DVD+R Multi-Media Command Set Description

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1 INTRODUCTION/SCOPE

DVD+R is a new form of DVD writable medium. DVD+R is a write-once medium with recording capabilities similar to. but improved over CD-R. Zero loss linking between 32KB ECC blocks provides for streamed recording without skipping.

As a data device, DVD+R is best utilized when the incremental recording procedures emulate those for CD-R. Due to the differences with CD-R, a direct copy of the methods cannot be defined, however, the differences are small and should require only small changes to host based software systems.

This document is organized to define changes and additions to a standard document such as the T10 Multi-Media Commands (MMC-3):

Clause 1: First, applicable references and definitions are covered.

Clause 2: The DVD+R Model shows that the medium can be used in a way that is functionally equivalent to CD-R.

Clause 3: Features and Profiles provide a way by which the device is able to tell its host that it has DVD+R capabilities.

Clause 4: The commands are described in terms of their differences from current operating definitions.

Clause 5: As an extension of clause 4, Mode Pages define how the host may control command execution. These are presented separately.

1.1 References

1.1.1 References from Public Standards Organisations

SCSI Parallel Interface 3 (SPI-3) ANSI NCITS 336:2000

SCSI-3 Primary Commands 2 (SPC-2) ANSI NCITS 351:2001

SCSI-3 MultiMedia Command Set-3 (MMC-3), ANSI INCITS 360:2002

SCSI-3 Block Command Set (SBC) ANSI NCITS.306:1998

Serial Bus Protocol 2 (SBP-2) ANSI NCITS.325:1998

ATA/ATAPI-5 ANSI NCITS 340:2000

ISO/IEC 16448, 120mm DVD Read-Only-Media (DVD-ROM)

ISO/IEC 16449, 80mm DVD Read-Only-Media (DVD-ROM)

ISO/IEC 16824, 120 mm DVD Rewritable Disc (DVD-RAM)

IEEE High Performance Serial Bus, IEEE 1394-1999B

1.1.2 References Under Development from Public Standards Organisations

SCSI-3 Primary Commands 3 (SPC-3) NCITS T10 Draft Standard xxxx-D

SCSI-3 Block Command Set - 2 (SBC-2) NCITS T10 Draft Standard 1417-D

Serial Bus Protocol 3 (SBP-3) NCITS T10 Draft Standard 1467-D

ATA/ATAPI-6 NCITS T13 Draft Standard 1410-D

1.1.3 References from Private Sources

OSTA Multi-Read Specifications for CD-ROM, CD-R, CD-R/RW, and DVD-ROM Devices, Revision 1.0 or higher.

DVD+R 4.7 Gbytes Basic Formats Specifications, version 1.1a, May 2002, Hewlett-Packard, Mitsubishi Chemical, Philips, Ricoh, Sony, Yamaha

1.2 Definitions, abbreviations and acronyms

ADIP

This refers to **AD**dress **I**n **P**re-groove. An address and recording information is encoded into the wobble groove on DVD+R media.

Closure

See session lead-out.

Disc Lead-in

The lead-in zone of the disc, according to the format specification, is the disc lead-in. The disc lead-in includes the "intro" of the first session.

Disc Lead-out

The lead-out zone of the disc, according to the format specification, is the disc lead-out. The disc lead-out includes the "closure" of the last session.

DVD-ROM

The medium specified by ISO/IEC 16448.

Fragment

A fragment is a logical sub-division of the media.

Intro

See session lead-in.

Logical Block

A host addressable unit of data is a logical block. Each logical block on DVD+R media is the user data of one of 16 sectors within an ECC block.

Logical Block Address (LBA)

A host referenced mapping to a linear address space of logical blocks.

Logical Sector Number (LSN)

Logical Sector Numbers are assigned contiguously from LSN 0, starting from the first PSN (030000h) to the end of the Data Zone. On DVD+R this is the same as Logical Block Address (LBA).

Optimum Power Calibration (OPC)

A procedure performed by the drive to calibrate the laser power to be used for a particular disc. Values from this calibration are used for subsequent write operations.

Physical Sector Number (PSN)

The first Physical Sector of the Data Zone shall be numbered 030000h. The PSNs increase by 1 for each next Physical Sector in the whole of the Information Zone.

Session

A continuous part of the Information Zone of the disc consisting of a session lead-in (Intro), a Data Zone and a session lead-out (Closure).

Session Lead-in

This lead-in part of any session is also referred to as the session's "intro".

Session Lead-out

This lead-out part of any session is also referred to as the session's "closure".

Track

A track is a logical sub-division of the media defined only for the purpose of communicating disc structure to the host. A fragment is a track when the fragment is in an open session. The data zone of a session is a track when the session is closed.

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2 DVD+R Model

The DVD+R medium was originally defined according to a simple, basic requirement of compatibility: when a fully recorded DVD+R medium is mounted on the spindle of a standard DVD player, the medium should be accepted as if it were a stamped DVD-ROM disc.

That was a good starting point, but the potential was greater, so the definition was expanded.

Meeting the original requirement means that the medium must have the physical characteristics to allow the DVD player to find the recording groove, track on the data, seek across the groove, and read and decode written data. Clearly, physical compatibility is important. Logical compatibility is also required.

2.1 Physical Overview

DVD+R media is either 8 or 12 centimeters in diameter and separated into zones as shown in .

R0	Center Hole	R4	3rd Transition Area
R1	1st Transition Area	R5	Information Zone
R2	2nd Transition Area	R6	Rim Area
R3	Clamping Zone		
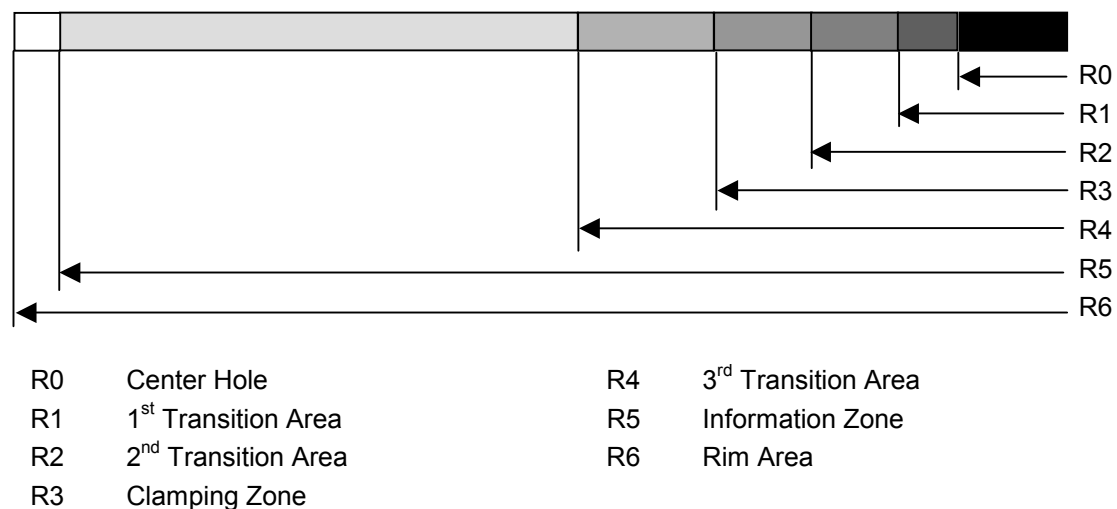
Figure 1 - The Zones of a DVD+R Medium

The Center Hole, 1st Transition Area, 2nd Transition Area, Clamping Zone, and 3rd Transition Area are all part of the alignment and clamping mechanisms. These areas have no direct involvement with the writable areas of the medium.

The Information Zone is the area in which actual recording may occur. It contains the lead-in, the data area, and the lead-out. This area begins at a radius of 22 millimeters and proceeds to the outer radius. For 120-millimeter media, the information zone ends at a nominal radius of 58.5 millimeters. For 80-millimeter media, the information zone ends at a nominal radius of 38.5 millimeters.

The Rim Area is simply the area beyond the data groove. For 120-millimeter media, it typically ends at a radius of 60 millimeters. For 80-millimeter media, it typically ends at a radius of 40 millimeters.

