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MMC-2 DVD MODEL

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4.0 DVD Model

The DVD has been selected by the industry to be the replacement for the CD of today. It has many advantages over the existing CD technology. The DVD Media Format is not backward comparable with the existing CD Logical Units. The primary reason for this change was driven by the need for very large amounts of data for Digital Video (Movies). Simple increase in density would not accomplish this.

Like CD Logical Units/Media there are three types of DVD Logical Unit/Media, Read Only (DVD-ROM), Write only Once (DVD-R) and Write Multiple times (DVD-RAM). The capacity of each of these media are different. In addition each of these media also have the possibility of multiple layers and single or double sides.

A DVD Logical Unit will be capable of reading CD-ROM, CD-R and possibly CD-E media. This backwards compatibility will allow a DVD Logical Unit to replace a CD-ROM Logical Unit in most systems. Although the DVD Logical Unit will be capable of reading the older CD media, it will not support the same commands as the CD-ROM Logical Unit to-day. There will be some simplifications to the command set supported. Commands that were necessary only for legacy support for the existing CD-ROM drivers will be removed.

The play mechanism may be removed from some DVD Logical Units. The DVD media provides several and better types of audio. It is likely that the system will provide the needed support for these new and more capable audio data streams.

A DVD Logical Unit will look different to the Host, depending on the type of media that is currently being used. The host system will now need to deal with a Logical Unit that changes the commands that are possible, based on the type of media that is currently in the Logical Unit. This type of operation will be handled via the use of Feature Sets. This new concept will allow the Logical Units to implement various capabilities. The Host will detect and configure the Logical Unit given the various capabilities that are possible.

4.1 DVD Media Organization

The DVD media is currently specified by the Physical section of DVD Book.

- DVD Media can contain information on one side (Single Sided) or on both sides (Double Sided).

- DVD-ROM disc has two types of layer structure, single layer and double layer.

- Each Layer on either side contains a spiral track. This track contains a Lead-in, Main area, an optional Middle Area and a Lead-out.

- double layer discs have two types of track path, parallel track path and opposite track path. In the case of the Parallel Track Path, there each layer is treated separately.

- The user Sector size is 2048 bytes only.

- One ECC-BLOCK, having 37856 bytes, consists of 16 sectors.

- There is no concept of TOC or Sub-channel data.

- Only general data is defined. There is no concept of AUDIO or VIDEO data.

- Addressing used is LBA (Logical Block Address) only.

- Information concerning error correction that has been performed is not usually returned to the Host.

- Data used only inside of the DVD Logical Unit is not transferred to the Host Computer, since it is impossible to access PBA out of LBA.

- The READ & WRITE unit is 2 Kilobytes (2048 Bytes).

4.2 Track Structure

There are two types of track path for double layer discs, either parallel or opposite. When the path is parallel each track is treated separately and has its own lead-in and lead-out.

There are two addresses used in the DVD system, the Block address contained in the sector headers (Physical Sector Number), and the address used to reference the blocks from the host system (LBA). The address used from the host starts at 0 and progresses up through the end of the recorded information on the disc. LBA 0 shall correspond with the sector address of 030000h on the DVD media. Only the User Area is generally addressable using an LBA address.

