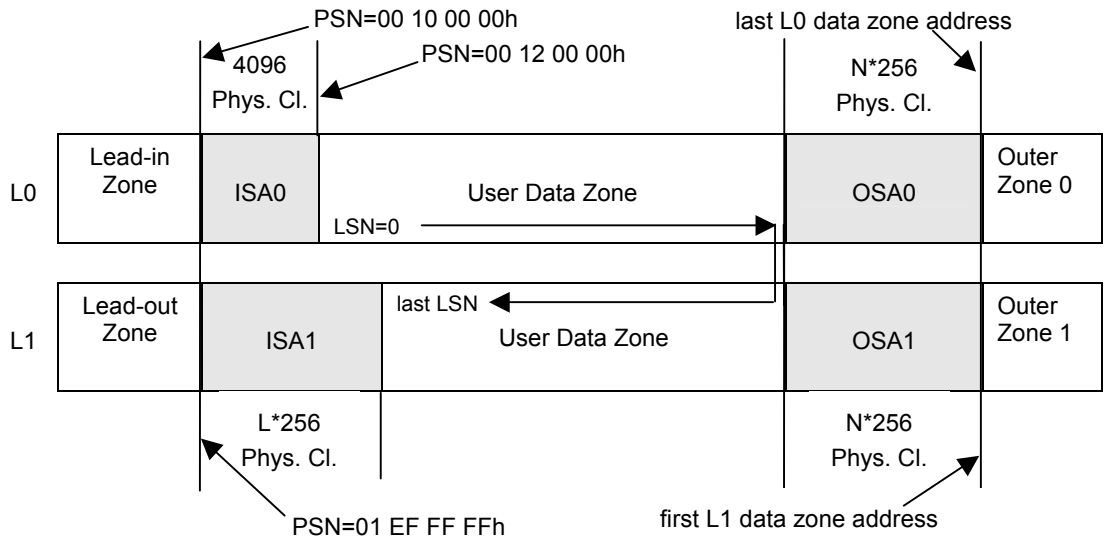


Figure 7 – Layout of Dual Layer BD-RE Disc

4.3.4 Sectors and Clusters

The logical block size of BD is 2048 bytes collected into recordable units called Clusters. A Cluster contains 32 logical sectors.

a. The user data within a BD sector is protected by the error correction coding in the Cluster that contains the sector.

b. BD discs may be recorded over one or two layers. In the case of two layers, the user area of each media appears to the Host as a single continuous address space.

The access model for BD is based upon the random access device model:

a. The user data space is organized in fixed size blocks (2048 bytes/block) and addressed as logical blocks. Blocks in this Logical Block Address space may be read using only the READ (10) and READ (12) commands.

b. Logical Block Addresses are numbered from 0 through CAPACITY-1. The value of CAPACITY-1 is the Logical Block Address returned by the READ CAPACITY command.

c. The READ TOC/PMA/ATIP command is implemented to assure compatibility with existing applications. Only formats 0 and 1 are implemented. Some structures may be fabricated.

d. Structures unique to BD may be read using the READ DISC STRUCTURE command.

4.4 BD-R

4.4.1 Overview

BD-R is a write-once media with the general BD structure. The default format for BD-R implements the track/session model as typified by the Incremental Streaming Writable feature.

In order to enable applications like mastering, It is also possible to format a BD-R disc without spare areas.

4.4.2 Information Area

Each layer of the BD-R Information Zone is divided into an embossed HFM area and a recordable area. The detailed spiral layout is shown in Figure 8.

Layer 0 Inner Radius

Direction of Increasing Physical Addresses

Embossed Zone	BCA		
		Protection zone 1	Seek overshoot protection zone
		PIC	Permanent Information & Control data Zone
Recordable Zone	Inner Zone 0 (Lead-in Zone)	Protection zone 2	Seek overshoot protection zone
		INFO2	DMA2 and PAC2
		OPC0	Optimum Power Calibration zone
		TDMA0	Temporary Disc Management Area 0
		INFO1	DMA1 and PAC1
	Data Zone	ISA0	Inner Spare Area
		User Data Zone	Primary user data zone 0
		OSA0	Outer Spare Area
	Outer Zone 0	INFO3/4	DMA3, DMA4 and control info
		DCZ0	Disc Calibration zone
		Protection zone 3	Seek overshoot protection zone

Layer 0 Outer Radius

Layer 1 Outer Radius

Direction of Increasing Physical Addresses

Recordable Zone	Outer Zone 1	Protection zone 3	Seek overshoot protection zone
		DCZ1	Disc Calibration Zone
		INFO3/4	DMA3, DMA4 and control info
	Data Zone	OSA1	Outer Spare Area 1
		User Data Zone	Primary user data area 1
		ISA1	Inner Spare Area 1
	Inner Zone 1 (Lead-out Zone)	INFO1	DMA1 and PAC1
		Reserved	—
		TDMA1	Temporary Disc Management Area 1
		INFO2	DMA2 and PAC2
		Buffer	
		OPC1	Test zone
		Buffer	
		Protection Zone 1	Seek overshoot protection zone

Layer 1 Inner Radius

Figure 8 —BD-R Zones

The recordable area of each layer is divided into an Inner Zone, a Data Zone, and an Outer Zone. On a single layer disc the Inner Zone is used as a disc Lead-in and the Outer Zone is used as a Lead-out. On a dual layer disc, Inner Zone 0 is the disc lead-in, Inner Zone 1 is the disc lead-out, and the Outer Zones are layer transition areas.

For a detailed description of specific zones, consult *System Description Blu-ray Disc Recordable Format, Part 1 Basic Format Specifications*.

4.4.2.1 Embossed Zone

The Embossed zone consists of:

Burst Cutting Area (BCA)	The BCA is used to add information to the disc after completion of the manufacturing process. The BCA-code can be written by a high-power laser system in case of Recordable discs.
Protection Zone 1	Protection Zone 1, on each layer, is meant as a protection area against overwriting the PIC zone by the Burst Cutting Area (BCA) that precedes the normal recording spiral.
Permanent Information & Control data Zone (PIC)	On layer zero, this Embossed area contains disc information that includes, but is not restricted to: 1. Physical media class and version 2. Physical address of the start of the Data Zone 3. Physical address of the start of the outer zone (if this is a single layer media, this is the lead-out) 4. Number of layers 5. Recording Density 6. Write power information The PIC zone on layer 1 is not required to be recorded.

4.4.2.2 Inner Zone 0 (Lead-in Zone)

An Inner Zone consists of:

Protection Zone 2	On both layers, this zone buffers the writable area from the embossed area.
INFO2	On both layers, INFO2 is reserved for DMA and PAC storage.
Optimum Power Calibration (OPC) Zone	On both layers, the OPC Zone is reserved for testing and calibration.
TDMA0, 1	Temporary Disc Management Areas
INFO1	On both layers, this area is reserved for DMA and PAC storage.

4.4.2.3 Data Zone

The Data Zone consists of:

Inner Spare Areas (ISA0, ISA1)	If spare Clusters are allocated for defect management, then ISA0 contains 4 096 Clusters and ISA1 has a maximum size of 16 384 Clusters allocated in 256 Cluster increments. Any part of the data zone that is not allocated for the ISAs is part of the User Data Zone. A TDMA may be allocated in increments of 256 Clusters from any Spare area. This action reduces the size of the Spare Area by the amount allocated for the TDMA.
User Data Zone	The User Data Zone is the logically addressed area of the disc.
Outer Spare Areas	If spare Clusters are allocated for defect management, then, OSA0 has a maximum size of 196 608 Clusters, allocated in 256 Cluster increments. On

(OSA0, OSA1)	DL discs, OSA1 shall be the same size as OSA0. A TDMA may be allocated in increments of 256 Clusters from any Spare Area. This action reduces the size of the Spare Area by the amount allocated for the TDMA.

4.4.2.4 Outer Zone 0 (Lead-out Zone on a SL disc)

On single layer media the Outer Zone has the function of the Lead-out Zone. On dual layer media, the Outer Zone 0 and Outer Zone 1 are layer transition zones between the two layers.

The Outer Zone consists of:

INFO3/4	On both layers, INFO3/4 is reserved for defect management and control information.
DCZ	The Drive Calibration Zone is reserved for calibration purposes.
Protection Zone 3	On both layers, this zone exists for seek overshoot protection at the disc's outer radius.

4.4.3 Logical Structure

4.4.3.1 Logical Structure of Single Layer BD-R

The single layer BD disc information zone is contained within a continuous spiral that begins near the inner radius and proceeds until the outer radius. The information zone is divided into three areas: the Lead-in Zone, Data Zone, and Lead-out Zone.

Spare Areas are allocated from the Data Zone, creating three areas within the data zone: Inner Spare Area (ISA0), User Data Zone, and Outer Spare Area (OSA0).

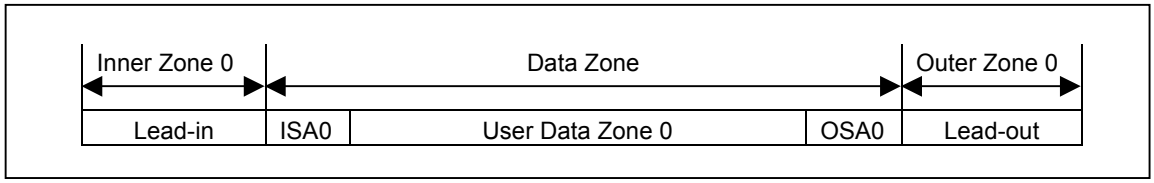


Figure 9 — SL BD-R Information Zone

Regardless of disc diameter, if ISA0 is present, it has a fixed size of 4096 Clusters. On 120 mm media, OSA0 has a variable size from 0 to 196 608 Clusters, allocated in increments of 256 Clusters. On 80 mm media, OSA0 has a variable size from 0 to 65 536 Clusters, allocated in increments of 256 Clusters.

The defect management and recording management information needs to be updated many times during use. For this purpose a special area is available in the Inner Zones called a Temporary Disc Management Area (TDMA). Additional TDMAs can be defined to facilitate more space for more updates of the defect and recording management information. These areas can be useful in the case of many ejects after short recordings or when a more frequent update scheme is desired for more robustness against for example power failures.

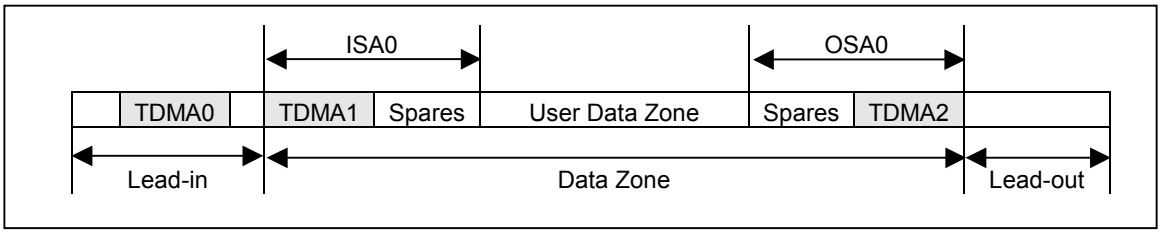


Figure 10 — TDMA Allocation on SL BD-R

TDMA0 is allocated from the Lead-in with 2 048 Clusters.

If necessary, TDMA1 may be allocated from ISA0. The size of TDMA1 shall be an integral multiple of 256 Clusters. TDMA1 is permitted to contain all of the Clusters of ISA0.

If necessary, TDMA2 may be allocated from OSA0. The size of TDMA2 shall be an integral multiple of 256 Clusters. TDMA2 is permitted to contain all of the Clusters of OSA0.

4.4.3.2 Logical Structure of Dual Layer BD-R

The layer 0 information zone of a dual layer BD disc is contained within a continuous spiral that begins near the inner radius and proceeds until the outer radius. The layer 1 information zone of a dual layer disc is contained within a continuous spiral that begins near the outer radius and proceeds until the inner radius. The layer 0 information zone is divided into three areas: the Lead-in Zone, Data Zone 0, and the Outer Zone 0. The layer 1 information zone is divided into three areas: the Outer zone 1, Data Zone 1, and the Lead-out zone. Defect Management areas are intermingled with these zones.

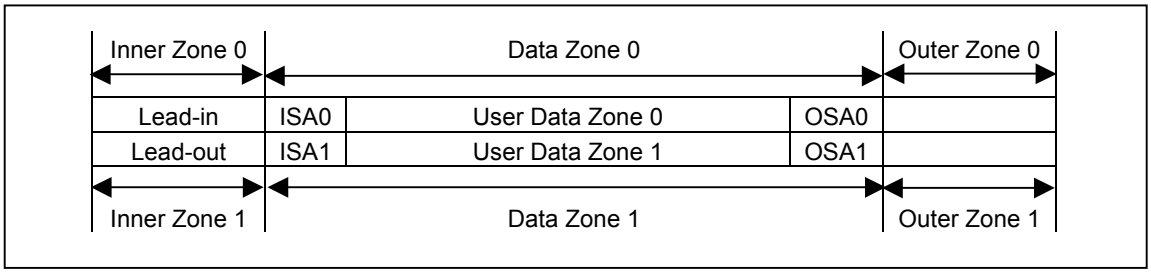


Figure 11 — DL BD-R Zones

Regardless of disc diameter, if ISA0 is present, it has a fixed size of 4096 clusters, and ISA1 has a variable size from 0 to 16 384 Clusters, in increments of 256 Clusters.

On 120 mm media, OSA0 has a variable size from 0 to 196 608 Clusters in increments of 256 Clusters. On 80 mm media, OSA0 has a variable size from 0 to 65 536 Clusters in increments of 256 Clusters. Regardless of disc diameter, OSA1 has the same size as OSA0.

The defect management and recording management information needs to be updated many times during use. For this purpose a special area is available in the Inner Zones called a Temporary Disc Management Area (TDMA). Additional TDMAs can be defined to facilitate more space for more updates of the defect and recording management information. These areas can be useful in the case of many ejects after short recordings or when a more frequent update scheme is desired for more robustness against for example power failures.

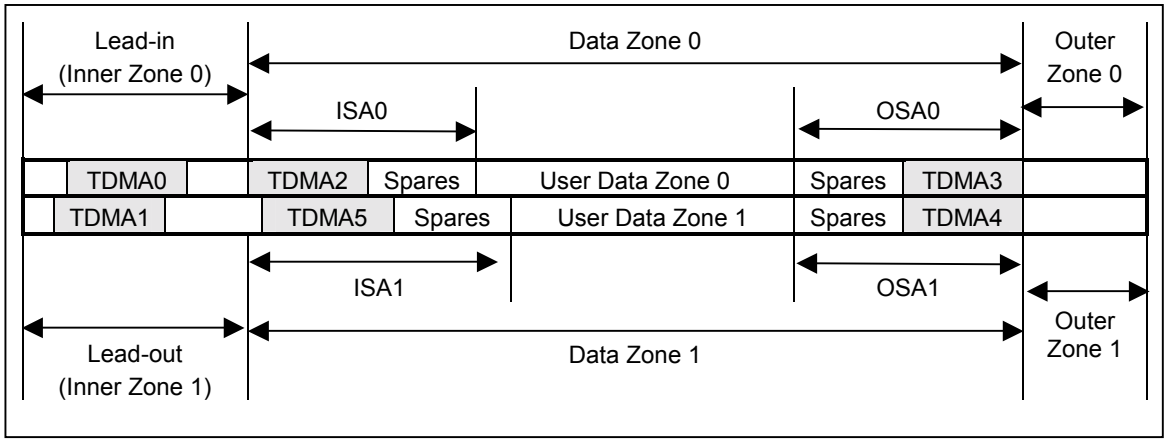


Figure 12 — TDMA Allocation on DL BD-R

TDMA0 is allocated in Inner Zone 0 (lead-in) and is 2 048 Clusters in size.

TDMA1 is allocated in Inner Zone 1 (lead-out) and is 2 048 Clusters in size.

TDMA2 may be allocated from ISA0. The size of TDMA2 shall be an integral multiple of 256 Clusters. TDMA2 is permitted to contain all of the Clusters of ISA0.

TDMA3 may be allocated from OSA0. The size of TDMA3 shall be an integral multiple of 256 Clusters. TDMA3 is permitted to contain all of the Clusters of OSA0.

TDMA4 may be allocated from OSA1. The size of TDMA4 shall be an integral multiple of 256 Clusters. TDMA4 is permitted to contain all of the Clusters of OSA1.

TDMA5 may be allocated from ISA1. The size of TDMA5 shall be an integral multiple of 256 Clusters. TDMA5 is permitted to contain all of the Clusters of ISA1.

4.4.4 BD-R Recording Models

BD-R has two basic recording modes: SRM (Sequential Recording Mode) and RRM (Random Recording Mode). Pseudo-Overwrite (POW) is defined as an additional capability for SRM.

The default mode for a blank BD-R disc is SRM with no spares allocated. Default mode is established if a blank BD-R is mounted and ready, and the Drive accepts and executes a RESERVE TRACK command, a WRITE (10) command or a WRITE (12) command.

Otherwise, specific recording mode is selected by use of the FORMAT UNIT command. If spares are to be allocated, the FORMAT UNIT command is used to select either default size or actual size of spare area.

Once the recording mode has been established, it is not changeable.

4.4.4.1 Random Recording Mode (RRM)

The Random Recording Mode (RRM) is an application of a Random Recording model that is similar to the Write-Once device model. A RRM formatted disc may be randomly recorded in Clusters.

The written status of user data area Clusters is maintained in a structure called the Space Bitmap. The Space Bitmap contains one bit per Cluster in Logical Address order. If a bit is set to zero, the associated Cluster has never been written. If the bit is set to one, the associated Cluster has been recorded.

4.4.4.2 Sequential Recording Mode (SRM)

4.4.4.2.1 General

The Sequential Recording Mode (SRM) is an application of the Track/Session model that has been previously defined for CD and DVD. In order to maintain a structure that is consistent with the historical models, all definitions are made with respect to logical addressing.

During the time that the Track/Session status of the disc is dynamic (i.e. when the disc is not finalized), status and boundary information about Tracks/Sessions are stored in a TDMS (Temporary Disc Management Structure). TDMS updates are made serially in areas called Temporary Disc Management Areas (TDMAs). When the disc is finalized (i.e. no further changes are permitted), all pending TDMS updates shall be written, and the most recent copy of the TDMS is copied into each of the DMAs (4 on SL and 8 on DL) on the disc.

4.4.4.2.2 Definitions

4.4.4.2.2.1 Logical Blocks

A Logical Block is the smallest logically addressable unit of data that is readable by the Host. For BD-R, the Logical Block size is 2048 bytes. This value is specified in the Logical Block Size field in the Random Readable Feature Descriptor.

4.4.4.2.2.2 Recordable Units

A recordable unit is the smallest physically writable collection of contiguous Logical Blocks. For BD-R the recordable unit size is 32 Logical Blocks, one Cluster. This value is specified in the Blocking field of the Random Readable Feature Descriptor.

4.4.4.2.2.3 Logical Track: Sequential Recording Range (SRR)

A Logical Track is a set of sequential recordable units. Logical Tracks are numbered consecutively, starting with number one. On BD-R, the Logical Track is defined as a Sequential Recording Range (SRR). The physical extents of each SRR and the status of each SRR is defined in the SRR Information (SRRI) structure. The SRRI is a structure in the TDMS that is maintained in the Temporary Disc Management Areas (TDMA).

BD-R Logical Tracks bounds are defined only in the SRRI. No overhead blocks are used in the definition of a Logical Track on BD-R.

4.4.4.2.2.3.1 Logical Track Starting Address

The LBA of the first Logical Block of the Logical Track is the starting address of the Logical Track.

4.4.4.2.2.3.2 Logical Track Length

The number of Logical Blocks in the Logical Track is the track length. Since a BD-R Logical Track is a collection of Clusters, this value is an integral multiple of 32.

4.4.4.2.2.3.3 Next Writable Address (NWA)

The Host is only permitted to record a Logical Track sequentially, beginning with it's starting address. To facilitate this, the Drive maintains a Next Writable Address (NWA) for each open Logical Track. There is at most one NWA in a Logical Track.

If the Logical Track is blank, then the NWA is initialized to the starting address of the Logical Track. The NWA is advanced by the number of LBAs written in each write command after each write command has terminated.

Since writes may be buffered, the NWA may not always be at a Cluster boundary. If buffer synchronization is forced (e.g. SYNCHONIZE CACHE command), all buffered data is written to the disc. If the last buffered block is not sector 31 of a Cluster, then zero padding shall be added to the end of the Cluster prior to writing.

4.4.4.2.2.3.4 Last Recorded Address (LRA)

The last Cluster addressed by a WRITE command may be written in which 1 to 32 Logical Blocks contain Host supplied data. The Last Recorded Address (LRA) is the LBA of the last Logical Block of the Cluster that contains Host supplied data.

4.4.4.2.2.3.5 Blank Logical Track

If every Logical Block in a Logical Track is blank, the Logical Track is blank. The NWA of a blank Logical Track is the Logical Track starting address.

4.4.4.2.2.4 Open Logical Track

The SRRI contains a list of open SRRs. A Logical Track is open if it is in the list. In order to be in the list of open Logical Tracks: Start Address + Track Length - 1 > NWA. The SRRI open SRR list is limited to 16 open SRRs.

4.4.4.2.2.5 Closed Logical Track

A Logical Track is closed when the Logical Track is defined, but not in the SRRI list of open Logical Tracks. The Host may request that a Logical Track be closed by sending the CLOSE TRACK/SESSION command. A Logical Track becomes closed when:

1. All of its Logical Blocks have been written, or
2. When the Host has requested that the Logical Track be closed.

When a Logical Track is closed, the NWA no longer valid for appending new data.

If the invisible Logical Track, numbered N, is partially recorded and a close is requested by the Host, the Logical Track bounds are specified to include only the recorded Logical Blocks and a new, blank invisible Logical Track is created with Logical Track number N+1.

4.4.4.2.2.6 Session

A session is a collection of contiguous Logical Tracks. The bounds of a session are defined in the SRRI. Unlike CD and DVD sessions, the BD-R SRM session is defined only by the SRRI.

Consequently, there is neither a session lead-in nor a session lead-out. Sessions are numbered consecutively, starting with session one.

4.4.4.2.2.6.1 Open Session

A session is open if any of the Logical Tracks within the session are open.

4.4.4.2.2.6.2 Closed Session

A session is closed if all of the Logical Tracks within the session are closed. Once a session is closed, it is not permitted to add new Logical Tracks.

4.4.4.2.2.6.3 Finalized (Closed) Disc

A disc is finalized when all sessions are closed and each final DMS is recorded in the appropriate DMA. Once each DMS has been recorded, it is not necessary to record any other part of the Inner or Outer zones.

4.4.4.2.3 Logical to Physical Addressing

The logical to physical address mapping operates differently on layer 0 and layer 1.

On layer 0, the user data area begins at some physical address, K, where K is the PSN of the first block of the first Cluster after ISA0. $K+J_0$ is the PSN of the first block of the first Cluster of OSA0.

The primary Logical to physical mapping (LtoP) is defined as: For $0 \le N \le J_0-1$, LtoP(N) = N+K. Otherwise, N is not in the range of the mapping. See Figure 13.

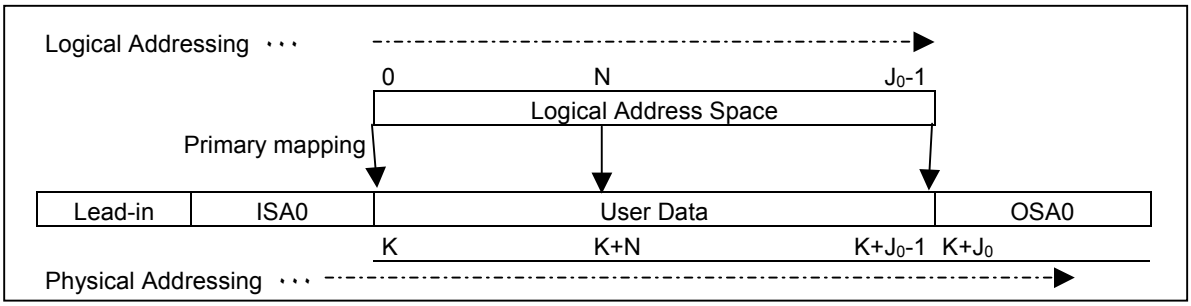


Figure 13 — Logical to Physical Addressing on Layer 0

If layer 1 is present, the disc's user data zone continues on layer 1 with the first block of the first Cluster after OSA1, J_1. The user data zone continues until the first block of the first Cluster of ISA1, at C. The primary Logical to physical mapping (LtoP) is extended to include layer 1:

$$\text{LtoP}(N) = \begin{cases} N+K \text{ when } 0 \le N \le J_0-1. \\ (N-J_0)+J_1 \text{ when } J_0 \le N \le C-1. \end{cases}$$

See Figure 14.

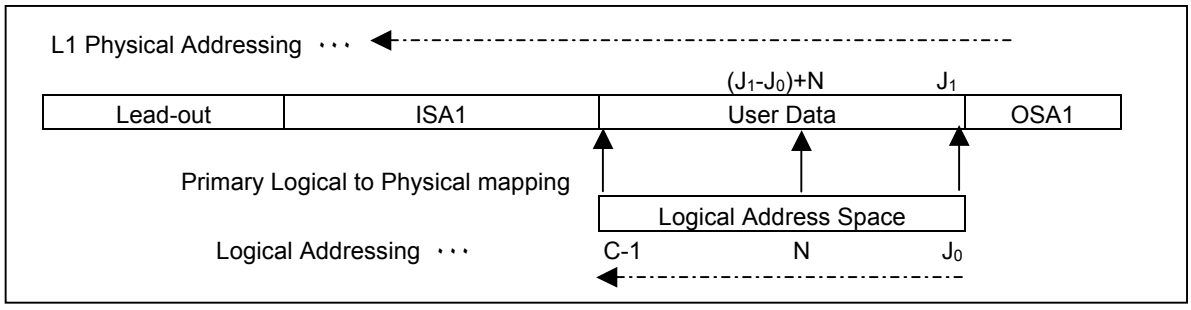


Figure 14 — Logical to Physical Addressing on Layer 1

If the disc is formatted with defect management, and if upon recording, LtoP(N) is found to be defective, the defect replacement mapping is applied to map LtoP(N) to a Cluster in a spare area.

