SONY Double Density – CD Drive (DDCD)

Command Set Proposal

Ver.0.1c

1.1. DDCD Model

The Double Density CD (DDCD) Media Format is an extension of CD family whose capacity is more than double. This capacity is achieved by using a conventional 780 nm laser and using a NA of 0.50 or 0.55, by:

- reduction of the track pitch (x 1.45)
- reduced minimum pit size (x 1.33)

Table 1 - Realization of higher density

Parameter	Red Book CD	DDCD	Factor
Track pitch (um)	1.60	1.10	1.45
Length of optical marks (3 n 11)	n*0.278	n*0.208	1.33
Program area radius (mm)	25-58 (120 mm disc) 25-37.5 (80 mm disc)	24-58 (120 mm disc) 24-37.5 (80 mm disc)	1.06
Total user bit rate/ Channel bit rate:	0.284 (CD-ROM *Mode 1*)	0.284 (CD-ROM *Mode 2*)	1.00

A DDCD medium is an 80 mm or a 120 mm disc with a continuously recorded physical track beginning from a radius of 24 mm and spiraling outward to a radius 37.5 mm or 58 mm.

Like a conventional CD Drive/Media there are three types of DDCD Drive/Media: Read Only (DDCD-ROM), Write Once (DDCD-R), and Rewritable (DDCD-RW). The capacities of these media are the same.

The DDCD Media Format is not backward compatible with existing CD devices

1.1.1. DD Media Description

1.1.1.1. DDCD Specifications

Comparing the new DDCD specifications with those of the conventional CD, some major specifications are the same, such as the size of the disc. Other specifications indicate that some adaptations have to be made to the media production process of the DDCD's.
Error correction and physical addressing require some changes to the decoding/encoding equipments.

Table 2 shows some DDCD parameters.

Table 2 – Main Parameters of DDCD

	DDCD-ROM	DDCD-R	DDCD-RW
Capacity (120 mm disc) [Mbytes]	1300	1300	1300
Capacity (80 mm disc) [Mbytes]	400	400	400
Wavelength of laser diode [nm]	780	780	780
Reference NA [for read] [for write]	> 0.50	> 0.50 0.55	> 0.50 0.55
Data Bit length [um]	0.442	0.442	0.442
Channel Bit length [um]	0.208	0.208	0.208
Minimum Pit/Mark length [um]	0.62	0.62	0.62
Maximum Pit/Mark length [um]	2.29	2.29	2.29
Track pitch [um]	1.10	1.10	1.10
Sense of disc rotation seen from reading side	Counter clockwise	Counter clockwise	Counter clockwise
Thickness of the disc [mm]	1.2	1.2	1.2
User data per sector [bytes]	2048	2048	2048
Error Correction Code	CIRC*	CIRC*	CIRC*
Layered ECC Constraint Length	1sector	1sector	1sector
Correctable burst error length [mm]	3.16	3.16	3.16
Scanning velocity at 1X speed [m/s]	0.90	0.90	0.90
Channel bit rate [Mbps]	4.3218	4.3218	4.3218
User data bit rate at 1X speed [Kbytes/s]	150	150	150

Note:

CIRC* is different from the conventional CD. In the DDCD system, the delay parameter “D” of CIRC is extended from 4 to 7 to improve burst error correction ability in case of higher recording density. The maximum burst error correction ability of CIRC* is extended to 837 symbols.

1.1.1.2. Disc Structure

There are three address expressions used in the DDCD system; the Block address contained in the sector header (Physical Sector Number), Subcode-Q channel (Subcode frame time number), and the address referred to the blocks of the Host system (LBA: Logical Block Address).

The address used by the Host system starts from 0 to the end of the recorded information on the disc. LBA 0 shall correspond with the sector header address of D2F0h and the Subcode-Q address of 0:12:00:00 (0 hour, 12 minutes, 00 second, 00 frame). Only the Data Area is generally addressable by using LBA.

Subcode-Qs are addressed in time based address. The representation for a time based address is H:MM:SS:FF, where H = hours, MM = minutes, SS = seconds, and FF = frames. Hour field is 1 digit. MM,SS,FF are 2 digits respectively.

One Hour is subdivided into 60 Minutes. One Minute is 60 seconds. One Second is 75 frames.

