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

Draft Version 0.25

18 January 2005

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1 Scope

Write-Once Blu-ray Disc is a media type that requires special behavior by the Initiator and device. This document describes the set of Multi-Media commands that allow an Initiator to utilize the capabilities of BD-R Logical Units. 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. Basic definitions are in SPC3. General Multimedia definitions are found in MMC-4.
4. Models - Modeling for the various media oriented behaviors that the Initiator may witness from BD-R devices provides an overview of internal drive operation for the Initiator application developer.
5. Features and Profiles - Features describe Logical Unit capabilities while Profiles exist to claim a collection of features.
6. Commands - Commands are described from the Initiator's point of view.
7. Mode Pages - Inputs required by the Logical Unit 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 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)
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 T13/1532D	AT Attachment with Packet Interface 7 (ATA/ATAPI-7)
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

Serial ATA: High Speed Serialized AT Attachment, INCITS T13/e03104r0. Note: This document is not a proposed standard. It is available to the public at www.t13.org.

System Description Blu-ray Disc Recordable Format, Part 1 Basic Format Specifications. For more information, contact: www.blu-raydisc.info.

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 BD

Blu-ray Disc (BD) is a high capacity system that defines media and includes devices capable of reading such media and optionally writes to recordable sub-types of that media.

3.2.2 BD-R

BD-R disc is a BD disc that is write-once. BD-R devices are devices that are able to read and Write BD-R discs.

3.2.3 Cluster

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

Inner Spare Area (ISA0, ISA1)

When defect management is used, a spare area is allocated in the inner radius of each layer. Each of these areas is an “Inner Spare Area”. The ISA on layer x is referenced as ISAx.

3.2.4 Disc Management Structure (DMS)

The DMS holds structures for Defect & LOW Management and Recording Mode information. There are two kinds of Disc Management Structures:

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

3.2.5 Disc Definition Structure (DDS)

The DDS is is a part of the DMS that is combined in one Cluster with a Space Bitmap in case of RRM and with an SRRI in case of SRM and shall be repeated for robustness reasons.

3.2.6 Defect List (DFL).

The DFL is a part of the DMS that maps defective Clusters to spare Clusters or replacement Clusters in the case of LOW. The DFL consists of four consecutive Clusters on an SL disc and of 8 consecutive Clusters on a DL disc and can be repeated 7 times.

3.2.7 Logical Overwrite (LOW)

By using the Linear Replacement algorithm of the BD Write-Once system, overwriting of a recorded Cluster is allowed. LOW replacements are mapped in the DFL.

3.2.8 Logical Sector Number (LSN)

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

3.2.9 Orphan LBA(s)

When a LOW is executed, the relocation occurs at the NWA, N of some SRR, T. After the LOW execution, the NWA is now N+32*K, where K is the number of LOWed 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 LOW operations. However, since there is not previous data to replace, these LBAs are Orphans.

3.2.10 Outer Spare Area (OSA0, OSA1)

When defect management is used, a spare area is allocated in the outer radius of each layer. Each of these areas is an “Outer Spare Area”. The OSA on layer x is referenced as OSAx.

3.2.11 Permanent Information & Control data (PIC) Zone

This zone contains general information about the disc. The PIC is pre-recorded.

3.2.12 Random Recording Mode (RRM)

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

3.2.13 Sequential Recording Mode (SRM)

Sequential Recording Mode on BD-R is recorded in defined, sequential ranges. To facilitate the recording of specific data at some pre-defined location on the disc at a later moment in time (such as for instance File System data), the disc can be divided into several continuous areas, referred to as Sequential Recording Ranges.

3.2.14 Sequential Recording Range (SRR)

BD-R in SRM has a physical representation of the Logical Track: a Sequential Recording Range (SRR).

3.2.15 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).

3.2.16 Space Bit Map (SBM)

The Space Bit Map specifies the recording status for each Recording Layer of the disc for the Random Recording Mode (RRM).

3.2.17 Temporary Disc Management Area (TDMA)

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 Zone called the Temporary Disc Management Area. Additional TDMAs may be defined within spare areas.

3.2.18 Temporary Disc Management Structure (TDMS)

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.

3.3 Abbreviations

BD	Blu-ray Disc
BD-R	Write-once Blu-ray Disc
BD-RE	Rewritable Blu-ray Disc
BD-ROM	Read-only Blu-ray Disc
DDS	Disc Definition Structure
DFL(x)	Defect List (x=0..7)
DL	Dual Layer
DMA(x)	Defect Management Area (x=1..4)
DMS	Defect Management Structure
INFOx	Information Zone (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
PIC	Permanent Information & Control data
RRM	Random Recording Mode
SL	Single Layer
SRM	Sequential Recording Mode
TDDS	Temporary Disc Definition Structure
TDFL	Temporary Defect List
TDMA	Temporary Disc Management Area
TDMS	Temporary Disc Management Structure

4 Models

4.1 BD Description

4.1.1 General

Blu-ray Disc (BD) is a collection of high-density optical media: ROM (Read-Only Memory), R (write-once Recordable), and RE (Rewritable). There is the possibility of either one or two layer discs. BD is typically available in both 120 mm and 80 mm discs.

The BD disc may have one readable/recordable layer or the BD disc may have two readable/ recordable layers. In the case of two layers, the BD disc is constructed only as opposite track path (OTP). Logically, the user area of each disc appears to the Initiator as a single continuous address space. Each layer has a continuous spiral track.

The logical block size of BD is 2 048 bytes collected into recordable units called clusters:

- A Cluster contains 32 logical sectors. The data of these 32 sectors 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.

4.1.2 Physical Characteristics

A BD disc have either 80 or 120 millimeters diameter and is separated into zones as shown in Figure 1.

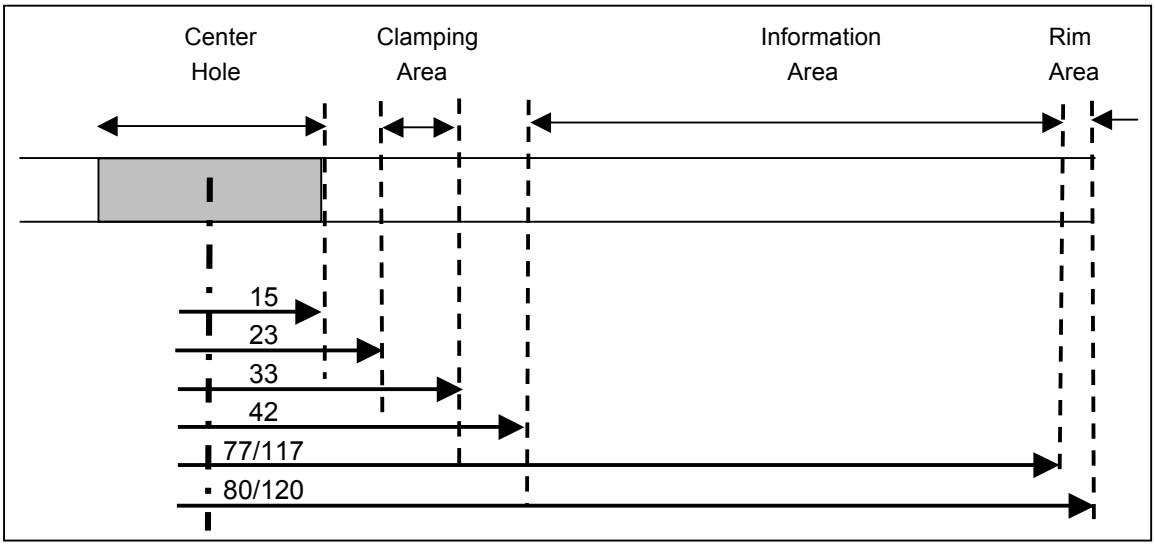

Figure 1 - The Areas of a BD-R Disc

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

4.2 BD-R Description

4.2.1 Blank Media Structure

BD-R is a write-once media that may consist of one or two layers. Each layer consists of single continuous groove structured only as opposite-track-path.

