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

**Draft Proposal**

**9 November 2004**

**COPYRIGHT**



**DISCLAIMER**

The information contained herein is believed to be accurate as of the date of publication, however, none of the Blu-ray Disc Founders will be liable for any damages, including indirect or consequential, from use of the *Multi-Media Command Set Description for Write-Once Blu-ray Disc (BD-R)* or reliance on the accuracy of this document.

**LICENSING**

Application of the *Multi-Media Command Set Description for Write-Once Blu-ray Disc (BD-R)* in host environments is permitted and no additional written copyright license regarding Blu-ray Disc Multi-Media Command Set Description from the Blu-ray Disc Founders is required.

**PURPOSE**

The information contained in this document is being made available for the purpose of standardization. Permission is granted to members of INCITS, its technical committees and their associated task groups to use, reproduce, or display this document solely for the purposes of INCITS standardization activities, provided this NOTICE shall be included in any reproduction of this document:

**NOTICE**

For any information regarding any patent license program on Blu-ray Disc Media, Players or Recorders, please consult with the patent owners, including but not limited to any of the above listed companies.
For any information regarding any Blu-ray Disc Rewritable Format and Logo license program on Blu-ray Disc Media, Players or Recorders, please consult with Sony Corporation, Tokyo, Japan.
For any further explanation of the contents of this document, or in case of any perceived inconsistency or ambiguity of interpretation, or for further details on contact persons of any of the above listed companies, please consult with:

Shunji Ohara
Matsushita Electric Industrial Co.,LTD
E-mail : ohara.shunji@jp.panasonic.com
Tel : +81-6-6900-9247
Fax : +81-6-6907-1725

# Contents

## Figures



## Tables

Error! No table of figures entries found.

# 1 Scope

The Write-once Blu-ray Disc (BD-R) 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 Logical Units that support BD-R discs. 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 Initiator may witness from the device provides an overview of internal drive operation to the Initiator application developer.
5. Features and Profiles – Features describe Logical Unit capability while profiles define a general device view.
6. Commands – Commands are described from the Initiator's point of view.
7. Mode Pages – 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 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 Rewritable 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 Write-once 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.

### 3.2.4 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.

### 3.2.5 Logical Sector Number (LSN)

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

### 3.2.6 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.

### 3.2.7 Permanent Information & Control data (PIC) Zone

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

### 3.2.8 Random Recording Mode (RRM)

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

### 3.2.9 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.

### 3.2.10 Logical Overwrite (LOW)

By using the Linear Replacement algorithm of the BD Write-Once system, overwriting of a recorded Cluster is allowed.

### 3.2.11 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.

## 3.3 Abbreviations

| | | | |
|---|---|---|---|
| BD | Blu-ray Disc | L0 | Layer 0 |
| BD-R | Write-once Blu-ray Disc | L1 | Layer 1 |
| DDS | Disc Definition Structure | LSN | Logical Sector Number |
| DFLx | Defect List (x=0..7) | OSA0 | Outer Spare Area, layer 0 |
| DL | Dual Layer | OSA1 | Outer Spare Area, layer 1 |
| DMAx | Defect Management Area (x=1..4) | PIC | Permanent Information & Control data |
| DMS | Defect Management Structure | RRM | Random Recording Mode |
| INFOx | Information Zone (x=1..4) | SL | Single Layer |
| ISA0 | Inner Spare Area, layer 0 | SRM | Sequential Recording Mode |
| ISA1 | Inner Spare Area, layer 1 | TDMA | Temporary Disc Management Area |

# 4 BD Models

## 4.1 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.

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.

For further details, consult *System Description Blu-ray Disc Write-once Format, Part 1 Basic Format Specifications*.

### 4.1.1 BD-R Recording Model

BD-R has three recording modes: SRM (Sequential Recording Mode), SRM with logical overwrite (SRM with LOW), and RRM (Random Recording Mode).

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.

The recording mode is not changeable once the recording mode has been established for the disc.

#### 4.1.1.1 SRM

The sequential recording mode BD-R is modeled by the Incremental Streaming Writable Feature.

In that model, the User Data Area may be subdivided into independent areas that are called Sequential Recording Range (SRR). The SRR is defined to match the MMC-4 definition of Logical Track.

A BD-R in SRM mode may be recorded in multiple sessions as described in MMC-4. An open SRM BD-R session can have a maximum of 16 appendable points (open Logical Tracks). The last of these open Logical Tracks is the Invisible (Incomplete) Logical Track. At most one open session is permitted on a SRM BD-R.