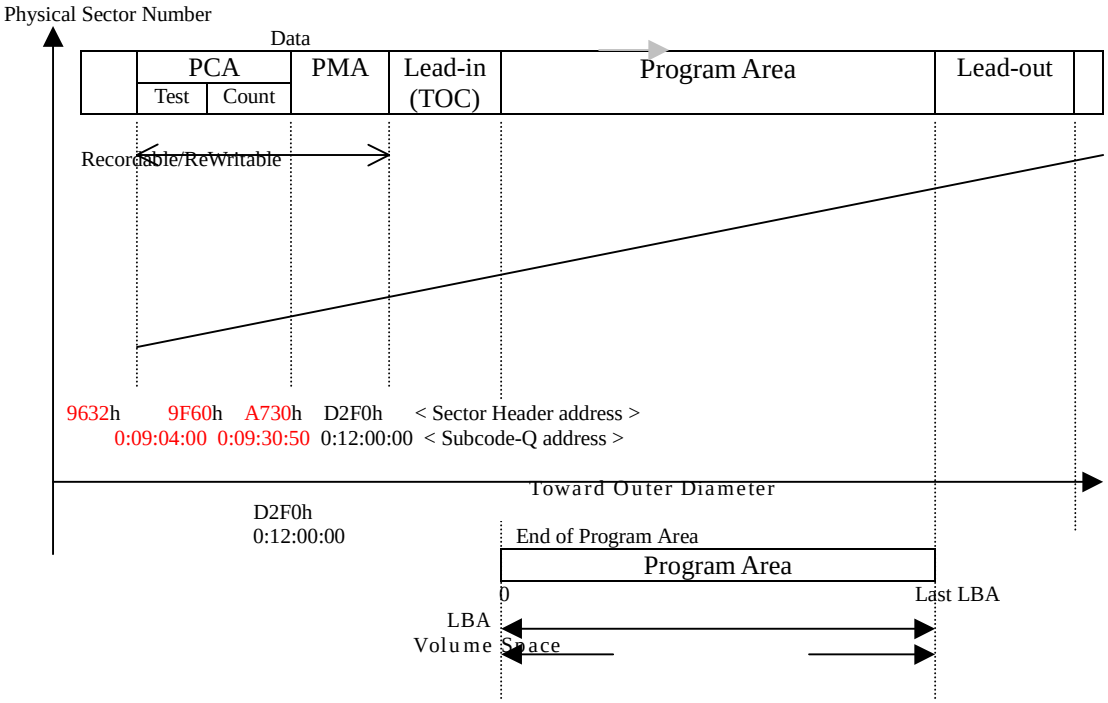

Figure 1 – Physical and Logical Layout of DDCD-ROM/R/RW

1.1.1.2.1. Single Session Disc

A Session is the recorded sequence: The Lead-in Area, The Program Area, The Lead-out Area. The Lead-in / Lead-out Area is a guard area at inner / outer part of the disc. The Lead-in Area also contains the table of contents (TOC) for Program Area. The Program Area is also known as the user area of the disc.

1.1.1.2.2. Multi-Session Disc

The multi-session allows a single disc to have several concatenated sessions. On a recorded disc, session may appear as shown in Figure 2.
DDCD read only drives are not typically capable of reading through unrecorded areas on the medium. The DDCD read only drive needs EFM data in order to find and stay in the physical track. This is to ensure that a DDCD read only drive is capable of accessing all areas of a Program Area.

Session1 Lead-in	Session1 Program Area	Session1 Lead-out	Session2 Lead-in	Session2 Program Area	Session2 Lead-out	……	Last Session Lead-in	Last Session Program Area	Last Session Lead-out

Figure 2 – Multi-Session Recorded Disc

In order to assure readability with DDCD read only drives, the recording system shall always close the session before attempting interchange.
Additional information is needed in order to locate all of the program areas.
This is accomplished by using Subcode-Q Mode 5 in the Lead-in areas.

1.1.1.3. Physical Sector

The physical format defined by the DDCD media standard provides 2,352 bytes per sector. For computer data applications, 2,048 bytes is used for user data, 12 bytes for a synchronization field, 4 bytes for a sector address, 8 bytes for an additional information and 276 bytes – the auxiliary field –for Layered ECC.

1.1.1.3.1. Sector structure

A Sector called Mode2 Sector shall consist of 2,352 bytes arranged with 12 Sync. bytes, 4 Header bytes, 8 Subheader bytes, 2,048 User Data bytes, and 4 Error Detection Code (EDC) bytes, 172 P-Parity bytes, 104 Q-Parity bytes. The User Data bytes are identified from 24th to 2071st. The Header shall consist of 3 bytes of Sector Address and 1 Mode byte. The Mode byte shall be 02h that indicates Mode 2 Disc Type.

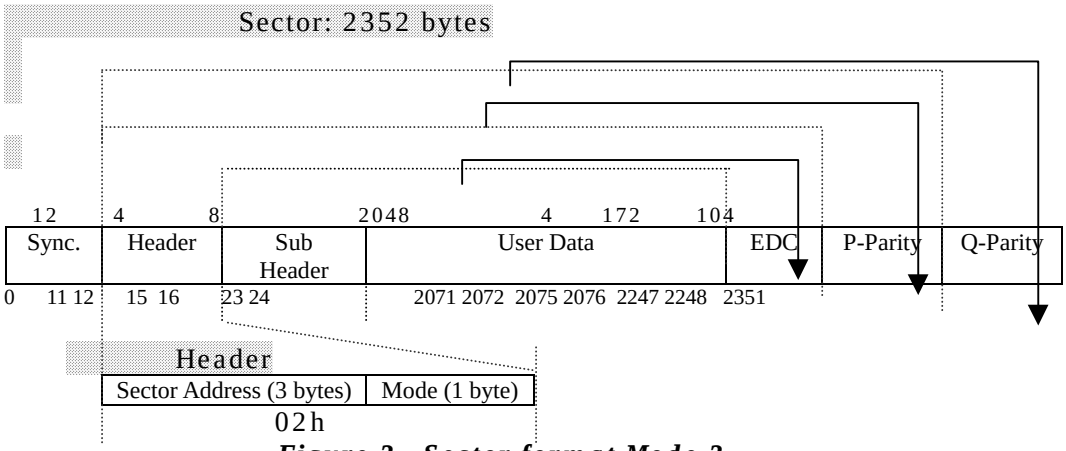

Figure 3 - Sector format Mode 2

The physical format of DDCD media uses smaller unit of synchronization than the other magnetic or optical recording systems.
The basic unit of the data stream synchronization is a small frame. This is different from large frame (sector) as referred to in the HMSF unit. Each small frame consists of 588 bits. A sector on DDCD media consists of 98 small frames.