2.2   Logical Overview

The Information zone is organized as a sequence of independently recorded units called ECC blocks.

Each ECC block contains 16 user sectors. Each sector is identified by a Physical Sector Number (PSN) and contains 2048 bytes of data.

The physical addresses advance incrementally beginning at the virtual address 00000000h. It is virtual, because the physical nature of a DVD+R device guarantees that no drive will ever be able to reach the sector with PSN = 0. Similarly, the media is made with a zone of protection in the groove. Consequently, the first sector which is required to exist, has PSN = 1D830h. As with DVD-ROM, the first user accessible sector has PSN = 30000h. The DVD+R 120-mm one-sided disc has 4.70GB available to the user, while the two-sided disc has 9.40GB. The DVD+R 80-mm one-sided disc has 1.46GB available to the user, while the two-sided disc has 2.92GB.

2.2.1   The ADIP (Address in Pre-groove)

Like CD-R media:

- DVD+R media has a wobble structure which defines the groove
- Information is modulated onto the wobble
- Within the Information Zone, this information contains the address of the associated sector
- Within the lead-in, there is additional information about the disc

This is generally called Address-In-Pre-groove or ADIP.

2.2.2   The ECC Block

The DVD+R ECC block is defined according to the DVD-ROM standard.

Unlike CD-R media, adjacent sectors of DVD+R media are not necessarily interleaved. An ECC block consists of 16 sectors with headers, EDC symbols, and ECC symbols. Individual sector data are interleaved in order to minimize the effects of a large media flaw. These ECC blocks are recorded serially on the medium.

2.2.2.1   The Structure of the Data Sector

A DVD+R data sector contains 2064 bytes, 2048 bytes of main data and 16 bytes of additional information.

The logical layout of a DVD+R data sector is shown in Figure 2.

4 bytes	2 bytes	6 bytes	2048 bytes	4 bytes
ID	IED	RSV	MAIN DATA	EDC
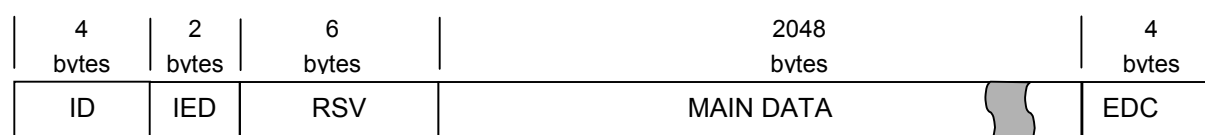
Figure 2 - Logical Layout of a DVD+R Data Sector

ID is a field that identifies the sector

IED contains 2 bytes of redundancy as an error detection code (EDC) for the ID field.

RSV is reserved and must be recorded with zeros.

MAIN DATA contains 2048 bytes and has 2 possible sources. The source is determined by the reference: *DVD+R 4.7 Gbytes Basic Format Specifications.* Except for format management overheads, the host is the source of Main Data for the part of the Information Zone called the Data Zone. For all other areas, the drive must generate the Main Data from information provided

by the host according to the format requirements of *DVD+R 4.7 Gbytes Basic Format Specifications.*

EDC contains 4 bytes of redundancy as an error detection code (EDC) for the entire sector. The ID field is viewed as a 32 bit field as shown in Figure 3.

Sector Information Bits 31 thru 24	Physical Sector Address Bits 23 through 0

Sector Format Type	Tracking Method	Reflectivity	Reserved	Zone Type	Data Type	Layer Number
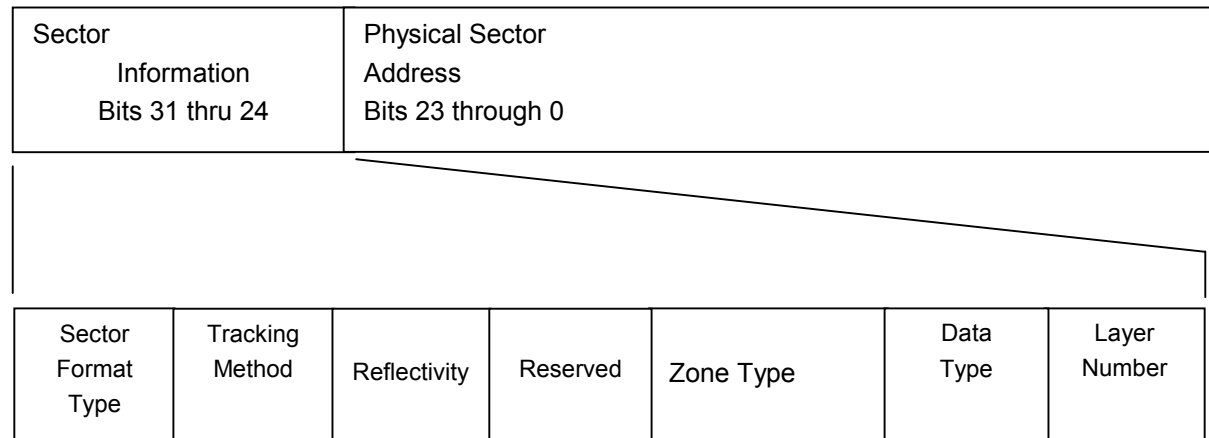
Figure 3 - ID Field Details

Sector Format Type (Bit 31)   is cleared to ZERO, indicating a CLV format

Tracking Method (Bit 30)   is set to ONE, indicating groove tracking

Reflectivity (Bit 29)   is cleared to ZERO indicating that the reflectivity exceeds 40 %

Reserved (Bit 28)   and shall be cleared to ZERO

Zone Type (Bits 27 and 26)   is valued as:

    00 when the sector is in the Data Zone

      (this includes session lead-in and session lead-out areas)

    01 when the sector is in the Disc Lead-in

    10 when the sector is in the Disc Lead-out

Data Type (Bit 25)   is cleared to ZERO, indicating write-once media

Layer Number (Bit 24)   is cleared to ZERO, indicating that through an entrance surface only one recording layer can be accessed

The least significant 24 bits (bits 23 through 0) contains the Physical Sector Number in binary notation. The Physical Sector Number of the first Physical Sector of an ECC Block shall be an integer multiple of 16.

2.2.2.2 The Structure of the ECC Block

A 2064 byte sector is divided into 12 rows of 172 bytes each. Main data is scrambled similar to CD-ROM data scrambling. Pack 16 sequential sectors in this way and there are 192 rows, each with 172 bytes. Error correction redundancy symbols are appended in order to produce 208 rows of 182 bytes each.

The organization of sector data and redundancy symbols within an ECC block is illustrated in Figure 4. Columnar symbols ($C_{x,y}$) are calculated and appended to rows, then Row symbols ($R_{x,y}$) are calculated and appended to columns. Columnar redundancy symbols are collectively known as Inner Parity (PI). Row redundancy symbols are collectively known as Outer Parity (PO).

	User Data					ECC Parity on Rows				
User Data	B1,0	B1,1	B1,2	…	B1,171	C1,0	C1,1	C1,2	…	C1,9
	B2,0	B2,1	B2,2	…	B2,171	C2,0	C2,1	C2,2	…	C2,9
	B3,0	B3,1	B3,2	…	B3,171	C3,0	C3,1	C3,2	…	C3,9
	…	…	…	…	…	…	…	…	…	…
	B190,0	B190,1	B190,2	…	B190,171	C190,0	C190,1	C190,2	…	C190,9
	B191,0	B191,1	B191,2	…	B191,171	C191,0	C191,1	C191,2	…	C191,9
ECC Parity	R0,0	R0,1	R0,2	…	R0,171	C192,0	C192,1	C192,2	…	C192,9
	R1,0	R1,1	R1,2	…	R1,171	C193,0	C193,1	C193,2	…	C193,9
	R2,0	R2,1	R2,2	…	R2,171	C194,0	C194,1	C194,2	…	C194,9
	…	…	…	…	…	…	…	…	…	…
	R15,0	R15,1	R15,2	…	R15,171	C207,0	C207,1	C207,2	…	C207,9

Figure 4 - ECC Block Structure

Each of the 16 sectors of an ECC block has a unique PSN. The PSNs are sequential such that if the smallest is N, then N+1, N+2, N+3, …, N+15 are also present in the ECC block. That is, the sectors are sequenced in an intuitively correct way.