Session and Logical Track boundaries exist only as address references in disc management structures in inner/outer areas. There is no overhead cost in the User Data Area.

A SRM Logical Track may be split into two Logical Tracks. The Logical Unit shall manage the Logical Track renumbering.

#### 4.1.1.2 SRM with LOW

If Logical OverWrite (LOW) is permitted, an attempted overwrite will result in the Initiator's data being written in some open track with DFL mappings that associate the new data to the old LBAs.

After this recording mode is selected by execution of the FORMAT UNIT command, there is exactly one Logical Track in one complete session. The session has complete status in order that the Logical Unit shall respond to the READ CAPACITY command with the LBA of the last logical block of the User Data Area. If the disc is not finalized, then the session is writable as if it

was open. If the disc is finalized then no recording is permitted. If the disc is formatted as SRM with LOW according to this command set document then a second session is not allowed.

Any written logical block may be overwritten, even if the Logical Track containing the logical block is closed. Sequential recording shall proceed from NWA.

#### 4.1.1.3 RRM

TBD

### 4.1.2 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 written.

## 4.2 Physical Media Structure

BD-R disc has a 12 centimeters diameter and is separated into zones as shown in Figure 1

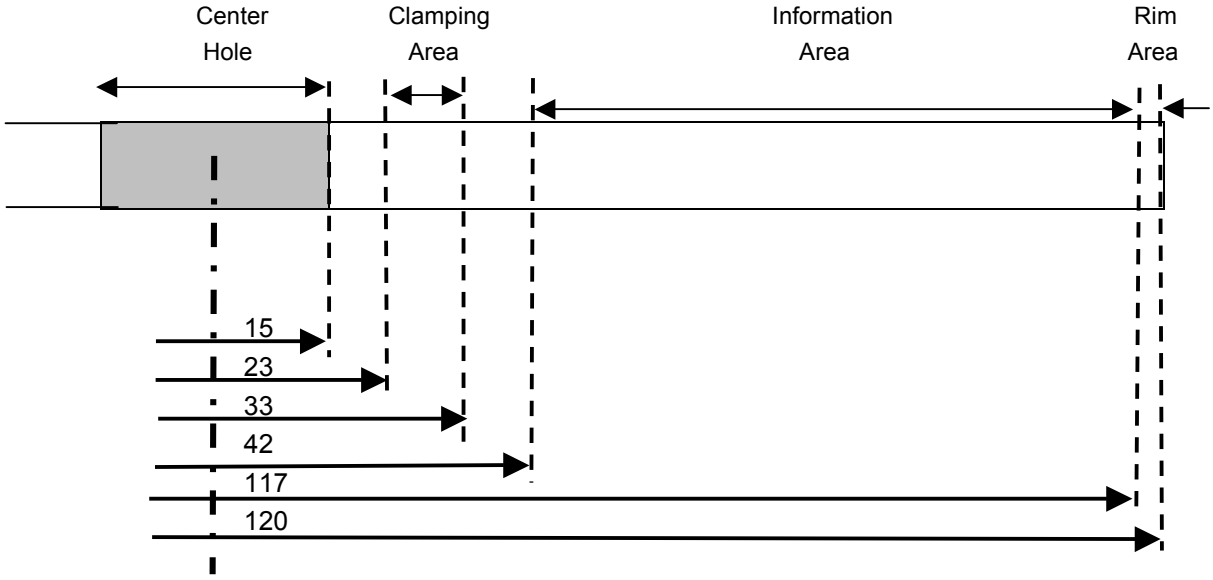


**Figure 1 - The Areas of a BD-R Disc**

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 millimeters and proceeds to the outer diameter. For 120-millimeter media, the information zone ends at a nominal diameter of 117 millimeters.

The Rim Area is simply the area beyond the data groove. For 120-millimeter media, it typically ends at a diameter of 120 millimeters.

## 4.3 Logical Media Structure

BD-R disc is a write-once media with 3 possible layer capacities: 23.3 GB, 25.0 GB, and 27.0 GB. BD has a single continuous groove on each layer and may consist of one or two layers. Dual layer media is structured only as opposite-track-path.

### 4.3.1 Track Structure (TBD)

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). If ISA0 is present, it has a fixed size of 4 096 Clusters. OSA0 has a variable size from 0 to 16 384 Clusters, allocated in increments of 256 Clusters. Consequently, OSA0 size in Clusters = N*256 Clusters, where 64 ≤ N ≤ 0.