A DDCD small frame consists of:
1. 1 synchronization pattern (24+3 bits)
2. 1 byte of sub-channel data (14+3 bits)
3. 24 bytes of data (24 x (14+3) bits)
4. 8 bytes of CIRC code (8 x (14+3) bits) Total:588 bits.

Data, sub-channel and CIRC bytes are encoded to 14-bit codes according to the EFM table; then three merging bits are added. The merging bits are chosen to minimize DSV (Digital Sum Value) and provide DC free characteristics.
The data bytes of 98 small frames comprise the physical unit of data referred to as a sector. 98 small frames times 24 bytes per small frame equals 2,352 bytes of data per sector.

1.1.1.3.2. Sub-channel Information Formats

The sub-channel 1 byte of each frame is assigned one bit for each of the 8 sub-channels, designated P, Q, R, S, T, U, V, W. Sub-channel P and R to W are all reserved and set to zero. All the sub-channel Q bits of a sector define the sub-

channel Q information block. The sub-channel Q block consists of 98 bits, one bit from each small frame in a sector.

The format provides the information of the location and is defined as follows:

1. 2-bits sub-channel synchronization field
2. 4-bits ADR field (defines the format)
3. 4-bits control field (defines the type of information in this sector)
4. 8-bits Track number
5. 8-bits index number
6. 28-bits reserved
7. 28-bits Absolute HMSF address (4-bits Hour, 8-bits Minutes, 8-bits Seconds, 8-bits Frames)
8. 16-bits CRC error detection code

ADR	TNO	INDEX	Reserved for future	AHOUR	AMIN	ASEC	AFRAME	CRC

Figure 4 – Subcode-Q Mode1 format recorded in Program Area

TNO = 01 to 9Fhex is the track number
INDEX = 00.
AHOUR, AMIN, ASEC, AFRAME
= the absolute time address expressed in 7 BCD digits.

1.1.2. DDCD Ready Condition/Not Ready Condition

The Ready Condition occurs after the disc is inserted and the Logical Unit has performed its initialization tasks. These tasks may include reading the lead-in information from the media. This “Ready” is different from and should not be confused with the ATA Ready Status. A CHECK CONDITION Status ***shall*** be returned for the Not Ready Condition only for Commands that require or imply disc access.

A Not Ready Condition may occur for the following reasons:
1. There is no disc.
2. The Logical Unit is unable to load or unload the disc.
3. The Logical Unit is performing an extended operation as the result of an Immediate
   mode Command such as FORMAT UNIT, BLANK, or CLOSE TRACK/SESSION commands

The Logical Unit ***shall*** spin up and make the disc ready for media accesses when a disc is detected.

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

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

Note: Accesses to the media can be satisfied from the Logical Unit’s cache and may not require the media to be spun up.

Some Commands are allowed to generate a “NOT READY” check condition, and others are not.

1.1.3. DDCD Address Reporting Format (HMSF bit)

Several (conventional) CD specific Commands can return addresses either in logical block address or in HMSF format. The READ HEADER, READ SUBCHANNEL, and READ TOC/PMA/ATIP Commands have this feature.

Table 3 – HMSF Address Format

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

The format is specified by an HMSF bit in the CDB. The HMSF bit of zero requests that the logical block address format be used for the absolute address field or for the offset from the beginning of the current Track.
An HMSF bit of one requests that the HMSF format be used for these fields. The H, M, S, and F Fields are expressed as binary numbers.

1.1.4. Error Reporting

If any of the following conditions occur during the execution of a Command, the DDCD Logical Unit ***shall*** return CHECK CONDITION status. The appropriate sense key and additional sense code ***shall*** be set. The following list illustrates some error conditions and the applicable sense keys. The list does not provide an exhaustive enumeration of all conditions that may cause the CHECK CONDITION status.

Table 4 – Error Conditions and Sense Key

Condition	Sense Key
Invalid logical block address	ILLEGAL REQUEST
Unsupported option requested	ILLEGAL REQUEST
Attempt to read a blank block	ILLEGAL REQUEST
Attempt to play a data block as audio	ILLEGAL REQUEST
Device reset or medium change Since last Command	UNIT ATTENTION
Self diagnostic failed	HARDWARE ERROR
Unrecovered read error	MEDIUM ERROR / HARDWARE ERROR
Recovered read error	RECOVERED ERROR
Overrun or other error that might be resolved by repeating the Command	ABORTED COMMAND

In case of an invalid logical block address, the sense data information field ***shall*** be set to the logical block address of the first invalid address.
In case of an attempt to read a blank or previously unwritten block, the sense data information field ***shall*** be set to the logical block address of the first blank block encountered. The data read up to the error block ***shall*** be transferred.
There are other special error situations for DDCD Logical Units. The following cases ***shall*** cause CHECK CONDITION Status, 5/63/00 END OF USER AREA ENCOUNTERED ON THIS TRACK:

1.1.5. Recording for DDCD media

There are several kinds of writing method of recording data in DDCD media. Session At Once, Track At Once, and Packet Writing are all used as methods of

recording DDCD media. There is a special case of Session At Once recording known as Disc At Once. Packet Writing can be further classified into Variable Packet Writing and Fixed Packet Writing.