4.4.4.2.4 Status after Formatting a Blank BD-R

If a blank BD-R disc is formatted in SRM, the User Data Zone consists of one open session with one open Logical Track (SRR). This Logical Track is the invisible Logical Track. As shown in Figure 15, the number of the track is 1, its start address is LBA = 0, and its length is the size of the User Data Zone (CAP). The Next Writable Address (NWA) for Logical Track 1 is LBA = 0.

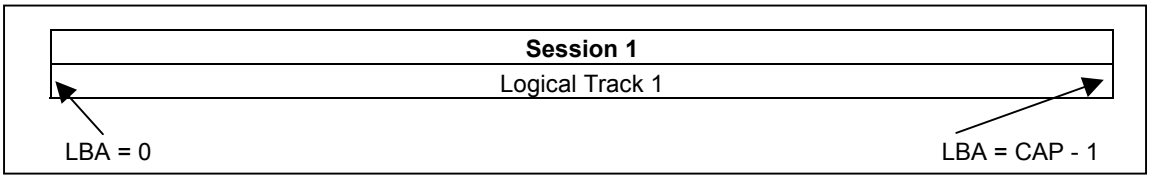


Figure 15 — Status of a BD-R Disc After Formatting in SRM

If a WRITE command is issued to the Drive, the Start LBA must be equal to the NWA. If the Start LBA of a WRITE command is not the NWA of some Logical Track, then the WRITE command shall be terminated with CHECK CONDITION status, and the sense shall be set to indicate ILLEGAL REQUEST/INVALID ADDRESS FOR WRITE.

4.4.4.2.5 Creating Additional Logical Tracks

The RESERVE TRACK command, may be used to define a fixed length Logical Track from the invisible track. The length of the new track, N2, is defined by the execution of the RESERVE TRACK command using parameters from the CDB. The length is specified as a number of Logical Blocks, but the RESERVE TRACK command performs the creation of the new track as a integral number of Clusters. Figure 16 shows the newly defined track is track 1, its start address is LBA = 0, its length is N2, and its NWA is 0. The invisible track is track 2, its start address is N2, its length is the remaining size of the User Data Zone, and its NWA = N2.

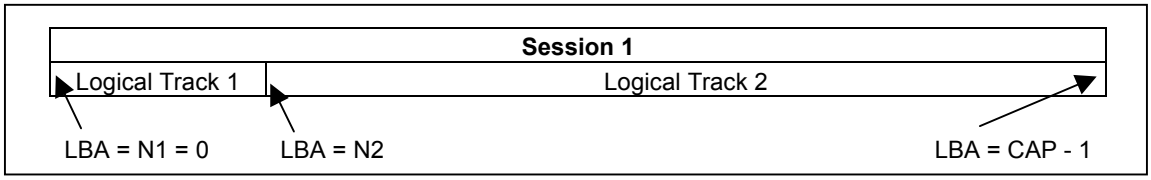


Figure 16 — Status of BD-R Disc After First RESERVE TRACK Command

The RESERVE TRACK command, may be used iteratively to define additional Logical Tracks from the invisible track as shown in Figure 17.

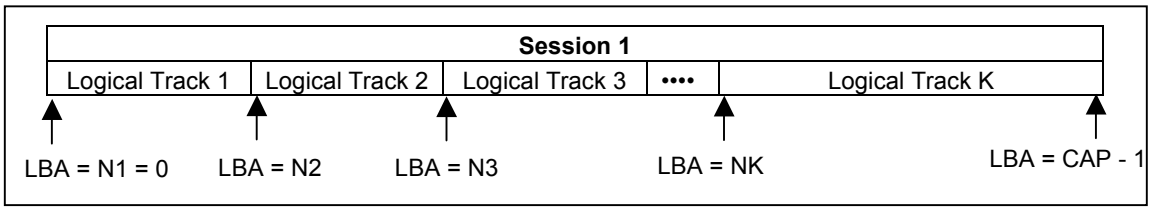


Figure 17 — Status of BD-R Disc Multiple RESERVE TRACK Commands

It is also possible to split an open Logical Track into two Logical Tracks. The split shall occur at the start of a Cluster within the Logical Track that is at or after the NWA. If the split occurs at the NWA, then the first of the two new tracks is created with closed status and the second track is blank.

4.4.4.2.6 Creating New Sessions

When a session is closed and the disc is not finalized, a new session is created that contains only the invisible Logical Track. See Figure 18.

Session 1				Session 2
Logical Track 1	Logical Track 2	••••	Logical Track K	Logical Track K+1 (Invisible Logical Track)

Figure 18 — Status of BD-R Disc after Closing Session 1

The process of creating session 2 can be iterated as with session 1 until the disc is finalized.

4.4.4.3 Defect Management

Defect management is used to solve problems related to areas on the disc that may become defective or unreliable due to damage or contamination. The Drive redirects the recording of the involved user data to another location, called spare areas. Information about these redirections is stored in the Defect List.

In order to ensure data integrity, it is recommended that WRITE (10) data be verified during the write process when the Defect Management feature is current. This is also recommended that WRITE (12) data be verified except when either VNR is set to one or Streaming is set to one.

4.4.4.4 Pseudo-OverWrite (POW)

Pseudo-Overwrite (POW) is used to make Write-Once media behave like Rewritable media. When the Host requests recording of user data on an already recorded area, then the Drive redirects the recording of the involved user data to an alternative location. Such Logical Overwrites (writing to the same LBA, but actually recording at a reassigned PSN) are treated in the same way as defects, i.e. information about the redirections is stored in the Defect List.

4.4.4.4.1 SRM+POW

When a SRM disc has the POW capability, the Logical Overwrite of a Cluster is redirected to the NWA of some open Logical Track. POW recording is permitted on the SRM logical structure:

a. A SRM disc with POW shall be initialized by the formatting process as a single session disc with a single Logical Track.
b. POW is not permitted on a finalized disc, because no NWA is valid.
c. If the disc is not finalized, POW is permitted in both open and closed Logical Tracks.
d. On SRM, each WRITE command shall start and end within the same Logical Track. This restriction does not apply to SRM+POW.

When POW is performed, it is recommended that the redirection be to a Cluster with NWA that is near the addressed Cluster. The actual algorithm for selecting the physical Cluster for the redirection is vendor specific.

4.4.4.4.2 Orphans

There is exactly one NWA for each Logical Track. The NWA follows the physical usage of the Logical Track rather than the Logical usage.

When a POW is applied to a Logical Block, the relocation occurs at the NWA of some open Logical Track. An entire Cluster must be used in the relocation, so the NWA is advanced by 32. Prior to the POW, 32 LBAs were associated with the Cluster beginning at the NWA. After the POW operation, those 32 LBAs are no longer available for append. The LBAs have not been lost, but they may be written only via another POW. Until written, these LBAs are called Orphans.

An orphan LBA has no associated logical content. If a READ command is issued to an orphan LBA, the Drive is permitted to either return all zeros or the data associated with the POWed LBA.

4.4.4.4.3 Closed Logical Tracks with Blank Clusters

Although a closed Logical Track has no valid NWA, it may contain blank Clusters. A POW to a Logical Block in a closed Logical Track may require a read-modify-write operation. Consequently, determination of blankness is necessary. If a POW of a blank Cluster is indicated, then any unsent Logical Blocks shall be zero padded prior to writing. Due to the inefficiency, it is recommended to avoid POWing blank Clusters in closed tracks.

4.4.4.5 SRM+POW Examples

For simplicity, the examples are described for single layer media.

4.4.4.5.1 Initialize the Disc as SRM+POW

A blank BD-R disc is formatted as SRM+POW. The PSN of the first block of the first Cluster after ISA0 is K. The PSN of the first block of the first Cluster of OSA0 is K+C, where C is the number of blocks in the User Data Zone.

The READ TRACK INFORMATION command for Logical Track 1 returns:

Start address = 0, NWA = 0 and free blocks = C.

The READ CAPACITY command returns C-1 as the last addressable logical block on the media.

See Figure 19.

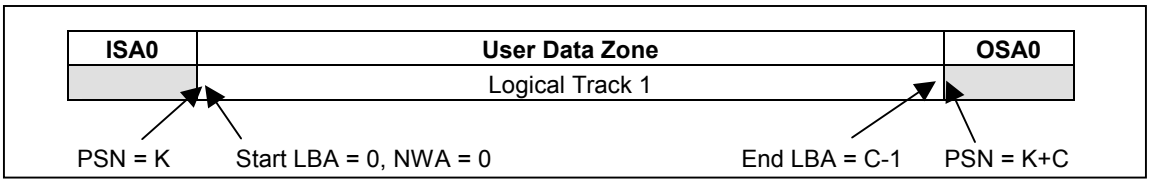


Figure 19 — Status after Formatting SRM+POW

4.4.4.5.2 Create a Small Outer Logical Track, Write it, and Close it

The RESERVE TRACK command is used to split the single, invisible track at LBA = C-256. This creates one large track, C-256 blocks in length, and one small track, 256 blocks in length.

The READ DISC INFORMATION command (requesting standard disc information) shall show one track prior to the RESERVE TRACK command and two tracks afterward.

A WRITE (10) command sends 64 blocks of data starting at the NWA (C-256) of Logical Track 2.

The CLOSE TRACK/SESSION command is used to close Logical Track 2.

The READ TRACK INFORMATION command for Logical Track 1 returns:

Start address = 0, NWA = 0 and free blocks = C-256.

The READ TRACK INFORMATION command for Logical Track 2 returns:

Start address = C-256, NWA is not valid, and free blocks = 0.

See Figure 20.

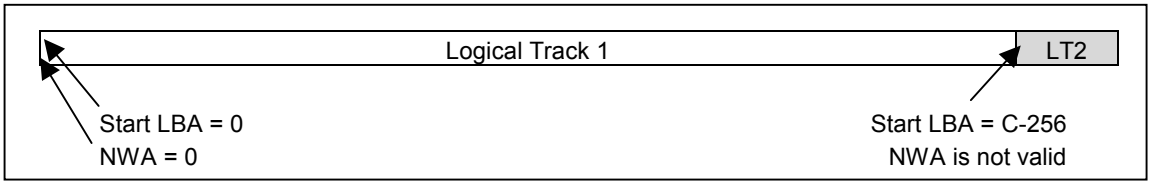


Figure 20 — Create, Write, and Close Small Outer Logical Track

4.4.4.5.3 Split Logical Track 1

The RESERVE TRACK command is used to split Logical Track 2 from Logical Track 1.

The READ TRACK INFORMATION command for Logical Track 1 returns:

Start address = 0, NWA = 0 and free blocks = 320.

The READ TRACK INFORMATION command for Logical Track 2 returns:

Start address = 320, NWA = 320 and free blocks = C-576.

See Figure 21.

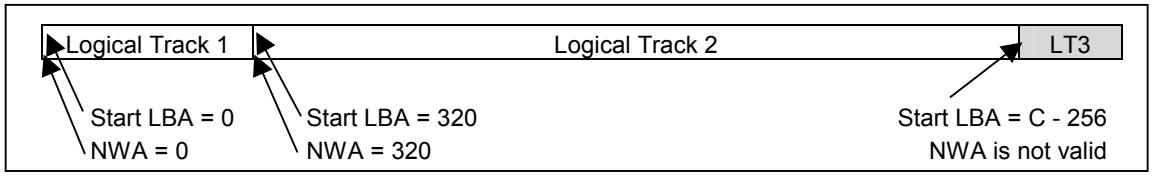


Figure 21 — Status after Splitting Logical Track 1

4.4.4.5.4 Split Logical Track 2

The RESERVE TRACK command is used to split Logical Track 3 from Logical Track 2.

The READ TRACK INFORMATION command for Logical Track 1 returns:

Start address = 0, NWA = 0 and free blocks = 320.

The READ TRACK INFORMATION command for Logical Track 2 returns:

Start address = 320, NWA = 320 and free blocks = 320.

The READ TRACK INFORMATION command for Logical Track 3 returns:

Start address = 640, NWA = 640 and free blocks = C-896.

See Figure 22.

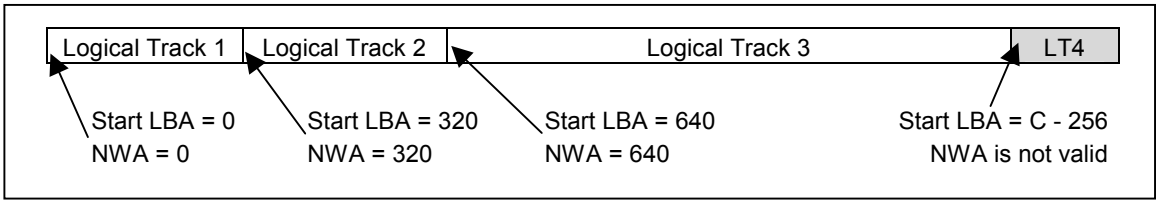


Figure 22 — Status after Splitting Logical Track 2

4.4.4.5.5 Write to Each Logical Track

A WRITE (10) command sends 160 blocks of data starting at the NWA (0) of Logical Track 1.

A WRITE (10) command sends 160 blocks of data starting at the NWA (320) of Logical Track 2.

A WRITE (10) command sends 32 blocks of data starting at the NWA (640) of Logical Track 3.

The READ TRACK INFORMATION command for Logical Track 1 returns:

Start address = 0, NWA = 160 and free blocks = 160.

The READ TRACK INFORMATION command for Logical Track 2 returns:

Start address = 320, NWA = 480 and free blocks = 160.

The READ TRACK INFORMATION command for Logical Track 3 returns:

Start address = 640, NWA = 672 and free blocks = C-864.

See Figure 23. Note that All 3 Logical Tracks are open.

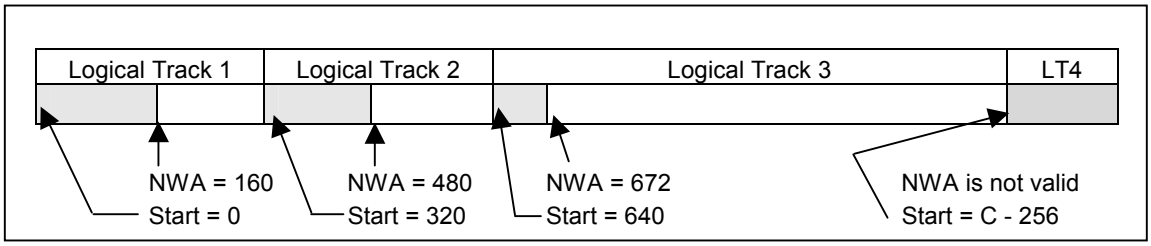


Figure 23 — Status after Writing to each Logical Track

4.4.4.5.6 POW a Logical Block in Logical Track 1

A WRITE (10) command writes one block of user data at LBA = 128.

This Logically OverWrites sector 128. The Cluster beginning at LBA 128 is read internally, the new data replaces the data for sector 128, and the Cluster is rewritten at the Logical Track 1 NWA (160). The NWA is now 192.

The READ TRACK INFORMATION command for Logical Track 1 returns:

Start address = 0, NWA = 192 and free blocks = 128.

In Figure 24, note that LBAs 160,..., 191 are now Orphans.

The logical length of Logical Track 1 is 320, however, the number of written LBAs in Logical Track 1 (160) plus the free blocks of Logical Track 1 (128) can be at most 288.

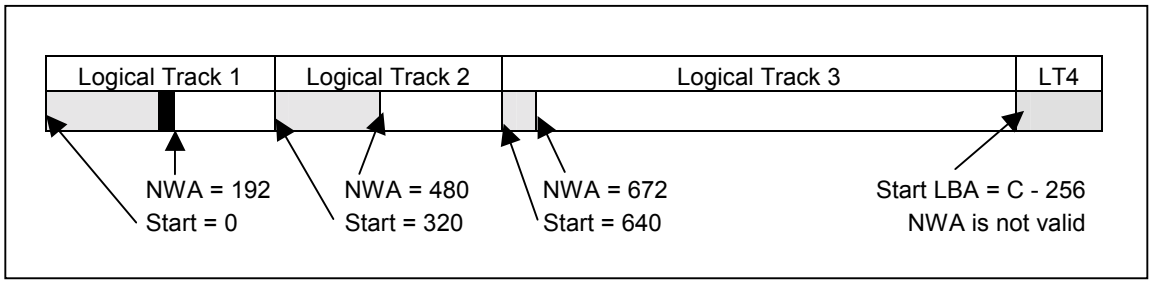


Figure 24 — Status after POW to LBA 128

4.4.4.5.7 Complete Writing Logical Track 1, POW LBA = 128 a Second Time

A WRITE (10) command sends 128 blocks of data starting at the NWA (192) of Logical Track 1.

A WRITE (10) command writes one block of user data at LBA = 128.

This Logically OverWrites sector 128. The Cluster beginning at LBA 128 is read internally, the new data replaces the data for sector 128, and the Cluster is rewritten at the Logical Track 2 NWA (480). The NWA is now 512. It is also permitted to POW to the NWA of another track.

The READ TRACK INFORMATION command for Logical Track 1 returns:

Start Address = 0, NWA is not valid, and free blocks = 0. Logical Track 1 is closed.

The READ TRACK INFORMATION command for Logical Track 2 returns:

Start address = 320, NWA = 512 and free blocks = 128.

The READ TRACK INFORMATION command for Logical Track 3 returns:

Start address = 640, NWA = 672 and free blocks = C-928.

See Figure 25.

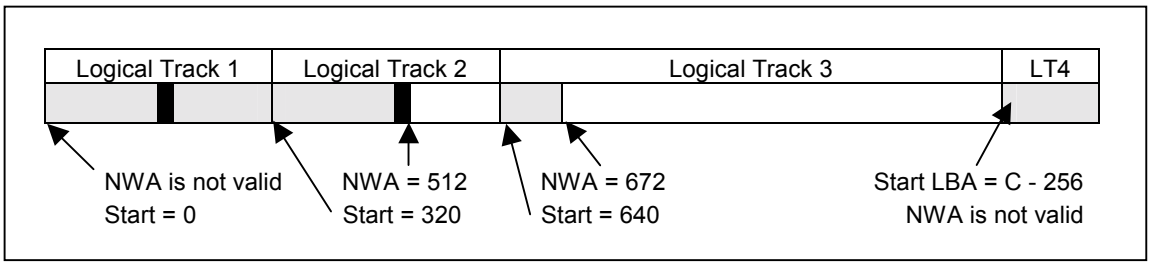


Figure 25 — Status after writing to Logical Track 1

4.4.4.5.8 Using Orphaned LBAs via POW

A WRITE (10) command writes 32 blocks of user data at LBA = 160.

This uses the LBAs that were orphaned by a previous POW. Using orphaned LBAs requires a new POW. The new data from the Host is written at the Logical Track 2 NWA (512). The NWA is now 544.

The READ TRACK INFORMATION command for Logical Track 1 returns:

Start Address = 0, NWA is not valid, and free blocks = 0. Logical Track 1 is closed.

The READ TRACK INFORMATION command for Logical Track 2 returns:

Start address = 320, NWA = 544 and free blocks = 96.

The READ TRACK INFORMATION command for Logical Track 3 returns:

Start address = 640, NWA = 672 and free blocks = C-928.

See Figure 26.

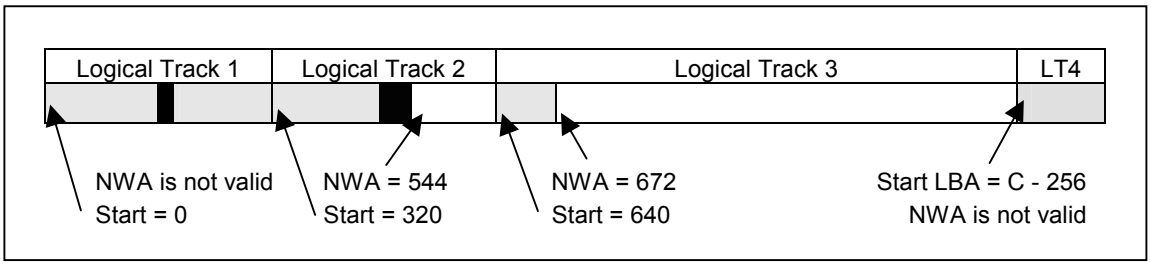


Figure 26 — Status after POW of LBA 160

Note that LBAs 512,...,543 are now orphaned.

4.4.4.5.9 The Expanding Orphanage

Each time a POW is performed, 32 orphaned LBAs are created. Orphans can be used, but since it is only possible to do so with a POW, new orphans are created in the process. Consequently, the number of Orphan LBAs is a monotonically increasing function. In 4.4.4.5.6, Orphan LBAs 160 through 191 were created by the POW of LBA 128.

In 4.4.4.5.7, Orphan LBAs 480 through 511 were created by the POW of LBA 128.

In 4.4.4.5.8, Orphan LBAs 512 through 543 were created when Orphan LBAs 160 through 191 were used.

Due to the inefficiency of media use and degradation of performance, it is preferred that the Host never use orphan LBAs.

4.4.4.6 Considerations for the Host When Writing on SRM+POW Discs

4.4.4.6.1 POW of Less than a Cluster

A WRITE command may request POW of less than one Cluster. The WRITE range is represented in Figure 27 by part E. Size of Part D + Size of Part E + Size of Part F = 32. It is possible that either part D or part F has zero length. In the most general case, it is assumed that both parts D and F have non-zero length.

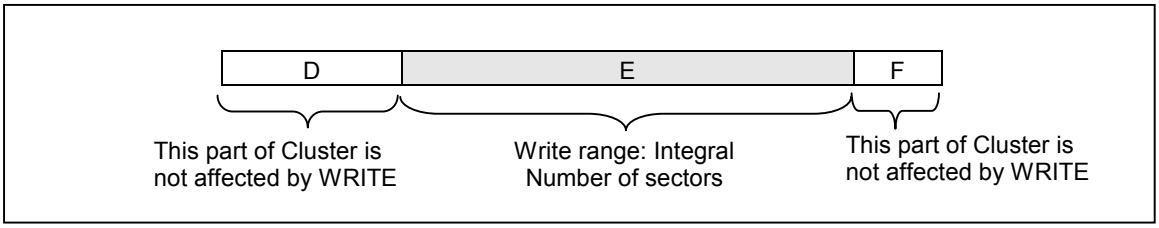


Figure 27 — Parts of a POWed Cluster

Parts D and F must be written using a read-modify-write operation through the buffer. If any padding is required, it shall be performed by the Drive.

The sectors of Part E may be written directly with no modification.

4.4.4.6.2 POW and Append in the Same Range

A WRITE command is permitted to start at a previously written LBA and end at never before written LBAs. See Figure 28.

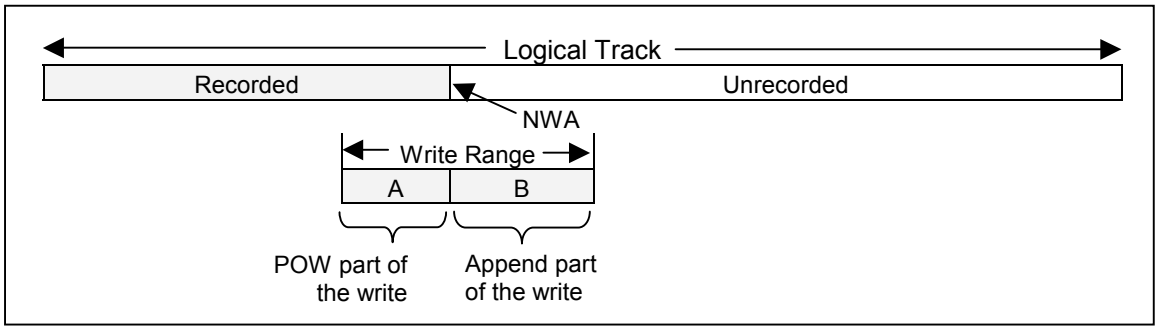


Figure 28 — POW and Append Parts of WRITE

WRITE range begins prior to the Logical Track NWA and ends after the Logical Track NWA. The Host may choose to control the writing. There are 2 possibilities:

1. In order to minimize the number of POWed Clusters, the Host should send two WRITE commands: the first WRITE command appends part B, and the second WRITE command performs the part A POW.
2. In order to maximize performance, the Host should send two WRITE commands: the first WRITE command performs the part A POW, and the second WRITE command performs the part B POW.

Some Host applications are constructed to be unaware of POWs. In this case, the Host is permitted to issue a single WRITE for all of the logical blocks. There are also two possibilities for the Drive:

1. In order to minimize the number of POWed Clusters, the Drive first appends part B. Next the Drive performs the part A POW. This has the same result as management by the Host in the case 1, above.
2. In order to maximize performance, the Drive performs POW of all the sectors in the range. This has the same result as management by the Host in the case 2, above.

The actual Drive behavior is vendor specific.

4.4.5 Using VNR with BD-R

If the Hardware Defect Management feature is current, non-streamed writes should be verified by the Drive in an automatic verify-after-write process. Some applications may be designed to expect behavior associated with Drives and media that do not automatically perform verify-after-write (e.g. write-once media without spare areas). In order to make that behavior available to BD-R Drives, the VNR (Verify Not Required) bit has been defined within the WRITE (12) CDB.

4.5 Emergency Brake

As a protection measure for possible fatal drive/media combinations, a data set is defined that can be used by specific drive models to recognize discs that need special handling to prevent fatal functioning. This data is called Emergency Brake (EB) data.

The EB data is specified in the first PIC Cluster of each Info Fragment. It consists of an EB Header, EB data field(s) and an EB Footer. EB data fields shall only be included after mutual agreement between the disc manufacturer and the involved drive manufacturer when specific models of the drive manufacturer's products require special actions when handling such discs, e.g. to prevent damage to the disc or the drive.