4.2.1.1 Primary Zones

Each layer is separated into 3 primary zones: 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.

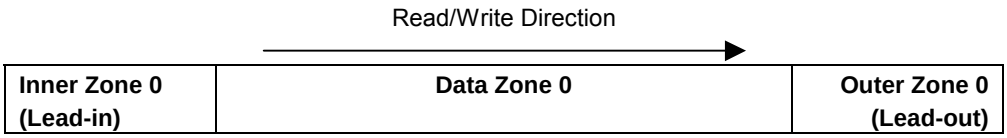

Figure 2 — Primary Zones of a Single Layer BD-R

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.

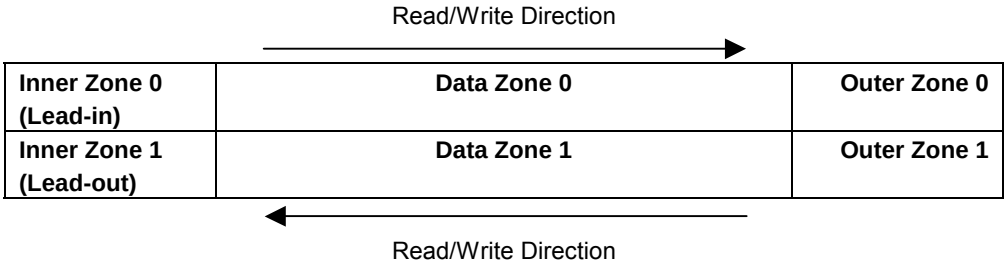

Figure 3 — Primary Zones of a Dual Layer BD-R

4.2.1.2 Capacity

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

Table 1 — BD-R Disc Capacities

Diameter	Single Layer	Dual Layer
80 mm	7.8 GB	15.6 GB
120 mm	23.3 GB	46.6 GB
	25.0 GB	50.0 GB

4.2.1.3 ADIP

BD-R is a grooved media with a fixed frequency wobble. 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 pre-recorded areas that occur prior to the Inner Zones.

4.2.1.4 Un-recorded Sector Addressing

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

4.2.2 Groove Layout

Each layer of the BD-R Information Zone is divided into an embossed (pre-recorded) high frequency modulated (HFM) area and a recordable area. The detailed groove layout is shown in Figure 4.

Layer 0 Information Zone	Pre-recorded Area	BCA		
			Protection zone 1	Seek overshoot protection zone
			PIC	Permanent Information & Control data Zone
	Recordable Area	Inner Zone 0 (Lead-in Zone)	Protection zone 2	Seek overshoot protection zone
			INFO2	DMA2 and PAC2
			OPC0	Optimum Power Calibration Zone
			OPC buffer	-
			TDMA0	Temporary Disc Management Area 0
			INFO1	DMA1 and PAC1
		Data Zone	ISA0	Inner Spare Area
			User Data Area	Primary user data area 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
Read Direction				
Layer 1 Information Zone	Recordable Area	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 Area	Primary user data area 1
			ISA1	Inner Spare Area 1
		Lead-out Zone (Inner Zone 1)	INFO1	DMA1 and PAC1
			Reserved	—
			TDMA1	Temporary Disc Management Area 1
			INFO2	DMA2 and PAC2
			Buffer Zone	
			OPC1	Optimum Power Calibration Zone
			Buffer Zone	
			Protection Zone 1	Seek overshoot protection zone

Figure 4 —BD-R Information Zones

The recordable area of each layer is divided into an Inner Zone, a data zone, and a 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 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 Write-once Format, Part 1 Basic Format Specifications*.

4.2.2.1 Pre-recorded Zone

The Pre-recorded zone consists of:

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 pre-recorded area contains disc information that includes, but is not restricted to: a. Physical media class and version b. Physical address of the start of the Data Zone c. Physical address of the start of the outer zone (if this is a single layer media, this is the lead-out) d. Number of layers e. Recording Density f. Write power information On layer 1 this pre-recorded area contains a copy of the layer 0 information, but the physical addresses refer to physical addresses on layer 1.

4.2.2.2 Lead-in Zone (Inner Zone 0)

An Inner Zone consists of:

Protection Zone 2	On both layers, this zone buffers the rewritable 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.

4.2.2.3 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 Area. 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 Area	The User Data Area is the logically addressed area of the disc.
Outer Spare Areas (OSA0, OSA1)	If spare Clusters are allocated for defect management, then, OSA0 has a maximum size of 196 608 Clusters, allocated in 256 Cluster increments. On 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.

4.2.2.4 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.

4.2.3 Logical Structure

4.2.3.1 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 Area, and Outer Spare Area (OSA0).

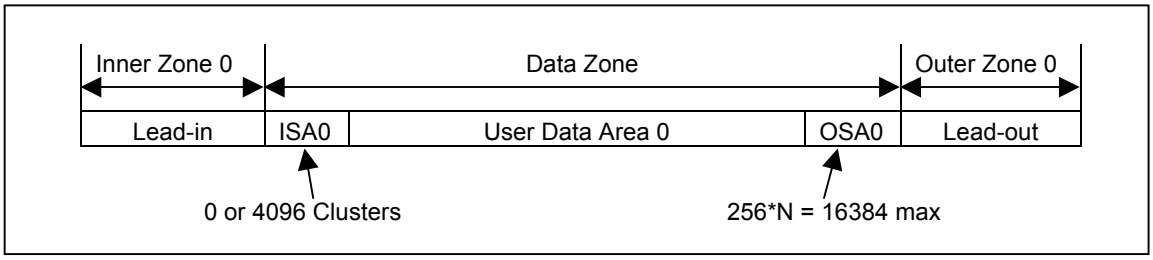

Figure 5 — SL BD-R Information Zone

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 Lead-in/Lead-out Zone 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. TDMA0 is allocated from the Lead-in with 2048 Clusters.