1.1.5.1. DDCD Recordable and DDCD ReWritable Media Structure

An unrecorded DDCD-R or DDCD-RW disc does not have an EFM to find the physical track in the traditional way of DDCD read only drives. A blank DDCD-R or DDCD-RW has pre-groove and it has the built in wobble for the purpose of defining and finding the physical track.
The wobble is a 22.05KHz signal modulated with digital information. The position within the pre-groove is contained in each pre-groove frame of 42 bits. This is known as an Absolute Time In Pre-groove (ATIP).
The ATIP frame shall consist of 42 bits.
The format of the ATIP frame is defined in Table 5:

Table 5 – ATIP format

Number of bits	4	3	21	14
Bit position	1234	567	0011 11111111 222222222 8901 23456789012345678	233333333334 44 901234567890 12
Data	Sync	Discriminator	Physical frame address	CRC remainder

In the area that is expected to be the disc's Lead-in Area, the additional information is interleaved between positional ATIP frames.
The additional information provided are:

- First possible start address for disc Lead-in (TOC)
- Last possible start address for disc Lead-out
- Special information about recording permissions
- Power and speed requirements for recording the medium
- DDCD-R vs. DDCD-RW medium

DDCD-R/RW discs have two additional areas prior to the first Lead-in; the Power Calibration Area (PCA), and the Program Memory Area (PMA).

The Power Calibration Area (PCA) is present only in DDCD-R and DDCD-RW media for the purpose of write power calibration. The PCA is divided into two areas: the test area and the count area. The test area is divided into 1000 calibration partitions. The count area is a counting area for use of the test recording.

The Program Memory Area (PMA) is present only for DDCD-R and DDCD-RW media for the purpose of counting for the use of user data area on the medium. This information is contained only within the Subcode-Q channel of the PMA frames.

1.1.5.2. Packet Layout for DDCD

The layout of a Packet on DDCD media is shown in Figure 5. Each packet starts with Link block followed by three Run-in blocks. The User data blocks are placed directly after the Run-in blocks. Finally, three Run-out blocks are located following the User data blocks. In the case of Fixed packet writing, the size of each Packet in a Track is constant in length.

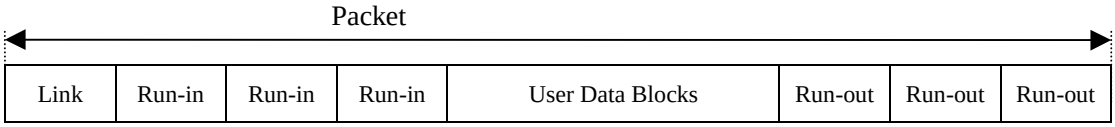

Figure 5 – Packet Layout

Blocks are uniquely identified by bit 5, 6, and 7 of the block's mode byte.

Table 6 – Block Identifier bits

Mode Byte Bit7, 6, 5	Block
000	User Data block
001	Third Run-in block
010	Second Run-in block
011	First Run-in block
100	Link block
101	Third Run-out block
110	Second Run-out block
111	First Run-out block

Figure 6 shows an example of the layout of packet written Track.

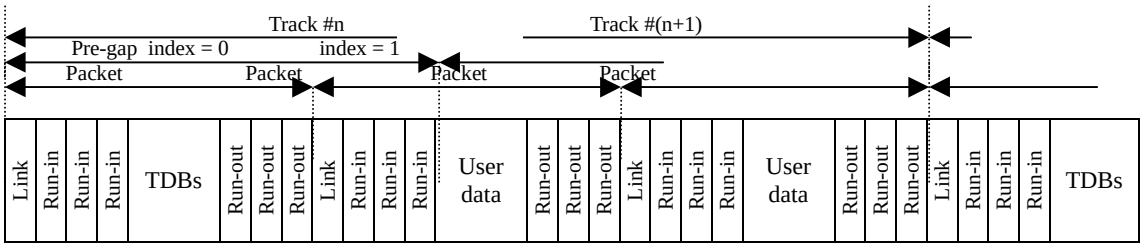

Figure 6 – Example of Packet written Track layout

1.1.5.3. Addressing Method

For DDCD media, there are two kinds of addressing. Except for the space within a Fixed Packet written Track, the Logical Block Address has a one-to-one relationship to the physical block number. This type of addressing is called "Method 1 Addressing" and Logical Block Numbers are assigned to Link, Run-in, and Run-out blocks as well as User Data Blocks.

In Fixed Packet written Tracks, the Logical Block Address is converted to the physical block number using "Method 2 Addressing." In this case, Logical Block Addresses are not assigned to Link, Run-in, and Run-out blocks.

1.1.5.4. Track Descriptor Block

Information about the current Track attributes is encoded in the Pre-gap in a Track Descriptor Block (TDB). Optionally, all preceding Track attributes are included in the TDB. The TDB is recorded in all sectors in the Pre-gap.

The TDB starts at byte 0 in the user data field of each sector. The TDB consists of the Track descriptor table and the Track descriptor unit(s). The Track descriptor unit gives the information such as the writing method of the Track and the packet size. The Track descriptor unit ***shall*** be used by the Logical Unit to determine Packet type and Packet size for a Packet recorded Track. If the disc is recorded using Session At Once, the TDB may not be present.