The Emergency Brake can be defined for BD-ROM, BD-RE, and BD-R.

If the Emergency Brake data from a BD disc indicates to the Drive that this disc should not be accessed by the Drive, then the TEST UNIT READY command and all media accessing commands shall be terminated with CHECK CONDITION status and sense bytes SK/ASC/ASCQ shall be set to NOT READY/UNIQUE DRIVE-MEDIA READ INCOMPATIBILITY (02/30/1B).

4.6 Physical Access Control (PAC)

4.6.1 Overview

Physical Access Control (PAC) Clusters are disc structures that include additional information to provide interchange information. PAC Clusters shall be recorded in the INFO1/PAC1 Area and backup copies shall be recorded in the INFO2/PAC2 Area.

A PAC may be read by using the READ DISC STRUCTURE command. If permitted, a PAC may be written by using the SEND DISC STRUCTURE command.

New PACs may be defined in the future for specific applications/functions. Drives designed before the introduction date of such new PACs shall treat such PACs as “Unknown PACs”. The “Unknown PAC Rules” field (see 4.6.2.3), provides a method to avoid compatibility problems. There are no generalized physical access restrictions for a "Known PAC".

4.6.2 General PAC Format

The general PAC format is shown in Table 2.

Table 2 – General PAC Format

	Byte Offset	Field Length in Bytes	Field Name
PAC Header	0	3	PAC ID
	3	1	PAC format number
	4	4	PAC Update Count
	8	4	Unknown PAC Rules
	12	1	Unknown PAC Entire Disc Flags
	13	2	Reserved (set to zeros)
	15	1	Number of Segments
	16	8	Segment 0
	24	8	Segment 1
	...	...	...
	264	8	Segment 31
	272	112	Reserved (set to zeros)
PAC Specific Data	384	1	Known PAC Entire Disc Flags
	385	3	Reserved
	388 ... 63487	...	PAC Specific Information
	63488 ··· 65535	2048	Reserved

4.6.2.1 PAC ID and Format

The PAC ID (3 bytes) identifies the specific PAC Cluster. PAC IDs 000000h and FFFFFFh are reserved. The Format number of the PAC identifies the PAC format version.

4.6.2.2 PAC Update Count

The PAC Update Count shall specify the total number of update operations of the current PAC. This field shall be set to 00000000h during the first format operation only, and shall be incremented by one each time the current PAC is re-written.

4.6.2.3 Unknown PAC Rules

The Unknown PAC Rules shall specify the required actions when the PAC ID is not set to a known value. These bytes form a field consisting of 32 individual bits. If a drive encounters multiple unknown PACs on one disc, it shall use the OR-function of the unknown PAC rules.

Each bit is either reserved, a write Control type, or a read Control type. Each Control type is associated with a specific disc area.

If a write Control type is set to zero, writing in the associated area is permitted. If a write Control type bit is set to one, writing in the associated area is prohibited.

If a read Control type is set to zero, reading in the associated area is permitted. If a read Control type bit is set to one, reading in the associated area is prohibited.

For BD-R, see *System Description Blu-ray Disc Recordable Format, Part 1 Basic Format Specifications* for specific Control type bit assignments.

For BD-RE, see *System Description Blu-ray Disc Rewritable Format, Part 1 Basic Format Specifications* for specific Control type bit assignments.

If execution of some command would result in violating any Unknown PAC rule, the command shall be terminated with CHECK CONDITION status and sense bytes SK/ASC/ASCQ shall be set to ILLEGAL REQUEST/DRIVE-MEDIA FORMAT INCOMPATIBILITY FORBIDS ACCESS (05/31/08).

4.6.2.4 Unknown PAC Entire Disc Flags

The Unknown PAC Entire Disc Flags byte specifies Unknown PAC Rules that cover the entire disc. Bits 1 through 7 are reserved. Bit 0 specifies re-initialization rules when the PAC is unknown. On BD-RE, if bit 0 is set to zero, re-initialization is permitted if it is not blocked by any other mechanism for the entire disc. On BD-RE, if bit 0 is set to one, re-initialization is prohibited. On BD-R, bit 0 shall be set to one.

4.6.2.5 Segments

A Segment field shall specify the start and end address of a contiguous range of Clusters, called a Segment. Segments are defined starting from Segment 0 to Segment N-1, where N is specified in the Number of Segments field ($0 \leq N \leq 32$). Segments shall not overlap and shall be sorted in ascending order according to their addresses. Segments shall only start and end at Cluster boundaries. All Segment i fields, where $i \geq N$, shall be set to zeros. The first four bytes of the Segment i field, if used, shall contain the first PSN of the first Cluster belonging to the Segment, and the last four bytes shall contain the last PSN of the last Cluster belonging to the Segment.

4.6.2.6 Known PAC Entire Disc Flags

The Known PAC Entire Disc Flags byte specifies rules for the entire disc in case the drive is able to interpret the PAC.

4.6.2.7 PAC specific Information

The PAC specific information fields contain information that is specific to the current PAC.

4.6.3 Primary PAC

The Primary PAC (PAC ID = 50524Dh ("PRM"), PAC Format = 00h) shall be included on each BD-ROM and BD-RE. The Primary PAC is not defined for BD-R.

4.6.3.1 Primary PAC on BD-ROM

PACs shall be recorded in INFO1/PAC1 and INFO2/PAC2 on each layer. The BD-ROM Primary PAC provides the status of PAC recording in each of those zones.

See *System Description Blu-ray Disc Read-only Format, Part 1 Basic Format Specifications* for detailed format of the Primary PAC on BD-ROM.

4.6.3.2 Primary PAC on BD-RE

The Primary PAC Cluster shall be included on each BD-RE disc to provide information about the date when the disc was initially recorded and to identify each recorder that have recorded individual Clusters on the disc.

Up to 252 recorders can be identified in the Primary PAC.

The READ DISC STRUCTURE command is used to read the Primary PAC. This permits the examination of the ideates of each Drive that has written the disc.

See *System Description Blu-ray Disc Rewritable Format, Part 1 Basic Format Specifications* for detailed format of the Primary PAC on BD-RE.

4.6.4 Disc Write Protect PAC

4.6.4.1 General

The Disc Write Protect PAC (PAC ID = 445750h ("DWP"), PAC Format = 00h) is optional and can be used to protect a disc against unintended write actions or write actions by unauthorized persons. For the case where the disc is protected against write actions by unauthorized persons, a password can be included. If a valid DWP PAC Cluster exists on the disc, products that understand the PAC shall follow the rules indicated by the Write protect control bits.

The READ DISC STRUCTURE command is used to read the DWP PAC. This allows the Host to examine the following:

a. Write protect status of the disc,
b. If write protected, the type of write protect: virtual or physical,
c. Status of an associated write protect password.

The SEND DISC STRUCTURE command is used to write the DWP PAC. This allows the Host to perform the following functions:

a. Write protect a write enabled disc.
b. Write enable a write protected disc.
c. Set, change, or remove the write protect password.

There are two fields specific to the DWP PAC: the Write Protect Control Byte and the Write Protect Password.

4.6.4.2 Write Protect Password

The Write protect password can consist of up to 32 characters according to ISO/IEC 646. Trailing bytes not used shall be set to 00h. The write protect password shall never be transferred outside the Drive.

If all bytes of the Write protect password field are set to 00h, then the Write protect password is inactive. If the Write protect password field is set to all FFh, then the disc is permanently write protected and further recording on the disc shall not be allowed.

4.6.4.3 Write Protect Control Byte

The Write protect control byte (Table 3) specifies allowed and required actions. The Write protect control byte is at byte offset 388 in the DWP PAC.

Table 3 — Write Protect Control Byte

7	6	5	4	3	2	1	0
Reserved					PWD	PHYS	WP

WP indicates the current status of write protection. If WP is set to 0, write protection is switched off and writing of user data is allowed without any restrictions. If WP is set to 1, write protection is switched on, and writing of user data or re-initializing the disc is restricted. On BD-RE, the WP bit is physically stored in the Write Protect Control Byte. On BD-R, the WP bit is physically stored in bit 0 of byte 1025 of the Temporary Disc Definition Structure (TDDS). In all cases, WP is presented to the Host as bit 0 of the Write Protect Control Byte.

The PHYS bit indicates the method of write protection. If PHYS is set to 0, virtual write protection is enabled (see 4.6.4.4). After host confirmation (including optional password), writing of user data can be performed without changing the write protection settings on the disc. If PHYS is set to 1, physical write protection is switched on.

The PWD bit indicates if write protection includes a password. If PWD is set to 0, there is no defined password. If PWD is set to 1, a valid password has been defined.

4.6.4.4 Virtual Write Enable (VWE)

The Virtual Write Enable is a bit in the header of the SEND BD STRUCTURE command when format code = 30h. The Virtual Write Enable bit enables or disables writing to a virtually write protected disc. When set to 1, it indicates that the host is requesting the capability to write on a virtually write protected disc. This is a temporary write capability, a media change or drive reset will cause the system to return to a write protected state. When VWE is set to 0, it indicates that the host is rescinding any temporary write capability.

Table 4 — Examples of Drive/Host Interaction

Initial PAC Write Protect Control Byte	Drive Behavior on Disc Mount	Host Command Issued	Drive Behavior after Host Command
No PWD/virtual/WP off 000b	No restrictions	No PWD/virtual/WP on 001b	Disc virtually write protected. PAC updated with new write protect control byte.
No PWD/virtual/WP on 001b	No data writing or WP changes until host confirmation	VWE = 1	Data writing or WP changes temporarily allowed (no changes to PAC). Media change, drive reset, host rescind (VWE=0 sent) returns disc to write protected state
No PWD/phys/WP off 010b	No restrictions	No PWD/phys/WP on 011b	Disc physically write protected. PAC updated with new write protect control byte.
No PWD/phys/WP on 011b	No data writing until confirmation and WP changed to off. No WP changes until host confirmation	No PWD/phys/WP off 010b	Data writing and WP changes allowed. PAC updated with new write protect control byte.
PWD/virtual/WP off 100b	Data writing permitted. No WP changes until host confirms password	No PWD/virtual/WP off 000b Matching password	No restrictions. PAC updated with new write protect control byte.
		Incorrect password	Error reported to host, no change in drive behavior or PAC.
PWD/virtual/WP on 101b	No data writing or WP changes until host confirms password	VWE=1 Matching password	Data writing or WP changes temporarily allowed (no changes to PAC). Media change, drive reset, host rescind (VWE=0 sent) returns disc to write protected state
PWD/phys/WP off 110b	No WP changes until host confirms password	PWD/phys/WP on Matching password	Disc is physically write protected with an associated password. PAC updated with new write protect control byte.
PWD/phys/WP on 111b	No data writing until confirmation and WP changed to off. No WP changes until host confirms password	PWD/phys/WP off Matching password	Data writing and WP changes allowed. PAC updated with new write protect control byte.

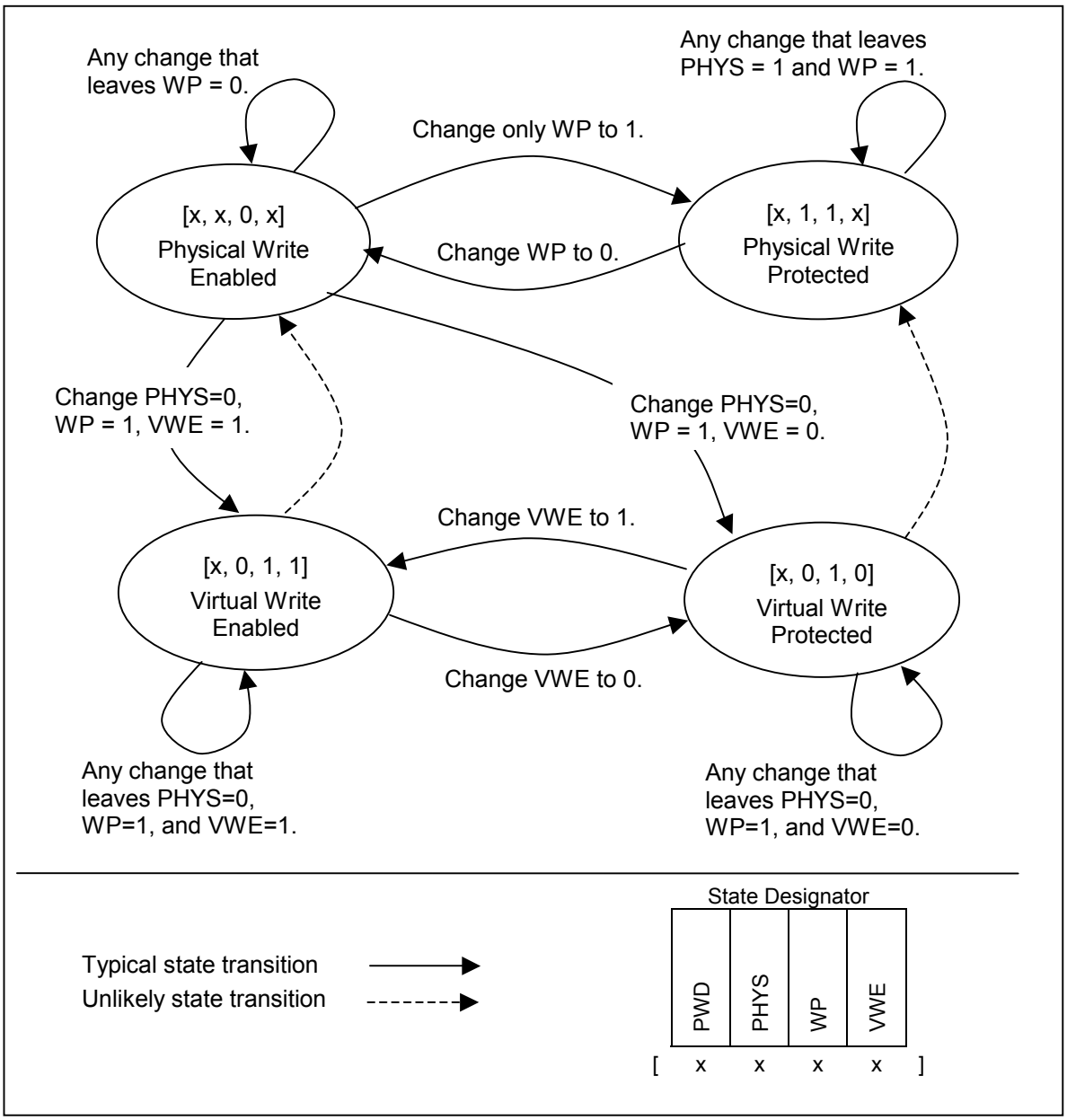


Figure 29 — Physical and Virtual Write Protect State Diagram

4.6.4.5 Changing the Write Protect Password

Changing the password in the PAC requires two separate steps from the host. If the current write protection method includes a password, the host must first send the matching password to the drive, followed by a separate command with the new password.

Table 5 — Changing the Write Protect Password

Current write protection status on the disc	Host actions required to change password
Virtual write protection with existing password	Step 1: Host sends DWP PAC to logical unit with correct password set, and VWE=1. Step 2: Host sends DWP PAC to logical unit with new password, and same WP control byte settings (PWD=1, PHYS=0, WP=1). Logical unit records new password onto the disc.
Virtual write protection without password	Step 1: Host sends DWP PAC to logical unit with VWE=1. Step 2: Host sends DWP PAC to logical unit with password set, and WP control byte settings set to indicate password protection (PWD=1, PHYS=0, WP=1). Logical unit records new password and WP control byte settings onto the disc.
Physical write protection with existing password	Step 1: Host sends DWP PAC to logical unit with correct password set, and WP control byte settings to switch off physical write protection (PWD=0, PHYS=1, WP=0). Logical unit records new WP control byte settings onto the disc. Step 2: Host sends DWP PAC to logical unit with password set, and WP control byte settings set to indicate password and write protection enabled (PWD=1, PHYS=1, WP=1). Logical unit records new password and WP control byte settings onto the disc.
Physical write protection without password	Step 1: Host sends DWP PAC to logical unit to switch off physical write protection (PWD=0, PHYS=1, WP=0). Logical unit records new WP control byte settings onto the disc. Step 2: Host sends DWP PAC to logical unit with password set, and WP control byte settings set to indicate password and physical write protection (PWD=1, PHYS=1, WP=1). Logical unit records new password and WP control byte settings onto the disc.
No write protection enabled, but password (PWD bit) is set. Note that this is not likely to be used by the host.	Step 1: Host sends DWP PAC to logical unit with correct password set and WP control byte settings to switch off password protection (PWD=0, PHYS=same setting, WP=0). Logical unit records new WP control byte settings onto the disc. Step 2: Host sends DWP PAC to logical unit with new password and WP control byte settings set to indicate password protection (PWD=1, PHYS=same setting, WP=0). Logical unit records new password and WP control byte settings onto the disc.

5 Features and Profiles for BD Devices

5.1 Feature Descriptions

5.1.1 Write Protect Feature (0004h)

This Feature identifies reporting capability and changing capability for Write protection status of the Drive. The Write Protect Feature descriptor response data to be returned to the Host is defined in Table 6.

Table 6 — Write Protect Feature Descriptor

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB)			Feature Code = 0004h				
1								(LSB)
2	Reserved			Version = 0010b			Persistent	Current
3	Additional Length = 04h							
4	Reserved				DWP	WDCB	SPWP	SSWPP
5	Reserved							
6	Reserved							
7	Reserved							

The Feature Code field shall be set to 0004h.

The Version Field shall be set to 0010b.

The Persistent bit shall be set to zero, indicating that this Feature may change its current status.

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 Current bit, when set to one, indicates that Drive is capable of changing some write protect status on the medium surface. This bit shall be set to zero if the Drive is unable to set/release some write protect status on the medium surface. The reporting capability of the Write Protect status is persistent and shall be supported regardless of the setting of the Current bit.

The Additional Length field shall be set to 04h.

The Supports SWPP (SSWPP) bit indicates that the Drive supports SWPP bit of Timeout & Protect Mode Page. This bit does not affect Current bit of this Feature Descriptor. If SWPP bit is set to one, the Drive shall support SWPP bit of Timeout & Protect Mode Page.

The Supports PWP (SPWP) bit indicates that the Drive supports set/release PWP status. If SPWP bit is set to one, the SEND DVD STRUCTURE command with Format = C0h shall be supported.

The WDCB bit indicates that the Drive supports writing the Write Inhibit DCB on DVD+RW media. If WCDB is set to one, the SEND DVD STRUCTURE command with format code = 30h shall be supported.

The DWP bit indicates that the Drive supports reading/writing the Disc Write Protect PAC on BD-R/-RE media. If DWP is set to one, the READ/SEND BD STRUCTURE command with format code = 30h shall be supported.

If Drive supports reporting Write Protection status but does not support changing, the Drive returns this Feature descriptor, however the Current bit is never set to one in the descriptor.

Drives with installed medium that support this Feature shall implement the commands listed in Table 7.

Table 7 — Write Protect Feature Commands

Op Code	Command Description	Reference
ADh	READ DISC (DVD) STRUCTURE Format code C0h when WDCB = 0 Format codes 30h and C0h when WDCB = 1	MMC-4
	READ DISC (BD) STRUCTURE Format codes 30h, C0h when DWP = 1	6.17
BFh	SEND DISC (DVD) STRUCTURE Format code C0h when SPWP = 1 Format code 30h when WDCB = 1	MMC-4
	SEND DISC (BD) STRUCTURE Format codes 30h when DWP = 1	6.23

5.1.2 Incremental Streaming Writable Feature (0021h)

This Feature identifies a Drive that is able to write data to a contiguous region, and is able to append data to a limited number of locations on the media. On CD media, this is known as packet recording, on DVD media it is known as Incremental Recording, and on a BD-R disc it is known as SRM recording.

The Feature descriptor response data is defined in Table 8.

Table 8 — Incremental Streaming Writable Feature Descriptor Format

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB) Feature Code = 0021h							
1								(LSB)
2	Reserved			Version = 0001b			Persistent	Current
3	Additional Length							
4	(MSB) Data Block Types Supported							
5								(LSB)
6	Reserved							BUF
7	Number of Link Sizes (L)							
8	Link Size							
9	Link Size							
...	...							
L+7	Link Size							
L+7+P	4 - (L MOD 4) Zero Pad bytes to ensure a structure size that is an integral multiple of 4							

The Feature Code field shall be set to 0021h.

The Version field is set to 1h.

The Persistent bit shall be set to zero, indicating that this Feature may change its current status.

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 shall be set to 4 + (Number of Link Sizes) + (Number of Pad bytes).

The Data Block Types Supported field is a bit field that identifies the supported Data Types as specified in the MMC-4 Write Parameters Mode Page description. A bit set to zero indicates the Data Type is not supported. A bit set to one indicates the Data Type is supported. Bit 0 equates to Data Type 0 and bit 15 equates to Data Type 15, etc.

BUF shall be set to 1.

The Number of Link Sizes shall specify the number of link sizes available for the current media. For CD media, this field should be 1. For DVD-R, this field should be 2. For a BD-R disc formatted in SRM, this field is set to 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 Drive to satisfy the writable unit specified by the Blocking field in the Random Readable Feature. This field is 7 for CD-R media, and may be 0, 1, or 16 for DVD media. This field contains 0 for BD-R. Link Size fields are reported by the Drive in the Drive's preferred order, most desirable first.

The Pad field shall contain zeros. The number of Pad bytes shall be 4 - (Number of Link Sizes MODULO 4). The Pad field is present to make the length of the Feature Descriptor a multiple of 4 bytes.

If a Drive reports this feature with the Current bit set to one, then the Drive shall support the commands shown in Table 9.

Table 9 — Command Support Required by the Incremental Streaming Writable Feature

Op Code	Command Description	Reference
A1h	BLANK (Use of this command is not defined for BD)	MMC-4
5Bh	CLOSE TRACK/SESSION	6.2
51h	READ DISC INFORMATION, Data type = 000b is mandatory	6.16
52h	READ TRACK INFORMATION	6.20
53h	RESERVE TRACK	6.22
54h	SEND OPC INFORMATION (Shall be supported if OPC information is ever returned in the READ DISC INFORMATION return data.)	6.24
35h	SYNCHRONIZE CACHE	6.28
2Ah	WRITE (10)	6.31

Drives that support this Feature shall implement the mode pages shown in Table 10.

Table 10 — Incremental Streaming Writable Feature Parameters

Page Code	Mode Page	Reference
05h	Write Parameters (Use of this mode page is not defined for BD)	MMC-4

5.1.3 Formattable Feature (0023h)

This Feature identifies a Drive that can format media into logical blocks. The Feature descriptor response data to be returned to the Host is defined in Table 11.

Table 11 — Formattable Feature Descriptor

Byte \ Bit	7	6	5	4	3	2	1	0
0	(MSB) Feature Code = 0023h							
1								(LSB)
2	Reserved			Version = 0001b			Persistent	Current
3	Additional Length = 8							
4	**Options for formatting BD-RE**							
	Reserved				RENoSA	Expand	QCert	Cert
5	Reserved							
6	Reserved							
7	Reserved							
8	**Options for formatting BD-R**							
	Reserved							RRM
9	Reserved							
10	Reserved							
11	Reserved							

The Feature Code field shall be set to 0023h.

The Version field shall be set to 0001b.

The Persistent bit shall be set to zero, indicating that this Feature may change its current status.

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. If a blank BD-R or BD-RE disc is present and the response to the TEST UNIT READY command is GOOD status, then the Current bit of this feature shall be set to one.

The Additional Length field shall be set to 4.

If the BD-RE Profile is not supported, byte 4 of the Formattable Feature Descriptor shall be set to zero.

If the BD-RE Profile is supported, the FORMAT UNIT command shall support Format Types 00h and 30h with Sub-type 00b shall be supported for BD-RE disc. Quick Reformat shall be supported.

If the Cert bit is set to zero, the Drive does not support Sub-type 10b (Full Certification) on formatting BD-RE disc. If the Cert bit is set to one, Format Type 30h with Sub-type 10b shall be supported for BD-RE disc.

If the Qcert bit is set to zero, the Drive does not support Sub-type 11b (Quick Certification) during formatting of previously formatted BD-RE disc. If the QCert bit is set to one, Format Type 30h with Sub-type 11b shall be supported for BD-RE disc.

If the Expand bit is set to zero, the Drive does not support Format Type 01h (Spare Area Expansion). If the Expand bit is set to one, Format Type 01h is supported for the expansion of the spare area on formatted BD-RE discs.

If the RENoSA bit is set to zero, Format Type 31h (BD-RE with no spares allocated) is not supported for BD-RE disc. If the RENoSA bit is set to one, Format Type 31h shall be supported for BD-RE disc.

If no BD-R profile is supported, byte 8 of the Formattable Feature Descriptor shall be set to zero.

If any BD-R Profiles are supported, then when a blank BD-R disc is present:

1. If a WRITE (10), WRITE (12), WRITE AND VERIFY (10), WRITE AND VERIFY (12), or RESERVE TRACK command is sent to the Drive when a blank BD-R disc is present and ready, then the disc shall be formatted as SRM with no spare areas allocated.
2. If the FORMAT UNIT command is used to select a BD-R format, SRM with defect management shall be an option (Sub-types 00b and 01b of Format Types 00h and 32h).
3. If the FORMAT UNIT command is used to select a BD-R format, SRM+POW shall be an option (Sub-type 00b of Format Types 00h and 32h).
4. If the RRM bit is set to one, then the FORMAT UNIT command shall provide RRM as an option (Sub-type 10b of Format Types 00h and 32h).

Drives that support this Feature shall implement the commands listed in Table 12.

Table 12 — Formattable Feature Commands

Op Code	Command	Reference
04h	FORMAT UNIT, Format Types 00h and 32h and sub-types 00b and 01b	6.3
23h	READ FORMAT CAPACITIES	6.18
03h	REQUEST SENSE	6.21
2Fh	VERIFY (10)	6.30

5.1.4 The BD Read Feature (0040h)

This Feature identifies a Drive that is able to read control structures and user data from the BD disc. The BD Read Feature descriptor response data to be returned to the Host is defined in Table 13.