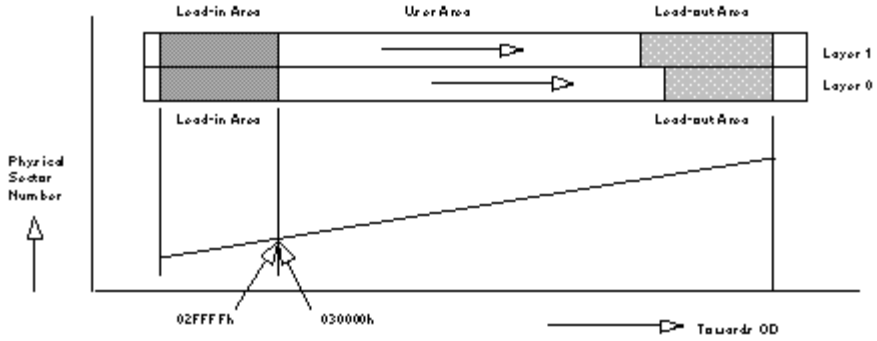


Figure 1 - Parallel Track Path Description

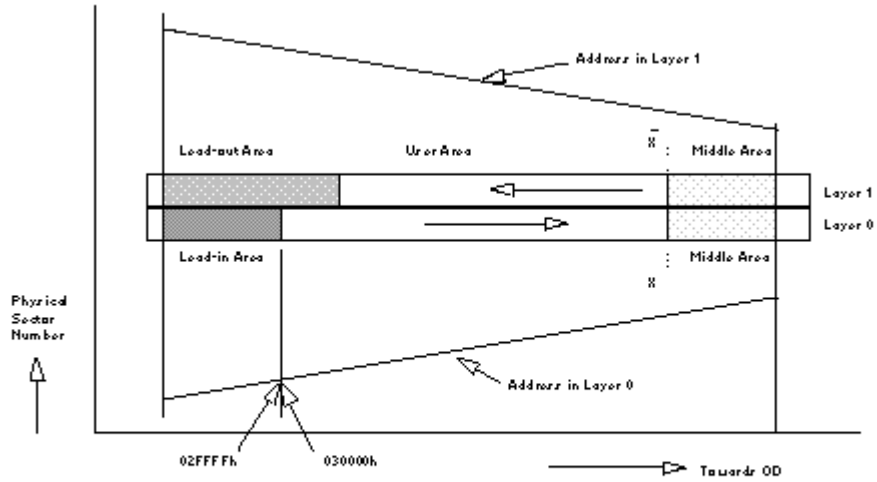


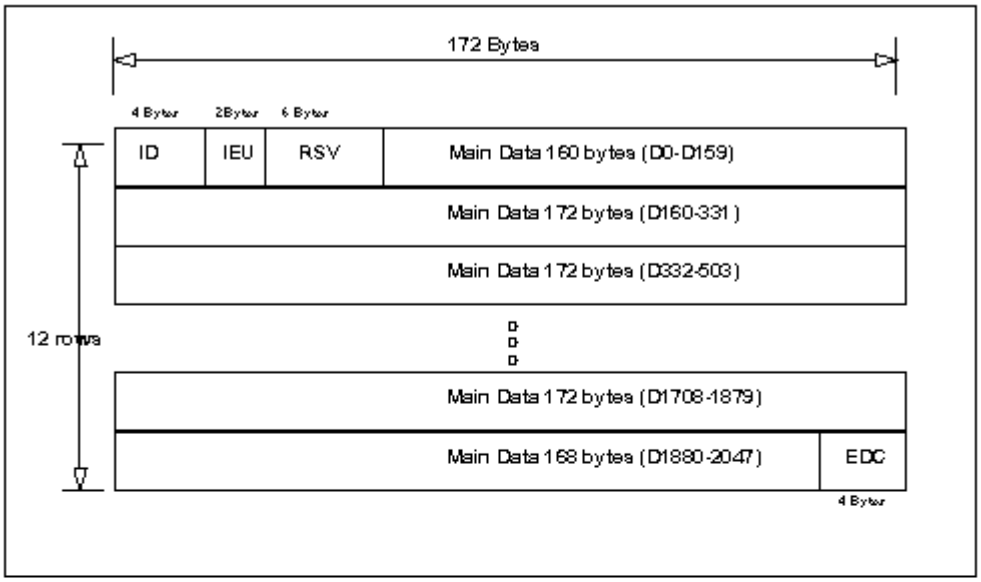
Figure 2 - Opposite Track Path Description

4.2.1 DVD Specifications

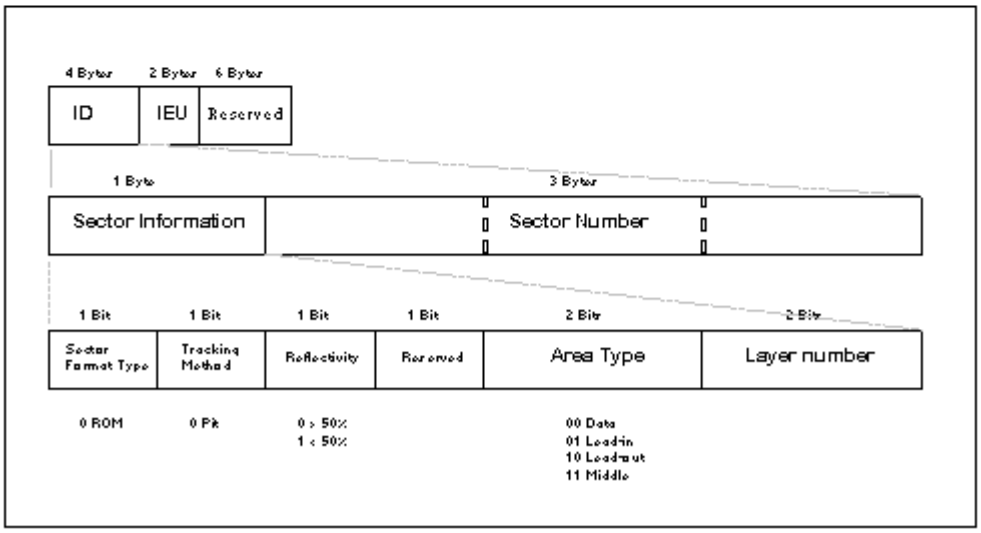
Table 2 - DVD Specifications

Specification		Single Layer	double Layer
Data Capacity		4.7Gbytes	8.5 Gbytes
Wave length		635-650nm	
NA of Objective		0.6	
Data bit length		0.267μm	0.293μm
Channel bit length		0.133 μm	0.147 μm
Min Pit length		0.40 μm	0.44μm
Max Pit length		1.87 μm	2.05μm
Track Pitch		0.74 μm	
User data per sector		2048	
Error correction		RS [208,192,17] x RS[182,172,11]	
ECC Length		16 Sectors	
correctable burst		6.0mm	6.5mm
scan velocity [Ref.]		3.49 m/s	3.84 m/s
channel bit rate		26.16 Mbps	
user data bit rate		11.08 Mbps	
Video rate		10.08 Mbps	
Playing time			
	4.7mb/sec	133 mm/side	242 mm/side
	3.7 mb/sec	169 mm/side	307 mm/side