Table 7 – Track Descriptor Block

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

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

Table 8 – Track Descriptor Table

Bit / Byte	7	6	5	4	3	2	1	0
0	Track Descriptor Identification (54h)							
1	Track Descriptor Identification (44h)							
2	Track Descriptor Identification (49h)							
3	Pre-Gap Length							
4								
5	Type of Track Descriptor Unit							
6	The number of the current Track, encoded in BCD							
7	The number of the current Track, encoded in BCD							

The Track Descriptor Identification fields contain the Hexadecimal code: ’54 44 49’ (ASCII “TDI”).
The Pre-Gap Length field contain the number of blocks of the second part of this Pre Gap, encoded in BCD.
The Type of Track Descriptor Unit field indicates which Track Descriptor Units are present. When this field set to 00h, indicates that Track Descriptor Units of previous Tracks are present in this Track Descriptor Block. When this field set to 01h, indicates that only the Track Descriptor Units of the current Track is present in this Track Descriptor Block. All other values are reserved for future use.
The Lowest Track Number field indicates that the lowest Track number described in this Track Descriptor Block, encoded in HEX.
The Highest Track Number field indicates that the highest Track number described in this Track Descriptor Block, encoded in HEX.
Track Descriptor Unit describes the data attributes of the Track and consists of 16 bytes. The contents of these 16 bytes are shown in Table 9.

Table 9 – Track Descriptor Unit

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

The Track Number field contains the track number to which this Track Descriptor Unit belongs, HEX encoded.
The Write Method of the Track field, when Bit 7 through Bit 4 set to 1000b, indicates that the Track is an uninterrupted written data track that consists of only one packet. In this case, Bit 3 through Bit 0 ***shall*** be reserved and set to 0000b.

When the Bit 7 through Bit 4 set to 1001b, it indicates that the Track is an incrementally written data track that consists of more than one packet. In this condition, when Bit 3 through Bit 0 set to 0000b, it indicates that the packet size is variable length. And if Bit 3 through Bit 0 set to 0001b, it indicates that the packet size is fixed length. All other values for Bit 3 through Bit 0 are reserved.
All other values for Bit 7 through Bit 4 are reserved. And any corresponded values for Bit 3 through Bit 0 are also reserved.
The Packet Size field ***shall*** be interpreted as follows:
For Incremental written Tracks with fixed Packet Size (Byte 1 = 91h), these bytes contains the BCD encoded Packet Size in sectors (MSBytes first). For Incremental written Tracks with variable Packet Size (Byte 1='90' hex), and Uninterrupted written Data Tracks (Byte 1 = 80h), these three bytes contain the code FFFFFFh.

1.2. FEATURE AND PROFILE CHANGES

1.2.1. Profile List

Table 10 – Profile List

Profile Number	Profile Name	Description
0000h	Reserved	
0001h	Non-removable disk	Re-writable disk, not capable of changing behavior
0002h	Removable disk	Re-writable; with removable media
0003h	MO Erasable	Magneto-Optical disk with sector erase capability
0004h	MO Write Once	Magneto-Optical write once
0005h – 0007h	Reserved	
0008h	CD-ROM	Read only Compact Disc capable
0009h	CD-R	Write once Compact Disc capable
000Ah	CD-RW	Re-writable Compact Disc capable
000Bh – 000Fh	Reserved	
0010h	DVD-ROM	Read only DVD
0011h	DVD-R	Write once DVD
0012h	DVD-RAM	Re-writable DVD
0013h – 001Fh	Reserved	
0020h	DDCD-ROM	Read only DDCD
0021h	DDCD-R	Write once DDCD
0022h	DDCD-RW	Re-writable DDCD
0023h – 002Fh	Reserved	
0030h – FFFEh	Reserved	
FFFFh	Logical Unit Not Conforming to a Standard Profile	The Logical Unit does not conform to any Profile.

1.2.2. Incremental Streaming Writable (0021h)

This Feature identifies a Logical Unit that can write data to a contiguous region, and can append data to a limited number of locations on the media. On CD or DD media, this is known as packet recording and on DVD media it is known as Incremental Recording. Logical Units that support this Feature shall implement the commands shown in Table 11.

Table 11 – Incremental Streaming Commands

Op Code	Command Description	Clause
A1h	BLANK (note1)	
5Bh	CLOSE TRACK/SESSION	
51h	READ DISC INFORMATION	
52h	READ TRACK INFORMATION	
54h	SEND OPC INFORMATION (note2)	
2Ah	WRITE(10)	
35h	SYNCHRONOUS CACHE	

Notes:
1. Shall be supported if the Erasable bit in READ DISC INFORMATION, returned data, is set to one.
2. Shall be supported if the OPC information is ever returned in the READ DISC INFORMATION return data.