Table 13 — BD Read Feature Descriptor

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB) Feature Code = 40h							
1								(LSB)
2	Reserved			Version			Persistent	Current
3	Additional Length = 1Ch							
4	Reserved							
5	Reserved							
6	Reserved							
7	Reserved							
8 ... 31	Read Support Bitmaps							

The Feature Code field shall be set to 0040h.

The Version field shall be set to 0h.

The Persistent bit shall be set to zero, indicating that this Feature may change its current status.

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. Whenever a BD-R or BD-RE disc is present, and a disc format is in progress, the Current bit shall be set to zero. The Current bit shall be set to one when the disc has been completely formatted.

The Additional Length field shall be set to 1Ch.

Bytes 8 through 15 (Table 14) contain version bitmaps of BD-RE disc classes that indicate read support provided by the Drive. If a bit is set to one, the Drive supports reading BD-RE discs of the Class and version.

Table 14 — BD-RE Read Support Bitmap

BD-RE Class	Bit / Byte	7	6	5	4	3	2	1	0
0	8	Ver 15	Ver 14	Ver 13	Ver 12	Ver 11	Ver 10	Ver 9	Ver 8
	9	Ver 7	Ver 6	Ver 5	Ver 4	Ver 3	Ver 2	Ver 1	Ver 0
1	10	Ver 15	Ver 14	Ver 13	Ver 12	Ver 11	Ver 10	Ver 9	Ver 8
	11	Ver 7	Ver 6	Ver 5	Ver 4	Ver 3	Ver 2	Ver 1	Ver 0
2	12	Ver 15	Ver 14	Ver 13	Ver 12	Ver 11	Ver 10	Ver 9	Ver 8
	13	Ver 7	Ver 6	Ver 5	Ver 4	Ver 3	Ver 2	Ver 1	Ver 0
3	14	Ver 15	Ver 14	Ver 13	Ver 12	Ver 11	Ver 10	Ver 9	Ver 8
	15	Ver 7	Ver 6	Ver 5	Ver 4	Ver 3	Ver 2	Ver 1	Ver 0

Bytes 16 through 23 (Table 15) contain version bitmaps of BD-R disc classes that indicate read support provided by the Drive. If a bit is set to one, the Drive supports reading BD-R discs of the Class and version.

Table 15 — BD-R Read Support Bitmap

BD-R Class	Bit / Byte	7	6	5	4	3	2	1	0
0	16	Ver 15	Ver 14	Ver 13	Ver 12	Ver 11	Ver 10	Ver 9	Ver 8
	17	Ver 7	Ver 6	Ver 5	Ver 4	Ver 3	Ver 2	Ver 1	Ver 0
1	18	Ver 15	Ver 14	Ver 13	Ver 12	Ver 11	Ver 10	Ver 9	Ver 8
	19	Ver 7	Ver 6	Ver 5	Ver 4	Ver 3	Ver 2	Ver 1	Ver 0
2	20	Ver 15	Ver 14	Ver 13	Ver 12	Ver 11	Ver 10	Ver 9	Ver 8
	21	Ver 7	Ver 6	Ver 5	Ver 4	Ver 3	Ver 2	Ver 1	Ver 0
3	22	Ver 15	Ver 14	Ver 13	Ver 12	Ver 11	Ver 10	Ver 9	Ver 8
	23	Ver 7	Ver 6	Ver 5	Ver 4	Ver 3	Ver 2	Ver 1	Ver 0

Bytes 24 through 31 (Table 18) contain version bitmaps of BD-ROM disc classes that indicate read support provided by the Drive. If a bit is set to one, the Drive supports reading BD-ROM discs of the Class and version.

Table 16 — BD-ROM Read Support Bitmap

BD-ROM Class	Bit / Byte	7	6	5	4	3	2	1	0
0	24	Ver 15	Ver 14	Ver 13	Ver 12	Ver 11	Ver 10	Ver 9	Ver 8
	25	Ver 7	Ver 6	Ver 5	Ver 4	Ver 3	Ver 2	Ver 1	Ver 0
1	26	Ver 15	Ver 14	Ver 13	Ver 12	Ver 11	Ver 10	Ver 9	Ver 8
	27	Ver 7	Ver 6	Ver 5	Ver 4	Ver 3	Ver 2	Ver 1	Ver 0
2	28	Ver 15	Ver 14	Ver 13	Ver 12	Ver 11	Ver 10	Ver 9	Ver 8
	29	Ver 7	Ver 6	Ver 5	Ver 4	Ver 3	Ver 2	Ver 1	Ver 0
3	30	Ver 15	Ver 14	Ver 13	Ver 12	Ver 11	Ver 10	Ver 9	Ver 8
	31	Ver 7	Ver 6	Ver 5	Ver 4	Ver 3	Ver 2	Ver 1	Ver 0

If a Drive reports this feature with the Current bit set to one, then the Drive shall support the commands shown in Table 17.

Table 17 — Command Support Required by the BD Read Feature

Op Code	Command Description	Reference
28h	READ (10)	6.12
A8h	READ (12)	6.13
ADh	READ DISC STRUCTURE (format = 0, 30h, FFh)	6.17
43h	READ TOC/PMA/ATIP (format 0 and 1)	6.19

5.1.5 The BD Write Feature (0041h)

This Feature identifies a Drive that is able to write control structures and user data to certain BD discs. The BD Write Feature descriptor response data to be returned to the Host is defined in Table 18.

Table 18 — BD Write Feature Descriptor

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB) Feature Code = 0041h							
1								(LSB)
2	Reserved			Version			Persistent	Current
3	Additional Length = 14h							
4	Reserved							SVNR
5	Reserved							
6	Reserved							
7	Reserved							
8 ... 23	Write Support Bitmaps							

The Feature Code field shall be set to 0041h.

The Version field shall be set to 0h.

The Persistent bit shall be set to zero, indicating that this Feature may change its current status.

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 shall be set to 20.

If the SVNR bit (Supports Verify Not Required) is set to one, then the WRITE (12) command supports the VNR bit set to one.

Bytes 8 through 15 (Table 19) contain version bitmaps of BD-RE disc classes that indicate write support provided by the Drive. If a bit is set to one, the Drive supports writing BD-RE discs of the Class and version.

Table 19 — BD-RE Write Support Bitmap

BD-RE Class	Bit / Byte	7	6	5	4	3	2	1	0
0	8	Ver 15	Ver 14	Ver 13	Ver 12	Ver 11	Ver 10	Ver 9	Ver 8
	9	Ver 7	Ver 6	Ver 5	Ver 4	Ver 3	Ver 2	Ver 1	Ver 0
1	10	Ver 15	Ver 14	Ver 13	Ver 12	Ver 11	Ver 10	Ver 9	Ver 8
	11	Ver 7	Ver 6	Ver 5	Ver 4	Ver 3	Ver 2	Ver 1	Ver 0
2	12	Ver 15	Ver 14	Ver 13	Ver 12	Ver 11	Ver 10	Ver 9	Ver 8
	13	Ver 7	Ver 6	Ver 5	Ver 4	Ver 3	Ver 2	Ver 1	Ver 0
3	14	Ver 15	Ver 14	Ver 13	Ver 12	Ver 11	Ver 10	Ver 9	Ver 8
	15	Ver 7	Ver 6	Ver 5	Ver 4	Ver 3	Ver 2	Ver 1	Ver 0

Bytes 16 through 23 (Table 20) contain version bitmaps of BD-R disc classes that indicate write support provided by the Drive. If a bit is set to one, the Drive supports writing BD-R discs of the Class and version.

Table 20 — BD-R Write Support Bitmap

BD-R Class	Bit / Byte	7	6	5	4	3	2	1	0
0	16	Ver 15	Ver 14	Ver 13	Ver 12	Ver 11	Ver 10	Ver 9	Ver 8
	17	Ver 7	Ver 6	Ver 5	Ver 4	Ver 3	Ver 2	Ver 1	Ver 0
1	18	Ver 15	Ver 14	Ver 13	Ver 12	Ver 11	Ver 10	Ver 9	Ver 8
	19	Ver 7	Ver 6	Ver 5	Ver 4	Ver 3	Ver 2	Ver 1	Ver 0
2	20	Ver 15	Ver 14	Ver 13	Ver 12	Ver 11	Ver 10	Ver 9	Ver 8
	21	Ver 7	Ver 6	Ver 5	Ver 4	Ver 3	Ver 2	Ver 1	Ver 0
3	22	Ver 15	Ver 14	Ver 13	Ver 12	Ver 11	Ver 10	Ver 9	Ver 8
	23	Ver 7	Ver 6	Ver 5	Ver 4	Ver 3	Ver 2	Ver 1	Ver 0

If a Drive reports this feature with the Current bit set to one, then the Drive shall support the commands shown in Table 21.

Table 21 - Command Support Required by the BD Write Feature

Op Code	Command Description	Reference
04h	FORMAT UNIT	6.3
2Ah	WRITE (10)	6.31
AAh	WRITE (12)	6.32

5.1.6 BD-R Pseudo-Overwrite (POW) Feature

A Drive that reports the feature is able to provide Logical Block overwrite service on BD-R discs that are formatted as SRM+POW. The feature descriptor is defined in Table 22.

Table 22 — Pseudo-OverWrite Feature Descriptor

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB) Feature Code = 0038h							
1								(LSB)
2	Reserved			Version			Persistent	Current
3	Additional Length = 4							
4	Reserved							
5	Reserved							
6	Reserved							
7	Reserved							

The Feature Code field shall be set to 0038h.

The Version field shall be set to 0h.

The Persistent bit shall be set to zero, indicating that this Feature may change its current status.

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 shall be set to 04h.

When this feature is current, the Drive shall provide Pseudo-overwrite services as described in UDF 2.60. The physical implementation shall be according to the rules for Logical OverWrite described in *System Description Blu-ray Disc Recordable Format, Part 1 Basic Format Specifications*. See 4.4.4.4 for a description of implementation requirements. This feature shall not be current on multi-session discs.

5.2 Profile Descriptions

5.2.1 Profile 0040h: BD-ROM

Drives identifying Profile 0040h as current shall support the features listed in Table 23.

Table 23 - Mandatory Features for BD-ROM

Feature Number	Feature Name	Description
0000h	Profile List	A list of all Profiles supported by the device
0001h	Core	Mandatory behavior for all devices
0002h	Morphing	Device changes operational behavior upon events external to the Host
0003h	Removable Medium	The medium may be removed from the device
0010h	Random Readable[1]	Read ability for storage devices with random addressing
0040h	BD Read	The ability to read BD specific structures
0100h	Power Management	Host and device directed power management
0105h	Timeout	Ability to respond to all commands within a specific time
0107h	Real-time Streaming	Ability to read (and optionally write) using Host requested performance parameters.

Notes:
1. PP bit in Random Readable Feature shall be set to 1.

Table 24 shows the decomposition of the profile into features and features into commands and mode pages.

Table 24 – BD-ROM Profile Decomposition

BD-ROM Profile	Core Feature	Get Configuration Command, Get Event Status Notification Command, Inquiry Command, Mode Select (10) Command, Mode Sense (10) Command, Request Sense Command, Test Unit Ready Command
	Morphing Feature	Get Configuration Command, Get Event Status Notification Command, Prevent Allow Medium Removal Command
	Removable Medium Feature	Mechanism Status Command, Prevent Allow Medium Removal Command, Start Stop Unit Command
	Random Readable Feature	Read Capacity Command, Read (10) Command, Read/Write Error Recovery Mode Page
	BD Read Feature	Read (10) Command, Read (12) Command, Read Disc Structure Command, Read TOC/PMA/ATIP Command
	Power Management Feature	Get Event Status Notification Command, Start Stop Unit Command, Power Condition Page
	Timeout Feature	Timeout and Protect Mode Page
	Real-time Streaming	Get Performance Command, Read (12) Command, , Set Streaming Command, Set Read Ahead Command

Note: The Read Buffer Capacity command and the Write (12) command are commands that are mandatory for the Real-time Streaming Feature only when stream writing is supported. Since writing cannot be supported on BD-ROM, these commands are not listed.

5.2.2 Profile 0041h: BD-R Sequential Recording (SRM) Profile

Drives identifying Profile 0041h as current shall support the features listed in Table 25.

Table 25 — Features For BD-R SRM Profile

Feature Number	Feature Name	Description
0000h	Profile List	A list of all Profiles supported by the device
0001h	Core	Mandatory behavior for all devices
0002h	Morphing	Device changes operational behavior upon events external to the Host
0003h	Removable Medium	The medium may be removed from the device
0010h	Random Readable[1]	Read ability for storage devices with random addressing
0021h	Incremental Streaming Writable	Write support for sequential recording
0023h	Formattable	Support for formatting of media
0024h	Defect Management[2]	The Drive/media system is able to provide an apparently defect-free LBA space
0038h	BD-R POW[3]	The ability to permit logical overwrites from the user data area of the disc
0040h	BD Read	The ability to read BD specific structures
0041h	BD Write	The ability to write BD user data areas and certain BD specific structures
0100h	Power Management	Host and device directed power management
0105h	Timeout	Ability to respond to all commands within a specific time
0107h	Real-time Streaming	Ability to read (and optionally write) using Host requested performance parameters.

[1]PP bit in Random Readable Feature shall be set to 1.

[2]Defect Management Feature shall be marked not Current when no spares are allocated.

[3]If both the BD-R SRM profile and the BD-R POW feature are current, then the basic characteristics of sequential recording are maintained, but limited Logical Overwrite is permitted. Such a disc is SRM+POW.

Table 26 shows the commands and Mode Pages required when the BD-R SRM Profile is current.

Table 26 — BD-R SRM Profile Decomposition

Features	Commands and Mode Pages
Core	Get Configuration command, Get Event Status Notification command, Inquiry command, Mode Select (10) command, Mode Sense (10) command, Request Sense command, Test Unit Ready command
Morphing	Get Configuration command, Get Event Status Notification command, Prevent Allow Medium Removal command
Removable Medium	Mechanism Status command, Prevent Allow Medium Removal command, Start Stop Unit command
Random Readable	Read Capacity command, Read (10) command, Read/Write Error Recovery Parameters Mode Page
Incremental Streaming Writable	BLANK command[1], Close Track Session command, Read Disc Information command, Read Disc Structure command, Read Track Information command, Reserve Track command, Send OPC Information command, Synchronize Cache command, Write (10) command, Write Parameters Mode Page[1]
Formattable	Format Unit command, Read Format Capacities command, Verify (10) command, Request Sense command
Defect Management	Read/Write Error Recovery Parameters Mode Page
BD-R POW	—
BD Read	Read (10) command, Read (12) command, Read BD Structure command, Read TOC/PMA/ATIP command, Read/Write Error Recovery Parameters Mode Page
BD Write	Format Unit command, Write (10) command
Power Management	Get Event Status Notification command, Start Stop Unit command, Power Condition Page
Timeout	Timeout and Protect Mode Page
Real-time Streaming	Get Performance command, Read (12) command, Read Buffer Capacity command[1], Set Streaming command, Set Read Ahead command, Write (12) command[1]
[1]The command or mode page is conditional according to the feature description.	

5.2.3 Profile 0042h: BD-R Random Recording (RRM) Profile

Drives identifying Profile 0042h as current shall support the features listed in Table 27.

Table 27 — Features For BD-R RRM Profile

Feature Number	Feature Name	Description
0000h	Profile List	A list of all Profiles supported by the device
0001h	Core	Mandatory behavior for all devices
0002h	Morphing	Device changes operational behavior upon events external to the Host
0003h	Removable Medium	The medium may be removed from the device
0010h	Random Readable[1]	Read ability for storage devices with random addressing
0023h	Formattable	Support for formatting of media
0024h	Defect Management[2]	The Drive/media system is able to provide an apparently defect-free LBA space
0025h	Write-once	Write support for write-once media that is writable in random order
0040h	BD Read[3]	The ability to read BD user data areas and certain BD specific structures
0041h	BD Write	The ability to write BD user data areas and certain BD specific structures
0100h	Power Management	Host and device directed power management
0105h	Timeout	Ability to respond to all commands within a specific time
0107h	Real-time Streaming	Ability to read (and optionally write) using Host requested performance parameters.

[1]PP bit in Random Readable Feature shall be set to 1.
[2]Defect Management Feature shall be marked not Current when no spares are allocated.
[3]BD Read Feature shall be marked not Current when media is physically blank.

Table 28 shows the commands and Mode Pages required when the BD-R RRM Profile is current.

Table 28 — BD-R RRM Profile Decomposition

Features	Commands and Mode Pages
Core	Get Configuration command, Get Event Status Notification command, Inquiry command, Mode Select (10) command, Mode Sense (10) command, Request Sense command, Test Unit Ready command
Morphing	Get Configuration command, Get Event Status Notification command, Prevent Allow Medium Removal command
Removable Medium	Mechanism Status command, Prevent Allow Medium Removal command, Start Stop Unit command
Random Readable	Read Capacity command, Read (10) command, Read/Write Error Recovery Parameters Mode Page
Formattable	Format Unit command, Read Format Capacities command, Verify (10) command, Request Sense command
Defect Management	Read/Write Error Recovery Parameters Mode Page
Write-Once	Read Capacity command, Synchronize Cache command, Write (10), Write and Verify (10), Read/Write Error Recovery Parameters Mode Page[1]
BD Read	Read (10) command, Read (12) command, Read BD Structure command, Read TOC/PMA/ATIP command, Read/Write Error Recovery Parameters Mode Page
BD Write	Format Unit command, Write (10) command
Power Management	Get Event Status Notification command, Start Stop Unit command, Power Condition Page
Timeout	Timeout and Protect Mode Page
Real-time Streaming	Get Performance command, Read (12) command, Read Buffer Capacity command[1], Set Streaming command, Set Read Ahead command, Write (12) command[1]

[1]The command or mode page is conditional according to the feature description.

5.2.4 Profile 0043h: BD-RE

Logical Units identifying Profile 0043h as current shall support the features listed in Table 23.

Table 29 - Mandatory Features for BD-RE

Feature Number	Feature Name	Description
0000h	Profile List	A list of all Profiles supported by the device
0001h	Core	Mandatory behavior for all devices
0002h	Morphing	Device changes operational behavior upon events external to the Host
0003h	Removable Medium	The medium may be removed from the device
0010h	Random Readable[1]	Read ability for storage devices with random addressing
0020h	Random Writable	Write support for randomly addressed writes
0023h	Formattable	Support for formatting of media
0024h	Defect Management[2]	The Logical Unit/media system is able to provide an apparently defect-free LBA space
0040h	BD Read[3]	The ability to read BD specific structures
0041h	BD Write	The ability to write BD user data areas and certain BD specific structures
0100h	Power Management	Host and device directed power management
0105h	Timeout	Ability to respond to all commands within a specific time
0107h	Real-time Streaming	Ability to read (and optionally write) using Host requested performance parameters.

[1]PP bit in Random Readable Feature shall be set to 1.
[2]Defect Management Feature shall be marked not Current when no spares are allocated.
[3]BD Read Feature shall be marked not Current when media is physically blank.

Table 24 shows the decomposition of the profile into features and features into commands and mode pages.

Table 30 – BD-RE Profile Decomposition

BD-RE Profile	Core Feature	Get Configuration command, Get Event Status Notification command, Inquiry command, Mode Select (10) command, Mode Sense (10) command, Request Sense command, Test Unit Ready command
	Morphing Feature	Get Configuration command, Get Event Status Notification command, Prevent Allow Medium Removal command
	Removable Medium Feature	Mechanism Status command, Prevent Allow Medium Removal command, Start Stop Unit command
	Random Readable Feature	Read Capacity command, Read (10) command, Read/Write Error Recovery Parameters Mode Page
	Random Writable Feature	Read Capacity command, Write (10) command, Write and Verify (10) command, Synchronize Cache command
	Formattable Feature	Format Unit command, Read Format Capacities command, Verify (10) command, Request Sense command
	BD Read Feature	Read (10) command, Read (12) command, Read Disc Structure command, Read TOC/PMA/ATIP command, Read/Write Error Recovery Parameters Mode Page
	Defect Management Feature	Read/Write Error Recovery Parameters Mode Page
	Power Management Feature	Get Event Status Notification command, Start Stop Unit command, Power Condition Page
	Timeout Feature	Timeout and Protect Mode Page
	Real-time Streaming	Get Performance command, Read (12) command, Read Buffer Capacity command[C], Set Streaming command, Set Read Ahead command, Write (12) command[C]

[C] marks a feature conditional command or mode page. All other commands and mode pages are mandatory.

6 Commands for BD Devices

6.1 Overview

The commands described in this clause are defined uniquely for BD Multi-Media Drives or have a unique behavior when executed by a BD Multi-Media Drive.

The commands described in this clause are listed in Table 31. MMC-4 is the primary reference for the command descriptions. For a given command, modified/additional behavior necessary for the support of BD is described in the specified sub-clause.

Table 31 – Commands for BD Multi-Media Drives

Command Name	Op Code	Reference
CLOSE TRACK SESSION	5Bh	6.2
FORMAT UNIT	04h	6.3
GET CONFIGURATION	46h	6.4
GET EVENT STATUS NOTIFICATION	4Ah	6.5
GET PERFORMANCE	ACh	6.6
INQUIRY	12h	6.7
MECHANISM STATUS	BDh	6.8
MODE SELECT (10)	55h	6.9
MODE SENSE (10)	5Ah	6.10
PREVENT ALLOW MEDIUM REMOVAL	1Eh	6.11
READ (10)	28h	6.12
READ (12)	A8h	6.13
READ BUFFER CAPACITY	5Ch	6.14
READ CAPACITY	25h	6.15
READ DISC INFORMATION	51h	6.16
READ DISC STRUCTURE	ADh	6.17
READ FORMAT CAPACITIES	23h	6.18
READ TOC/PMA/ATIP	43h	6.19
READ TRACK INFORMATION	52h	6.20
REQUEST SENSE	03h	6.21
RESERVE TRACK	53h	6.22
SEND DISC STRUCTURE	BFh	6.23
SEND OPC INFORMATION	54h	6.24
SET READ-AHEAD	A7h	6.25
SET STREAMING	B6h	6.26
START STOP UNIT	1Bh	6.27
SYNCHRONIZE CACHE	35h	6.28
TEST UNIT READY	00h	6.29
VERIFY (10)	2Fh	6.30
WRITE (10)	2Ah	6.31
WRITE (12)	AAh	6.32
WRITE AND VERIFY (10)	2Eh	6.33

6.2 CLOSE TRACK SESSION Command

The CLOSE TRACK/SESSION command allows closure of either a track or a session.

6.2.1 The CDB and Its Parameters

The CLOSE TRACK/SESSION CDB is shown in Table 32.

Table 32 — CLOSE TRACK SESSION CDB

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation Code (5Bh)							
1	Reserved							IMMED
2	Reserved					Close Function		
3								
4	(MSB) Logical Track Number							
5								(LSB)
6	Reserved							
7	Reserved							
8	Reserved							
9	Control							

6.2.1.1 IMMED

The IMMED bit allows execution of the close function as an immediate operation. If IMMED is zero, then the requested close operation is processed to completion prior to returning status. If IMMED is one, then status is returned once the close operation has begun.

6.2.1.2 Close Function

Close Function definitions are media specific. See 6.2.2.1.1 through 6.2.2.1.4.

6.2.1.3 Logical Track Number

The Logical Track Number (T) is valid only when the Close Function = 001b. If T_{MAX}.is the maximum Logical Track number currently defined on the disc and T > T_{MAX}, the command shall be terminated with CHECK CONDITION status and SK/ASC/ASCQ values shall be set to ILLEGAL REQUEST/INVALID FIELD IN CDB.

6.2.2 Command Execution

6.2.2.1 Close Functions for BD-R in SRM

6.2.2.1.1 Close Function 001b: Close a Logical Track

Close the Logical Track (SRR) identified by Logical Track Number field (T) in the CDB.

A BD-R SRR is closed by removing its number from the list of open SRRs in the SRRI. Padding is not required. Since the disc is not finalized, the updated SRRI shall be written into the current TDMA as a TDMS update unit. The actual write may be deferred.

If T is the invisible SRR and the invisible SRR is blank, then the command shall be terminated with GOOD status and sense data shall be set to NO SENSE/NO ADDITIONAL INFORMATION. If T is the invisible SRR and the invisible SRR is not blank, then the length of T shall be set to its recorded length, creating a new, blank invisible SRR with Logical Track Number = T+1.

6.2.2.1.2 Close Function 010b: Close the Open Session

Close the currently open session on a SRM Disc.

If the currently mounted disc is formatted SRM+POW, the command shall be terminated with CHECK CONDITION and sense bytes SK/ASC/ASCQ shall be set to ILLEGAL REQUEST/INVALID FIELD IN CDB.

If the currently mounted disc is SRM and the currently open session is empty, the command shall be terminated with GOOD status.

If the currently mounted disc is SRM and the currently open session is non-empty, each open SRR in the last Session shall be closed by the Drive prior to closing the session.

6.2.2.1.3 Close Function 110b: Close the Open Session and Finalize the Disc

Close the last session and finalize the disc. Once this close function has been processed, no more writing to the disc is allowed. Each open SRR in the last Session shall be closed by the Drive prior to closing the session.

6.2.2.1.4 Reserved Close Functions

When a BD-R disc is present, Close Functions 000b, 011b, 100b, 101b, and 111b are reserved. If the Close Function is reserved for the currently mounted medium the command shall be terminated with CHECK CONDITION status and SK/ASC/ASCQ values shall be set to ILLEGAL REQUEST/INVALID FIELD IN CDB.