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 the Temporary Disc Management Area. 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 the typical allocation for SL BD-R. When formatted RRM, TDMA1 is also allocated.
Figure 2 shows the layout of a single layer BD-R.

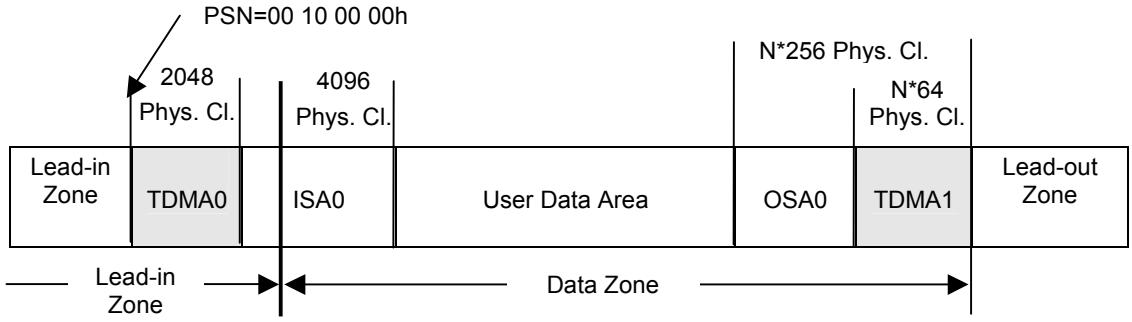


**Figure 2 – Layout of Single Layer BD Disc**

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.

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 32 ≤ N ≤ 0. OSA1 has the same size as OSA0. ISA1 has a variable size from 0 to 4096 Clusters, in increments of 256 Clusters. Consequently, ISA1 size in Clusters = L*256 Clusters, where 64 ≤ L ≤ 0.

TDMA0 and TDMA1 are the typical allocations for DL BD-R. When formatted RRM, TDMA2, TDMA3, and TDMA4 should also be allocated.
Figure 3 shows the layout of a dual layer BD-R.

Changes are coming TDMA allocations will change in next Formats document.

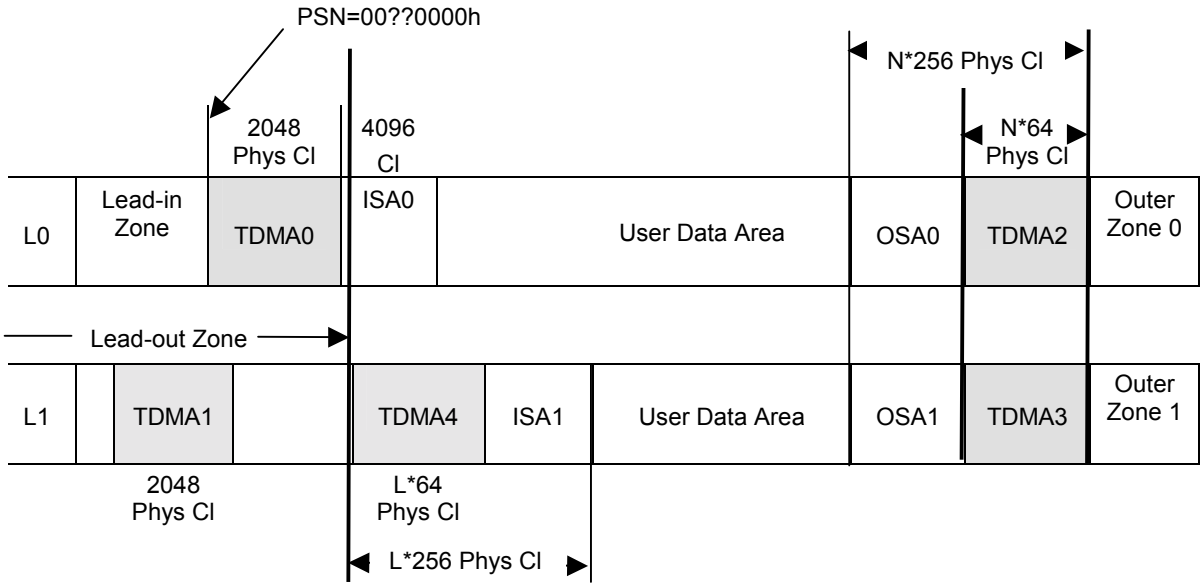


**Figure 3 – Layout of Dual Layer BD Disc**

### 4.3.2 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.
- Except in the case of SRM without LOW, 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. 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.
- 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.