Table 12 – Incremental Streaming Parameters

Page Code	Mode page	Clause
05h	Write Parameters	

Table 13: Incremental Streaming Writable Descriptor Format

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB) Feature Code = 0021h							
1								(LSB)
2	Reserved			Version			Persistent	Current
3	Additional Length							
4	Data Type Supported							
5								
6	Reserved							
7	Number of Link Sizes							
8-n	Link Size							
n- ?	Pad							

The Feature Code field shall be set to 0021h.
The Version field is set to 1h.
The Persistent bit shall be set to zero if the medium is removable.
The Current shall be set to zero if sequential write media is not present.
The Additional Length field shall be set to 4 + (Number of Link Sizes) + (Number of Pad bytes).
The Data Type Supported field is a bit field that identifies the supported Data Type.
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..
The Number of Link Sizes shall specify the number of link sizes available for the current media. For CD and DDCD media, this field should be 1. For DVD-R, this field should be 2.
Each Link Size field shall indicate the number of logical blocks per link. Links occur on sequentially written media between independent write operations. The link size does not include any logical blocks written by the Logical Unit to satisfy the writable unit specified by the Blocking field in the Random Readable Feature. This field is 7 for CD-R media and for DDCD-R media and may be 0, 1, or 16 for DVD media. 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 * IP((Number of Link Sizes + 3)/4) -(Number of Link Sizes), where IP() is the integer part of the number. The Pad field is present to make the length of the Feature Descriptor a multiple of 4 bytes.

1.2.3. Restricted Overwrite Feature (0026h)

This Feature identifies a Logical Unit that shall have the ability to overwrite logical blocks only in fixed sets at a time. Logical Units that write and read CD-RW/DDCD-RW media shall support the commands specified in Table 14.

Table 14 – Restricted Overwrite Commands

Op Code	Command Description	Clause
25h	READ CAPACITY	
51h	READ DISC INFORMATION	
52h	READ TRACK INFORMATION	
35h	SYNCHRONIZE CACHE	
2Ah	WRITE(10)	

Table 15 – Restricted Overwrite Parameters

Page Code	Mode page	Clause
05h	Write Parameters	

The Feature descriptor response data to be returned to the Host is defined in Table 16.

Table 16: Restricted Overwrite Descriptor Format

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB) Feature Code = 0026h							
1								(LSB)
2	Reserved			Version			Persistent	Current
3	Additional Length = 00h							
4	Reserved							

The Feature Code field shall be set to 0026h.
The Persistent bit shall be set to zero if the medium is removable.
The Current bit shall be set to zero if Restricted Overwritable medium is not present.
The Additional Length field shall be set to 0.

1.2.4. A New Feature: Double Density CD Read Feature

This Feature identifies a Logical Unit that can read DDCD specific information from the media and can read user data from DDCD blocks.

Table 17: DDCD Read Descriptor Format

Bit / Byte	7	6	5	4	3	2	1	0
0	Feature Code = 0030h							
1								
2	Reserved			Feature Version = 0000b			Persistent	Current
3	Additional Length = 00h							

Since DDCD-ROM medium is removable, Persistent is cleared to zero.
Current bit shall be set to zero if DDCD-ROM media is not present.
A Logical Unit that read DDCD-ROM media shall support the commands specified in Table 18.

Table 18 : DDCD Read Commands

Op Code	Command Description
BEh	READ CD
43h	READ TOC/PMA/ATIP

1.2.5. A New Feature: Double Density CD-R Write Feature

This Feature identifies a Logical Unit that can write data to DDCD-R. A Logical Unit that write and read DDCD-R media shall support the commands specified in Table 19.

Table 19 : DDCD-R Write Commands

Op Code	Command Description
51h	READ DISC INFORMATION
52h	READ TRACK INFORMATION
53h	RESERVE TRACK
2Ah	WRITE(10)
AAh	WRITE(12)

Table 20 : DDCD-R Write Feature Descriptor Format

Bit / Byte	7	6	5	4	3	2	1	0
0	Feature Code = 0031h							
1								
2	Reserved		Feature Version = 0000b				Persistent	Current
3	Additional Length = 4							
4	Reserved					TestWR	Reserved	
5	Reserved							
6	Reserved							
7	Reserved							

The Feature Code field shall be set to 0031h
Since DDCD-R medium is removable, Persistent is cleared to zero.
The Current bit, when set to zero, shall indicate DDCD-R media is not present.
The Additional Length field shall be set to 04h.
The TestWR bit, when set to zero, shall indicate that the Logical Unit is not capable of performing test writes. When set to one, the Logical Unit shall be capable of performing test writes.

1.2.6. A New Feature: Double Density CD-RW Write Feature

This Feature identifies a Logical Unit that can write data to DDCD-RW. Logical Unit that write and read DDCD-RW media shall support the commands specified in Table 21.

Table 21 : DDCD-RW Write Commands

Op Code	Command Description
51h	READ DISC INFORMATION
52h	READ TRACK INFORMATION
53h	RESERVE TRACK
2Ah	WRITE(10)
AAh	WRITE(12)

Table 22 : DDCD-RW Write Feature Descriptor Format

Bit / Byte	7	6	5	4	3	2	1	0
0	Feature Code = 0032h							
1								
2	Reserved		Feature Version = 0000b				Persistent	Current
3	Additional Length = 4							
4	Reserved						Intermediate	Blank
5	Reserved							
6	Reserved							

7	Reserved

The Feature Code field shall be set to 0032h
Since DDCD-RW medium is removable, Persistent is cleared to zero.
The Current bit, when set to zero, shall indicate DDCD-RW media is not present.
The Additional Length field shall be set to 04h.

The Intermediate bit, if set to 1, shall indicate that the Logical Unit suppots quick formatting (Format Type of xxh - Quick Format). If set to 0, shall indicate that the Logical Unit does not support and quick formatting.
The Blank bit, if set to 1, shall indicate that the Logical Unit supports BLANK Command, Blanking Type 00h and 01h.
If set to 0, shall indicate that the Logical Unit does not support BLANK Command.