6.2.2.2 Immediate Operation

During a Close Track/Session operation that began with the IMMED bit set to one, the Drive shall respond to commands as follows:

a) In response to all commands except REQUEST SENSE, INQUIRY, GET CONFIGURATION, GET EVENT STATUS NOTIFICATION, and TEST UNIT READY, the Drive shall return CHECK CONDITION status and set SK/ASC/ASCQ to NOT READY/LOGICAL UNIT NOT READY/OPERATION IN PROGRESS.
b) In response to the TEST UNIT READY command, the Drive should return CHECK CONDITION status and set SK/ASC/ASCQ to NOT READY/LOGICAL UNIT NOT READY/OPERATION IN PROGRESS. Some legacy implementations allowed for a GOOD status response to a TEST UNIT READY command. This behavior is not recommended.
c) In response to the INQUIRY, GET CONFIGURATION, GET EVENT STATUS NOTIFICATION commands, the Drive shall respond as commanded.
d) In response to the REQUEST SENSE command, unless an error has occurred, the Drive shall return with SK/ASC/ASCQ values set to NOT READY/LOGICAL UNIT NOT READY/LONG WRITE IN PROGRESS or NOT READY/LOGICAL UNIT NOT READY/OPERATION IN PROGRESS, with the sense key specific bytes set for progress indication.

If the Drive changes to a not ready state during execution, an Operational Change Event shall be generated. When execution is completed and the state returns to ready, an Operational Change Event shall be generated. If the Closing a Track or Session results in one or more features changing currency, an additional Operational Change Event shall be generated.

6.3 FORMAT UNIT

The FORMAT UNIT command formats a medium into Host addressable logical blocks according to Host defined options. The medium may be certified and control structures created for the management of the medium and defects. The medium may or may not be altered.

6.3.1 The CDB and Its Parameters

The FORMAT UNIT command descriptor block is shown in Table 33.

Table 33 — FORMAT UNIT Command Descriptor Block

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation Code (04h)							
1	Reserved			FmtData	CmpList	Format Code		
2	Reserved							
3	(MSB) Interleave Value							
4	(LSB)							
5	Control Byte							

6.3.1.1 FmtData

If the FmtData bit is zero, there is no parameter list. If FmtData is one, a parameter list is available from the Host. For all Multi-media Drives, FmtData shall be set to one. If FmtData is zero, the command shall be terminated with CHECK CONDITION status and SK/ASC/ASCQ shall be set to to ILLEGAL REQUEST/INVALID FIELD IN CDB.

6.3.1.2 CmpList

For recordable BD discs, CmpList bit shall be set to zero. If CmpList is set to one, the command shall be terminated with CHECK CONDITION status and SK/ASC/ASCQ shall be set to to ILLEGAL REQUEST/INVALID FIELD IN CDB.

6.3.1.3 Format Code

The Format Code identifies the parameter list format. When BD-R disc is present, the Format Code shall be set to one (001b).

6.3.1.4 Interleave Value

For BD, Interleave Value shall be zero. If Interleave Value is not set to zero, the command shall be terminated with CHECK CONDITION status and SK/ASC/ASCQ shall be set to to ILLEGAL REQUEST/INVALID FIELD IN CDB.

6.3.2 Format Parameter List

The FORMAT UNIT parameter list (Table 34) consists of three descriptors: the Format List Header, the Initialization Pattern Descriptor, and the Format Descriptor.

Table 34 — Format Unit Parameter List

Bit / Byte	7	6	5	4	3	2	1	0
0 — 3	Format List Header							
4 — n	Initialization Pattern Descriptor (present if IP = 1)							
n+1 to n+8	Format Descriptor							

6.3.2.1 Format List Header

The Format List Header (Table 35) provides several format control bits. Drives that implement these bits give Hosts additional control over the formatting operation. If the Host attempts to select any function not implemented by the Drive, the Drive shall terminate the command with CHECK CONDITION status and SK/ASC/ASCQ values shall be set to ILLEGAL REQUEST/INVALID FIELD IN PARAMETER LIST.

Table 35 — 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							
3	(LSB)							

If the Format Options Valid (FOV) bit is zero, the Drive shall use its default settings for the values of DPRY, DCRT, STPF, IP, and Try-out. For recordable BD discs, the defaults shall be all bits set to zero.

If FOV is one, the Drive shall examine the setting of the DPRY, DCRT, STPF, IP, and Try-out. When BD-R disc is present, the DPRY, DCRT, STPF, IP, Try-out, IMMED, and VS bits are defined as follows:

Disable primary (DPRY), Disable Certification (DCRT), Stop Format (STPF), Initialization Pattern (IP), and Try-out bits are reserved and shall be set to zero. If any of these bits is set to one, the Drive shall terminate the command with CHECK CONDITION status and set SK/ASC/ASCQ values to ILLEGAL REQUEST/INVALID FIELD IN PARAMETER LIST.

If the immediate (IMMED) bit is zero, status shall be returned only after the format operation has completed. If the IMMED bit is set to one, the Drive shall return status as soon as the CDB and the Format Descriptor have been validated and the format process has begun.

The Vendor Specific (VS) bit has a vendor-specific definition.

The Format Descriptor Length field in the Format list header specifies the total length in bytes of the Format descriptors. The Format Descriptor Length shall be set to 8. If any other value in found in this field, the Drive shall terminate the command with CHECK CONDITION status and SK/ASC/ASCQ values shall be set to ILLEGAL REQUEST/INVALID FIELD IN PARAMETER LIST.

6.3.2.2 Format Descriptor

When the CDB Format Code is 001b, a Format Descriptor is included in the FORMAT UNIT Parameter List. The Format Descriptor (Table 36) is a structure that is 8 bytes in length.

Table 36 — Format Code 001b Format Descriptor

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB)							
1	Number of Blocks							
2								
3								(LSB)
4	Format Type						Format Sub-type	
5	(MSB)							
6	Type Dependent Parameter							
7								(LSB)

6.3.2.2.1 Number of Blocks

The Number of Blocks field provides a method for specifying the number of addressable blocks that shall be formatted for the entire disc. The method of specification is dependent upon the Format Type.

6.3.2.2.2 Format Type

The Format Type field specifies the type of formatting.

When a BD-RE disc is present, Format Types 00h and 30h shall be supported. Format Types 01h and 31h are optional for BD-RE discs.

When a BD-R disc is present, only Format Types 00h and 32h shall be supported.

6.3.2.2.3 Format Sub-type

The Format Sub-type field specifies additional behavior beyond that specified by the Format Type code.

6.3.2.2.4 Type Dependent Parameter

Type Dependent Parameter field depends on Format Type.

6.3.3 Command Execution

6.3.3.1 Format Type = 00h, BD-R

Table 37 shows the Format Descriptor for Format Type 00h.

Table 37 - Format Descriptor (Format Type = 00h)

Byte \ Bit	7	6	5	4	3	2	1	0
0	(MSB)							
1	Number of Blocks							
2								
3								(LSB)
4	Format Type = 00h						Format sub-type	
5	(MSB)							
6	Block Length = 0800h							
7								(LSB)

Format Type 00h requires that the Drive execute the formatting process by using its default User Data Zone size, default spares allocation, and default TDMA allocation.

Format Sub-type selects a sub-type of format Type 00h for BD-R as shown in Table 38.

Table 38 — Sub-type Field

Sub-type Value	Description
00b	SRM+POW
01b	SRM-POW
10b	RRM
11b	Reserved

The Drive ignores the Number of Blocks field, and the Block Length field. The total User Data Zone on the disc shall be the default size as reported by the Format Type 00h format descriptor returned by READ FORMAT CAPACITIES command.

As a part of the format process, the Drive shall allocate TDMA and spare areas according to vendor specific defaults. Table 39 shows an example of defaults for different BD-R discs.

Table 39 — Example of Default Allocations for Format Type 0, Sub-type 0

BD-R Disc	Allocations			
	Area	Spares	TDMA	Totals
80 mm Single Layer	ISA0	2 048	2 048	4 096
	OSA0	0	0	0
80 mm Dual Layer	ISA0	2 048	2 048	4 096
	OSA0	0	0	0
	OSA1	0	0	0
	ISA1	2 048	2 048	4 096
120 mm Single Layer	ISA0	2 048	2 048	4 096
	OSA0	4 096	4 096	8 192
120 mm Dual Layer	ISA0	2 048	2 048	4 096
	OSA0	4 096	4 096	8 192
	OSA1	4 096	4 096	8 192
	ISA1	2 048	2 048	4 096

6.3.3.2 Format Type = 00h, BD-RE

Format Type 00h requires that the Logical Unit execute the formatting process by using its default User Data Zone size. The Logical Unit ignores the Number of Blocks field, and the Block Length field. The Sub-type field is reserved. The default behavior of the format process is Quick Reformat.

The total User Data Zone on the disc shall be the default size as reported by the Format Type 00h format descriptor returned by READ FORMAT CAPACITIES command.

The Spare Area size shall be the default size as resulting from the default User Data Zone Size.

6.3.3.3 Format Type = 01h (Spare Area Expansion on BD-RE)

If the Expand bit is set to one in the Formattable Feature descriptor, Format Type 01h is supported and is used to convert some of the User Data Zone into Spare Area. Spare areas are permitted to be expanded when the total spare area size is non-zero. If the current disc formatting has no spare area allocated, then this command shall be terminated with CHECK CONDITION status and the sense bytes SK/ASC/ASCQ shall be set to ILLEGAL REQUEST/INVALID FIELD IN PARAMETER LIST.

If the Number of Blocks field does not provide space for additional spare area, the command shall be terminated with GOOD status.

Only the last spare area may be expanded. On a SL disc, only the OSA0 may be expanded. On a DL disc, only the ISA1 may be expanded.

The Host should determine the location and size of the part of the User Data Zone that it expects to be taken as spares. User Data in that area should be preserved by the Host and all address links to that User Data should be removed.

Although defect status may change, each registered defect within the range of the area taken as spares shall remain a registered defect after 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.

Once formatting has completed, if space is available, the Host should restore any data that was copied off the disc.

6.3.3.4 Format Type = 30h (Format BD-RE with Spare Areas)

Table 40 shows the Format Descriptor for Format Type 30h.

Table 40 - Format Descriptor (Format Type = 30h)

Byte \ Bit	7	6	5	4	3	2	1	0
0	(MSB)							
1	Number of Blocks							
2								
3								(LSB)
4	Format Type = 30h						Format Sub-type	
5	(MSB)							
6	Spare Area size in Clusters							
7								(LSB)

Format Sub-type (Table 41) selects a sub-type of Format Type 30h that is independent of the setting of the DCRT bit in the Format List Header.

Table 41 – Format Sub-type Field

Sub-type Value	Description
00b	Quick Reformat: If the disc is blank, the format process shall simply initialize the disc structures with no certification. If the disc has been previously formatted, a Quick Reformat shall be performed. Quick Reformat consists of declaring that all Clusters marked as defective in the DFL become marked as possibly bad during the reformat. Assigned spares are released.
01b	No Certification: No certification shall be applied to the data area after disc structures have been initialized. The defect tables shall be initialized to indicate no media defects.
10b	Full Certification: The entire data area shall be certified. The defect tables shall be initialized with defects discovered during the certification process.
11b	Quick Certification: If the media has been previously formatted, the defect tables shall be reconstructed by certifying only the Clusters that were previously declared to be defective.

Format Type 30h requires that the Logical Unit format the disc in order that the User Data Zone contains at least Number of Blocks. The number of spare Clusters allocated shall be less than or equal to:

S = IP[(Data Zone Size - Number of Blocks)/32], where IP is the integer part of the result.

Allocation rules for spare areas differ for disc size (i.e. 80mm or 120mm) and number of layers as shown in Table 42.

Table 42 — Maximum Spare Area Sizes on BD-RE

Spare Area \ Disc	80 mm Single Layer	80 mm Dual Layer	120 mm Single Layer	120 mm Dual Layer
ISA0[1]	4096	4096	4096	4096
OSA0[2]	0	0	16384	8192
OSA1[2]	-	0	-	8192
ISA1[2]	-	16384	-	16384
Totals	4096	20480	20480	36864

[1]The size of ISA0 is fixed at 4096 Clusters, regardless of size of number of layers.
[2]The spare area must be allocated in increments of 256 Clusters.

Since the formatted capacity of the media may be larger than the Number of Blocks field, when formatting has completed, the Host should send the READ CAPACITY command in order to determine the actual capacity.

Sub-type identifies certification to be performed as described in Table 45. The Spare Area size in Clusters field is ignored by the Logical Unit.

6.3.3.4.1 Spares Allocation on 80mm Single Layer BD-RE

S shall be at least 4096. If S is less than 4096, then 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 LIST.

6.3.3.4.2 Spares Allocation on 80mm Dual Layer BD-RE

S shall be at least 4096. If S is less than 4096, then 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 LIST.

If S > 4096, then set S_1 = MIN(256*IP[(S - 4096)/256], 16384). ISA1 shall be allocated S_1 spare Clusters.

6.3.3.4.3 Spares Allocation on 120mm Single Layer BD-RE

S shall be at least 4096. If S is less than 4096, then 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 LIST.

If S > 4096, then set S_1 = MIN(256*IP[(S - 4096)/256], 16384). OSA0 shall be allocated S_1 spare Clusters.

6.3.3.4.4 Spares Allocation on 120mm Dual Layer BD-RE

S shall be at least 4096. If S is less than 4096, then 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 LIST.

ISA0 shall be allocated 4096 Clusters.

Due to the fixed size of ISA0, it is preferred to allocate OSA0, OSA1, and ISA1 such that the size of ISA1 is at least twice the size of OSA0. Thus, when S > 4096, the preferred allocations for ISA1, OSA0, and OSA1 are given by the following:

$$SizeofOSA0 = SizeofOSA1 = 256 * IP\left(\frac{S - 4096}{4 * 256}\right)$$

and

$$SizeofISA1 = 256 * IP\left(\frac{S - 4096}{256}\right) - 2 * SizeofOSA0$$

6.3.3.5 Format Type = 31h (Format BD-RE without Spare Areas)

If the RENoSA bit is set to one in the Formattable Feature descriptor, Format Type 31h is supported. Format Type 31h specifies the drive to execute the formatting process with no Spare Area.

Table 43 - Format Descriptor (Format Type = 31h)

Byte \ Bit	7	6	5	4	3	2	1	0
0	(MSB)							
1	User Data Zone Size							
2								
3								(LSB)
4	Format Type = 31h						Sub-type	
5	(MSB)							
6	Block Length							
7								(LSB)

The User Data Zone size specifies the total number of user accessible blocks on all layers of the disc. The recommended value of this field for the mounted disc is obtained by READ FORMAT CAPACITIES command. The value of User Data Zone size field shall be less than or equal to the Number of Blocks field value in the Formattable Capacity Descriptor for the minimum Spare Area size, and shall be greater than or equal to the Number of Blocks field value in the Formattable Capacity Descriptor for the maximum Spare Area size.

Sub-type identifies certification to be performed as described in Table 45.

The Block Length specifies the length in bytes of each sector.

6.3.3.6 Format Type = 32h (Format BD-R with Spare Areas)

6.3.3.6.1 Overview

Format Type 32h permits formatting a BD-R disc in SRM+POW, SRM, or RRM. When formatted with Format Type 32h, the BD-R disc is required to allocate a non-zero number of spares.

Table 44 shows the Format Descriptor for Format Type 32h.

Table 44 - Format Descriptor (Format Type = 32h)

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB)							
1	Number of Blocks							
2								
3								(LSB)
4	Format Type = 32h						Format Sub-type	
	Type Dependent Parameters							
5	ISA_V	Reserved			Spare Area Distribution Parameter			
6	TDMA_V	Reserved			TDMA Distribution Parameter			
7	Reserved							

Number of Blocks contains the minimum number of LBAs that shall be formatted on the disc.

Format Sub-type selects a sub-type of format Type 32h.

Table 45 — Sub-type Field

Sub-type Value	Description
00b	SRM+POW
01b	SRM
10b	RRM
11b	Reserved

If ISA_V is set to one, the Spare Area Distribution Parameter is valid. If ISA_V is set to zero, a vendor specific default shall be assigned for the numeric value of the Spare Area Distribution Parameter.

The Drive shall interpret Spare Area Distribution Parameter as the integer between 1 and 15 that most nearly satisfies:

$$\frac{SpareAreaDistributionParameter}{16} = \frac{ISA0size + ISA1size}{TotalSAsize} = \frac{4096 + ISA1size}{S}$$

If TDMA_V is set to one, the TDMA Distribution Parameter is valid.

If TDMA_V is set to zero, a vendor specific default shall be assigned for the numeric value of the TDMA Distribution Parameter.

The Drive shall interpret TDMA Distribution Parameter as the nearest integer that satisfies:

$$\frac{TDMADistributionParameter}{16} = \frac{TDMAsize}{TotalSAsize}$$

Consequently,

$$TDMAsize = TotalSAsize * \frac{TDMADistributionParameter}{16}$$

6.3.3.6.2 Calculating Spare Size

Allocation rules for spare areas differ for disc size (i.e. 80mm or 120mm) and number of layers as shown in Table 46.

Table 46 — Maximum Spare Area Sizes on BD-R

Disc / Spare Area	80 mm Single Layer	80 mm Dual Layer	120 mm Single Layer	120 mm Dual Layer
ISA0[1]	4096	4096	4096	4096
OSA0[2]	65536	65536	196608	196608
OSA1[2]	-	65536	-	196608
ISA1[2]	-	16384	-	16384
Max Possible Allocatable Spares	4096	151552		413696

[1]The size of ISA0 is fixed at 4096 Clusters, regardless of size of number of layers.
[2]The spare area must be allocated in increments of 256 Clusters.

Format Type 32h requires that the Drive format the disc in order that the User Data Zone contains at least Number of Blocks. The number of spare Clusters allocated shall be at most:

$$S = 256 * IP\left(\frac{DataZoneSize - NumberOfBlocks}{256 * 32}\right)$$

where IP is the integer part of the result.

S is a count of Clusters that is an integral multiple of 256.

S shall be at least 4096. If S is less than 4096, then 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 LIST.

If the disc is single layer and S > 4096, then

$$ISA0size = 4096$$

and

$$OSA0size = MIN\left[MaxOSA0size, S - 4096\right].$$

If the disc is dual layer and S > 4096, then

$$ISA0size = 4096,$$

$$ISA1size = MIN\left[MaxISA1size, 256 * IP\left(\frac{\frac{S * SADP}{16} - 4096}{256} \right) \right],$$

and

$$OSA0size = OSA1size = MIN\left[MaxOSA0size, 256 * IP\left(\frac{S - 4096 - ISA1size}{2 * 256} \right) \right].$$

6.3.3.6.3 Calculating Additional TDMA Space

Spare area sizes must be determined prior to calculating the TDMA allocations.

Inner Zone TDMAs has a fixed size of 2048 Clusters each. Additional TDMA space is taken from the spare areas. The amount of each spare area that is allocated for TDMA is determined by the TDMA Distribution Parameter.

When the BD-R disc is single layer:

$TDMA0size = 2048$,

$$TDMA1Size = 256 * IP\left(\frac{4096 * TDMADistributionParameter}{16 * 256} \right),$$ and

$$TDMA2Size = 256 * IP\left(\frac{OSA0size * TDMADistributionParameter}{16 * 256} \right).$$

When the BD-R disc is dual layer:

$TDMA0size = 2048$,

$TDMA1size = 2048$,

$$TDMA2Size = 256 * IP\left(\frac{4096 * TDMADistributionParameter}{16 * 256} \right),$$

$$TDMA3Size = TDMA4size = 256 * IP\left(\frac{OSA0size * TDMADistributionParameter}{16 * 256} \right),$$ and

$$TDMA5Size = 256 * IP\left(\frac{ISA1size * TDMADistributionParameter}{16 * 256} \right).$$

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6.4 GET CONFIGURATION Command

The Core and Morphing Features require that this command be implemented. The BD-ROM Profile includes the Core Feature. From the Host's perspective, use of this command requires no special behavior from a Drive when the BD Read Feature is current.

See MMC-4 for a description of this command.

6.5 GET EVENT STATUS NOTIFICATION Command

The Core and Morphing Features require that this command be implemented. The BD-ROM Profile includes the Core Feature. From the Host's perspective, use of this command requires no special behavior from a Drive when the BD Read Feature is current.

Drives that support BD shall implement the Operational Change Event class, the Media Event class, the Device Busy class, and the Power Management Class Event.

See MMC-4 for a description of this command.

6.6 GET PERFORMANCE Command

The Real-time Streaming Feature requires that this command be implemented. The BD-ROM Profile
includes the Real-time Streaming Feature. From the Host's perspective, use of this command requires no special behavior from a Drive when the BD Read Feature is current.

See MMC-4 for a description of this command.

6.7 INQUIRY Command

The Core Feature requires that this command be implemented. The BD-ROM Profile includes the Core Feature. From the Host's perspective, use of this command requires no special behavior from a Drive when the BD Read Feature is current.

See MMC-4 for a description of this command.

6.8 MECHANISM STATUS Command

The Removable Medium Feature requires that this command be implemented. The BD-ROM Profile includes the Removable Medium Feature. From the Host's perspective, use of this command requires no special behavior from a Drive when the BD Read Feature is current.

See MMC-4 for a description of this command.

6.9 MODE SELECT (10) Command

The Core Feature and all other features that specify mode page support require that this command be implemented. The BD-ROM Profile includes the Core Feature. From the Host's perspective, use of this command requires no special behavior from a Drive when the BD Read Feature is current.

See MMC-4 for a description of this command.

6.10 MODE SENSE (10) Command

The Core Feature and all other features that specify mode page support require that this command be implemented. The BD-ROM Profile includes the Core Feature. From the Host's perspective, use of this command requires no special behavior from a Drive when the BD Read Feature is current.

See MMC-4 for a description of this command.

6.11 PREVENT ALLOW MEDIUM REMOVAL Command

The Removable Medium and Morphing Features requires that this command be implemented. The BD-ROM Profile includes the Removable Medium Feature. From the Host's perspective, use of this command requires no special behavior from a Drive when the BD Read Feature is current.

See MMC-4 for a description of this command.

6.12 READ (10) Command

The Random Readable and BD Read Features require that this command be implemented. The BD-ROM Profile includes those features. From the Host's perspective, use of this command requires no special behavior from a Drive when the BD Read Feature is current.

See MMC-4 for a description of this command.

6.13 READ (12) Command

The BD Read and Real-time Streaming Features require that this command be implemented. The BD-ROM Profile includes those features. From the Host's perspective, use of this command requires no special behavior from a Drive when the BD Read Feature is current.

See MMC-4 for a description of this command.

6.14 READ BUFFER CAPACITY Command

The Real-time Streaming Feature requires that this command be implemented. Each BD-R Profile includes the Real-time Streaming Feature. From the Host's perspective, use of this command requires no special behavior from the Drive.

See MMC-4 for a description of this command.

6.15 READ CAPACITY Command

The READ CAPACITY command provides a means for the Host to request information regarding the capacity of media currently loaded into the Drive. This capacity is reported with respect to reading operations. For capacity associated with writing operations, see 6.18, READ FORMAT CAPACITIES Command.

6.15.1 The CDB and Its Parameters

6.15.1.1 The CDB

The READ CAPACITY CDB is shown in Table 47.

Table 47 – READ CAPACITY CDB

Bit / Byte	7	6	5	4	3	2	1	0
0	OPERATION CODE (25h)							
1	Reserved							RelAdr=0
2	(MSB)							
3	Logical Block Address=0000 0000h							
4								
5								(LSB)
6	Reserved							
7	Reserved							
8	Reserved							PMI=0
9	Control							

6.15.1.2 RelAdr

The RelAdr field is not used by MM Drives and shall be set to zero.

6.15.1.3 Logical Block Address

The Logical Block Address field is not used by MM Drives and shall be set to zero.

6.15.1.4 PMI

The PMI field is not used by MM Drives and shall be set to zero.

6.15.2 Command Execution

The Drive shall respond to this command by returning eight bytes of READ CAPACITY response data. The format of response data is shown in Table 48.

Table 48 – READ CAPACITY Response Data

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB)							
1	Logical Block Address							
2								
3								(LSB)
4	(MSB)							
5	Block Length in Bytes = 2 048							
6								
7								(LSB)

The returned Logical Block Address is dependent upon media and format type according to Table 49.

Table 49 — READ CAPACITY LBA

BD Disc	Format	READ CAPACITY LBA
BD-ROM	-	The first PSN in the User Data Zone is 00100000h. The Last PSN of the User Data Zone, L, is specified in the DI. The READ CAPACITY LBA is L - 00100000h.
BD-RE	Unformatted	The command shall be terminated with CHECK CONDITION status and sense bytes SK/ASC/ASCQ shall be set to either MEDIUM ERROR/MEDIUM FORMAT CORRUPTED or MEDIUM ERROR/MEDIUM NOT FORMATTED
	Formatted	The DDS contains a field named: Last LSN of User Data Zone. The contents of that field is the READ CAPACITY LBA.
BD-R	Blank	Since no sectors are readable, the LBA reported is 00000000h
	SRM-POW	The LBA of the last addressable user data block (= Last Recorded Address) in the last track of the last complete session.
	RRM and SRM+POW	LBA of the last sector of the last writable Cluster in the User Data Zone. The (T)DDS contains a field named: Last LSN of User Data Zone. The contents of that field is the READ CAPACITY LBA.

6.16 READ DISC INFORMATION Command

The READ DISC INFORMATION command allows the Host to request information about the currently mounted MM disc.

When this command is required by an implemented Feature and media is present and ready, the command shall always function, even if that Feature's Current bit becomes zero.

6.16.1 The CDB and Its Parameters

The READ DISC INFORMATION CDB is shown in Table 50.

Table 50 – READ DISC INFORMATION CDB

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation Code (51h)							
1	Reserved						Data Type	
2	Reserved							
3	Reserved							
4	Reserved							
5	Reserved							
6	Reserved							
7	(MSB) Allocation Length							
8								(LSB)
9	Control Byte							

6.16.1.1 Data Type

When BD-R disc is present, Data Type defines the specific information requested. Defined data types are shown in Table 51.