### 4.3.3 The Information Zones (TBD)

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

| | | | | |
|---|---|---|---|---|
| Layer 0 Information Zone | Pre-recorded Area | BCA | | |
| | | | Protection zone 1 | Seek overshoot protection zone |
| | | | PIC | Permanent Information & Control data Zone |
| | Writable Area | Lead-in Zone (Inner Zone 0) | Protection zone 2 | Seek overshoot protection zone |
| | | | INFO2 | Defect Management information |
| | | | OPC0 | Optimum Power Calibration Zone |
| | | | OPC buffer | - |
| | | | TDMA0 | Temporary Disc Management Area 0 |
| | | | INFO1 | Drive information area |
| | | Data Zone | ISA0 | Inner Spare Area |
| | | | User Data Area | Primary user data area 0 |
| | | | OSA0 | Outer Spare Area |
| | | Outer Zone 0 | INFO3/4 | Defect management and control info |
| | | | DCZ0 | Disc Calibration Zone |
| | | | Protection zone 3 | Seek overshoot protection zone |
| Read Direction | | | | |
| Layer 1 Information Zone | Writable Area | Outer Zone 1 | Protection zone 3 | Seek overshoot protection zone |
| | | | DCZ1 | Disc Calibration Zone |
| | | | INFO3/4 | Defect management and control info |
| | | Data Zone | TDMA3 | Extra TDMA |
| | | | OSA1 | Outer Spare Area 1 |
| | | | User Data Area | Primary user data area 1 |
| | | | ISA1 | Inner Spare Area 1 |
| | | | TDMA4 | Extra TDMA |
| | | Lead-out Zone (Inner Zone 1) | INFO1 | Drive information area |
| | | | Reserved | - |
| | | | TDMA1 | Temporary Disc Management Area 1 |
| | | | INFO2 | Defect Management information |
| | | | Buffer Zone | |
| | | | OPC1 | Optimum Power Calibration Zone |
| | | | Buffer Zone | |
| | | | Protection Zone 1 | Seek overshoot protection zone |
| | | | | |

**Figure 4 –BD-R Information Zone**

Each layer of the Information Zone is divided into an embossed (pre-recorded) high frequency modulated (HFM) area and a recordable area. The recordable area of layer 0 is divided into a lead-in zone, a data zone, and a Outer Area. 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.

#### 4.3.3.1 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:<br>a. Physical media class and version<br>b. Physical address of the start of the Data Zone<br>c. Physical address of the start of the outer zone (if this is a single layer media, this is the lead-out)<br>d. Number of layers<br>e. Recording Density<br>f. Write power information<br>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. |

#### 4.3.3.2 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 defect management information 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 Area |
| INFO1 | On both layers, this area is reserved for drive specific information and PAC storage. |

#### 4.3.3.3 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 4096 Clusters.<br>If spare Clusters are allocated for defect management, ISA1 is a 16384-Cluster 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 Area.<br>A additional TDMA (TDMA4) may be allocated from ISA1. |
| User Data Area | The User Data Area is the logically addressed area of the disc. When no spares are allocated, this area has a maximum layer capacity of 23.3 GB, 25.0 GB, and 27.0 GB on 120 mm discs and 7.3 GB, 7.8 GB, and 8.4 GB on 80 mm discs. |
| Outer Spare Areas (OSA0, OSA1) | If spare Clusters are allocated for defect management, OSA0 is an 8192 (16384 on single layer) Cluster area available for spare area allocation in 256 Cluster increments. Any part of this area that is not allocated for spare Clusters is part of the User Data Area.<br>If spare Clusters are allocated for defect management, OSA1 is an 8192-Cluster 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 Area.<br>OSA1 has the same size as OSA0.<br>An additional TDMA (TDMA3) may be allocated from OSA1. |

#### 4.3.3.4 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 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. |
| 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. |

### 4.3.4 Blank Media Structure

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 lead-in area, 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 lead-in zone.

### 4.3.5 Defect Management and the SRM and SRM with LOW BD-R Disc

The Defect Management system of BD-R provides methods by which a defective Cluster in the User Data Area may be replaced by a Cluster from a spare area.

Defective clusters are replaced from the allocated spares. LOW sectors are replaced by user data area sectors at an NWA.

# 5 Features and Profiles

TBD

# 6 Commands

TBD

# 7 Mode Pages

TBD

# Annex A Using BD-R

TBD