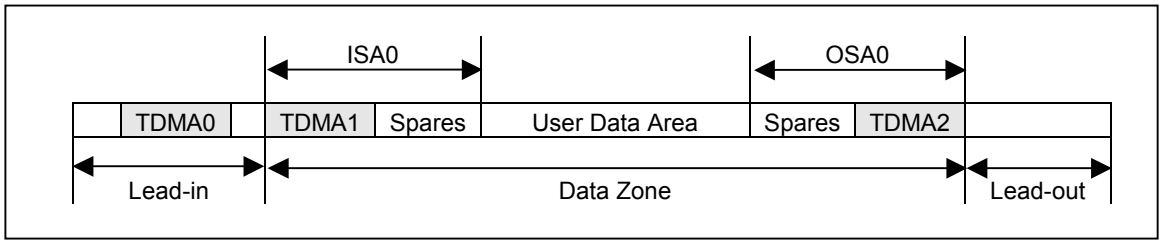

Figure 6 — TDMA Allocation on SL BD-R

If necessary, TDMA1 may be allocated from ISA0. The size of TDMA1 shall be:

TDMA1_size = m ∗ 256 Physical Clusters with $0 \leq m \leq 16$ (max ≡ ISA0_size).

If necessary, TDMA2 may be allocated from OSA0. The size of TDMA2 shall be:

TDMA2_size = n ∗ 256 Physical Clusters with $0 \leq n \leq 64$ (max ≡ OSA0_size).

4.2.3.2 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.

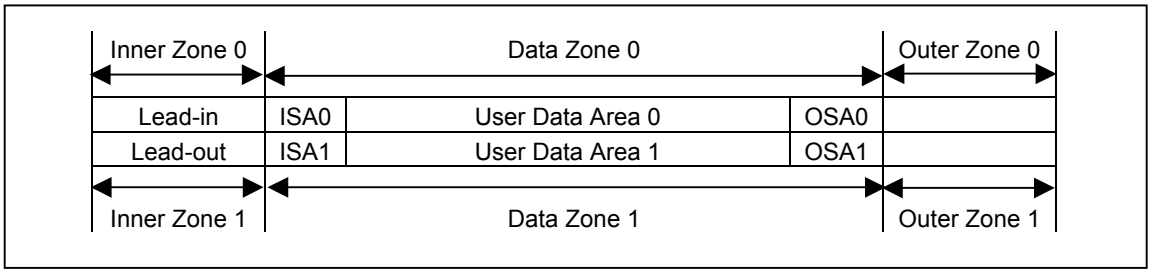

Figure 7 — DL BD-R Information Zones

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.

TDMA0 and TDMA1 are defined in each inner zone at 2048 Clusters each. 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.

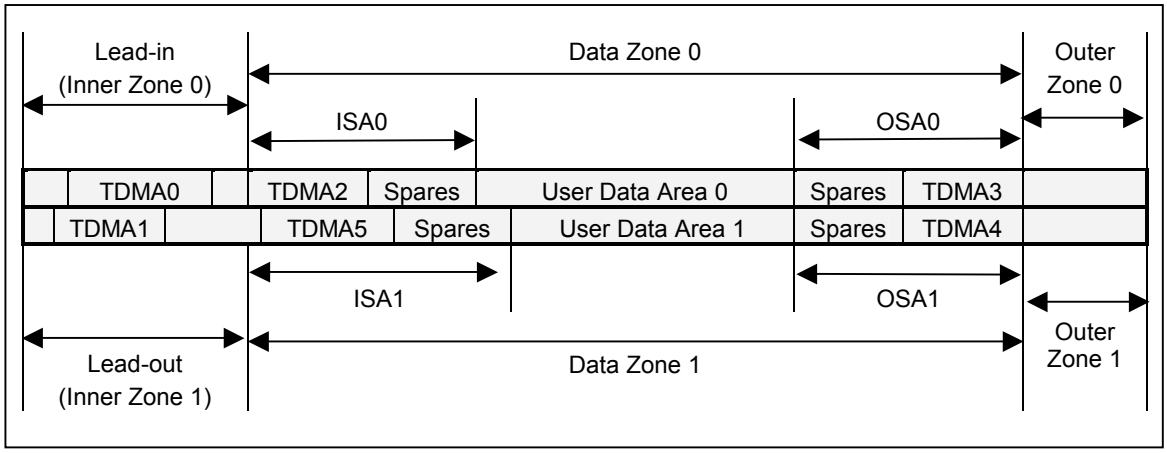

Figure 8 — TDMA Allocation on DL BD-R

TDMA0 and TDMA1 are the typical allocations for DL BD-R. If additional TDMA space is needed in layer 0, TDMA2 may be allocated from ISA0 and TDMA3 may be allocated from OSA0. If additional TDMA space is needed in layer 1, TDMA4 may be allocated from OSA1 and TDMA5 may be allocated from ISA1. These additional TDMAs are allocated in increments of 256 Clusters. Each such defined TDMA may include up to the entire spare area from which it is allocated.

4.2.3.3 Sectors and Clusters

The logical block size of BD is 2 048 bytes collected into recordable units called clusters. A Cluster contains 32 logical sectors.

- The user data within a BD sector is protected by the error correction coding in the Cluster that contains the sector.
- 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 Initiator as a single continuous address space.

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

- The user data space is organized in fixed size blocks (2 048 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.
- Logical addresses are numbered from 0 through CAPACITY LBA. The value of CAPACITY LBA is the logical block address returned by the READ CAPACITY command.
  - When the recording mode is SRM (without LOW), the READ CAPACITY command returns the last logical block address in the last complete session. If no sessions are closed, the READ CAPACITY command returns zero.
  - When the recording mode is either RRM or SRM with LOW, the READ CAPACITY command returns the LBA of the last recordable block in the User Data Zone.
- 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.
- Logical sectors are written to the BD-R disc using the WRITE (10), WRITE (12), or the WRITE AND VERIFY (10) commands.

4.3 BD-R Recording Models

BD-R has two basic recording modes: SRM (Sequential Recording Mode) and RRM (Random Recording Mode). Logical Overwrite (LOW).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 Logical Unit accepts and executes a RESERVED 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.

4.3.1 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.

4.3.2 Sequential Recording Mode (SRM)

4.3.2.1 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 (2 on SL and 4 on DL) on the disc.

4.3.2.2 Definitions

4.3.2.2.1 Logical Blocks

A Logical Block is the smallest logically addressable unit of data that is readable by the Initiator. 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.

4.3.2.2.2 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.

4.3.2.2.3 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.

4.3.2.2.3.1 Logical Track Starting Address

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

4.3.2.2.3.2 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.

4.3.2.2.3.3 Next Writable Address (NWA)

The Initiator is only permitted to record a Logical Track sequentially, beginning with it's starting address. To facilitate this, the Logical Unit 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.

4.3.2.2.3.4 Last Recorded Address (LRA)

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

4.3.2.2.3.5 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.

4.3.2.2.3.6 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.

4.3.2.2.3.7 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 Initiator 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 Initiator 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 Initiator, 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.

4.3.2.2.4 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.