1.2.7. Profile: DDCD-R/RW Drive

1.2.7.1. Profile 20: DDCD-ROM

Logical units identifying Profile 20 as current shall support the Feature listed in Table 23.

Table 23: Mandatory Feature List for the DDCD-ROM Drive

Feature Number	Feature Name	Description
0000h	Profile List	A list of all profiles supported by the device
0001h	Core	Basic Functionality
0002h	Morphing	Ability to notify the host about operational changes and accept host requests to prevent operational changes
0003h	Removable Medium	The medium may be removed from the device
0010h	Random Readable, PP = 1	Read ability for storage with random addressing
0030h	DDCD Read	The ability to read DDCD specific structure
0100h	Power Management	Host and device directed power management.
0105h	Time-out	Ability to response to all commands within a specific time

1.2.7.2. Profile 21: DDCD-R

Logical units identifying Profile 21 as current shall support the Feature listed in Table 24.

Table 24: Mandatory Feature List for the DDCD-R/RW Drive

Feature Number	Feature Name	Description
0000h	Profile List	A list of all profiles supported by the device
0001h	Core	Basic Functionality
0002h	Morphing	Ability to notify the host about operational changes and accept host requests to prevent operational changes
0003h	Removable Medium	The medium may be removed from the device
0010h	Random Readable, PP = 1	Read ability for storage with random addressing
0021h	Incremental Streaming Writable	Write support of sequential recording
0030h	DDCD Read	The ability to read DDCD specific structure
0031h	DDCD-R Write	The ability to write DDCD-R specific structure
0100h	Power Management	Host and drive power management.
0105h	Time-out	Ability to response to all commands within a specific time
0107h	Real-Time Streaming	Ability to read and write using Host requested

		performance parameters

1.2.7.3. Profile 22: DDCD-RW

Logical units identifying Profile 22 as current shall support the Feature listed in Table 25.

Table 25: Mandatory Feature List for the DDCD-R/RW Drive

Feature Number	Feature Name	Description
0000h	Profile List	A list of all profiles supported by the device
0001h	Core	Basic Functionality
0002h	Morphing	Ability to notify the host about operational changes and accept host requests to prevent operational changes
0003h	Removable Medium	The medium may be removed from the device
0010h	Random Readable, PP = 1	Read ability for storage with random addressing
0020h	Random Writable	Write support for randomly addressed writes
0021h	Incremental Streaming Writable	Write support of sequential recording
0023h	Formattable	Support for formatting of media
0026h	Restricted Overwrite	Write support for media that shall be written in multiples of logical blocks
0030h	DDCD Read	The ability to read DDCD specific structure
0031h	DDCD-R Write	The ability to write DDCD-R specific structure
0032h	DDCD-RW Write	The ability to write DDCD-RW specific structure
0100h	Power Management	Host and drive power management.
0105h	Time-out	Ability to response to all commands within a specific time
0107h	Real-Time Streaming	Ability to read and write using Host requested performance parameters

2. APPENDIX

2.1. Track at Once Procedure

1. Issue Read Disc Information command to check if the last session is empty and to know the Last Track Number and Disc Type, if present. Disc Status shall be Empty Disc or partly recorded.

2. Set the Write Parameters Mode Page:
   Set the Write Type to "Track-at-once" (01h).
   Set the Data Block Type = 0Ah for DDCD Mode2).
   Set the MS field as appropriate
   (e.g. 11b for "Allowed Next Session").
   Assign value of COPY = 1 for "Not Protected".
   Set the Track Mode as appropriate (e.g. 0110b for TAO and COPY=1).
   Set the Media Catalog Number to zero.
   Set the ISRC to zero.
   Set the Host Application Code to zero.
   Set the Session Format as appropriate.
   Set the Sub-header Byte 0-3 to zero.

2. Use the Read Track Information command to get the Logical Block Address of the first user data block.
   Note: This address reflects the next writable address after the drive writes the pre-gap.

3. Use the Write command to send blocks of data. The drive shall generate necessary
   information: header, Q sub-channel, EDC and ECC parity as appropriate
   and indicated by the block size Each subsequent write shall have an LBA specified that is n higher than the previous write command, where n is the number of blocks
   specified in the previous write command.
   An underrun may be indicated if the drive reports that this LBA is invalid.

4. After all the data sent to the drive, the drive writes the run-out and link blocks.
   Note: The end of data can be determined by an underrun, a Synchronize Cache command, or a Close Track/Session command.
   Repeat as desired.

2.2. Packet Writing Procedure

Command Sequence for Fixed Packet Writing

Step 0: Insert Blank CD-R disc in the drive and clear up the Unit Attention condition.

Step 1: Set up Writer Parameters Mode Page.