Table 51 — Disc Information Data Types

Data Type	Returned Data
000b	Standard Disc Information
001b	Track Resources
010b	POW Resources
011b - 111b	Reserved

If Data Type is not zero and the currently mounted disc is not BD-R, the command shall be terminated with CHECK CONDITION status and sense bytes SK/ASC/ASCQ shall be set to ILLEGAL REQUEST/INVALID FIELD IN CDB.

6.16.1.2 Allocation Length

The number of Disc 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 Disc Information Data, only the available data is transferred.

6.16.2 Command Execution

6.16.2.1 Standard Disc Information

The Drive shall gather information about the medium, format it as shown in Table 52, and transfer to the Host, limited by the Allocation Length.

Table 52 – Standard Disc Information Block

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB) Disc Information Length							
1								(LSB)
2	Disc Information Data Type = 000b			Erasable	State of last Session		Disc Status	
3	Number of First Track on Disc							
4	Number of Sessions (Least Significant Byte)							
5	First Track Number in Last Session (Least Significant Byte)							
6	Last Track Number in Last Session (Least Significant Byte)							
7	DID_V	DBC_V	URU	DAC_V	Resv	DBit	BG Format Status	
8	Disc Type							
9	Number of Sessions (Most Significant Byte)							
10	First Track Number in Last Session (Most Significant Byte)							
11	Last Track Number in Last Session (Most Significant Byte)							
12	(MSB) Disc Identification							
13								
14								
15								(LSB)
16	(MSB) Last Session Lead-in Start Address							
17								
18								
19								(LSB)
20	(MSB) Last Possible Lead-out Start Address							
21								
22								
23								(LSB)
24	(MSB) Disc Bar Code							
...								
31								(LSB)
32	Disc Application Code							
33	Number of OPC Tables							
34 - n	OPC Table Entries							

Table 53 shows Standard Disc Information Block (DIB) values when the disc is a BD-ROM.

Table 53 – DIB of BD-ROM Discs

DIB Field	Value	Meaning
Erasable	ROM = 0b	BD-ROM is not recordable.
State of Last Session	Complete=11b	BD-ROM is always complete.
Disc Status	Finalized=10b	BD-ROM is always finalized.
Number of First Track on Disc	0001h	BD-ROM has exactly 1 logical track.
Number of Sessions	0001h	BD-ROM has exactly 1 session.
First Track Number in Last Session	0001h	BD-ROM has exactly 1 logical track.
Last Track Number in Last Session	0001h	BD-ROM has exactly 1 logical track.
DID_V	0b	BD-ROM does not have a Disc ID
DBC_V	0b	BD-ROM does not have a disc bar code
URU	1b	BD-ROM disc is unrestricted use
DAC_V	0b	BD-ROM does not have an Application Code.
Dbit	0b	BD-ROM is not Formattable
BG Status	00b	BD-ROM is not Formattable
Disc Type	00h	BD has no CD equivalent type.
Disc Identification	00000000h	BD has no CD equivalent type.
Last Session Lead-in Start Address	00000000h	BD-ROM is not recordable
Last Possible Lead-out Start Address	00000000h	BD-ROM is not recordable
Disc Bar Code	All zeros	BD does not have a disc bar code
Disc Application Code	00h	BD does not have an Application Code.
Number of OPC Table entries	0	BD-ROM is not recordable
OPC Table	None	BD-ROM is not recordable

Table 54 — DIB of BD-RE Discs

DIB Field	BD-RE	
	Value	**Meaning**
Erasable	RE = 1b	RE is rewritable.
State of Last Session	Empty = 00b Complete=11b	The last session of an unformatted RE is always empty. The last session of a formatted RE is always complete.
Disc Status	Blank = 00b Finalized=10b	An unformatted RE is empty. A formatted RE is always finalized.
Number of First Track on Disc	0001h	Formatted RE has exactly 1 logical track.
Number of Sessions	0001h	Formatted RE has exactly 1 session.
First Track Number in Last Session	0001h	Formatted RE has exactly 1 logical track.
Last Track Number in Last Session	0001h	Formatted RE has exactly 1 logical track.
DID_V	0b	BD does not have a Disc ID
DBC_V	0b	BD does not have a disc bar code
URU	0b	BD disc is unrestricted use
DAC_V	0b	BD does not have an Application Code.
Dbit	0b	RE always formats in foreground.
BG Status	00b	RE always formats in foreground.
Disc Type	00h	BD has no CD equivalent type.
Disc Identification	00000000h	BD has no CD equivalent type.
Last Session Lead-in Start Address	00000000h	RE is single session.
Last Possible Lead-out Start Address	Capacity	Number of blocks From READ FORMAT CAPACITIES maximum capacity descriptor
Disc Bar Code	All zeros	BD does not have a disc bar code
Disc Application Code	00h	BD does not have an Application Code.
Number of OPC Table entries	0	RE devices do not provide OPC info.
OPC Table	None	RE devices do not provide OPC info.

Table 55 shows Standard Disc Information Block (DIB) values when the disc is a blank BD-R.

Table 55 — DIB of a Blank BD-R Disc

DIB Field	Value	Meaning
Erasable	0b	R is not rewritable.
State of Last Session	Empty=00b	Empty Session
Disc Status	Empty=00b	Empty Disc
Number of First Track on Disc	0001h	A blank disc is assumed to be SRM
Number of Sessions	0001h	A blank disc is assumed to be SRM
First Track Number in Last Session	0001h	A blank disc is assumed to be SRM
Last Track Number in Last Session	0001h	A blank disc is assumed to be SRM
DID_V	0b	BD does not have a CD equivalent Disc ID
DBC_V	0b	BD does not have a bar codes
URU	1b	BD-R is an unrestricted use disc
DAC_V	0b	BD has no defined application code
Dbit	0b	BD-R is always formatted in foreground
BG Status	00b	BD-R is always formatted in foreground
Disc Type	00h	BD has no CD equivalent type
Disc Identification	00000000h	BD has no CD equivalent type
Last Session Lead-in Start Address	00000000h	BD-R SRM has no session lead-ins
Last Possible Lead-out Start Address	Capacity	Number of blocks From READ FORMAT CAPACITIES maximum capacity descriptor
Disc Bar Code	All zeros	BD does not have bar codes
Disc Application Code	00h	BD has no defined application code
Number of OPC Table entries	00h	BD-R Devices do not report OPC information
OPC Table	None	BD-R Devices do not report OPC information

Table 56 shows Standard Disc Information Block (DIB) values when the disc is BD-R formatted in either SRM or SRM+POW.

Table 56 — DIB of a BD-R Disc Formatted as SRM or SRM+POW

DIB Field	Value	Meaning
Erasable	0b	R is not rewritable.
State of Last Session	xxb	SRM-POW reports according to MMC-4. SRM+POW reports Incomplete session until the disc is closed.
Disc Status	01b	Incomplete disc until disc is closed.
Number of First Track on Disc	0001h	BD-R requires first track be numbered 1
Number of Sessions	S	Number of sessions indicated in SRRI.
First Track Number in Last Session	TLS1	Definition is unchanged from CD
Last Track Number in Last Session	TLSL	Definition is unchanged from CD
DID_V	0b	BD does not have a CD equivalent Disc ID
DBC_V	0b	BD does not have a bar codes
URU	1b	BD-R is an unrestricted use disc
DAC_V	0b	BD has no defined application code
Dbit	0b	BD-R is always formatted in foreground
BG Status	00b	BD-R is always formatted in foreground
Disc Type	00h	BD has no CD equivalent type
Disc Identification	00000000h	BD has no CD equivalent type
Last Session Lead-in Start Address	00000000h	BD-R SRM has no session lead-ins
Last Possible Lead-out Start Address	Capacity	Number of blocks From READ FORMAT CAPACITIES current capacity descriptor
Disc Bar Code	All zeros	BD does not have bar codes
Disc Application Code	00h	BD has no defined application code
Number of OPC Table entries	00h	BD-R Devices do not report OPC information
OPC Table	None	BD-R Devices do not report OPC information

Table 57 shows Standard Disc Information Block (DIB) values when the disc is BD-R formatted in RRM.

Table 57 — DIB of a BD-R Disc Formatted as RRM

DIB Field	Value	Meaning
Erasable	0b	R is not rewritable.
State of Last Session	01b	Incomplete session until disc is closed.
Disc Status	01b	Incomplete disc until disc is closed.
Number of First Track on Disc	0001h	RRM is not subdivided into tracks
Number of Sessions	0001h	RRM is not subdivided into sessions
First Track Number in Last Session	0001h	RRM is not subdivided into tracks
Last Track Number in Last Session	0001h	RRM is not subdivided into tracks
DID_V	0b	BD does not have a CD equivalent Disc ID
DBC_V	0b	BD does not have a bar codes
URU	1b	BD-R is an unrestricted use disc
DAC_V	0b	BD has no defined application code
Dbit	0b	BD-R is always formatted in foreground
BG Status	00b	BD-R is always formatted in foreground
Disc Type	00h	BD has no CD equivalent type
Disc Identification	00000000h	BD has no CD equivalent type
Last Session Lead-in Start Address	00000000h	BD-R RRM has no session lead-ins
Last Possible Lead-out Start Address	Capacity	Number of blocks From READ FORMAT CAPACITIES current capacity descriptor
Disc Bar Code	All zeros	BD does not have bar codes
Disc Application Code	00h	BD has no defined application code
Number of OPC Table entries	00h	BD-R Devices do not report OPC information
OPC Table	None	BD-R Devices do not report OPC information

6.16.2.2 Format of Track Resources Disc Information

The format of the Track Resources Disc Information is shown in Table 58.

Table 58 — Track Resources Disc Information Block

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB) Disc Information Length = 14							
1								(LSB)
2	Disc Information Data Type = 001b			Reserved				
3	Reserved							
4	(MSB) Maximum possible number of the Tracks on the disc							
5								(LSB)
6	(MSB) Number of the assigned Tracks on the disc							
7								(LSB)
8	(MSB) Maximum possible number of appendable Tracks on the disc							
9								(LSB)
10	(MSB) Current number of appendable Tracks on the disc							
11								(LSB)
12	Reserved							
13	Reserved							
14	Reserved							
15	Reserved							

On BD-R, the Maximum possible number of the Tracks on the disc is fixed at 7927.

On BD-R, Number of the assigned Tracks on the disc is the number of active entries in the SRRI.

On BD-R, Maximum possible number of appendable Tracks on the disc is 16.

On BD-R, Current number of appendable Tracks on the disc is the currently number of open Logical Tracks.

6.16.2.3 Format of POW Resources Disc Information

The format of the POW Resources Disc Information is shown in Table 59.

Table 59 — POW Resources Disc Information Block

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB) Disc Information Length = 18							
1								(LSB)
2	Disc Information Data Type = 010b			Reserved				
3	Reserved							
4	(MSB)							
5	Remaining POW Replacements							
6								
7								(LSB)
8	(MSB)							
9	Remaining POW Reallocation Map Entries							
10								
11								(LSB)
12	(MSB)							
13	Number of Remaining POW Updates							
14								
15								(LSB)

On BD-R, the Remaining POW Replacements is the sum of all the Free Blocks fields of all the Track Information Blocks (See 6.20, READ TRACK INFORMATION Command) divided by Cluster size in Logical Blocks (32). This is the number of potential POWs that may be performed.

On BD-R, Remaining POW Reallocation Map Entries is the number of unused entries in the TDFL.

On BD-R, Number of Remaining POW Updates is the number of unused Clusters in the TDMAs.

6.17 READ DISC STRUCTURE Command

The READ DISC STRUCTURE command requests that the Drive transfer to the Host information about the currently mounted disc.

6.17.1 The CDB and Its Parameters

The READ DISC STRUCTURE CDB is shown in Table 60.

Table 60 – READ DISC STRUCTURE CDB

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation Code (ADh)							
1	Reserved				Media Type			
2	(MSB)							
3	Address							
4								
5								(LSB)
6	Layer Number							
7	Format Code							
8	(MSB)			Allocation Length				
9								(LSB)
10	Reserved							
11	Control							

6.17.1.1 Media Type

The Media Type field identifies the Media Type to which this command is directed. The BD disc type is 0001b. The Media Type for all other media is 0000b.

6.17.1.2 Address

Use and definition of the Address field is dependent upon the Format Code.

6.17.1.3 Layer Number

Use and definition of the Layer Number field is dependent upon the Format field value.

6.17.1.4 Format Code when Media Type = 0001b

The Format Code (Table 61) indicates the type of information that is requested by the Host.

Table 61 - Format Code Definitions

Format Code	Structure	Address	Layer Number	Description
00h	DI	-	Layer	Disc Information from PIC in Embossed area • Address field is reserved • Layer field specifies layer for DI read
01h — 07h	Reserved	-	-	-
08h	DDS	-	-	Disc Definition Structure
09h	Cartridge Status	-	-	Cartridge status.
0Ah	Spare Area Information	-	-	Status of Spare Areas
0Bh - 11h	Reserved	-	-	-
12h	Raw DFL	Offset	-	Unmodified DFL
13h — 2Fh	Reserved	-	-	-
30h	PAC	ID and Format Number	-	Physical Access Control Structure
31h — BFh	Reserved	-	-	-
C0h	Write Protection Status	-	-	Generic Write Protection status
C1h —FEh	Reserved	-	-	-
FFh	Structure List	-	-	BD Structure list

6.17.1.5 Allocation Length

The Allocation Length field specifies the maximum number of bytes that may be returned by the Drive. An Allocation Length of zero shall not be considered an error.

6.17.2 Command Execution

6.17.2.1 General

If the READ DISC STRUCTURE CDB validation permits execution of the command, the Drive shall collect the request information and return it to the Host according to the general formatting shown in Table 62.

Table 62 – BD Structure Returned Data Format

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB)			Data Structure Length = N+2				
1								(LSB)
2	Reserved							
3	Reserved							
Disc Structure Data								
0	Returned Data							
1								
…								
N-1								

6.17.2.2 Format Code 00h: Disc Information (DI)

Disc Information and Emergency Brake data shall be read from the PIC zone. DI units that contain physical information shall be returned. Emergency Brake data shall be returned. The information shall be collected from the layer specified in the Layer field of the CDB. If any data can be returned, 4 100 bytes shall be returned.

The Disc Information structure format is shown in Table 63.

Table 63 – BD Structure Format Code 00h: Disc Information

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB) Data Structure Length = 4 098							
1								(LSB)
2	Reserved							
3	Reserved							
Disc Information								
0	Disc Information Data							
1								
…								
4095								

The format of the Disc Information Data is shown in Table 64.

Table 64 — Disc Information Data Format

Fields	BD-ROM Field Size	BD-R/RE Field Size
Disc Information (DI) Units	2048	3584
Emergency Brake (EB) Data	2048	512

The general format of a DI unit is shown in Table 65.

Table 65 — General DI Unit Format

	DI Unit on ROM		DI Unit on R/RE		Field
	Offset	Size	Offset	Size	
Header	0	2	0	2	Disc Information Identifier "DI"
	2	1	2	1	Disc Information Format
	3	1	3	1	Number of DI units in each DI block
	4	1	4	1	Reserved (each byte set to 00h)
	5	1	5	1	DI unit Sequence Number
	6	1	6	1	Number of bytes in use in this DI unit
	7	1	7	1	Reserved (each byte set to 00h)
Body	8	3	8	3	Disc Type Identifier
	11	1	11	1	Disc Size/Class/Version
	12	52	12	100	DI Unit Format dependent contents
Trailer	-	-	100	6	Disc Manufacturer ID
	-	-	106	3	Media Type ID
	-	-	109	2	Time Stamp
	-	-	111	1	Product Revision Number

= "BDO" for BD-ROM

= "BDW" for BD-RE

= "BDR" for BD-R

The DI Unit Format dependent contents are disc specific. For detailed definition of the BD-ROM DI unit, see *System Description Blu-ray Disc Read-only Format, Part 1 Basic Format Specifications*. For detailed definition of the BD-R DI unit, see *System Description Blu-ray Disc Recordable Format, Part 1 Basic Format Specifications*. For detailed definition of the BD-RE DI unit, see *System Description Blu-ray Disc Rewritable Format, Part 1 Basic Format Specifications*.

6.17.2.3 Format Code 08h: Disc Definition Structure (DDS)

The DDS is a disc management structure that contains basic disc usage parameters for BD-R and BD-RE. The minimum defined size for the DDS is 60 bytes. The DDS definition is permitted to expand to 2048 bytes.

There is no DDS defined for BD-ROM. If the DDS is requested for any disc that has no DDS defined, the command shall be terminated with CHECK CONDITION status and sense bytes SK/ASC/ASCQ shall be set to ILLEGAL REQUEST/INVALID FIELD IN CDB.

On BD-RE, the DDS is written into the DMA zones. See *System Description Blu-ray Disc Rewritable Format, Part 1 Basic Format Specifications* for detailed format of the DDS.

On BD-R, the DDS is written only when the disc is finalized. Prior to finalization, the DDS is represented by the TDDS that is recorded in a TDMA. If the disc is not finalized, the structure returned shall be the most recent version found in the current TDMA. See *System Description Blu-ray Disc Recordable Format, Part 1 Basic Format Specifications* for detailed format of the DDS on BD-R.

The DDS structure format is shown in Table 66.

Table 66 — BD Structure Format Code 08h: Disc Definition Structure

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB) Data Structure Length							
1								(LSB)
2	Reserved							
3	Reserved							
Disc Definition Structure								
0	DDS Data							
1								
…								
N-1								

The general format of the DDS is shown in Table 67.

Table 67 —Format of the DDS

Byte Offset	Field	Number of Bytes
0	(T)DDS Identifier "DS"	2
2	DDS format	1
3	Reserved	1
4	DDS Update Count	4
8	Reserved	8
16	First PSN of Drive Area	4
20	Reserved	4
24	First PSN of Defect List	4
28	Reserved	4
32	PSN of LSN 0 of user area	4
36	PSN of Last LSN of user area	4
40	ISA0 size	4

Byte Offset	Field	Number of Bytes
44	OSA size	4
48	ISA1 size	4
52	Spare Area full flags	1
53	Reserved	1
54	Disc Type specific field	1
55	Reserved	1
56	Disc Type specific field	4
60	Reserved	4
64	Status bits of INFO1/2 and PAC1/2 on L0 and L1	32
96	Disc Type specific data	···

6.17.2.4 Format Code 09h: Cartridge Status

The Medium Status structure (Table 68) includes information about cartridge status.

Table 68 — BD Format Structure Code 09h: Cartridge Status

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB)			Data Structure Length = 6				
1								(LSB)
2	Reserved							
3	Reserved							
	Medium Status Structure							
0	Cartridge	OUT	Reserved			CWP	Reserved	
1	Reserved							
2	Reserved							
3	Reserved							

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 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.

6.17.2.5 Format Code 0Ah: Spare Area Information

The Spare Area Information structure contains status information about the defect management systems spare blocks on BD-R and BD-RE discs. The format of the Spare Area Information structure is shown in Table 69.

Table 69 — Format Code 0Ah: Spare Area Information

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB)			Data Structure Length = 000Eh				
1								(LSB)
2	Reserved							
3	Reserved							
Spare Area Information								
0	(MSB)							
...				Reserved				
3								(LSB)
4	(MSB)							
...				Number of Free Spare Blocks				
7								(LSB)
8	(MSB)							
...				Number of Allocated Spare Blocks				
11								(LSB)

Number of free Spare blocks field is the number of unused spare blocks that are not considered defective in the Spare Areas.

Number of Allocated Spare blocks is the number of spare blocks reserved on the disc as defective block replacements.

6.17.2.6 Format Code 12h: Raw Defect List (DFL)

The DFL is a defect management structure on BD-R and BD-RE discs that identifies the locations and status of known defective Clusters on the disc. There is no DFL defined for BD-ROM. If the DFL is requested for any disc that has no DFL defined, the command shall be terminated with CHECK CONDITION status and sense bytes SK/ASC/ASCQ shall be set to ILLEGAL REQUEST/INVALID FIELD IN CDB.

The DFL is a defect management structure that identifies the locations and status of known defective Clusters on the disc. The length of the DFL is variable. The minimum defined size is 72 bytes. The DFL may occupy as many as 8 Clusters (524 288 bytes). The actual length of the DFL is recorded in the DFL header.

On BD-R, the DFL is written only when the disc is finalized. Prior to finalization, the DFL is represented by the TDFL that is recorded in a TDMA. If the disc is not finalized, the structure returned shall be the most recent version found in the current TDMA.

The DFL is viewed as being contained within 16 packages (numbered from 0 through 15), each 32K (32 768) bytes in length. The Address field in the CDB is used to address a specific package. If the Address field value is larger than 15, the command shall be terminated with CHECK CONDITION and sense bytes SK/ASC/ASCQ shall be set to indicate ILLEGAL REQUEST/INVALID FIELD IN CDB. It is only possible to read a single package with one command. In order to read the entire DFL it is necessary to read all of the DFL packages.

The DFL structure format is shown in Table 70.

Table 70 — BD Structure Format Code 12h: Defect List

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB)			Data Structure Length				
1								(LSB)
2	Reserved							
3	Number of Packages in DFL							
Defect List Structure								
0	DFL Data from addressed package							
1								
…								
N-1								

The Host is required to read packages 0 through "Number of Packages in DFL" - 1 in order to receive all of the DFL.

The Data Structure Length is the number of bytes that follow the Data Structure Length field. The maximum value for this field is 32770 (a complete package + 2). If Data Structure Length = 0002h, the addressed DFL package is empty.

The general DFL format is shown in Table 71.

Table 71 — General DFL Format

Field Offset	Contents	Field Size
0	DFL Identifier "DL"	2
2	DFL format	1
3	Reserved	1
4	DFL Update Count	4
8	Reserved	4
12	Number of DFL Entries	4
16	Disc Type Specific information	48
64	Defect Entries - eight bytes each	...

See *System Description Blu-ray Disc Recordable Format, Part 1 Basic Format Specifications* for detailed format of the DFL on BD-R. See *System Description Blu-ray Disc Rewritable Format, Part 1 Basic Format Specifications* for detailed format of the DFL on BD-RE.

6.17.2.7 Format Code 30h: Physical Access Control (PAC)

6.17.2.7.1 General

Physical Access Control (PAC) Clusters are provided as structures on the disc to include additional information for interchange between interchange parties. PAC Clusters shall be recorded in the INFO1/PAC1 Area. Backup copies shall be recorded in the INFO2/PAC2 Area. The format for all PACs is shown in Table 2.

The specific PAC ID and format number of the PAC addressed by the READ DISC STRUCTURE command is contained the Address field of the CDB as shown in Table 72.

Table 72 — PAC ID and Format Number in CDB Address Field

Byte	Field
2	(MSB)
3	PAC ID
4	(LSB)
5	Format Number

Valid values for the PAC ID and Format Number fields are shown in Table 73.

Table 73 — PAC ID and Format Number Fields

PAC		Definition
ID	Format	
000000h	00h	Return a list of PAC headers of all PACs that are written on the currently mounted disc. The list shall be given in ascending order according to PAC ID.
	01h - FFh	Reserved
000001h - FFFFFEh	00h - FFh	The PAC information of the addressed PAC shall be returned.
FFFFFFh	00h - FEh	Reserved
	FFh	Return a list of PAC headers of all PACs that are known to the Drive. The list shall be given in ascending order according to PAC ID.

In the case that the PAC ID and Format Number requested are both zero, the Drive shall return a list of the headers of all PACs that are written on the currently mounted disc. The PAC headers shall be ordered according to PAC ID.

Table 74 — Returned Data Format for PAC ID/Format = 000000h/00h

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB)			Data Structure Length = 384*N+2				
1								(LSB)
2	Reserved							
3	Reserved							
PAC Header List								
0	Header of first written PAC							
...								
383								
384	...							
...								
384*(N-1)	Header of Nth written PAC							
...								
384*N-1								

In the case that the PAC ID/Format Number requested is neither 000000h/00h nor FFFFFFh/FFh, the Drive shall return the most recently recorded copy of the requested PAC. If reading the PAC is not permitted, then only the PAC header shall be returned. If there is no PAC with the specified ID and Format Number, the command shall be terminated with CHECK CONDITION status and sense bytes SK/ASC/ASCQ shall be set to indicate ILLEGAL REQUEST/INVALID FIELD IN CDB. The format of returned PAC data is shown in Table 75.

Table 75 — Returned Data Format for 000001h ≤ PAC ID ≤ FFFFFEh

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB)			Data Structure Length				
1								(LSB)
2	Reserved							
3	Reserved							
PAC								
0	PAC Header							
...								
383								
384	PAC Specific Information							
...								
N-1								

The length of a PAC is at most 63488 bytes (31 logical blocks).

In the case that the PAC ID requested is FFFFFFFFh, the Drive shall return a list of the PAC IDs of all PACs that are known to the Drive. The list shall be ordered according to PAC ID in ascending order.

Table 76 — Returned Data Format for PAC ID = FFFFFFFFh

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB)			Data Structure Length = 4*(N-1)+2				
1								(LSB)
2	Reserved							
3	Reserved							
PAC Header List								
0	PAC ID and Format of first known PAC							
...								
3								
4	...							
...								
...								
4*(N-2)	PAC ID and Format of Nth known PAC							
...								
4*(N-1)-1								

6.17.2.7.2 Primary PAC

The Primary PAC (PAC ID = 50524Dh ("PRM"), PAC Format = 00h) shall be included on each BD-ROM and BD-RE. The Primary PAC is not defined for BD-R.

See *System Description Blu-ray Disc Read-only Format, Part 1 Basic Format Specifications* for detailed format of the Primary PAC on BD-ROM. See *System Description Blu-ray Disc Rewritable Format, Part 1 Basic Format Specifications* for detailed format of the Primary PAC on BD-RE.

The format of the Primary PAC structure is shown in Table 77.

Table 77 — Primary PAC

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB) Data Structure Length = N+2							
1								(LSB)
2	Reserved							
3	Reserved							
Primary PAC Data								
0	PAC Data							
1								
…								
N-1								

The maximum value for N is 404 on BD-ROM and 32768 on BD-RE.