2.2.3 DVD+R Groove Layout

The groove, when recorded, is a continuous sequence of ECC blocks. If ECC block E and E+1 are consecutive, then whenever N is the largest PSN in E, then N+1 is the smallest address in E+1. That is, the ECC blocks are sequenced in an intuitively correct way.

The rest of logical groove architecture is given by specific use of individual sectors.

The DVD+R format provides only a continuous address space with no possibility of defect management. If defect management is desired, it is recommended that the host's system software provide the function.

Table 1 shows the zoned layout of the DVD+R groove. The Data Zone boundaries are based upon a single session recording.

Table 1 - DVD+R Format Lay-out

Disc Area	Zone	120 mm Disc		80 mm Disc	
		Start PSN (h)	Length (d)	Start PSN (h)	Length (d)
INNER DRIVE AREA	Initial Zone	-	Blank	-	Blank
	Inner Disc Test Zone	023480h	16 384	023480h	16 384
	Inner Disc Count Zone	027480h	4 096	027480h	4 096
	Inner Disc Administration Zone	028480h	4 096	028480h	4 096
	Table of Contents Zone	029480h	4096	029480h	4096
LEAD-IN	Guard Zone 1	02A480h	14 848	02A480h	14 848
	Reserved Zone 1	02DE80h	4 096	02DE80h	4 096
	Reserved Zone 2	02EE80h	64	02EE80h	64
	Inner Disc Identification Zone	02EEC0h	256	02EEC0h	256
	Reserved Zone 3	02EFC0h	64	02EFC0h	64
	Reference Code Zone	02F000h	32	02F000h	32
	Buffer Zone 1	02F020h	480	02F020h	480
	Control Data Zone	02F200h	3 072	02F200h	3 072
	Buffer Zone 2	02FE00h	512	02FE00h	512
DATA	Data Zone	030000h	max=2 295 104	030000h	max=714 544
LEAD-OUT	Buffer Zone 3	max = 260540h	768	max=0DE730h	768
	Outer Disc Identification Zone	max = 260840h	256	max=0DEA30h	256
	Guard Zone 2	max = 260940h	4 096	max=0DEB30h	4 096
OUTER DRIVE AREA	Outer Disc Administration Zone	261940h	4 096	0DFB30h	4 096
	Outer Disc Count Zone	262940h	4 096	0E0B30h	4 096
	Outer Disc Test Zone	263940h	16 384	0E1B30h	16 384
	Guard Zone 3	2652C0h	Blank	0E5B30h	Blank

2.3 Recording on DVD+R

2.3.1 Recording Structures

2.3.1.1 ECC Blocks

The minimal writable entity on DVD+R is the 32KB ECC block. Physically, DVD+R is randomly writable in 32KB ECC blocks, but not necessarily randomly readable. An ECC block is not fully decodable when it follows a blank area of media. In order to ensure readability, ECC blocks must be written in sequential regions.

2.3.1.2 Fragments

A fragment is a set of contiguous ECC blocks in the Data Area that contains at least one ECC block. Fragments are distinct. That is, given two different fragments, there are no ECC blocks in common. A fragment is the only unit of allocation on DVD+R.

Fragments are uniquely numbered beginning with one. The start address of fragment one is LBA 0. Fragments are numbered sequentially with no gaps. That is, if fragment N and fragment M are different fragments and there are no fragments between fragment N and fragment M, then M = N+1.

Fragment Oriented Definitions:

    Reserved Fragment – Fragment allocation may be explicit, where both the start address and end address are specified. When this information is written in a Fragment Item in the identification zone for the session, the Fragment is Reserved. The RT bit in the Track Information Block corresponding with this Fragment is the Reserved status of the Fragment. A Fragment that is defined by using the RESERVE TRACK command is Reserved, however a Reserved Fragment may achieve that status in other ways (e.g. CLOSE TRACK).

    The Invisible (Incomplete) Fragment – This is the Fragment where the start address of the fragment is specified, but the end address is limited only by disc capacity. The invisible fragment may be transformed into two fragments: a reserved fragment and a new invisible fragment.

    Blank Fragment – If every ECC block within the fragment is blank, then the fragment is blank. This status is available in the Blank bit of the Track Information Block associated with the Fragment.

    Closed (or Complete) Fragment – If the Fragment has Reserved status, and every ECC block within the Fragment is written, the fragment is closed. A Fragment that is Closed by using the CLOSE TRACK/ SESSION command is Closed, however a Closed Fragment may achieve that status in other ways (e.g. writing all ECC blocks of a reserved fragment).

    Next Writable Address – Fragments must be written sequentially, beginning with the start address of the fragment. This maintains the fragment in two parts: the written part that begins at the fragment start address and the blank part that begins with the first ECC block in the fragment that has not been written. The LBA of the first sector of the blank part is the Next Writable Address (NWA) of the fragment. The NWA of a blank fragment is the start address of the fragment.

The host may write using a 2 048-byte block size. The drive shall buffer sequentially written data and write to the media only when at least one of the following is true:

1. An ECC block amount of data has been received from the host,
2. The host issues a SYNCHRONIZE CACHE command,
3. The host issues a CLOSE TRACK command,
4. A new WRITE command is received for the NWA of a different fragment.

In cases 2 through 4, remaining user data in the ECC block shall be zero filled by the drive prior to writing the ECC block. If no data is buffered for a partial ECC block, then cases 2 through 4 shall not cause a write to occur.

2.3.1.3   Sessions

The data area of a DVD+R disc may be recorded in sessions similar to session recording in CD-R. Each session contains a lead-in equivalent area called the session Intro, a data area equivalent called session User Data, and a lead-out equivalent called the session Closure. The first session has no Intro. The Disc Lead-in is used for the equivalent purpose. The final session has no Closure. The Disc Lead-out is used for the equivalent purpose. Each Intro (not the disc lead-in) is encoded as data. Each Closure (not the disc lead-out) is encoded as data.

Sessions are uniquely numbered beginning with one. The start address of the user data of session one is LBA 0. Sessions are numbered with sequentially with no gaps. That is, if session N and session M are different sessions and there are no sessions between session N and session M, then M = N+1.

Figure 5 shows an example of a multi-session layout on a DVD+R disc. Session 2 is called an interior session. If the disc has no interior sessions, it is a single session disc.

	Disc Lead-in
Session 1	**User Data**
	Closure
	Intro
Session 2	**User Data**
	Closure
	...
	Intro
Final Session	**User Data**
	Disc Lead-out
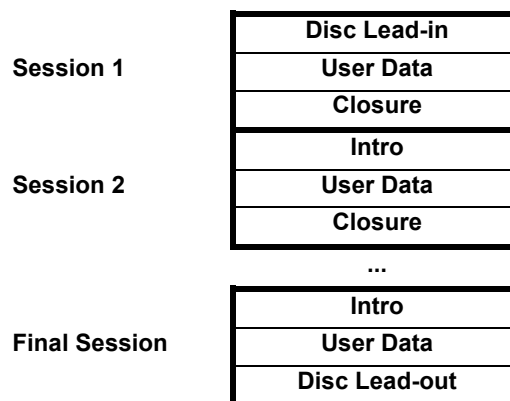
Figure 5 – General Layout of a Multi-Session DVD+R

The user data zone of a session is made up of a collection fragments. The user data zone contains at least one fragment and may contain up to 16 fragments.

Session Oriented Definitions:

   Empty (Blank) Session – If no ECC block in a session is written, the session is blank.

   Closed Session – If every ECC block within the session is written, the session is closed.

   Open Session – If a session is not closed, then the session is open. An empty session is open.

   Open (Incomplete, or Appendable) Disc – If a disc has an open session, then the disc is open.

   Closed Disc – During the process of closing a session, the host may specify that no new sessions are allowed. That session is called the Final session and once that session is closed, the disc is closed. No new writing is allowed on a closed disc.

   Run-in Block – A single ECC block, zero filled and written, shall separate two adjacent fragments within a session. This Run-in Block ensures that the first ECC block of the second fragment will be readable.

The status of a session and of the fragments within its user data zone is found within the session's Intro.

Table 2 shows the zones of a session.