4.3.2.2.4.1 Open Session

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

4.3.2.2.4.2 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.

4.3.2.2.4.3 Finalized (Closed) Disc

A disc is finalized when all sessions are closed and each DMS copy is recorded. Since the DMS on layer 0 is different from the DMS on layer 1, the process for dual layer media is different from the process for single layer media.

Once each DMS is recorded in the appropriate DMA, is It is not necessary to record any other part of the Inner or Outer zones.

4.3.2.3 Logical to Physical Addressing

Logical to physical addressing maps differently on single layer and dual layer media.

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

The primary Logical to physical mapping is defined as: For $0 \le N \le J_0-1$, Map(N) = N+K. Otherwise, N is not in the range of the mapping. See Figure 9.

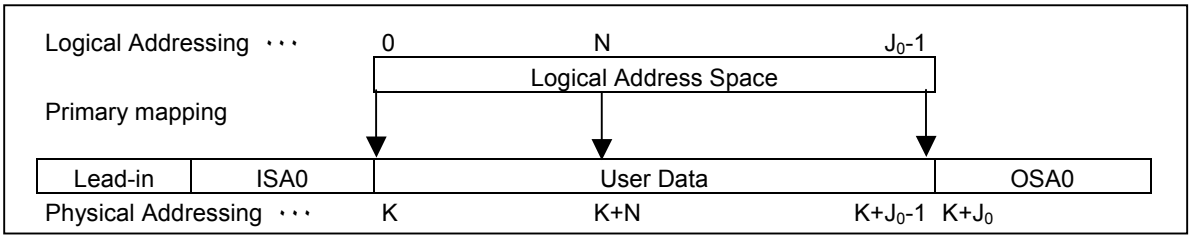

Figure 9 — Logical to Physical Addressing on Single Layer

If the disc is formatted with defect management, and if upon use, N+K is found to be defective, N may be mapped from the primary address of N+K to a Cluster in a spare area.

If the media is dual layer, the disc's user data area continues with the first block of the first Cluster after OSA1, J_1. The user data area continues until the first block of the first Cluster of ISA1, at C. The primary Logical to physical mapping is extended to include layer 1:

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

See Figure 10.

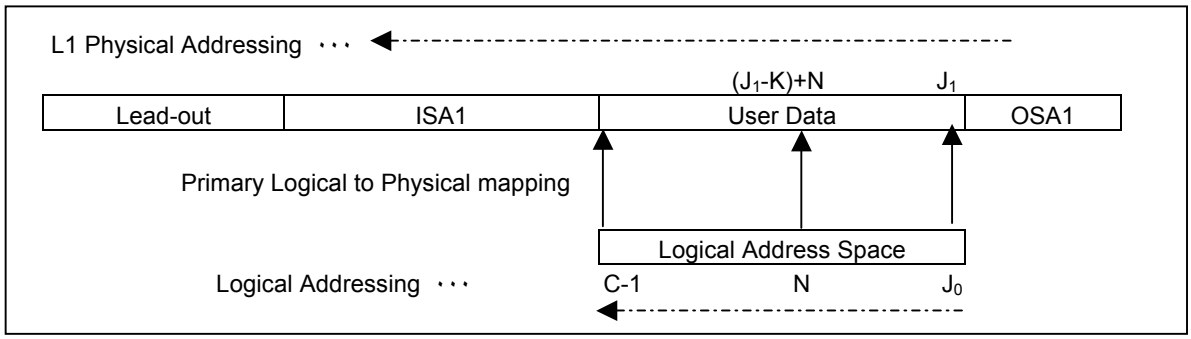

Figure 10 — Logical to Physical Addressing on Dual Layer

As with single layer media, if the disc is formatted with defect management, and if upon use, the primary physical block is defective, the block may mapped from the primary address to a Cluster in a spare area.

4.3.2.4 Status after Formatting a Blank BD-R

If a blank BD-R disc is formatted in SRM, the User Data Area consists of one open session with one open Logical Track (SRR). This Logical Track is the invisible Logical Track. As shown in Figure 11, the number of the track is 1, its start address is LBA = 0, and its length is the size of the User Data Area (CAP). The Next Writable Address (NWA) for Logical Track 1 is LBA = 0.

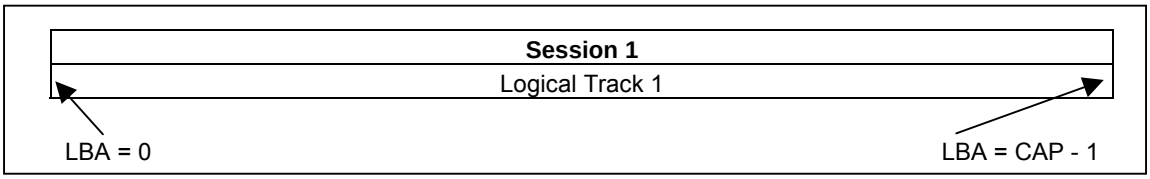

Figure 11 — Status of a BD-R Disc After Fomattting in SRM

If a WRITE command is issued to the Logical Unit, the Starting LBA must be equal to the NWA. If the starting 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.

4.3.2.5 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 12 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 Area, and its NWA = N2.

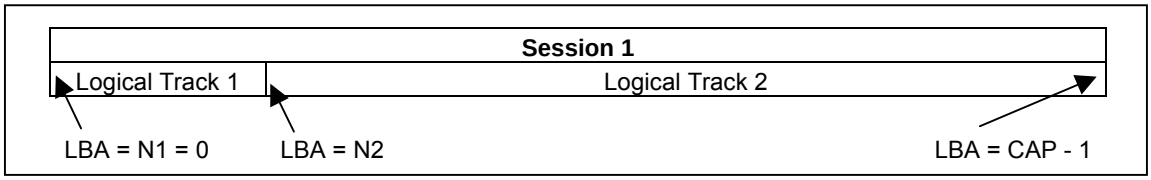

Figure 12 — Status of BD-R Disc After First RESERVE TRACK Command

The RESERVE TRACK command, may be used iteratively to define additional Logical Tracks from the invisible track as shown in Figure 13.

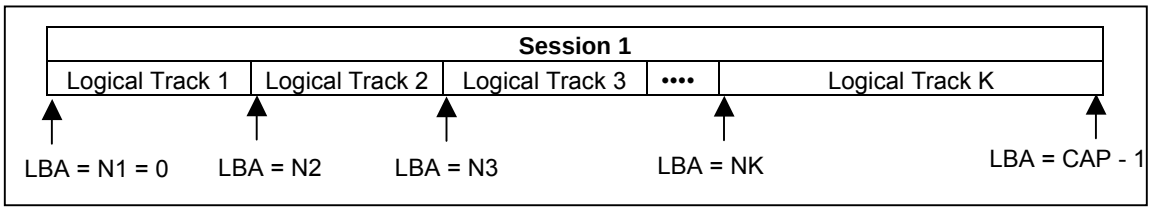

Figure 13 — Status of BD-R Disc Multiple RESERVE TRACK Commands

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 closed and the second is blank.