6.17.2.7.3 Disc Write Protect PAC

The Disc Write Protect (DWP) PAC Cluster is used to protect a disc against unintended write actions or write actions by unauthorized persons. For the case where the disc is protected against write actions by unauthorized persons, a password can be included. Recognition and reading the DWP PAC is mandatory.

The format of the Disc Write Protect PAC structure is shown in Table 78.

Table 78 — DWP PAC

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB) Data Structure Length = 430							
1								(LSB)
2	Reserved							
3	Reserved							
DWP PAC Data								
0	DWP PAC Header							
1								
…								
383								
384	Known PAC Entire_Disc_Flags							
385	Reserved							
386	Reserved							
387	Reserved							
388	Write Protect Control Byte (see Table 3 and **Error! Reference source not found.**)							
389 - 395	Reserved							
396 - 427	Write Protect Password							

The Write Protect Password field is zero filled prior to transfer of this structure.

The length of a DWP PAC is 428 bytes.

6.17.2.8 Format Code C0h: Write Protection Status

The Write protection status is returned in the format as shown in Table 79.

Table 79 – READ DVD STRUCTURE Data Format (Format field = C0h)

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB)			Data Structure Length = 6				
1								(LSB)
2	Reserved							
3	Reserved							
	Write Protection Status							
0	Reserved				MSWI	CWP	PWP	SWPP
1	Reserved							
2	Reserved							
3	Reserved							

The Data Structure Length field shall be set to 6.

If Software Write Protection until Power down (SWPP) is set to one, the software write protection is active. If SWPP is set to zero, the software write protection is inactive. If the Logical Unit does not support SWPP, this bit shall be set to zero.

If Persistent Write Protection (PWP) is set to one, the media surface is set to write protected status. If PWP is set to zero, 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.

If Write Inhibit is implemented via a WDCB, then any write inhibit action specified in the WDCB shall result in PWP set to one.

If Write Protect is implemented via a DWP PAC, then any write inhibit action specified in the DWP PAC shall result in PWP set to one.

If Media Cartridge Write Protection (CWP) is set to one, the write protect switch/tabs on a cartridge is set to write protected state. If CWP bit is set to zero, the write protect switch/tabs on a cartridge is set to write permitted state. If there is no cartridge or if the cartridge has no CWP function, CWP shall be set to zero.

The Media Specific Write Inhibition (MSWI) bit of one indicates that any writing is inhibited by some media specific condition. The MSWI bit of zero indicates that writing is not inhibited by the media specific reason.

6.17.2.9 Format Code FFh: BD Structure List

The BD Structure List is returned in the format as shown in Table 80.

Table 80 — BD Structure Format Code FFh: BD Structure List

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB)			Data Structure Length				
1								(LSB)
2	Reserved							
3	Reserved							
BD Structure List								
0 - n	Structure List							

The Data Structure Length specifies the length in bytes of the following BD STRUCTURE data that is available to be transferred to the Host. The Data Structure Length value does not include the Data Structure Length field itself.

The Structure List is returned as a sequence of Structure List Entries as shown in Table 81.

Note: This BD Structure is generated by the Drive rather than read from the medium. Consequently, this structure shall be returned regardless of media presence.

Table 81 — 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 BD Structure that is readable/writable via the READ/SEND DISC STRUCTURE commands.

The SDS bit, when set to zero, shall indicate that the BD structure is not writable via the SEND DISC STRUCTURE command. When set to one, shall indicate that the BD structure is writable via the SEND DISC STRUCTURE command.

The RDS bit, when set to zero, shall indicate that the BD structure is not readable via the READ DISC STRUCTURE command. When set to one, shall indicate that the BD structure is readable via the READ DISC STRUCTURE command.

The Structure Length field shall specify the length of the BD Structure that is identified by the Format Code.

6.18 READ FORMAT CAPACITIES Command

The READ FORMAT CAPACITIES command allows the Host to request a list of the possible format capacities for an installed writable media. This command also has the capability to report the writable capacity for a media when it is installed.

6.18.1 The CDB and Its Parameters

The READ FORMAT CAPACITIES CDB is shown in Table 82.

Table 82 — READ FORMAT CAPACITIES CDB

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation Code (23h)							
1	Reserved							
2	Reserved							
3	Reserved							
4	Reserved							
5	Reserved							
6	Reserved							
7	(MSB) Allocation Length							
8								(LSB)
9	Control							

The Allocation Length field specifies the maximum number of bytes that an 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 Drive shall terminate the data transfer when Allocation Length bytes have been transferred or when all available data have been transferred to the Host, whatever is less.

6.18.2 Command Execution

The Drive shall construct a set of data structures that shall be transferred to the Host. The format of this returned data is a 4-byte header followed by some non-zero number of 8-byte format descriptors as shown in Table 83.

Table 83 — 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 1							
..								
7								
….								
0	Formattable Capacity Descriptor n							
..								
7								

6.18.2.1 Capacity List Header

The Capacity List Header (Table 84) precedes all other returned data.

Table 84 — Capacity List Header

Bit / Byte	7	6	5	4	3	2	1	0
0	Reserved							
1	Reserved							
2	Reserved							
3	Capacity List Length							

The Capacity List Length specifies the length in bytes of the available 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 < 31.

6.18.2.2 Current/Maximum Capacity Descriptor

The Current/Maximum Capacity Descriptor (Table 85) shall appear after the header.

Table 85 — Current/Maximum Capacity Descriptor

Bit / Byte	7	6	5	4	3	2	1	0
4	(MSB)							
5	Number of Blocks							
6								
7								(LSB)
8	Reserved						Descriptor Type	
9	(MSB)							
10	Block Length/Spare Area Size							
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 Block Length/Spare Area Size definition is media specific.

For BD-R, the specific field values are shown in Table 86.

Table 86 — Current/Maximum Capacity Descriptor for BD-R

Descriptor Type	Format Status	Number of Blocks	Block Length/Spare Area Size
00b	Reserved		
01b	Unformatted Media	The reported value is the total number of blocks of the Data Zone(s) on the mounted BD disc	Maximum number of Spare Area Clusters allowed for the currently mounted BD-R disc.
10b	Formatted Media	The reported value is the current media's total number of blocks in User Data Zone(s).	Number of Clusters allocated for Spare Area on the currently mounted BD-R disc.
11b	No Media Present	The reported value is for the maximum capacity of a media that the Drive is capable of reading.	Block Length that specifies the length in bytes of each logical blocks. 800h for Multi-Media devices.

For BD-R, the specific field values are shown in Table 87.

Table 87 – Current/Maximum Capacity Descriptor for BD-RE

Descriptor Type	Format Status	Number of Blocks	Block Length/Spare Area Size
00b	Reserved		
01b	Unformatted Media	The reported value is the total number of blocks of the Data Zone(s) on the mounted BD disc	Maximum number of Spare Area Clusters allowed for the currently mounted BD-RE disc.
10b	Formatted Media	The reported value is the current media's total number of blocks in User Data Zone(s).	Number of Clusters allocated for Spare Area on the currently mounted BD-RE disc.
11b	No Media Present	The reported value is for the maximum capacity of a media that the Logical Unit is capable of reading.	Block Length that specifies the length in bytes of each logical blocks. 800h for Multi-Media devices.

6.18.2.3 Formattable Capacity Descriptor(s)

The Drive shall return only Formattable Capacity Descriptors (Table 88) that apply to the installed media. If there is no medium installed, the Drive shall return only the Current/Maximum Capacity Descriptor, with the maximum capacity of a medium that the Drive is capable of reading.

Table 88 — Formattable Capacity Descriptor

Bit / Byte	7	6	5	4	3	2	1	0
4	(MSB)							
5	Number of Blocks							
6								
7								(LSB)
8	Format Type						Reserved	
9	(MSB)							
10	Type Dependent Parameter							
11								(LSB)

A Formattable Capacity Descriptor of Format Type 00h shall be reported if any other Formattable Capacity Descriptor is reported. The Drive may not support type 0 (e.g. CD-RW).

If the currently mounted media is neither BD-R nor BD-RE, refer to MMC-4 for the permitted Formattable Capacity Descriptors.

When a BD-RE or BD-R Profile is current the format descriptors shown in Table 89 shall be returned.

Table 89 — Format Descriptors Returned for BD-R and BD-RE

Format Type	Description	Type Dependent Parameter
00h (BD-R)	When the currently mounted media is a blank BD-R disc, the descriptor shall contain the total number of addressable blocks and the block size used for formatting the whole media. Spares shall be allocated. All parameters in the descriptor are vendor selected default values for BD-R discs.	Total Spare Area size in Clusters
00h (BD-RE)	When the currently mounted media is a BD-RE disc, the descriptor shall contain the total number of addressable blocks and the block size used for formatting the whole media. Spares shall be allocated. All parameters in the descriptor are vendor selected default values for BD-RE discs. The following are recommended Spare area distributions: For 80mm SL BD-RE discs: ISA0 size = 4096 Clusters and OSA0 size = 0 Clusters. For 80mm DL BD-RE discs: ISA0 size = ISA1 size = 4096 Clusters and OSA0 size = OSA1 size = 0 Clusters. For 120mm SL BD-RE discs: ISA0 size = 4096 Clusters and OSA0 size = 8192 Clusters. For 120mm DL BD-RE discs: ISA0 size = ISA1 size = 4096 Clusters and OSA0 size = OSA1 size = 8192 Clusters.	Total Spare Area size in Clusters
01h (BD-RE)	The descriptor shall contain the minimum User Data Zone size in sectors. and the block size used for formatting the whole media. This Format Type is used to expand a Spare Area.	Block length in bytes
30h (BD-RE)	The descriptor shall contain the total number of addressable blocks and the total number of Spare Area size used for formatting the whole media. Three descriptors are reported: The first descriptor values are vendor preferred for the BD device. The second descriptor values are selected to reflect maximum Spare Area sizes: For 80mm SL BD-RE discs, ISA0 size = 4096 Clusters and OSA0 size = 0 Clusters. For 80mm DL BD-RE discs, ISA0 size = 4096 Clusters, ISA1 size = 16384 Clusters and OSA0 size = OSA1 size = 0 Clusters. For 120mm SL BD-RE discs, ISA0 size = 4096 Clusters and OSA0 size = 16384 Clusters. For 120mm DL BD-RE discs, ISA0 size = 4096 Clusters, OSA0 size = OSA1 size = 8192 Clusters, and ISA1 size = 16384 Clusters. The third descriptor values are selected to reflect minimum Spare Area size. For 80mm, 120mm SL and DL BD-RE discs, ISA0 size = 4096 and ISA1 size = OSA0 size = OSA1 size = 0 Clusters.	Total Spare Area size in Clusters
31h (BD-RE)	The descriptor shall contain the total number of addressable blocks and the block size used for formatting the whole media. All parameters in the descriptor is for the format with no Spare Area. By using this parameter in FORMAT UNIT command, the Hardware Defect Management Feature (and consequently, Removable Disk Profile) becomes not Current.	Block length in bytes
32h (BD-R)	The descriptor shall contain the total number of addressable blocks and the total number of Spare Area sizes used for formatting the whole media. Three descriptors are reported: The first descriptor values are vendor preferred for the BD device. The second descriptor values are selected to reflect maximum Spare Area sizes, resulting in minimum User Data Zone size. The third descriptor values are selected to reflect minimum (but non-zero) Spare Area size, resulting in maximum User Data Zone size.	Set to zeros

6.19 READ TOC/PMA/ATIP Command

READ TOC/PMA/ATIP (Table 90) is a CD function that has been adapted to other media. For BD discs, returned data shall be fabricated by the Drive. The information returned is minimized and may have no relationship to media structure.

6.19.1 The CDB and Its Parameters

The READ TOC/PMA/ATIP CDB is shown in Table 90.

Table 90 – READ TOC/PMA/ATIP CDB

Bit / Byte	7	6	5	4	3	2	1	0
0	OPERATION CODE (43h)							
1	Reserved						MSF	Reserved
2	Reserved				Format			
3	Reserved							
4	Reserved							
5	Reserved							
6	Track/Session Number							
7	(MSB) Allocation Length							
8	(LSB)							
9	Control							

6.19.1.1 MSF bit

When MSF is set to zero, the address fields in returned data formats shall be in LBA form. When MSF is set to one, the address fields in returned data formats shall be in MSF form.

6.19.1.2 Format field

The Format field is used to select a specific returned data format. For BD discs, only Format 0 and Format 1 are valid. If a BD disc is present and the Format code is neither 0 nor 1, the command shall be terminated with CHECK CONDITION status and sense bytes SK/ASC/ASCQ shall be set to ILLEGAL REQUEST/INVALID FIELD IN CDB.

6.19.1.3 Track/Session Number field

Track/Session Number shall be set to either zero or one when a BD disc is present. If Track/Session Number is neither zero nor one, the command shall be terminated with CHECK CONDITION status and sense bytes SK/ASC/ASCQ shall be set to ILLEGAL REQUEST/INVALID FIELD IN CDB.

6.19.1.4 Allocation Length

The Allocation Length field specifies the maximum number of bytes that may be returned by the Drive. An Allocation Length of zero shall not be considered an error.

6.19.2 Command Execution

The READ TOC/PMA/ATIP command was originally designed for CD media. For BD discs the returned data is fabricated.

6.19.2.1 Format 0: Track List

6.19.2.1.1 BD-ROM

A BD-ROM disc is viewed shall be reported as a single track, single session disc. TOC Format 0 shall have the format shown in Table 91.

Table 91 – TOC Data Format 0: Data Returned for formatted BD-ROM disc

	Byte(s)	Field	Value
Header	0, 1	TOC Data Length	0012h
	2	First Track	01h
	3	Last Track	01h
Track 1 Descriptor	4	Reserved	00h
	5	ADR/CTL	14h
	6	Track Number	01h
	7	Reserved	00h
	8-11	Track Start Address	LBA form = 000000h, MSF form = 00:02:00
Track AAh (Lead-out) Descriptor	12/20	Reserved	00h
	13/21	ADR/CTL	14h
	14/22	Track Number	AAh
	15/23	Reserved	00h
	16-19/ 24-27	Track Start Address	LBA form = READ CAPACITY LBA + 1 MSF form = MSF translation of LBA form with a maximum MSF address of 00h, FFh, 3Bh, 4Ah

6.19.2.1.2 Blank BD-RE

A blank BD-RE disc has no structure to report. If the currently mounted media is an unformatted BD-RE, the command shall be terminated with CHECK CONDITION status and sense bytes SK/ASC/ASCQ shall be set to ILLEGAL REQUEST/INCOMPATIBLE MEDIUM INSTALLED.

6.19.2.1.3 Formatted BD-RE

A formatted BD-RE disc shall be reported as a single track, single session disc. TOC Format 0 shall have the format shown in Table 91.

6.19.2.1.4 Blank BD-R

A blank BD-R disc has no structure to report. If the currently mounted media is a blank BD-R, the command shall be terminated with CHECK CONDITION status and sense bytes SK/ASC/ASCQ shall be set to ILLEGAL REQUEST/INCOMPATIBLE MEDIUM INSTALLED.

6.19.2.1.5 BD-R RRM

A BD-R disc formatted in RRM shall be reported as a single track, single session disc. TOC Format 0 shall have the format shown in Table 91.

6.19.2.1.6 BD-R and BD-R SRM

The READ TOC/PMA/ATIP command was originally designed for CD media. Since the lead-out is reported as Logical Track AAh (=170, at most 169 Logical Tracks can be reported). Accurately adapting this command to BD-R formatted in SRM or SRM+POW cannot be done, so the returned data is fabricated to maximize backward compatibility without being limited by the Logical Track number range.

Based upon format, the disc shall be viewed as shown in Table 92.

Table 92 — BD-R Track Translation for READ TOC/PMA/ATIP

BD-R Format	TOC Fabrication
Blank disc	Terminate the command with CHECK CONDITION status and set SK/ASC/ASCQ values to ILLEGAL REQUEST/INVALID FIELD IN CDB.
SRM-POW, one open session	Terminate the command with CHECK CONDITION status and set SK/ASC/ASCQ values to ILLEGAL REQUEST/INVALID FIELD IN CDB.
SRM-POW, one closed session	The one closed session is Viewed as one track.
SRM-POW, N > 1 Closed Sessions	The concatenation of the first N-1 sessions is viewed as Track 1. Session N (the last closed session) is viewed as Track 2.
SRM+POW	A disc formatted as SRM+POW is viewed as a closed disc with one session. The session is viewed as Track 1.

TOC fabrication for SRM-POW and SRM+POW as shown in Table 93.

Table 93 — TOC Data Format 0: Data Returned for formatted BD-R discs

	Byte(s)	Field	Value
Header	0, 1	TOC Data Length	0012h (or 001Ah if Track 2 Descriptor is present)
	2	First Track	01h
	3	Last Track	01h (or 02h if Track 2 Descriptor is present)
Track 1 Descriptor	4	Reserved	00h
	5	ADR/CTL	14h
	6	Track Number	01h
	7	Reserved	00h
	8-11	Track Start Address	LBA form = 000000h, MSF form = 00:02:00
Track 2 Descriptor (if present)	12	Reserved	00h
	13	ADR/CTL	14h
	14	Track Number	02h
	15	Reserved	00h
	16-19	Track Start Address	LBA form = Start LBA of last closed session. MSF form = MSF translation of LBA form with a maximum MSF address of 00h, FFh, 3Bh, 4Ah
Track AAh (Lead-out) Descriptor	12/20	Reserved	00h
	13/21	ADR/CTL	14h
	14/22	Track Number	AAh
	15/23	Reserved	00h
	16-19/ 24-27	Track Start Address	LBA form = READ CAPACITY LBA + 1 MSF form = MSF translation of LBA form with a maximum MSF address of 00h, FFh, 3Bh, 4Ah

6.19.2.2 Format 1: Session Information

When a BD-ROM, formatted BD-R, and BD-RE is present, the TOC Format 1 returned data shall have the format shown in Table 94.

Table 94 – TOC Data Format 1: Data Returned for BD Discs

	Byte(s)	Field	Value
Header	0, 1	TOC Data Length	000Ah
	2	First Session Number	01h
	3	Last Session Number	01h
Track Descriptor	4	Reserved	00h
	5	ADR/CTL	14h
	6	First Track Number in Last Complete Session	01h
	7	Reserved	00h
	8 - 11	Track Start Address	LBA form = 000000h, MSF form = 00:02:00

6.20 READ TRACK INFORMATION Command

The READ TRACK INFORMATION Command provides information about a logical track.

When this command is required by an implemented Feature, the command shall always function, even if that Feature's Current bit becomes zero.

6.20.1 The CDB and Its Parameters

The READ TRACK INFORMATION CDB is shown in Table 95.

Table 95 – READ TRACK INFORMATION CDB

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation Code (52h)							
1	Reserved					Open	Address/Number Type	
2	(MSB)							
3	Logical Block Address/							
4	Track/Session Number							
5								(LSB)
6	Reserved							
7	(MSB)			Allocation Length				
8								(LSB)
9	Control Byte							

6.20.1.1 Open

On BD-R discs formatted as SRM or SRM+POW, Open permits locating an Open Logical Track.

6.20.1.2 Address/Number Type

The Address/Number Type field in byte 1 is used to specify the contents of the Logical Block Address/Track/Session Number field, bytes 2 through 5 of the CDB. See Table 96.

6.20.1.3 Logical Block Address/Track/Session Number Fields

The Logical Block Address/Track/Session Number field either directly or indirectly specifies a logical track number, T_A. See Table 96.

Table 96 —Addressed Track (T_A) According to LBA/Track/Session Number Field

Address/ Number Type field	Logical Block Address/Track/Session Number	Description
00b	Logical Block Address (LBA)	MAX = Last Possible Lead-out Start Address as returned by the READ DISC INFORMATION command. If LBA ≥ MAX, the command shall be terminated with CHECK CONDITION status and sense bytes SK/ASC/ ASCQ shall be set to ILLEGAL REQUEST/LOGICAL BLOCK ADDRESS OUT OF RANGE. Otherwise, LBA lies within some logical track, T_A.
01b	Logical track number (LTN)	T_M = Last Track Number in the Last Session as returned by the READ DISC INFORMATION command. If LTN > T_M, the command shall be terminated with CHECK CONDITION status and sense bytes SK/ASC/ASCQ shall be set to ILLEGAL REQUEST/INVALID FIELD IN CDB. Otherwise, T_A = LTN.
10b	Session Number (S_N)	S_M is the Number of Sessions as returned by the READ DISC INFORMATION command. If S_N > S_M, the command shall be terminated with CHECK CONDITION status and sense bytes SK/ASC/ASCQ shall be set to ILLEGAL REQUEST/INVALID FIELD IN CDB. Otherwise the T_A = the first logical track in session S_N.
11b	Reserved	

6.20.1.4 Determining the Specific Logical Track

When the currently mounted disc is either BD-ROM, formatted BD-RE, or BD-R formatted as RRM, then T_A is only permitted to be 1. If the currently mounted disc is either BD-ROM, formatted BD-RE, or BD-R formatted as RRM, and T_A is not 1, then command shall be terminated with CHECK CONDITION status and sense bytes SK/ASC/ASCQ shall be set to ILLEGAL REQUEST/ INVALID FIELD IN CDB.

For BD-R formatted as either SRM or SRM+POW, there are potentially 3 logical track numbers to be determined: T, T_A , and T_O.

1. T is the Logical Track number for which Track Information shall be returned.
2. The Address/Number Type and the Logical Block Address/Track/Session Number fields specify an addressed logical track, T_A.
3. T_O is the smallest track number such that T_O is open and $T_A \leq T_O$. If the disc contains no open tracks, then T_O shall be set to FFFFh.

If Open is set to zero, then $T = T_A$. If Open is set to one, then T shall be set to T_O.

6.20.1.5 Allocation Length

The number of Track Information Block bytes returned is limited by the Allocation Length field of the CDB. An Allocation Length of zero is not an error.

6.20.2 Command Execution

The Drive shall collect the information requested by the Host into a Track Information Block structure, and transfer to the Host, restricted by Allocation Length.

The format and content of the Track Information Block is shown in Table 97.

Table 97 – Track Information Block

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB) Data Length							
1								(LSB)
2	Track Number (Least Significant Byte)							
3	Session Number (Least Significant Byte)							
4	Reserved							
5	Reserved		Damage	Copy	Track Mode			
6	RT	Blank	Packet/Inc	FP	Data Mode			
7	Reserved						LRA_V	NWA_V
8	(MSB) Track Start Address							
9								
10								
11								(LSB)
12	(MSB) Next Writable Address							
13								
14								
15								(LSB)
16	(MSB) Free Blocks							
17								
18								
19								(LSB)
20	(MSB) Fixed Packet Size/ Blocking Factor							
21								
22								
23								(LSB)
24	(MSB) Track Size							
25								
26								
27								(LSB)
28	(MSB) Last Recorded Address							
29								
30								
31								(LSB)
32	Track Number (Most Significant Byte)							
33	Session Number (Most Significant Byte)							
34	Reserved							
35	Reserved							
36	(MSB) Read Compatibility LBA							
…								
39								(LSB)

Table 98 shows required content when BD-ROM disc is present.

Table 98 –TIB Fields for BD-ROM Discs

TIB Field	Value	Meaning
Track Number	1	BD-ROM is always one track
Session Number	1	BD-ROM is always one session
Damage	0b	Not used by BD-ROM and shall be 0b
Copy	0b	Not used by BD-ROM and shall be 0b
Track Mode	4h	BD sectors approximate CD track mode 4
RT	1b	The BD-ROM track is always reserved.
Blank	0b	The BD-ROM track is never blank.
Packet/Inc	1b	Recording is incremental by Cluster
FP	0b	FP has no meaning on BD-ROM
Data Mode	1h	BD sectors approximate CD data mode 1
LRA_V	0	Not used by BD-ROM and shall be 0b
NWA_V	0	Not used by BD-ROM and shall be 0b
Track Start Address	00000000h	Not used by BD-ROM and shall be zeros
Next Writable Address	00000000h	Not used by BD-ROM and shall be zeros
Free Blocks	00000000h	Not used by BD-ROM and shall be zeros
Fixed Packet Size/Blocking Factor	00000020h	Cluster size in sectors
Track Size	READ CAPACITY LBA + 1	BD-ROM is always one track
Last Recorded Address	00000000h	Not used by BD-ROM and shall be zeros
Read Compatibility LBA	00000000h	Not used by BD-ROM and shall be zeros

Table 99 describes TIB fields when the currently mounted disc is SRM.

Table 99 — TIB Fields for a Disc Formatted as SRM

TIB Field	Value	Meaning
Track Number	T	Current Track Number: 1 ≤ T ≤ 7927
Session Number	S	Current Session Number: 1 ≤ S ≤ 7927
Damage	xb	Default value is zero. Set to 1 only when Drive cannot recover most recent copy of TDMS.
Copy	0b	Not used by BD-R and shall be 0b
Track Mode	4h	BD sectors approximate CD track mode 4
RT	0b	The invisible/incomplete track
	1b	Track is not invisible/incomplete
Blank	0b	When Track NWA = Track Start Address
	1b	When Track NWA ≠ Track Start Address
Packet/Inc	1b	Recording is incremental by Cluster
FP	0b	FP has no meaning on BD-ROM
Data Mode	1h	BD sectors approximate CD data mode 1
LRA_V	xb	Specifies validity of LRA field. Shall be set to zero when format is SRM+POW.
NWA_V	xb	Specifies validity of NWA field
Track Start Address	SLBA	LBA of first user block in track.
Next Writable Address	NWA	Append LBA for track
Free Blocks	FB	Number of blocks in track from NWA until end
Fixed Packet Size/Blocking Factor	00000020h	Cluster size in sectors
Track Size	N - SLBA	If T+1 exists, then N = SLBA of T+1. If T+1 does not exist, then N = READ CAPACITY LBA+1.
Last Recorded Address	LRA	LBA of last block appended with Host supplied data
Read Compatibility LBA	00000000h	This field is not used by BD devices and shall be 00000000h

Table 100 describes TIB fields when the currently mounted disc is RRM.