Table 2 – Zones of a Session

Session Zone	Description	Size	
		Physical Sectors	**ECC Blocks**
Disc Lead-in (used in place of an Intro for session 1)	Guard Zone 1	14 848	928
	Reserved Zone 1	4 096	256
	Reserved Zone 2	64	4
	Inner Disc Identification Zone	256	16
	Reserved Zone 3	64	4
	Reference Code Zone	32	2
	Buffer Zone 1	480	30
	Control Data Zone	3 072	192
	Buffer Zone 2	512	32
Session (≠1) Intro	Buffer Zone A	64	4
	Inner Session Identification Zone	256	16
	Session Control Data Zone	640	40
	Buffer Zone B	64	4
User Data Zone	User Data	minimum = 16	minimum = 1
Session (not final) Closure	Buffer Zone C	768	48
	Outer Session Identification Zone	256	16
Disc Lead-out (used in place of a Closure for the final session)	Buffer Zone 3	768	48
	Outer Disc Identification Zone	256	16
	Guard Zone 2 (minimum size)	4 096	256

The time to write each of these areas is as follows:

- Reserved Zone 2 and Buffer Zone 2 must be completely written when session 1 first becomes non-empty open. Buffer Zone A and Buffer Zone B are completely written when the session (≠1) becomes non-empty open.
- The User Data area is written as the host provides data.
- The Inner Disc/Session Identification Zone is written incrementally as fragments within the session are defined. When a fragment is defined, a record (the Fragment Item) is included in the Inner Disc/Session Identification Zone that identifies the boundaries of the fragment. When the session is closed, all unused ECC blocks within the Inner Disc/Session Identification Zone are written with all zeros.
- The remaining areas are written when the session is closed. Sectors in the Outer Disc/Session Identification Zone shall be either zero filled or copies of the Inner Disc/Session Identification Zone.

NOTE: When the final session is closed, the ECC blocks of the lead-out shall be encoded as lead-out.

Session Oriented Rules:

There may be at most one open session on a disc - the session that contains the current invisible fragment.

When a session is closed a new ECC block is appended to the Table of Contents Zone (see Table 1) containing a TOC item that identifies the bounds of the new session.

A session may be closed only when every fragment within the session is closed.

2.3.2 The Host's Perspective

The MMC command set was developed specifically for CD. Rather than force a new model upon host software developers, the command set described here is designed to maintain the CD-R model when working with DVD+R. Some differences cannot be avoided. The following should clarify.

The host approaches the device and the media from the perspective of CD-R: sectors, packets, tracks, and sessions. For the host, a track is the unit of allocation. The host views a DVD+R fragment as a fixed packet track where the packet size is 16 sectors. When a DVD+R session is open, fragment is equivalent to track. When a DVD+R session is closed, session is equivalent to track. Numbering for CD-R tracks and DVD+R tracks is different:

The user data zone of a closed session is viewed as a track and its number is the session number.

Fragments in the open session are viewed as tracks with:

Track Number =

Session Number + Fragment Number - Fragment Number of first fragment in the session.

The READ TOC/PMA/ATIP command reports the Lead-out as track number AAh. This places a practical limit for track numbers at A9h (169d). So,

Maximum Track Number (=169) = Number of Closed Sessions +

Maximum Number of Fragments in Open Session.

Maximum Number of Fragments in Open Session is 16 (see 2.3.3), so Number of Closed Sessions = 169 - 16 = 153. The Maximum Final Session is then numbered 154.

The following commands are defined for the purpose of inspecting and recording DVD+R media:

READ DISC INFORMATION (4.14) – Provides detailed information about disc status.

READ TRACK INFORMATION (4.17) – Provides detailed information about any track. Track number translation is according to the above description. A reference to track number FFh results in information for the invisible fragment.

READ TOC/PMA/ATIP (form 0) (4.16.1) – Provides general information about tracks on the media. Tracks reported in response to this command represent only closed sessions. Since CD identifies the lead-out as track AAh, the maximum track number is A9h (169d). This provides for a maximum of 153 closed sessions and 16 fragments in the open session.

READ TOC/PMA/ATIP (form 1) (4.16.2) – Provides general information about the last closed session.

WRITE (10 or 12) (4.10, 4.11) – Allows writing any sector with location restrictions. The first sector in the write must begin with the NWA for some track (fragment) in the open session.

SYNCHRONIZE CACHE (4.26) – When writes to a track (fragment) may not have reached an ECC block boundary, the host may issue this command in order to ensure that all buffered data is actually written to the disc.

RESERVE TRACK (4.20)– Provides the host with the ability to reserve blank disc space for a single track (fragment). The track is not referenced by a number. The fragment will be created from the beginning of the invisible fragment. The new, reserved fragment will receive the fragment number of the old invisible fragment, and a new invisible fragment will be given the next fragment number.

CLOSE TRACK/SESSION (Track) (4.1) – The host may choose to close a reserved track (fragment) or to define a track (fragment) from the written part of the invisible fragment.

CLOSE TRACK/SESSION (Session) (4.1) – For the purpose of making the disc read compatible with a DVD-ROM device, the equivalent of a lead-out (closure) or a real lead-out must follow user data. The host may request either case with this command.

2.3.3   Building from a Blank Disc

When a DVD+R disc is blank, the user definable space begins as session 1, fragment 1 at LBA 0. In this state fragment 1 is invisible. When beginning recording on a blank disc, the host has two options: WRITE beginning at LBA 0 or RESERVE TRACK beginning at LBA 0.

- If the host chooses to WRITE, then the host's data is written beginning with LBA 0. The end address of fragment 1 is still unknown, so fragment 1 remains the only fragment on the disc. When this write is executed by the drive, it shall record a session identification item in the first ECC block of the Inner Disc/Session Identification Zone, leaving 15 blank ECC blocks in that zone. This allows for at most 15 incrementally defined fragments in the session. In this case the session may contain at most 15 fragments. Writing may proceed until the host determines that the fragment is completed. At that point the host may define the fragment as complete by issuing a CLOSE TRACK command. The drive shall respond by appending an ECC block into the Inner Disc/Session Identification Zone with a new fragment identification item.

- If the host chooses to issue the RESERVE TRACK command, then a size must be selected. The size will be rounded up to an ECC block boundary. At this point, the end address of fragment 1 is known, thereby defining fragment 2 as an invisible fragment beginning at an ECC block after fragment 1. In executing the RESERVE TRACK command the drive shall record a session identification item and a fragment identification item (for fragment 1) in the Inner Disc/Session Identification Zone, leaving 15 blank ECC blocks in that zone. This allows for at most 16 incrementally defined fragments in the session. In this case the session may contain at most 16 fragments. The reserved fragment may be written sequentially as the host deems it necessary. If all necessary writing to this fragment has been done, the host may define the fragment as complete by issuing a CLOSE TRACK command. The drive shall respond by writing all blank ECC blocks in the fragment with zero filled data.

Subsequent fragment usage should be handled similarly.

When the user wishes to eject the disc, the host may elect to close the currently open session prior to disc eject. This will ensure that the disc will have read compatibility with DVD read-only devices. If the user wishes to disallow further writing after the session is closed, it is possible to select a close function that will close the disc.

3   Features and Profiles

A DVD+R drive might be capable of reading many different types of media. A DVD+R drive might be capable of writing many different types of media. The response from the GET CONFIGURATION Command contains a report of each media capability. Rather than attempt to predict the combinations of supported profiles, this document shall only focus on the features and profiles required to support reading and writing DVD+R media. The requirements for a read-only device can be extrapolated.

3.1   Feature 002Bh: DVD+R

A DVD+R device must report the DVD-ROM Profile (Profile 10h). The DVD Read Feature within the DVD-ROM Profile implies the physical capability of reading DVD+R media, however, such a device may not recognize logical structures unique to the DVD+R format (e.g. Disc Control Blocks).

The presence of the DVD+R Feature indicates that the drive is capable of reading a recorded DVD+R disc that is written according to *DVD+R 4.7 Gbytes Basic Format Specifications.* Specifically, this includes the capability of reading DCBs. The DVD+R Feature descriptor is shown in Table 3.