4.3.2.6 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 14.

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

Figure 14 — 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.

4.3.3 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 Logical Unit redirects the recording of the involved user data to another location, called spare areas. Information about these redirections is stored in the Defect List.

4.3.4 Logical OverWrite (LOW)

Logical Overwrite (LOW) is used to make Write-Once media behave like Rewritable media. When the Initiator requests recording of user data on an already recorded area, then the Logical Unit 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 PBA) are treated in the same way as defects, i.e. information about the redirections is stored in the Defect List.

4.3.4.1 POW on SRM

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

a. A SRM disc with LOW shall be initialized by the formatting process as a single session disc with a single Logical Track.
b. LOW 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. Each WRITE command shall start and end within the same Logical Track.

When LOW 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.

4.3.4.2 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 LOW 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 LOW, 32 LBAs were associated with the Cluster beginning at the NWA. After the LOW operation, those 32 LBAs are no longer available for append. The LBAs have not been lost, but they may be used only via another LOW. Until used, these LBAs are called Orphans.

4.3.4.3 Closed Logical Tracks with Blank Clusters

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

4.3.5 SRM and SRM+LOW Examples

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

4.3.5.1 Initialize the Disc as SRM with LOW

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

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 15.

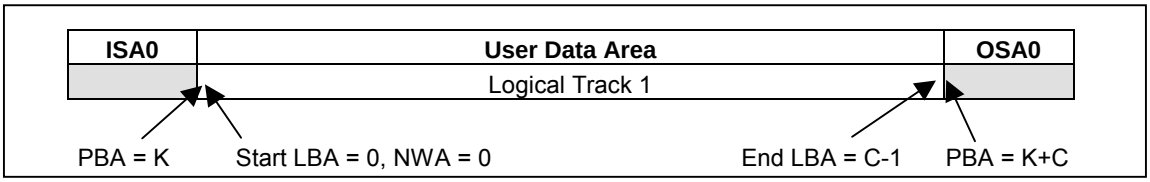

Figure 15 — Status after Formatting SRM with LOW

4.3.5.2 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.

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 16.

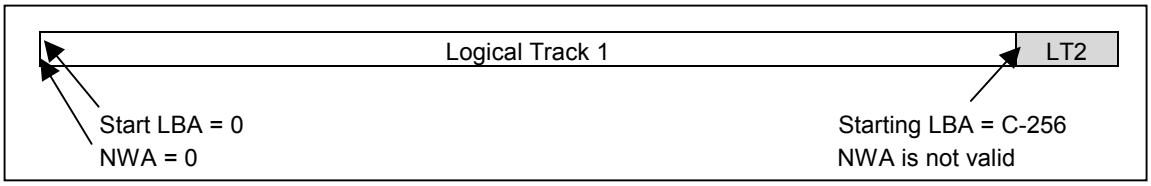

Figure 16 — Create, Write, and Close Small Outer Logical Track

4.3.5.3 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 17.

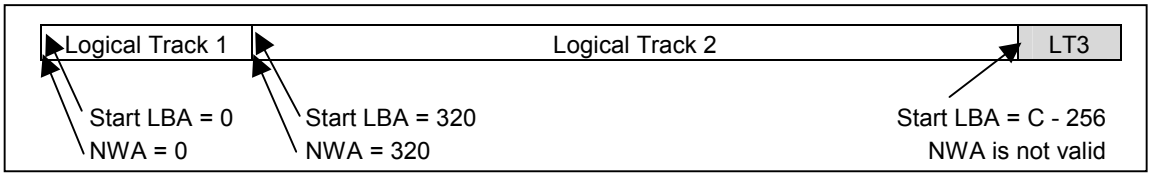

Figure 17 — Status after Splitting Logical Track 1

4.3.5.4 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 18.

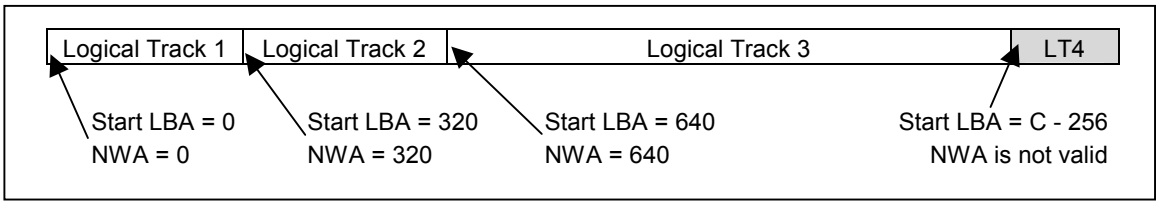

Figure 18 — Status after Splitting Logical Track 2

4.3.5.5 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-672.

See Figure 19. Note that All 3 Logical Tracks are open.

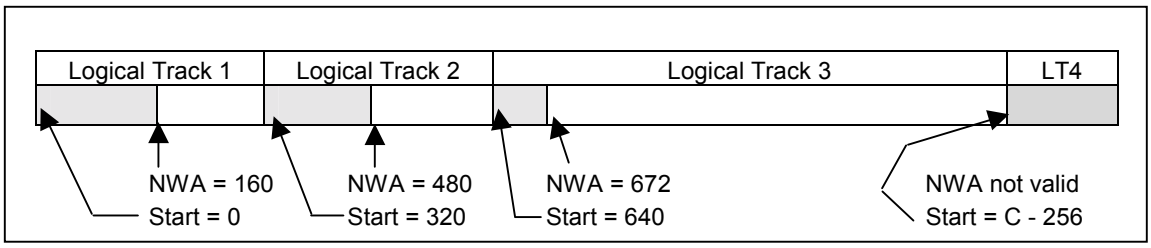

Figure 19 — Status after Writing to each Logical Track

4.3.5.6 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 20 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.

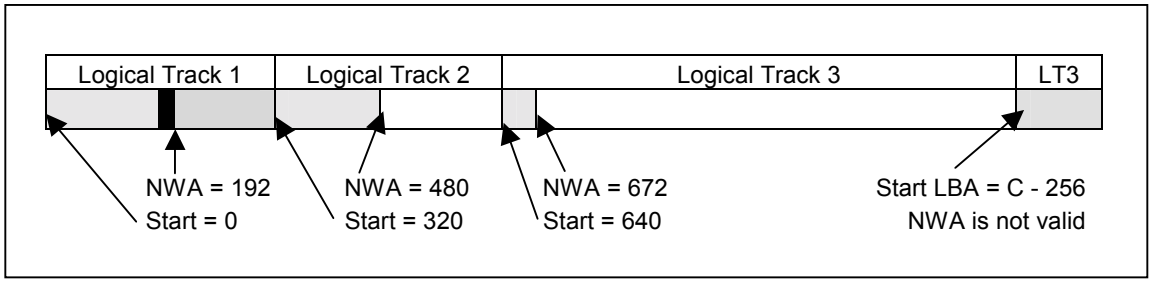

Figure 20 — Status after LOW to LBA 256

4.3.5.7 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.