Table 100 —TIB Fields for a BD-R Disc Formatted as RRM

TIB Field	Value	Meaning
Track Number	1	BD-R RRM is viewed as one track
Session Number	1	BD-R RRM is viewed as one session
Damage	x	Default value is zero. Set to 1 only when Drive cannot recover most recent copy of TDMS.
Copy	0	Not used by BD-R and shall be 0b
Track Mode	4h	BD sectors approximate CD track mode 4
RT	0b	Not used by BD-R and shall be 0b
Blank	1b	A formatted RRM disc is not blank
Packet/Inc	1b	Recording is incremental by Cluster
FP	1b	Recording is incremental by Cluster
Data Mode	1h	BD sectors approximate CD data mode 1
LRA_V	0	Not used by BD-R RRM and shall be 0b
NWA_V	0	Not used by BD-R RRM and shall be 0b
Track Start Address	00000000h	Not used by Random Writable devices
Next Writable Address	00000000h	Not used by Random Writable devices
Free Blocks	00000000h	Not used by Random Writable devices
Fixed Packet Size/Blocking Factor	00000020h	Cluster size in sectors
Track Size	CAP + 1	CAP = LBA from READ CAPACITY command
Last Recorded Address	00000000h	This field is not used for RRM discs.
Read Compatibility LBA	00000000h	This field is not used by BD devices.

Table 101 shows required content when BD-RE disc is present.

Table 101 – TIB Fields for BD-RE Discs

TIB Field	Value	Meaning
Track Number	1	BD-RE is viewed as one track
Session Number	1	BD-RE is viewed as one session
Damage	0b	Not used by BD-RE and shall be 0b
Copy	0b	Not used by BD-RE and shall be 0b
Track Mode	4h	BD sectors approximate CD track mode 4
RT	0b	Not used by BD-RE and shall be 0b
Blank	1b	When the BD-RE disc is blank, Blank = 1.
	0b	Once formatted, Blank = 0.
Packet/Inc	1b	Recording is incremental by Cluster
FP	0b	FP has no meaning on BD-RE
Data Mode	1b	BD sectors approximate CD data mode 1
LRA_V	0b	Not used by BD-RE and shall be 0b
NWA_V	0b	Not used by BD-RE and shall be 0b
Track Start Address	00000000h	Not used by Random Writable devices
Next Writable Address	00000000h	Not used by Random Writable devices
Free Blocks	00000000h	Not used by Random Writable devices
Fixed Packet Size/Blocking Factor	00000020h	Cluster size in sectors
Track Size	CAP + 1	CAP = LBA from READ CAPACITY command
Last Recorded Address	00000000h	This field is not used by BD-RE devices and shall be 00000000h
Read Compatibility LBA	00000000h	This field is not used by BD-RE devices and shall be 00000000h

6.21 REQUEST SENSE Command

The Core Feature requires that this command be implemented. The BD-ROM Profile includes the Core Feature. From the Host's perspective, use of this command requires no special behavior from a Drive when the BD Read Feature is current.

See MMC-4 for a description of this command.

6.22 RESERVE TRACK Command

6.22.1 Introduction

The RESERVE TRACK command allows creation of a new logical track.

6.22.2 The CDB and Its Parameters

The RESERVE TRACK CDB is shown in Table 102.

Table 102 — RESERVE TRACK CDB

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation Code (53h)							
1	Reserved							ARSV
2	Logical Track Reservation Parameter							
3								
4								
5								
6								
7								
8								
9	Control							

If the currently mounted disc is BD-R formatted as RRM, the command shall be terminated with CHECK CONDITION status and SK/ASC/ASCQ values shall be set to ILLEGAL REQUEST/ CANNOT WRITE MEDIUM/INCOMPATIBLE FORMAT.

If the currently mounted disc is BD-R - either blank or formatted as SRM and ARSV is set to zero, the Logical Track Reservation Parameter is Reservation Size as shown in Table 103. The Reservation Size is the number of user blocks desired for the track reservation. The actual number of blocks allocated is calculated according to the currently mounted media. Rounding up is permitted. For BD-R, rounding shall be to the next Cluster boundary. In all cases, if Reservation Size is larger than available space, the command shall be terminated with CHECK CONDITION status and SK/ASC/ASCQ values shall be set to ILLEGAL REQUEST/ INVALID FIELD IN CDB.

If Reservation Size is set to zero, the command shall be terminated with CHECK CONDITION status and SK/ASC/ASCQ values shall be set to ILLEGAL REQUEST/ INVALID FIELD IN CDB.

Table 103 — Reservation Size form of Logical Track Reservation Parameter

Bit / Byte	7	6	5	4	3	2	1	0
0	Reserved							
1	Reserved							
2	Reserved							
3	(MSB) Reservation Size							
4								
5								
6								(LSB)

If the currently mounted disc is BD-R - either blank or formatted as SRM and ARSV is set to one, the Reservation Size/LBA field is Reservation LBA as shown in Table 104. If Reservation by LBA is not supported for the currently mounted disc, then the command shall be terminated with CHECK CONDITION status and SK/ASC/ASCQ values shall be set to ILLEGAL REQUEST/INVALID FIELD IN CDB.

Table 104 — LBA form of Logical Track Reservation Parameter

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB)							
1	Logical Block Address							
2								
3								(LSB)
4	Reserved							
5	Reserved							
6	Reserved							

Otherwise a new logical track is created with Start LBA set to the Reservation LBA unless:

1. If Reservation LBA is greater than the largest possible user data area LBA for this disc, the command shall be the command shall be terminated with CHECK CONDITION status and SK/ASC/ASCQ values shall be set to ILLEGAL REQUEST/ LOGICAL BLOCK ADDRESS OUT OF RANGE.
2. Logical Tracks on BD-R shall begin with the first block of a Cluster. If the LBA is not the address of the first block of a Cluster, the command shall be terminated with CHECK CONDITION status and SK/ASC/ASCQ values shall be set to ILLEGAL REQUEST/ INVALID FIELD IN CDB.
3. The second track of a split shall be blank. If the track is closed or Reservation LBA is less than the NWA of the logical track that contains the LBA, then the command shall be terminated with CHECK CONDITION status and SK/ASC/ASCQ values shall be set to ILLEGAL REQUEST/INVALID ADDRESS FOR WRITE.
4. It is not permitted to use track splitting to create a Logical Track with a length less than 32. If Reservation LBA = Logical Track Start Address of any Logical Track, then the command shall be terminated with CHECK CONDITION status and SK/ASC/ASCQ values shall be set to ILLEGAL REQUEST/ INVALID FIELD IN CDB.

6.22.3 Command Execution

6.22.3.1 Logical Track Creation by Number of Blocks

A new logical track shall be created from the invisible/incomplete track as shown in Table 105.

Table 105 — Track Creation from the Invisible/Incomplete Track

Logical Track	Invisible/Incomplete Track Prior to Reservation	New Logical Track	Invisible/Incomplete Track After Reservation
Track Number	N[1]	N	N+1
Start LBA	A[2]	A	A+L
Length	RC[3]-A	L	RC-(A+L)

[1] N is at least 1. The maximum value is media type dependent.
[2] LBA A may be any valid LBA within any logical track. On BD-R, A shall be the LBA of the first block of a Cluster.
[3] RC is the recordable capacity of the media. If the largest possible recordable LBA is CAP, then RC = CAP + 1.

6.22.3.2 Logical Track Creation by LBA (Track Splitting)

When a logical track is split by specifying the start LBA of the new track, the new logical track shall be blank. If Reservation LBA is in logical track N, then the new track with start address equal to Reservation LBA shall be numbered N+1. If M is a logical track and M > N prior to the track split, then it shall be numbered M+1 after the track split.

6.23 SEND DISC STRUCTURE Command

The SEND DISC STRUCTURE command provides a means for the Host to transfer BD STRUCTURE data to the Drive.

6.23.1 The CDB and Its Parameters

The SEND DISC STRUCTURE CDB is shown in Table 106.

Table 106 — SEND DISC STRUCTURE Command Descriptor Block

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation Code (BFh)							
1	Reserved				Media Type			
2	Reserved							
3	Reserved							
4	Reserved							
5	Reserved							
6	Reserved							
7	Format							
8	(MSB) Parameter List Length							
9								(LSB)
10	Reserved							
11	Control							

6.23.1.1 Media Type

The Media Type field identifies the Media Type to which this command is directed. The BD disc type is 0001b.

6.23.1.2 Format

Table 107 shows the valid Format field values when Media Type is set to 0001b.

Table 107 — Format Field Definitions for Media Type = 0001b

Format	Data	Description
0Fh	Timestamp	Send Timestamp data
30h	PAC	Send PAC data

6.23.1.3 Parameter List Length

The Parameter List Length field specifies the length in bytes of the DISC STRUCTURE data to be transferred from the Host to the Drive after the CDB is transferred. A Structure Data Length field of zero indicates that no data shall be transferred. This condition shall not be considered an error.

6.23.2 Command Execution

The description of the command execution is dependent upon the Format field of the CDB.

6.23.2.1 Format Code = 0Fh: Timestamp

The format of Timestamp field is structured as shown in Table 108.

The time should be current UTC (Universal Coordinated Time) 24 hour clock.

Table 108 — SEND DISC STRUCTURE Data Format (Format Code = 0Fh)

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

The Data Structure Length field specifies the length in bytes of the Timestamp Data to follow. A Data Structure Length field of zero indicates that no Disc Timestamp Data shall be transferred. This condition shall not be considered an error.

The Year field shall specify the year encoded according to ISO/IEC 646 in the range “0001” to “9999”.

The Month field shall specify the month of the year encoded according to ISO/IEC 646 in the range “01” to “12”.

The Day field shall specify the day of the month encoded according to ISO/IEC 646 in the range “01” to “31”.

The Hour field shall specify the hour of the day encoded according to ISO/IEC 646 in the range “00” to “23”.

The Minute field shall specify the minute of the hour encoded according to ISO/IEC 646 in the range “00” to “59”.

The Second field shall specify the second of the minute encoded according to ISO/IEC 646 in the range “00” to “59”.

6.23.2.2 Format Code 30h: Physical Access Control (PAC)

6.23.2.2.1 General

Physical Access Control (PAC) Clusters are provided as a structure on the disc to include additional information for interchange between interchange parties. PAC Clusters shall be recorded in the INFO1/PAC1 Area and backup copies shall be recorded in the INFO2/PAC2 Area. The format of PAC data provided by the Host is shown in Table 109.

Table 109 — Physical Access Control Send Data Format

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB) Data Structure Length = N+2							
1								(LSB)
2	Reserved							Erase
3	Reserved							
PAC Structure								
0	PAC Header							
...								
383								
384	PAC Specific Information							
...								
N-1								

If the Erase bit is set to zero, the remainder of the structure contains the PAC Cluster content that should be written to the media.

If the Erase bit is set to one, each occurrence of a PAC with the PAC ID matching the PAC ID in the CDB shall be erased (on BD-RE) or invalidated (on BD-R). The PAC information following the disc structure header shall be ignored.

The Drive shall neither record nor erase any PAC that is unknown to the Drive.
The value for N (PAC structure size) is at least 384 and at most 63488.

6.23.2.2.2 DWP PAC

The Disc Write Protect (DWP) PAC Cluster is used to protect a disc against unintended write actions or write actions by unauthorized persons. For the case where the disc is protected against write actions by unauthorized persons, a password can be included. Recognition and reading the DWP PAC is mandatory. Writing the DWP PAC is optional. If the Drive does not support writing the DWP PAC, the command shall be terminated with CHECK CONDITION status and sense bytes SK/ASC/ASCQ shall be set to ILLEGAL REQUEST/INVALID FIELD IN CDB..

The format of the Disc Write Protect PAC structure is shown Table 110.

Table 110 — DWP PAC

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB)			Data Structure Length = 430				
1								(LSB)
2	Reserved						VWE	Erase
3	Reserved							
DWP PAC Data								
0	DWP PAC Header							
1								
…								
383								
384	Known PAC Entire_Disc_Flags							
385	Reserved							
386	Reserved							
387	Reserved							
388	Write Protect Control Byte (see Table 3 and **Error! Reference source not found.**)							
389 - 395	Reserved							
396 - 427	Write Protect Password							

The VWE (Virtual Write Enable) bit is used to enable or disable writing to a virtually write protected disc. When VWE is set to 1, the Host is requesting the ability to write on a virtually write protected disc. This is a temporary write capability, a media change or drive reset will cause the system to return to a write protected state. When VWE is set to 0, it indicates that the host is rescinding temporary write ability.

If the Erase bit is defined as in the general case specified in 6.23.2.2.1.

If there is a current valid Write Protect Password on the disc, then the Drive shall process this request only if the Write Protect Password field matches the Password on the disc.

The length of a DWP PAC is 428 bytes.

6.24 SEND OPC INFORMATION Command

The SEND OPC INFORMATION command descriptor block (Table 111) allows the Host to request that the Drive perform Optimum Power Calibration (OPC) on the currently mounted medium.

Table 111 — SEND OPC INFORMATION Command Descriptor Block

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation Code (54h)							
1	Reserved							DoOpc
2	Reserved						Exclude1	Exclude0
3	Reserved							
4	Reserved							
5	Reserved							
6	Reserved							
7	(MSB) Parameter List Length							
8								(LSB)
9	Control							

If DoOpc is set to one, the Drive shall determine OPC values for the current recording conditions. It may be necessary to perform an OPC operation. These OPC values shall become current. When DoOpc is set to one, the Parameter List Length field is ignored.

If DoOpc is set to zero, the Drive shall perform no OPC operation.

Exclude0 and Exclude1 allow the Host to select the layers to be calibrated.

Table 112 shows the behavior given various combinations of control bits from byte 1.

Table 112 — Drive Action with Combinations of DoOPC, Exclude0, and Exclude1

DoOpc	Exclude0	Exclude1	Drive Response
1	0	0	Perform OPC operation on each layer to set OPC values for current media speed.
1	0	1	Perform OPC operation only on layer 0 to set OPC values for current media speed.
1	1	0	Perform OPC operation only on layer 1 to set OPC values for current media speed.
1	1	1	No operation — GOOD status shall be returned
0	x	x	If Parameter List Length is zero, no operation — GOOD status shall be returned.

If the mounted media is not a recordable dual layer media supported by the Drive and either Exclude0 or Exclude1 is non-zero, then the command shall be terminated with CHECK CONDITION status and sense bytes SK/ASC/ASCQ shall be set to ILLEGAL REQUEST/INVALID FIELD IN CDB.

BD-R Drives do not support receiving OPC information from the Host. If Parameter List Length is not zero, the command shall be terminated with CHECK CONDITION status and sense bytes SK/ASC/ASCQ shall be set to ILLEGAL REQUEST/INVALID FIELD IN CDB.

6.25 SET READ-AHEAD Command

The Real-time Streaming Feature requires that this command be implemented. The BD-ROM Profile
includes the Real-time Streaming Feature. From the Host's perspective, use of this command requires no special behavior from a Drive when the BD Read Feature is current.

See MMC-4 for a description of this command.

6.26 SET STREAMING Command

The Real-time Streaming Feature requires that this command be implemented. The BD-ROM Profile includes the Real-time Streaming Feature. From the Host's perspective, use of this command requires no special behavior from a Drive when the BD Read Feature is current.

See MMC-4 for a description of this command.

6.27 START STOP UNIT Command

The Removable Medium and Power Management Features require that this command be implemented. The BD-ROM Profile includes those features. From the Host's perspective, use of this command requires no special behavior from a Drive when the BD Read Feature is current.

See MMC-4 for a description of this command.

6.28 SYNCHRONIZE CACHE Command

The Incremental Streaming Writable Feature requires that this command be implemented. Each BD-R Profile includes the Incremental Streaming Writable Feature. From the Host's perspective, use of this command requires no special behavior from the Drive.

See MMC-4 for a description of this command.

6.29 TEST UNIT READY Command

The Core Feature requires that this command be implemented. The BD-ROM Profile includes the Core Feature. From the Host's perspective, use of this command requires no special behavior from a Drive when the BD Read Feature is current.

See MMC-4 for a description of this command.

6.30 VERIFY (10) Command

The Formattable Feature requires that this command be implemented. Each BD-R Profile includes the Formattable Feature. From the Host's perspective, use of this command requires no special behavior from the Drive.

See MMC-4 for a description of this command.

6.31 WRITE (10) Command

The WRITE (10) Command requests that the Drive write Host provided data to the medium.

6.31.1 The CDB and its Parameters

The WRITE (10) CDB is shown in Table 113.

Table 113 — WRITE (10) CDB

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation Code (2Ah)							
1	Reserved			DPO	FUA	Reserved		RelAdr
2	(MSB)							
3	Logical Block Address							
4								
5								(LSB)
6	Reserved							
7	(MSB)							
8	Transfer Length							(LSB)
9	Control							

6.31.1.1 DPO

Disable Page Out (DPO) is not used by MM Drives and shall be set to zero.

6.31.1.2 FUA

A FUA (force unit access) bit, set to one, indicates that the Drive shall access the media in performing the command prior to returning GOOD status. 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. WRITE commands shall not return GOOD status until the logical blocks have actually been written on the media, and the Write process is complete. This mode may not operate correctly with a sequence of writes intended to produce a continuous stream unless command queuing is implemented

A FUA bit of zero indicates that the Drive may satisfy the command by accessing the cache memory. For WRITE operations, logical blocks may be transferred directly to the cache memory. GOOD status may be returned to the Host prior to writing the logical blocks to the medium. Any error that occurs after the GOOD status is returned is a deferred error, and information regarding the error is not reported until the following command.

6.31.1.3 RelAdr

RelAdr (Relative Address) is not used by MM Drives and shall be set to zero.

6.31.1.4 Logical Block Address

The Logical Block Address field specifies the logical block where the write operation shall begin. If Starting Logical Block Address is not within the range specified by the READ CAPACITY command response, the command shall be terminated with CHECK CONDITION status and sense bytes SK/ASC/ASCQ shall be set to ILLEGAL REQUEST/LOGICAL BLOCK ADDRESS OUT OF RANGE.

6.31.1.5 Transfer Length

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.

6.31.2 Command Execution

6.31.2.1 BD-RE

No change from Removable Disk Profile behavior. Since this includes the Random Writable Feature with a write block size of 2048 bytes. This requires that the Drive implement a read-modify-write process in order to support random logical block writing.

6.31.2.2 BD-R RRM

If the LBA of any block in the write range has already been written, the command shall be terminated with CHECK CONDITION and SK/ASC/ASCQ values shall be set to ILLEGAL REQUEST/INVALID ADDRESS FOR WRITE.

6.31.2.3 BD-R SRM

If the Logical Block Address field is not the NWA of some open Logical Track, then the command shall be terminated with CHECK CONDITION status and SK/ASC/ASCQ values shall be set to ILLEGAL REQUEST/INVALID ADDRESS FOR WRITE.

Data from a previous write command(s) may be buffered for recording to Logical Track N. If the current WRITE command starts with the NWA of Logical Track M ≠ N, then it is recommended that the Drive pad the buffered data to a Cluster boundary and flush to the disc prior to buffering for data for append to Logical Track M.

If the FUA bit is set to 1 all data supplied from this command shall be recorded prior to returning command status. If the data for last block of this command is not stored in sector 31 of the targeted Cluster, the Drive shall append padding blocks until the end of the Cluster.

6.31.2.4 BD-R SRM Flush Conditions

If a sequence of appending write commands leaves the last Cluster buffer only partially filled, the Drive shall typically wait for additional appending write commands in order to complete filling the Cluster buffer. If instead, a different disc accessing command is received, the Cluster buffer shall be padded with zeros and written to the disc prior to executing the new command. This is called flushing the Cluster. If the new command is:

TEST UNIT READY,
READ TRACK INFORMATION,
GET EVENT/STATUS NOTIFICATION,
GET CONFIGURATION,
REQUEST SENSE,
INQUIRY, or
READ BUFFER CAPACITY,

the command shall be executed to completion and the Cluster shall not be flushed.

TDMS updates are not typically performed each time the TDMS changes. Updates are collected and performed at some vendor specific time. If a

CLOSE TRACK/SESSION command,
FORMAT UNIT command,
RESERVE TRACK command,
SEND DISC STRUCTURE command,(PAC),
SYNCHRONIZE CACHE command, or
START STOP UNIT command (Eject, Sleep)

is received while TDMS changes are pending, the TDMS shall be updated prior to executing any subsequent WRITE command.

6.32 WRITE (12) Command

The WRITE (12) command requests that the Drive write Host data to the medium. In order to achieve correct operation, the Drive may require information from the Write Parameters Mode Page.

6.32.1 The CDB and Its Parameters

The WRITE (12) CDB is shown in Table 114.

Table 114 — WRITE (12) CDB

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation Code (AAh)							
1	Reserved				FUA	Reserved		
2	(MSB)							
3	Logical Block Address							
4								
5								(LSB)
6	(MSB)							
7	Transfer Length							
8								
9								(LSB)
10	Streaming	VNR	Reserved					
11	Control							

6.32.1.1 FUA

A FUA (Force Unit Access) bit, set to one, indicates that the Drive shall access the media in performing the command prior to returning GOOD status. 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. WRITE commands shall not return GOOD status until the logical blocks have actually been written on the media, and the Write process is complete. This mode may not operate correctly with a sequence of writes intended to produce a continuous stream unless command queuing is implemented

A FUA bit of zero indicates that the Drive may satisfy the command by accessing the cache memory. For WRITE operations, logical blocks may be transferred directly to the cache memory. GOOD status may be returned to the Host prior to writing the logical blocks to the medium. Any error that occurs after the GOOD status is returned is a deferred error, and information regarding the error is not reported until the following command.

6.32.1.2 Logical Block Address

The Logical Block Address field specifies the logical block where the write operation shall begin. If Starting Logical Block Address is not within the range specified by the READ CAPACITY command response, the command shall be terminated with CHECK CONDITION status and sense bytes SK/ASC/ASCQ shall be set to ILLEGAL REQUEST/LOGICAL BLOCK ADDRESS OUT OF RANGE.

6.32.1.3 Transfer Length

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.

6.32.1.4 Streaming

According to MMC-4.

6.32.1.5 VNR

6.32.1.5.1 When the Currently Mounted Disc is not BD-R

VNR is applicable only to BD-R. The Drive shall ignore VNR when the currently mounted media is not BD-R.

6.32.1.5.2 When the Currently Mounted Disc is BD-R

If the Hardware Defect Management feature is current, non-streamed writes should be verified by the Drive in an automatic, verify-after-write process. Some applications may be designed to expect behavior associated with Drives and media that do not automatically perform verify-after-write (e.g. write-once media without spare areas). The VNR (Verify-Not-Required) bit provides a method by which the Drive can provide both behaviors.

If Streaming is set to one, VNR has no meaning.

If Streaming is set to zero and VNR is set to one, the default behavior of automatic verify-after-write functions are unchanged.

If Streaming is set to zero and VNR is set to one, the default automatic verify-after-write functions in the BD-R Drive should be disabled.

6.32.1.6 Blocking Factor

The Start LBA and the Transfer Length identify a logical track into which the data is to be written. The Track Information for that logical track identifies a Blocking Factor. When the Host issues the command with the Streaming bit set to one, the values of the Starting Logical Block Address and the Transfer Length fields shall each be an integral multiple of the Blocking factor. If either the Starting Logical Block Address field or the Transfer Length field is not set to an integral multiple of the Blocking Factor, the command shall be terminated with CHECK CONDITION status and sense bytes SK/ASC/ASCQ shall be set to ILLEGAL REQUEST/INVALID FIELD IN CDB.

6.32.2 Command Execution

See 6.31.2.

6.33 WRITE AND VERIFY (10) Command

The WRITE AND VERIFY (10) command requests that the Drive write the data transferred from the Host to the medium and then verify that the data is correctly written.

6.33.1 The CDB and Its Parameters

The WRITE AND VERIFY (10) CDB is shown in Table 115.

Table 115 — WRITE AND VERIFY (10) CDB

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation Code (2Eh)							
1	Reserved							
2	(MSB)							
3	Starting Logical Block Address							
4								
5								(LSB)
6	Reserved							
7	(MSB)			Transfer Length				
8								(LSB)
9	Control							

6.33.1.1 Starting Logical Block Address

Starting Logical Block Address references the block at which the operation shall begin.

6.33.1.2 Transfer Length

Transfer length 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.

6.33.2 Command Execution

Writing shall be according to the description of the WRITE (10) command when the FUA bit is set to one. Verify Error Recovery Mode Page parameters are not supported by MM Drives. The Drive shall utilize the Read/Write Error Recovery Mode Page as verify parameters. The AWRE and ARRE bits shall control automatic reallocation.

7 Mode Parameters for BD Devices

7.1 Mode Parameter List

The presence of the BD-ROM Profile causes no change in either the Mode Parameter List or Mode Parameter List Header.

See MMC-4 for a description of this mode page.

7.2 Read/Write Error Recovery Parameters Mode Page (Page Code 01h)

The BD-ROM Profile requires the support of this mode page in the Random Readable Feature. From the Host's perspective, use of this mode page requires no special behavior from a Drive when the BD-ROM Profile is current.

See MMC-4 for a description of this mode page.

7.3 Power Condition Page (Page Code 1Ah)

The Power Management Feature requires that this mode page be implemented. The BD-ROM Profile includes the Power Management Feature. From the Host's perspective, use of this mode page requires no special behavior from a Drive when the BD-ROM Profile is current.

See MMC-4 for a description of this mode page.

7.4 Timeout and Protect Page (Page Code 1Dh)

The Timeout Feature requires that this mode page be implemented. The BD-ROM Profile includes the Timeout Feature. From the Host's perspective, use of this mode page requires no special behavior from a Drive when the BD-ROM Profile is current.

See MMC-4 for a description of this mode page.

END