Table 3 - DVD+R Feature Descriptor

Bit Byte	7	6	5	4	3	2	1	0
0	Feature Code = 002Bh							
1								
2	Reserved		Feature Version				Persistent	Current
3	Additional Length							
4	Reserved							Write
5	Reserved							
6	Reserved							
7	Reserved							

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.

> Note: When Current = 0, either no disc is mounted or the disc currently mounted is not a DVD+R disc. When Current = 1, a disc is mounted and it is a DVD+R disc.

The Additional Length field shall be set to 04h.

This feature may be present only to represent additional capability to the DVD-ROM Profile.   If the Write bit is cleared to zero, then no additional capability is claimed. A device may report this feature only when Profile 10h (DVD-ROM) is reported.   No additional commands or mode parameters are required.

If the Write bit is set to one, then the drive is also capable of writing DVD+R discs according to *DVD+R 4.7 Gbytes Basic Format Specifications.*

If a device reports this feature with the Write bit is set to one, then the drive shall support the commands shown in Table 4.

Table 4 - Command Support Required by the DVD+R Feature with Write

Op Code	Command Description	Reference
5Bh	Close Track/Session	4.1
51h	Read Disc Information	4.14
52h	Read Track Information	4.17
53h	Reserve Track	4.20
BFh	Send DVD Structure	4.21
35h	Synchronize Cache	4.26
2Ah	Write (10)	4.10

Due to the lower complexity of the DVD+R format as compared to CD-R, the DVD+R Feature does not require the use of the Write Parameters Mode Page.

Note: If the Write Parameters Mode Page is supported for other media types, the drive must accept valid mode selects to the Write Parameters Mode Page. The host must be aware that the drive will always ignore the Write Parameters Mode Page when the DVD+R Feature is current.

3.2   Profile 001Bh: DVD+R

Logical units identifying Profile 001B as current shall support the features listed in Table 5.

Table 5 - Mandatory Features for DVD+R

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	The device changes its operational behavior due to events external to the Host
0003h	Removable Medium	The medium may be removed from the device
0010h	Random Readable, PP=1	Read ability for storage devices with random addressing
001Fh	DVD Read	The ability to read DVD specific structures
002Bh	DVD+R	Support for reading and optionally writing DVD+R Media
0100h	Power Management	Host and device directed power management
0105h	Time-Out	Ability to respond to all commands within a specific time
0107h	Real-time Streaming	Ability to read and write using Host requested performance parameters

The presence of the DVD+R Profile indicates that the drive is capable of reading a DVD+R disc that has been recorded according to *DVD+R 4.7 Gbytes Basic Format Specifications.* In addition, the presence of the DVD+R Profile indicates that the WRITE bit in the DVD+R feature must be set to one.

3.3   Other Profiles and Features

A drive that reports the DVD+R Feature shall also claim the DVD-ROM Profile (0010h).

Certainly, other media and consequently other profiles may be supported.

4   Command Descriptions

The features require that specific commands be implemented. A small number of commands are optional. Table 6 shows the decomposition of the DVD+R Profile first into Features and then commands and mode pages.

Table 6 - DVD+R Profile Decomposition

DVD+R Profile	Core Feature	Get Configuration Command
		Get Event Status Notification Command
		Inquiry Command
		Mode Select (10)
		Mode Sense (10)
		Request Sense
		Test Unit Ready
	Morphing Feature	Get Configuration Command
		Get Event Status Notification Command
		Prevent Allow Medium Removal Command
		Send Event Command
	Removable Medium Feature	Mechanism Status Command
		Prevent Allow Medium Removal Command
		Start Stop Unit Command
	Random Readable Feature	Read Capacity Command
		Read (10) Command
		Read/Write Error Recovery Mode Page
	DVD Read Feature	Read (10) Command
		Read (12) Command
		Read DVD Structure Command
		Read TOC/PMA/ATIP Command
	DVD+R Feature	Close Track/Session Command
		Read Disc Information Command
		Read Track Information Command
		Reserve Track Command
		Send DVD Structure Command
		Synchronize Cache Command
		Write (10) Command
	Real-time Streaming Feature	Get Performance Command
		Read (12) Command
		Read Buffer Capacity Command[C]
		Set CD Speed Command[C]
		Set Read Ahead Command
		Set Streaming Command
		Write (12) Command[C]
		Capabilities and Mechanical Status Mode Page[C]
	Power Management Feature	Get Event Status Notification Command
		Start Stop Unit Command
		Power Condition Page
	Timeout Feature	Timeout and Protect Mode Page

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

The decomposition shown on Table 6 results in the command list shown in Table 7.

Table 7 - Commands for DVD+R Devices

SCSI Commands	Op Code	Reference
CLOSE TRACK/SESSION	5Bh	4.1
GET CONFIGURATION	46h	MMC-3
GET EVENT/STATUS NOTIFICATION	4Ah	MMC-3
GET PERFORMANCE	ACh	MMC-3
INQUIRY	12h	SPC-2
MECHANISM STATUS	BDh	MMC-3
MODE SELECT (10)	55h	SPC-2
MODE SENSE (10)	5Ah	SPC-2
PREVENT/ALLOW MEDIA REMOVAL	1Eh	MMC-3
READ (10)	28h	MMC-3
READ (12)	A8h	MMC-3
READ BUFFER CAPACITY	5Ch	MMC-3
READ CAPACITY	25h	MMC-3
READ DISC INFORMATION	51h	MMC-3, 4.14
READ DVD STRUCTURE	Adh	MMC-3
READ TOC/PMA/ATIP	43h	MMC-3
READ TRACK INFORMATION	52h	MMC3, 4.17
REPORT KEY	A4h	MMC-3
REQUEST SENSE	03h	MMC-3
RESERVE TRACK	53h	MMC-3, 4.20
SEND DVD STRUCTURE	BFh	MMC-3
SEND KEY	A3h	MMC-3
SET READ AHEAD	A7h	MMC-3
SET STREAMING	B6h	MMC-3
START/STOP UNIT	1Bh	MMC-3
SYNCHRONIZE CACHE	35h	MMC-3
TEST UNIT READY	00h	MMC-3
WRITE (10)	2Ah	MMC-3
WRITE (12)	AAh	MMC-3

For the most part, these commands are adequately described by the appropriate standards reference. In a small number of cases, changes/additions have been made in order to provide support for DVD+R medium.

4.1 CLOSE TRACK/SESSION COMMAND

The CLOSE TRACK/SESSION Command, Table 8, allows closure of either a track or a session. The command description that follows is specific to DVD+R. For other media types and formats, refer to MMC-3.

Table 8 - Close Track/Session Command Descriptor Block

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

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

The DVD+R drive shall respond to the Close Function code as shown in Table 9.

Table 9 - DVD+R Drive Responses to Close Function

Close Function	Close Action By DVD+R Drive
000b	Reserved
001b	Close the track associated with the track number in the CDB as follows:
	If the current track is reserved and blank or partially written, the DVD+R Drive shall pad the track to its defined length. User data areas in all pad sectors shall be zero filled. If the track being closed is the invisible track and the invisible track is not blank, then a new DCB shall be appended into the Session Identification Zone defining the existence of the track. If the track being closed is the invisible track and the invisible track is blank, then the command shall be terminated with GOOD status and sense data shall be set to NO SENSE/NO ADDITIONAL INFORMATION.
010b	Close the last session. If not all Tracks in the last Session are closed, the DVD+R Drive shall terminate this command with CHECK CONDITION Status and sense data shall be set to ILLEGAL REQUEST/SESSION FIXATION ERROR/ INCOMPLETE TRACK IN SESSION.
	If upon completion of the closure, less than 65 ECC blocks would remain, the drive shall finalize the disc.
	If the session being closed is session number 154, when the close session is requested, the drive shall finalize the disc.
011b	Reserved
100b	Reserved
101b	Close the last session and finalize the disc. Once this close function has been executed, no more writing to the disc is allowed. If not all Tracks in the last Session are closed, the DVD+R Drive shall terminate this command with CHECK CONDITION Status and sense data shall be set to ILLEGAL REQUEST/SESSION FIXATION ERROR/ INCOMPLETE TRACK IN SESSION.
	In order to assure maximum interchange compatibility with read only devices, Guard Zone 2 shall be recorded to a device defined PSN that approximates a disc radius of 30 mm. Suggested value: 70DE0h (462 304).
110b	Close the last session and finalize the disc. Once this close function has been executed, no more writing to the disc is allowed. If not all Tracks in the last Session are closed, the DVD+R Drive shall terminate this command with CHECK CONDITION Status and sense data shall be set to ILLEGAL REQUEST/SESSION FIXATION ERROR/ INCOMPLETE TRACK IN SESSION.
111b	Reserved

During the Close Track/Session where the IMMED bit was set to one, the DVD+R Drive shall respond to commands as follows:

1. The DVD+R Drive may respond to commands that are allowed to return NOT READY sense by terminating the command with CHECK CONDITION Status and setting sense data to NOT READY, LOGICAL UNIT NOT READY, OPERATION IN PROGRESS.