- Issue a MODE SENSE (10) with page code 05h and disable block descriptor to get
  current settings
- Set fields of Write Parameters Page (page code 05h):
  Write Type = 00h for Packet Writing
  Test Write = 0 for real writing mode or 1 for test writing mode

Track Mode = Control nibble for Q channel, set as appropriate
Copy = 0 for Serial Copy Mgmt off
FP = 1 for Fixed Packet
Multisession = 00b for No B0 pointer, Next Ses. Not allowed or 01b for B0= F:FF: FF: FF, Next Ses. Not allowed or 11b for Next Session Allowed, B0 set = NPA (field used at CLOSE SESSION)
Data Block Type = 0Ah for DDCD Mode2, block size = 2048
Host Application Code = must be invalid
Session Format = 20h for DDCD-ROM Disc (must match Data Block Type)
Packet Size = set 32d (as UDF expects)
Audio Pause Length = set to zero
MCN = set to zero
ISRC = set to zero
Sub Header Byte 0 = 00h
Sub Header Byte 1 = 00h
Sub Header Byte 2 = 00h
Sub Header Byte 3 = 00h

- Issue a MODE SELECT (10) with modified Sense data

Step 2: Determine address to begin writing
- Use READ DISC INFORMATION to find Disc Type and number of the Invisible Track
- Use READ TRACKS INFORMATION, track = Invisible Track to get start address

Step 3: Stream data to the disc
- Use sequence of WRITE (10) commands with proper LBA, starting at first LBA.
- READ TRACK INFORMATION can be used during writing to determine the Next Writable Address, that address will be the next expected LBA.

2.3. Disc-at Once/Session-at-Once Procedure

Driver issues (+) Drive returns (=)

+ MODE SELECT
with MS field setting of Write Parameter Page
(Note 1)
--->
<--- = Good Status

Note 1: If MS (Multi Session) field is set to 00b or 01b, the device shall perform disc-at-once recording. If MS field is set to 11b (Next session allowed), the device shall perform session-at-once.

+ SEND CUE SHEET
(Note 2)
--->
[During cue sheet analysis]
<--- = Good Status
[Buffer capacity become available after this command].

Note 2: SEND CUE SHEET command may take long execution time to complete for

large cue sheet.

+ SEND OPC INFORMATION
with DoOPC=1
(Note 3)

--->
[Power calibration]
<--- = Good Status

Note 3: If SEND OPC INFORMATION command is omitted, power calibration will be done prior to next write operation: power calibration will be done in next write command with zero transfer.

+ WRITE (or WRITE CONTINUE)
with zero transfer length
(Note 4,5)

--->
[Start writing lead-in]
<--- = Good Status

Note 4: WRITE (or WRITE CONTINUE) command with zero transfer length gives start timing of writing lead-in area. If this command is omitted, the drive does not start writing; therefore next polling by READ BUFFER CAPACITY shall also be omitted. In this case next write command takes longer execution time over 1 minutes during lead-in writing.

Note 5: In case that the drive needs user data transfer by WRITE(or WRITE CONTINUE) command with non-zero transfer length prior to start writing of Lead-In, e.g. cue sheet for any WRITE (or WRITE CONTINUE) command with zero transfer length shall not be issued before the user data transfer is started by first WRITE (or WRITE CONTINUE) with non-zero transfer length:
if any WRITE (or WRITE CONTINUE) with zero transfer length is issued before the user data transfer, buffer underrun occurs because no user data present in buffer when drive starts writing Lead-In.
For such case, first WRITE (or WRITE CONTINUE) command shall be issued with first part of user data for Lead-In writing.
The succeeding WRITE (or WRITE CONTINUE) commands shall be issued to build remaining user data in buffer before drive starts writing Lead-In.
Next WRITE (or WRITE CONTINUE) command shall be issued to start writing Lead-In: The command shall be issued with transfer length which causes buffer full (non-zero transfer length) or also WRITE (or WRITE CONTINUE) command with zero transfer length shall be available to start writing Lead-In.
WRITE or write continue command with zero transfer length shall be issued after first user data transferred that is described by next step.

+ READ BUFFER CAPACITY

--->
[Report available buffer capacity]
<--- = Good Status

+ WRITE (or WRITE CONTINUE)
with transfer length
less than the available buffer capacity
(Note 6)

--->
[Immediately receive all data at once into drive buffer]
<--- = Good Status

Note 6: If the transfer length is more than or equal to the capacity as reported by previous Read Buffer Capacity command, drive may enter long busy state until buffer becomes ready to receive the all data of the WRITE command: it is recommended that all WRITE command have transfer length less than available buffer capacity which is reported by READ BUFFER CAPACITY command.

Repeatedly
+ READ BUFFER CAPACITY
(Note 7,8)
--->
[Report available buffer capacity]
<--- = Good Status
Until drive has enough buffer space to receive next WRITE (or WRITE CONTINUE) data.

+WRITE (or WRITE CONTINUE)
with transfer length
less than the available buffer capacity
(Note 8,9,10)
--->
[Immediately receive all data at once into drive buffer]
<--- = Good Status

Note 7: This READ BUFFER CAPACITY shall be issued repeatedly until drive has enough buffer space to be able to receive all data of next WRITE (or WRITE CONTINUE) command.

Note 8: This polling of READ BUFFER CAPACITY and WRITE
(or WRITE CONTINUE) shall be issued repeatedly until the completion of all user data transfer.

Note 9: If transfer length of WRITE (or WRITE CONTINUE) is not more than the available buffer capacity the WRITE (or WRITE CONTINUE) shall be executed immediately without any busy wait condition.

Note 10: If total amount of WRITE (or WRITE CONTINUE) data is over the total size of all user data which is given by cue sheet, the last WRITE (or WRITE CONTINUE) is terminated with Check Condition Status with sense 05/24/00)
(Next polling sequence is to detect when the recording completes)

Repeatedly
+ READ DISC INFORMATION
--->
<--- = Check condition (05/64/00)
Until last Good READ DISC INFORMATION:
+ READ DISC INFORMATION
--->
<--- = Good Status