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-672.

See Figure 21.

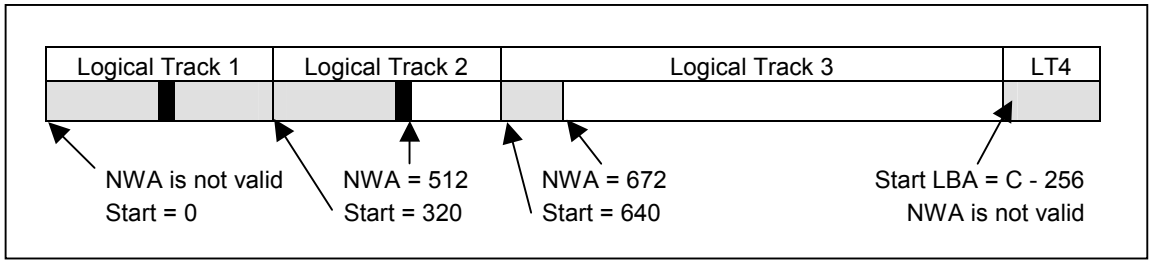

Figure 21 — Status after writing to Logical Track 1

4.3.5.8 Recover Orphaned LBAs via POW

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

This recovers the LBAs that were orphaned by a previous LOW. Recovering orphaned LBAs requires a new POW. The new data from the Initiator 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-672.

See Figure 22.

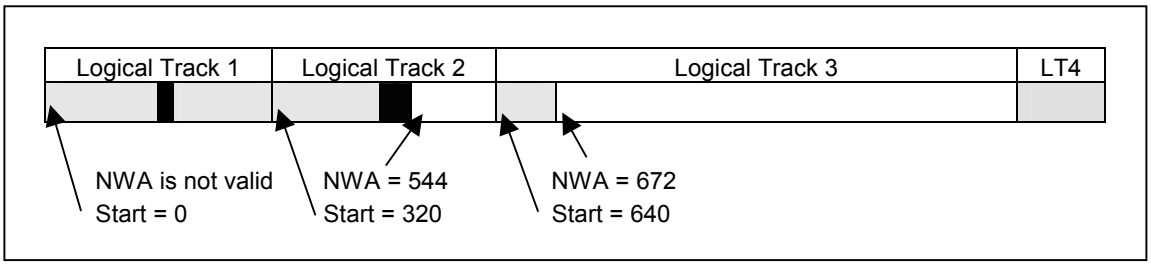

Figure 22 — Status after LOW of LBA 256

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

4.3.5.9 The Expanding Orphanage

Each time a POW is performed, 32 orphaned LBAs are created. Orphans can be recovered, 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 4.3.5.6, Orphan LBAs 160 through 191 were created by the POW of LBA 128.

In 4.3.5.7, Orphan LBAs 480 through 511 were created by the POW of LBA 128.

In 4.3.5.8, Orphan LBAs 512 through 543 were created when Orphan LBAs 160 through 191 were recovered.

5 Features and Profiles

5.1 Features

5.1.1 Incremental Streaming Writable (0021h)

This Feature identifies a Logical Unit 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 2.

Table 2 — 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							
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 specifieded 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.

If the BUF bit is set to 1, the Logical Unit is capable of zero loss linking.

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 Logical Unit 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 Logical Unit in the Logical Unit'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 Logical Unit reports this feature with the Current bit set to one, then the Logical Unit shall support the commands shown in Table 3.

Table 3 — Command Support Required by the Incremental Streaming Writable Feature

Op Code	Command Description	Reference
5Bh	CLOSE TRACK/SESSION	6.2
51h	READ DISC INFORMATION	6.16
53h	RESERVE TRACK	6.22
35h	SYNCHRONIZE CACHE	6.28
2Ah	WRITE (10)	6.31

Logical Units that support this Feature shall implement the mode pages shown in Table 4.

Table 4 — Incremental Streaming Writable Feature Parameters

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

5.1.2 The Formattable Feature (0023h)

This Feature identifies a Logical Unit that can format media into logical blocks. The Feature descriptor response data to be returned to the Initiator is defined in Table 5.

Table 5 — Formattable Feature Descriptor

Bit / Byte	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, 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 Logical Unit 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 Logical Unit 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 Logical Unit does not support Format Type 01h (Spare Area Expansion). If the Expand bit is set to zero, Format Type 01h is supported for the expansion of the spare area on formatted BD-RE disc.

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 Logical Unit 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 for the Initiator.
3. If the FORMAT UNIT command is used to select a BD-R format, SRM+LOW shall be an option for the Initiator.

If the RRM bit is set to zero, then formatting a blank BD-R disc in RRM is not supported. If the RRM bit is set to one, then the FORMAT UNIT command shall provide RRM as an option for the Initiator.

Logical Units that support this Feature shall implement the commands listed in Table 6.

Table 6 — Formattable Feature Commands

Op Code	Command	Reference
04h	FORMAT UNIT, Format Types 00h and 32h	
23h	READ FORMAT CAPACITIES	
03h	REQUEST SENSE	
2Fh	VERIFY (10)	

5.1.3 The BD Read Feature (0040h)

This Feature identifies a Logical Unit 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 Initiator is defined in Table 7.

Table 7 — BD Read Feature Descriptor

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB)			Feature Code = 0040h				
1								(LSB)
2	Reserved			Version			Persistent	Current
3	Additional Length = 28							
4	Reserved							
5	Reserved							
6	Reserved							
7	Reserved							
	Class 0 Bitmap identifying BD-RE Read Support							
8	Version 15	Version 14	Version 13	Version 12	Version 11	Version 10	Version 9	Version 8
9	Version 7	Version 6	Version 5	Version 4	Version 3	Version 2	Version 1	Version 0
	Class 1 Bitmap identifying BD-RE Read Support							
10	Version 15	Version 14	Version 13	Version 12	Version 11	Version 10	Version 9	Version 8
11	Version 7	Version 6	Version 5	Version 4	Version 3	Version 2	Version 1	Version 0
	Class 2 Bitmap identifying BD-RE Read Support							
12	Version 15	Version 14	Version 13	Version 12	Version 11	Version 10	Version 9	Version 8
13	Version 7	Version 6	Version 5	Version 4	Version 3	Version 2	Version 1	Version 0
	Class 3 Bitmap identifying BD-RE Read Support							
14	Version 15	Version 14	Version 13	Version 12	Version 11	Version 10	Version 9	Version 8
15	Version 7	Version 6	Version 5	Version 4	Version 3	Version 2	Version 1	Version 0
16 - 23	Class Bitmaps identifying BD-R Read Support							
24 - 31	Class Bitmaps identifying BD-ROM Read Support							

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.

The Additional Length field shall be set to 1Ch.