2. In response to the INQUIRY, GET CONFIGURATION, and GET EVENT/STATUS NOTIFICATION commands, the DVD+R Drive shall respond as commanded.

3. Closing a Track or Session shall cause a Class 1 Event when the command is issued if the DVD+R Drive becomes NOT READY. A Class 1 Event shall occur if the medium returns to READY or if the medium becomes not writable. Other Class 1 Events may occur due to closing a Track or Session.

4.2   GET CONFIGURATION Command

Although a new feature has been defined, DVD+R requires no modification to the behavior of this command.

4.3   GET EVENT/STATUS NOTIFICATION Command

The presence of the DVD+R Feature has no effect upon the host/drive interface with respect to this command.

4.4   GET PERFORMANCE COMMAND

The presence of the DVD+R Feature has no effect upon the host/drive interface with respect to this command.

4.5   INQUIRY COMMAND

The presence of the DVD+R Feature has no effect upon the host/drive interface with respect to this command.

4.6   MECHANISM STATUS COMMAND

The presence of the DVD+R Feature has no effect upon the host/drive interface with respect to this command.

4.7   MODE SELECT (10) COMMAND

The presence of the DVD+R Feature has no effect upon the host/drive interface with respect to this command.

4.8   MODE SENSE (10) COMMAND

The presence of the DVD+R Feature has no effect upon the host/drive interface with respect to this command.

4.9   PREVENT/ALLOW MEDIA REMOVAL COMMAND

The presence of the DVD+R Feature has no effect upon the host/drive interface with respect to this command.

4.10 READ (10) COMMAND

When some sector in the address range is physically blank, the command will be terminated with CHECK CONDITION status and sense bytes SK/ASC/ASCQ shall be set to ILLEGAL REQUEST/END OF USER AREA ENCOUNTERED ON THIS TRACK. The command should be processed normally until the first blank sector is encountered.

In all other respects, the presence of the DVD+R Feature has no effect upon the host/drive interface with respect to this command.

4.11 READ (12) COMMAND

When some sector in the address range is physically blank, the command will be terminated with CHECK CONDITION status and sense bytes SK/ASC/ASCQ shall be set to ILLEGAL REQUEST/END OF USER AREA ENCOUNTERED ON THIS TRACK. The command should be processed normally until the first blank sector is encountered.

In all other respects, the presence of the DVD+R Feature has no effect upon the host/drive interface with respect to this command.

4.12 READ BUFFER CAPACITY

The presence of the DVD+R Feature has no effect upon the host/drive interface with respect to this command.

4.13 READ CAPACITY

The READ CAPACITY command (Table 10) provides a means for the Host to request information regarding the capacity of the currently mounted medium. The command description that follows is specific to DVD+R. For other media types and formats, refer to MMC-3.

Table 10: READ CAPACITY Command Descriptor Block

Bit Byte	7	6	5	4	3	2	1	0
0	Operation Code (25h)							
1	Reserved							
2	(MSB)							
3	Logical Block							
4	Address							
5								(LSB)
6	Reserved							
7	Reserved							
8	Reserved							PMI
9	Control							

The RelAdr, PMI bits, and Logical Block Address field shall be set to zero for Logical Units.

Eight bytes of READ CAPACITY response data (Table 11) shall be returned in response to the command.

Table 11: READ CAPACITY Response Data

Bit Byte	7	6	5	4	3	2	1	0
0	(MSB)							
1	Logical Block							
2	Address							
3	(LSB)							
4	(MSB)							
5	Block Size							
6	(Must be 2 048)							
7								(LSB)

If the mounted medium is a non-blank DVD+R disc, then the value returned in the Logical Block Address field is the LBA that represents the last block of the last closed session. For blank DVD+R media, the Logical Block Address field is cleared to zero.

For DVD+R media, the Block Length shall be reported, in bytes, as 2 048.

4.14 READ DISC INFORMATION COMMAND

The Read Disc Information Command (the CDB is unchanged and thus not shown) returns detailed information about the medium. This information is returned in the Disc Information Block. All fields currently defined in MMC-3 shall remain unchanged.

Table 12 - Disc Information Block

Byte \ Bit	7	6	5	4	3	2	1	0
0	(MSB)			Disc Information				
1				Length				(LSB)
2	Reserved			Erasable	State of last Session		Disc Status	
3	Number of First Track on Disc							
4	Number of Sessions (LSB)							
5	First Track Number in Last Session (LSB)							
6	Last Track Number in Last Session (LSB)							
7	DID_V	DBC_V	URU	DAC_V	Reserved		Background Format Status	
8	Disc Type							
9	Number of Sessions (MSB)							
10	First Track Number in Last Session (MSB)							
11	Last Track Number in Last Session (MSB)							
12	(MSB)							
13				Disc				
14				Identification				
15								(LSB)
16	(MSB)							
17				Last Session Lead-in Start Time				
18				MSF				
19								(LSB)
20	(MSB)							
21				Last Possible Start Time for Start of Lead-out				
22				MSF				
23								(LSB)
24	(MSB)							
...				Disc Bar Code				
31								(LSB)
32	Disc Application Code							
33	Number of OPC Table Entries							
34 - n	OPC Table Entries							

For DVD+R media:

- Disc Information Length shall be set to 32+8*N_{OPC}, where N_{OPC} is the number of OPC table entries,
- Erasable shall be cleared to zero,
- State of last Session shall be according to the MMC-3 definition for CD-R,
- Disc Status shall be according to the MMC-3 definition for CD-R,
- Number of First Track on Disc shall be set to 1,
- Number of Sessions is the actual number of sessions on the medium - including the open session, if it exists,
- First Track Number in Last Session is equal to the number of the last session,
- Last Track Number in Last Session is exactly the last track number in the last session,
- DID_V shall be cleared to zero.
- DBC_V shall be cleared to zero.
- Certain host applications may be restricted to writing only media that has a specific Disc Application Code (byte 32). If the media has one of those restricted use codes, then URU (UnRestricted Use) shall be zero. Otherwise, URU shall be set to one. See the appropriate media specification for restricted code values.
- DAC_V specifies the validity of the Disc Application Code in byte 32.
- Background Format Status shall be cleared to zero,
- Disc Type shall be set to 00h,
- Disc Identification is unique to CD. For DVD+R, this field shall be cleared to zero,
- Last Session Lead-in Start Time shall be reported as a LBA,
- Last Possible Start Time for Start of Lead-out shall be reported as a LBA,
- Disc Bar Code shall be cleared to zero,
- Disc Application Code shall be the value discovered on the disc. If the disc has no Disc Application Code, then the contents shall be set to zero.
- Number of OPC Table Entries shall not exceed 27.

4.15 READ DVD STRUCTURE COMMAND

A DVD+R drive must support all formats supported by DVD-ROM devices. This is simply a requirement of the DVD Read Feature.

A DVD+R drive shall support the format field codes shown in Table 13.

Table 13 - DVD+R Format Code Support for Read DVD Structure Command

Format Code	Description
00h	Information in the DVD Lead-in area.
01h	The Copyright information from the DVD Lead-in area
03h	The BCA information on DVD media
04h	The Disc Manufacturing information from the DVD Lead-in area
05h	The Copyright Management
30h	Disc Control Block identified by the Content Descriptor
FFh	A list of DVD Structures present in the specified Layer

In the specific case of DCBs, the Session DCB may be of interest to an application that may wish to reconstruct the sequence of track creation and session closure.