Bytes 8 and 9 contain a bit map of versions of BD-RE media class 0 that this Logical Unit is capable of reading. Bytes 10 and 11 contain a bit map of versions of BD-RE media class 1 that this Logical Unit is capable of reading. Bytes 12 and 13 contain a bit map of versions of BD-RE media class 2 that this Logical Unit is capable of reading. Bytes 14 and 15 contain a bit map of versions of BD-RE media class 3 that this Logical Unit is capable of reading. If the Version K bit (K = 0...15) of the Class M (M = 0...3) bit map is set to zero, the Logical Unit claims no read capabilities for BD-RE discs of Class M and Version K. If the version K bit is set to one, the Logical Unit is able to read BD-RE discs of class 0 and version K.

Bytes 16 - 23 contain a bit map identifying the class/version of BD-R media that this Logical Unit is capable of reading:

- Bytes 16 and 17 contain a bit map of versions of BD-R media class 0 that this Logical Unit is capable of reading.
- Bytes 18 and 19 contain a bit map of versions of BD-R media class 1 that this Logical Unit is capable of reading.
- Bytes 20 and 21 contain a bit map of versions of BD-R media class 2 that this Logical Unit is capable of reading.
- Bytes 22 and 23 contain a bit map of versions of BD-R media class 3 that this Logical Unit is capable of reading.

The Version bit meanings are as defined for BD-RE media.

Bytes 24 - 31 contain a bit map identifying the class/version of BD-ROM media that this Logical Unit is capable of reading:

- Bytes 24 and 25 contain a bit map of versions of BD-ROM media class 0 that this Logical Unit is capable of reading.
- Bytes 26 and 27 contain a bit map of versions of BD-ROM media class 1 that this Logical Unit is capable of reading.
- Bytes 28 and 29 contain a bit map of versions of BD-ROM media class 2 that this Logical Unit is capable of reading.
- Bytes 30 and 31 contain a bit map of versions of BD-ROM media class 3 that this Logical Unit is capable of reading.

The Version bit meanings are as defined for BD-RE media.

If a Logical Unit reports this feature with the Current bit set to one, then the Logical Unit shall support the commands shown in Table 8.

Table 8 - Command Support Required by the BD Read Feature

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

5.1.4 The BD Write Feature (0041h)

This Feature identifies a Logical Unit 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 Initiator is defined in Table 9.

Table 9 — 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 = 4							
4	Reserved							
5	Reserved							
6	Reserved							
7	Reserved							
	Class 0 Bitmap identifying BD-RE Write Support							
8	Version 15	Version 14	Version 13	Version 12	Version 11	Version 10	Version 9	Version 8
9	Version 7	Version 6	Version 5	Version 4	Version 3	Version 2	Version 1	Version 0
	Class 1 Bitmap identifying BD-RE Write Support							
10	Version 15	Version 14	Version 13	Version 12	Version 11	Version 10	Version 9	Version 8
11	Version 7	Version 6	Version 5	Version 4	Version 3	Version 2	Version 1	Version 0
	Class 2 Bitmap identifying BD-RE Write Support							
12	Version 15	Version 14	Version 13	Version 12	Version 11	Version 10	Version 9	Version 8
13	Version 7	Version 6	Version 5	Version 4	Version 3	Version 2	Version 1	Version 0
	Class 3 Bitmap identifying BD-RE Write Support							
14	Version 15	Version 14	Version 13	Version 12	Version 11	Version 10	Version 9	Version 8
15	Version 7	Version 6	Version 5	Version 4	Version 3	Version 2	Version 1	Version 0
16 - 23	Class Bitmaps identifying BD-R Write Support							

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 1Ch.

Bytes 8 and 9 contain a bit map of versions of BD-RE media class 0 that this Logical Unit is capable of writing. Bytes 10 and 11 contain a bit map of versions of BD-RE media class 1 that this Logical Unit is capable of writing. Bytes 12 and 13 contain a bit map of versions of BD-RE media class 2 that this Logical Unit is capable of writing. Bytes 14 and 15 contain a bit map of versions of BD-RE media class 3 that this Logical Unit is capable of writing. If the Version K bit (K = 0...15) of the Class M (M = 0...3) bit map is set to zero, the Logical Unit claims no write capabilities for BD-RE discs of Class M and Version K. If the version K bit is set to one, the Logical Unit is able to write BD-RE discs of class 0 and version K.

Bytes 16 - 23 contain a bit map identifying the class/version of BD-R media that this Logical Unit is capable of recording:

- Bytes 16 and 17 contain a bit map of versions of BD-R media class 0 that this Logical Unit is capable of recording.
- Bytes 18 and 19 contain a bit map of versions of BD-R media class 1 that this Logical Unit is capable of recording.
- Bytes 20 and 21 contain a bit map of versions of BD-R media class 2 that this Logical Unit is capable of recording.
- Bytes 22 and 23 contain a bit map of versions of BD-R media class 3 that this Logical Unit is capable of recording.

The Version bit meanings are as defined for BD-RE media.

Bytes 24 - 32 contain a bit map identifying the class/version of BD-ROM media that this Logical Unit is capable of recording:

- Bytes 24 and 25 contain a bit map of versions of BD-ROM media class 0 that this Logical Unit is capable of recording.
- Bytes 26 and 27 contain a bit map of versions of BD-ROM media class 1 that this Logical Unit is capable of recording.
- Bytes 28 and 29 contain a bit map of versions of BD-ROM media class 2 that this Logical Unit is capable of recording.
- Bytes 30 and 31 contain a bit map of versions of BD-ROM media class 3 that this Logical Unit is capable of recording.

The Version bit meanings are as defined for BD-RE media.

If a Logical Unit reports this feature with the Current bit set to one, then the Logical Unit shall support the commands shown in Table 10.

Table 10 - Command Support Required by the BD Write Feature

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

5.1.5 BD-R Pseudo-Overwrite (POW) Feature

A Logical Unit that reports the feature is able to provide Logical Block overwrite service on BD-R discs that are formatted as SRM+LOW. The feature descriptor is defined in Table 11.

Table 11 — 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 Logical Unit 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 4.3.4, Logical OverWrite (LOW) for a description of implementation requirements. This feature shall not be supported on multi-session discs.

5.2 Profiles

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

Logical Units identifying Profile 0041h as current shall support the features listed in Table 12.

Table 12 — 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 Initiator
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 Logical Unit/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	Initiator 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 Initiator 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+LOW.

Table 13 shows the commands and Mode Pages required when the BD-R SRM Profile is current.

Table 13 — 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	Close Track Session command, Read Disc Information command, Read Track Information command, Reserve Track 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.	

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

Logical Units identifying Profile 0042h as current shall support the features listed in Table 14.

Table 14 — 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 Initiator
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 Logical Unit/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	Initiator 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 Initiator 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 15 shows the commands and Mode Pages required when the BD-R RRM Profile is current.

Table 15 — 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.