Table 14 shows the Read DVD Structure CDB when reading DCBs from a DVD+R medium.

Table 14 - Read DVD Structure CDB for Reading DCBs

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation Code (ADh)							
1	Reserved							
2	(MSB)							
3	DCB Content Descriptor = 53444200h							
4								
5								(LSB)
6	Session Number							
7	Format = 30h							
8	(MSB)		Allocation Length					
9								(LSB)
10	AGID			Reserved				
11	Control							

The data from the most recently recorded DCB (the SDCB) within the specified session shall be returned. The format of the SDCB is to be found in *DVD+R 4.7 Gbytes Basic Formats Specifications.*

If Session Number does not exist, the drive shall terminate the command with CHECK CONDITION status and set sense codes shall be set to ILLEGAL REQUEST/INVALID PARAMETER IN CDB.

4.16 READ TOC/PMA/ATIP COMMAND

The definition for the returned data has some differences with other types of DVD media.

The Read TOC Command reports track information only for closed sessions.

4.16.1 TOC Form 0

Due to track merging, TOC form 0 reports each closed session as a track. Since DVD+R supports at most 154 sessions, TOC form 0 may have at most 154 track descriptors. Thus, the maximum size of returned data for TOC form 0 is 1 532 (i.e. 4 + 8*154).

The TOC form 0 format is presented to the host as shown in Table 15:

Table 15 - TOC Form 0 Format

	Bit	7	6	5	4	3	2	1	0
TOC Header									
Byte									
0		(MSB)			TOC Data Length				
1									(LSB)
2		Number of First Closed Session on disc (=01h)							
3		Number of Last Closed Session on Disc							
Track Descriptor Format									
0		Reserved							
1		ADR				CTL			
2		Session Number							
3		Reserved							
4		(MSB)							
5		Session Start Address							
6		(Address of first sector of user data in session)							
7									(LSB)

If the host requests this TOC form for a disc that has no closed sessions, the drive shall terminate the READ TOC/PMA/ATIP command with CHECK CONDITION status and set sense data to ILLEGAL REQUEST/INVALID PARAMETER IN CDB.

If the MSF (TIME) bit in the CDB is set to zero, then the Address field (bytes 4 - 7) shall contain the LBA of the first sector of the first user ECC block of the session.

If the MSF (TIME bit in the CDB is set to one, then the Address field (bytes 4 - 7) shall contain an MSF representation of the LBA. When LBA is less than 1 152 000d, M,S and F are selected so that:

LBA = MIN (4500*M + 75*S + F - 150. Otherwise, M, S, and F shall be selected as 0FFh, 3Bh, and 4Ah.

4.16.2 TOC Form 1

The TOC form 1 format for DVD+R is as follows:

	Bit	7	6	5	4	3	2	1	0
Byte									
		TOC Header							
0		(MSB)			TOC Data Length				
1									(LSB)
2		Number of First Closed Session on Disc (01h)							
3		Number of Last Closed Session on Disc							
		Track Descriptor Format							
0		Reserved							
1		ADR				CTL			
2		Number of Last Closed Session on Disc							
3		Reserved							
4		(MSB)							
5		Session Start Address							
6		(Address of first sector of user data in session)							
7									(LSB)

If the MSF (TIME) bit in the CDB is set to zero, then the Address field (bytes 4 - 7) shall contain the LBA of the first sector of the first user ECC block of the session.

If the MSF (TIME bit in the CDB is set to one, then the Address field (bytes 4 - 7) shall contain an MSF representation of the LBA. When LBA is less than 1 152 000d, M,S and F are selected so that:

LBA = MIN (4500*M + 75*S + F - 150. Otherwise, M, S, and F shall be selected as 0FFh, 3Bh, and 4Ah.

4.16.3 TOC Form 2

TOC form 2 is not defined for DVD+R media. If the host requests this TOC form, the drive shall terminate the READ TOC/PMA/ATIP command with CHECK CONDITION status and set sense data to ILLEGAL REQUEST/INVALID PARAMETER IN CDB.

4.16.4 TOC Form 3

TOC form 3 is not defined for DVD+R media. If the host requests this TOC form, the drive shall terminate the READ TOC/PMA/ATIP command with CHECK CONDITION status and set sense data to ILLEGAL REQUEST/INVALID PARAMETER IN CDB.

4.16.5 TOC Form 4

TOC form 4 is not defined for DVD+R media. If the host requests this TOC form, the drive shall terminate the READ TOC/PMA/ATIP command with CHECK CONDITION status and set sense data to ILLEGAL REQUEST/INVALID PARAMETER IN CDB.

4.16.6 TOC Form 5

TOC form 5 is not defined for DVD+R media. If the host requests this TOC form, the drive shall terminate the READ TOC/PMA/ATIP command with CHECK CONDITION status and set sense data to ILLEGAL REQUEST/INVALID PARAMETER IN CDB.

4.17 READ TRACK INFORMATION

The Read Track Information Command (the CDB is unchanged and thus not shown) returns detailed information about the medium. This information is returned in the Track Information Block.

Table 16 - Track Information Block

Bit Byte	7	6	5	4	3	2	1	0
0	(MSB)			Data Length				
1								(LSB)
2	Track Number (LSB)							
3	Session Number (LSB)							
4	Reserved							
5	Reserved		Damage	Copy	Track Mode			
6	RT	Blank	Packet	Fixed	Data Mode			
7	Reserved						LRA_V	NWA_V
8	(MSB)							
…				Track Start Address				
11								(LSB)
12	(MSB)							
…				Next Writable Address				
15								(LSB)
16	(MSB)							
…				Free Blocks				
19								(LSB)
20	(MSB)							
…				Packet Size/Blocking Factor				
23								(LSB)
24	(MSB)							
…				Track Size				
27								(LSB)
28	(MSB)							
…				Last Recorded Address				
31								(LSB)
32	Track Number (MSB)							
33	Session Number (MSB)							
34	Reserved							
35	Reserved							
36	(MSB)							
37	Read Compatibility LBA							
38								
39								(LSB)

For DVD+R:

- Data Length shall be set to 34 (22h) or 38 (26h).
- Track Number shall be equal to session number if the session is closed. Otherwise, Track Number shall be set according to MMC-3.
- Session Number shall be set according to MMC-3.
- Damage has no meaning for DVD+R and shall be cleared to zero.
- Copy has no meaning for DVD+R and shall be cleared to zero.
- Track Mode shall be set to 7h.
- RT shall be set according to MMC-3.
- Blank shall be set according to MMC-3.
- Packet has no meaning for DVD+R and shall be cleared to zero.
- FP has no meaning for DVD+R and shall be cleared to zero.
- Data Mode shall be set to 1.
- LRA_V shall be cleared to zero.
- NWA_V shall be set according to MMC-3 and shall point to the first sector of an ECC block.
- Track Start Address set to the user data sector of the session if the session is closed. Otherwise, it shall be set according to MMC-3.
- Next Writable Address shall be set according to MMC-3.
- Free Blocks shall be set according to MMC-3.
- Packet Size/Blocking Factor shall be set to10h.
- Track Size shall be equal to session data zone size if the session is closed. Otherwise, it shall be set according to MMC-3.
- Last Recorded Address shall be cleared to zeros.
- If the track is the invisible track (i.e. RT=0), the Read Compatibility LBA shall be present. Read Compatibility LBA is an approximation of a logical block address at or beyond a 30mm disc radius. The host may use this address as a minimal pad limit prior to closing the current session in order to maximize compatibility with read-only devices.

4.18 REPORT KEY COMMAND

DVD+R requires no changes or additions.

4.19 REQUEST SENSE COMMAND

The presence of the DVD+R Feature has no effect upon the host/drive interface, but some sense codes not now used by other DVD rewritable devices must be implemented by a write capable DVD+R compliant drive.

4.20 RESERVE TRACK

This command operates in an equivalent way to the function described for CD in MMC-3, with some small exceptions:

Reservation Length is given as a count of 2 KB sectors. If this number is not an integral multiple of 16, then the drive shall increase the value to the next integral multiple of 16. This is the value used by the drive. A track always begins with the first sector of an ECC block. A run-in ECC block shall be written between any two tracks within a session just prior to writing the first ECC block of the following track. The run-in ECC block does not belong to either track.

4.21 SEND DVD STRUCTURE

A DVD+R drive shall support the format field codes shown in Table 17, as required by the DVD+R Feature description.

Table 17 - DVD+R Format Code Support for Send DVD Structure Command

Format Code	Data Description
05h	Copyright Management

Drive support for writing user defined DCBs is optional. The drive shall not allow DCBs defined in *DVD+R 4.7 Gbytes Basic Formats Specifications* to be modified by the host.

4.22 SEND KEY COMMAND

DVD+R requires no changes or additions.

4.23 SET READ AHEAD COMMAND

DVD+R requires no changes or additions.

4.24 SET STREAMING COMMAND

DVD+R requires no changes or additions.

4.25 START/STOP UNIT COMMAND

DVD+R requires no changes or additions.

4.26 SYNCHRONIZE CACHE COMMAND

DVD+R requires no changes or additions.

4.27 TEST UNIT READY COMMAND

DVD+R requires no changes or additions.

4.28 WRITE (10) COMMAND

DVD+R requires no changes or additions.

4.29 WRITE (12) COMMAND

DVD+R requires no changes or additions.

5 Mode Pages

Required features of the DVD+R read/write device also dictate support of certain mode pages.

Table 18 - Feature Specified DVD+R Mode Page Support

Description	Page Code	Reference
Capabilities and Mechanism Status Page	2Ah	MMC3
Power Condition Page	1Ah	MMC3
Read/Write Error Recovery Page	01h	MMC3
Time-out and Protect Page	1Dh	MMC3

5.1 Capabilities and Mechanical Status Page

DVD+R requires no changes or additions.

5.2 Power Condition Page

DVD+R requires no changes or additions.

5.3 Read/Write Error Recovery Page

Since DVD+R has no defect management system, ARRE and AWRE shall default to zero and cannot be set to one by the host.

Otherwise, DVD+R requires no changes or additions.

5.4 Time-out and Protect Page

DVD+R requires no changes or additions.

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6 Host Usage

6.1 Media Recognition and Initialization

It is presumed that the host has a continuous Get Event Status Notification poll operating in its background. The host is expected to take no additional action until a NewMedia Media Event is detected.

6.1.1 Discovering Blank DVD+R Media

The GESN poll reports a NewMedia Media Event.

The GESN poll reports NoEvent (no additional Media Events to report).

The GET CONFIGURATION Command is issued, and reports DVD+R Feature as current.

The READ DISC INFORMATION Command is issued.

It is discovered that the media is BLANK and not RW.

The host may now conclude that the media mounted is DVD+R and blank.

6.1.2 Discovering DVD+R Media with the Basic Format

The GESN poll reports a NewMedia Media Event.

The GESN poll reports NoEvent (no additional Media Events to report).

The GET CONFIGURATION Command is issued, and reports DVD+R Profile as current.

The READ DISC INFORMATION Command is issued.

It is discovered that the media is not RW and not BLANK.

The host may now conclude that the media mounted is DVD+R and some amount of data has been written.

Upon further inspection, the Disc Information Block shows the current session status. If the last session is open, then the number of the last open track within that session may be determined. Repeated use of the Read Track Information command will yield detailed information about each track within the open session.

6.2 Reading DVD+R

When a DVD+R media has been identified, it is presented to the host as randomly readable in 2 048 byte sectors. The drive must emulate this capability by reading only ECC blocks and separating individual sector data in its buffer. In the event that an unrecoverable read error occurs (READ (10) or READ (12) with streaming = 0), the drive must terminate the command with CHECK CONDITION status and set sense data to reflect the appropriate error.

If the host requests to read a sector within a blank ECC block, the drive shall terminate the command with CHECK CONDITION status and set sense data to ILLEGAL REQUEST/END OF USER AREA ENCOUNTERED ON THIS TRACK.

DVD+R is well suited for streamed applications. In using the media for that purpose, the READ (12) command should be used with the streaming bit set to one. All unrecoverable read errors will be ignored by the drive and whatever data has been recovered will be delivered to the host.

6.3 Writing DVD+R

DVD+R media is only sequentially writable in 2 048 byte sectors appended to open tracks. The drive shall buffer sequential host writes until an ECC block of data has been collected. The ECC block is then written.

If the host wishes to change to a different sequential data stream, the host may write to the NWA of some other track. If the current ECC block under construction has not been completely filled, then it shall be zero padded and written before dedicating the drive to a different data stream.

If the host wishes to terminate writing to the current ECC block prior to filling it, the SYNCHRONIZE CACHE command must be issued. If any write command is issued to an address that is not the NWA of some track, then the drive shall terminate the command with

CHECK CONDITION status and sense codes shall be set to ILLEGAL REQUEST/INVALID ADDRESS FOR WRITE.

In typical usage, the host will reserve some small number of tracks for incremental updates to the host's file system. Use data will be written into the invisible track and occasionally, the host will write update information into one of the reserved tracks.

DVD+R is well suited for streamed applications. In using the media for that purpose, the WRITE (12) command should be used with the streaming bit set to one. All unrecoverable write errors will be ignored by the drive.

6.4 DVD+R Multi-Session Device Drivers for Legacy DVD-ROM drives

A Legacy DVD-ROM drive is a drive that is compliant with MMC-2 or MMC-3, but is not aware of DVD+R structure. When such drives are able to mount and read a multi-session DVD+R disc, it is possible to create a device driver within the host environment that allows the remainder of the OS to view the drive as DVD+R capable.

6.4.1 Multi-Session Recognition Algorithm

In order to recognize a DVD+R Multi-Session disc, the location of the last session should be discovered first. Each session has an Intro at its beginning. The Intro that offers the session information "Session Control Data Zone". If there is no more Intro and the read attempt to it failed in errors, then the session is the last session.

6.4.2 Example of Recognition Sequence

Note: For full details, see DVD+R 4.7 Gbytes Basic Formats Specifications.

1. Issue a READ DVD STRUCTURE (Format 00h - Physical Format Information, Length 804h) command after mounting the DVD+R Multi-Session disc and retrieve the LWA of the first session. StartAddress and EndAddress of the first session are recorded at 0xF8h and 0xFCh respectively. If full 2 048 byte is not returned by DVD-ROM drives, estimate the addresses with reading Partition Descriptor of UDF file system.

2. Recognize the next session by searching Session Control Data Zone in the Intro by using the LWA (StartAddress and EndAddress of the next session are at same offsets as before). If read attempt of the data at the address of (LWA+1024+64+256) sector with the length of 16 sectors succeeds, then there exists the next session, vice versa.

3. If there is no more session, then the session is the last session. Host should search the anchor point which will start at address "S" (the start address of the session) to mount the disc.

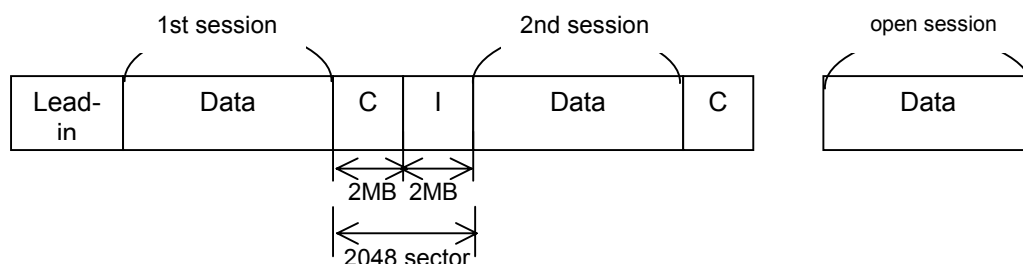4. If there is next session, the transaction #2 is repeated.

Figure 6 – Multi-Session DVD+R with Open Session

6.4.3 OS Specific Cases

For Win XP/2000:

The OS's will try to read the Multi-Session by issuing READ TOC command. The device drivers should respond with the data, which is expected as the drive is Multi Session enabled, when the host issues READ TOC command.

For Win 9X/ME:

The integrated file system does not support Multi Session. The device drivers should recognize the Multi-Session file system like existing UDF Reader for CD-R/RW.

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