6 Commands

6.1 Overview

The commands described in this clause are defined uniquely for BD Multi-Media Logical Units or have a unique behavior when executed by a BD Multi-Media Logical Unit. The commands described in this clause are listed in . 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 16 — Commands for BD-R Devices

Command Name	Op Code	Reference
CLOSE TRACK SESSION	5Bh	
FORMAT UNIT	04h	
GET CONFIGURATION	46h	
GET EVENT STATUS NOTIFICATION	4Ah	
GET PERFORMANCE	ACh	
INQUIRY	12h	
MECHANISM STATUS	BDh	
MODE SELECT (10)	55h	
MODE SENSE (10)	5Ah	
PREVENT ALLOW MEDIUM REMOVAL	1Eh	
READ (10)	28h	
READ (12)	A8h	
READ BD STRUCTURE	ADh	
READ BUFFER CAPACITY	5Ch	
READ CAPACITY	25h	
READ DISC INFORMATION	51h	
READ FORMAT CAPACITIES	23h	
READ TOC/PMA/ATIP	43h	
READ TRACK INFORMATION	52h	
REQUEST SENSE	03h	
RESERVE TRACK	53h	
SEND BD STRUCTURE	BFh	
SEND OPC INFORMATION	54h	
SET READ-AHEAD	A7h	
SET STREAMING	B6h	
START STOP UNIT	1Bh	
SYNCHRONIZE CACHE	35h	
TEST UNIT READY	01h	
VERIFY (10)	2Fh	
WRITE (10)	2Ah	
WRITE (12)	AAh	
WRITE AND VERIFY (10)	2Eh	
WRITE AND VERIFY (12)	AEh	

6.2 CLOSE TRACK SESSION Command

TBD

6.3 FORMAT UNIT

TBD

6.4 GET CONFIGURATION Command

The Core Feature requires that this command be implemented. Each BD-R Profile includes the Core Feature. From the Initiator's perspective, use of this command requires no special behavior from the Logical Unit.

See MMC-4 for a description of this command.

6.5 GET EVENT STATUS NOTIFICATION Command

The Core Feature requires that this command be implemented. Each BD-R Profile includes the Core Feature. From the Initiator's perspective, use of this command requires no special behavior from the Logical Unit.

Logical Units that support BD-R shall implement the Operational Change Event class, the Media Event class, and the Device Busy class.

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. Each BD-R Profile includes the Real-time Streaming Feature. If the SW bit in the Real-time Streaming Feature Descriptor is set to one, support of Type 01h is mandatory. Otherwise, from the Initiator's perspective, use of this command requires no special behavior from the Logical Unit.

See MMC-4 for a description of this command.

6.7 INQUIRY Command

The Core Feature requires that this command be implemented. Each BD-R Profile includes the Core Feature. From the Initiator's perspective, use of this command requires no special behavior from the Logical Unit.

See MMC-4 for a description of this command.

6.8 MECHANISM STATUS Command

The Removable Medium Feature requires that this command be implemented. Each BD-R Profile includes the Removable Medium Feature. From the Initiator's perspective, use of this command requires no special behavior from the Logical Unit.

See MMC-4 for a description of this command.

6.9 MODE SELECT (10) Command

The Core Feature requires that this command be implemented. Each BD-R Profile includes the Core Feature. From the Initiator's perspective, use of this command requires no special behavior from the Logical Unit.

See MMC-4 for a description of this command.

6.10 MODE SENSE (10) Command

The Core Feature requires that this command be implemented. Each BD-R Profile includes the Core Feature. From the Initiator's perspective, use of this command requires no special behavior from the Logical Unit.

See MMC-4 for a description of this command.

6.11 PREVENT ALLOW MEDIUM REMOVAL Command

The Removable Media Feature requires that this command be implemented. Each BD-R Profile includes the Removable Media Feature. From the Initiator's perspective, use of this command requires no special behavior from the Logical Unit.

See MMC-4 for a description of this command.

6.12 READ (10) Command

The Random Readable Feature requires that this command be implemented. Each BD-R Profile includes the Random Readable Feature. From the Initiator's perspective, use of this command requires no special behavior from the Logical Unit.

See MMC-4 for a description of this command.

6.13 READ (12) Command

The BD Read Feature requires that this command be implemented. Each BD-R Profile includes the BD Read Feature. From the Initiator's perspective, use of this command requires no special behavior from the Logical Unit.

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 Initiator's perspective, use of this command requires no special behavior from the Logical Unit.

See MMC-4 for a description of this command.

6.15 READ CAPACITY Command

The Random Readable Feature requires that this command be implemented. Each BD-R Profile includes the Random Readable Feature. From the Initiator's perspective, use of this command requires no special behavior from the Logical Unit.

See MMC-4 for a description of this command.

6.16 READ DISC INFORMATION

TBD

6.17 READ DISC (BD) STRUCTURE

TBD

6.18 READ FORMAT CAPACITIES

TBD

6.19 READ TOC/PMA/ATIP

TBD

6.20 READ TRACK INFORMATION

TBD

6.21 REQUEST SENSE

TBD

6.22 RESERVE TRACK Command

TBD

6.23 SEND DISC (BD) STRUCTURE

TBD

6.24 SEND OPC INFORMATION

TBD

6.25 SET READ-AHEAD

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

See MMC-4 for a description of this command.

6.26 SET STREAMING

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

See MMC-4 for a description of this command.

6.27 START STOP UNIT

The Removable Medium Feature requires that this command be implemented. Each BD-R Profile includes the Removable Medium Feature. From the Initiator's perspective, use of this command requires no special behavior from the Logical Unit.

See MMC-4 for a description of this command.

6.28 SYNCHRONIZE CACHE

The Incremental Streaming Writable Feature requires that this command be implemented. Each BD-R Profile includes the Incremental Streaming Writable Feature. From the Initiator's perspective, use of this command requires no special behavior from the Logical Unit.

See MMC-4 for a description of this command.

6.29 TEST UNIT READY

The Core Feature requires that this command be implemented. Each BD-R Profile includes the Core Feature. From the Initiator's perspective, use of this command requires no special behavior from the Logical Unit.

See MMC-4 for a description of this command.

6.30 VERIFY (10)

The Formattable Feature requires that this command be implemented. Each BD-R Profile includes the Formattable Feature. From the Initiator's perspective, use of this command requires no special behavior from the Logical Unit.

See MMC-4 for a description of this command.

6.31 WRITE (10)

TBD

6.32 WRITE (12)

TBD

6.33 WRITE AND VERIFY (10)

TBD

7 Mode Parameters

7.1 Mode Parameter List

The presence of a BD-R 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 Defect Management Feature requires that this mode page be implemented. Each BD-R Profile includes the Defect Management Feature. From the Initiator's perspective, use of this mode page requires no special behavior from a Logical Unit when a BD-R 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. Each BD-R Profile includes the Power Management Feature. From the Initiator's perspective, use of this mode page requires no special behavior from a Logical Unit when a BD-R 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. Each BD-R Profile includes the Timeout Feature. From the Initiator's perspective, use of this mode page requires no special behavior from a Logical Unit when a BD-R Profile is current. The Initiator should note that the Group 1 and Group 2 minimum timeout values are larger than those for writable BD types.

See MMC-4 for a description of this mode page.

END