4.3 Sector Layout



4.4 Header Layout



4.5 Lead-in Contents

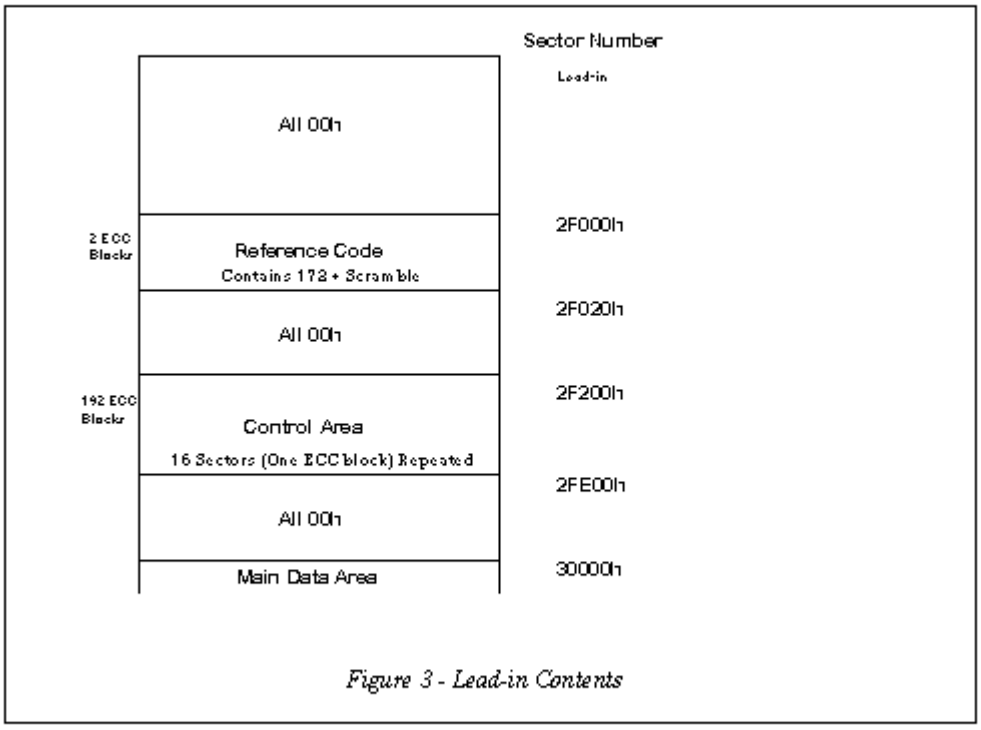


Figure 3 - Lead-in Contents

4.5.1 - Control Area Data

Contains 192 ECC Blocks. Each of the ECC Blocks (16) Sectors contain one of three distinct type of data.

Table 3 - Control Area Definition

Sector Number	Description
0	Physical Format Information
1	Disc Manufacturing Information
2	Copyright Information
. . .	
14	
15	

4.5.2 - Control Area Sector Descriptions

Table 4 - Physical Format Information

Byte \ Bit	7	6	5	4	3	2	1	0
0	Book Type				Book Version			
1	Disc Size				Minimum Rate			
2	Reserved		Number of Layers		Track Path	Layer Type		
3	Linear Density				Track Density			
4	Recorded area allocation							
5								
. . .								
14								
15								

Table 5 - Recorded Area Allocation Definition

Byte	Single Layer	Parallel Track Path	Opposite Track Path
4	00h	00h	00h
5	Starting Sector Number of Main Data (030000h)	Starting Sector Number of Main Data (030000h)	Starting Sector Number of Main Data (030000h)
6			
7			
8	00h	00h	00h
9	End Sector of Main Data	End Sector of Main Data	End Sector of Main Data
10			
11			
12	00h	00h	00h
13	000000h	000000h	End Sector Number in Layer 0
14			
15			

4.6 Commands for C/DVD Logical Units

The following table defines commands that are described in this standard. These commands make up the core command set for C/DVD Logical Units. For some interfaces such as SCSI, there are other commands that are necessary for proper functioning. These commands are documented in the appropriate standard for that interface.

Table 6 - Packet Commands for C/DVD Logical Units

Command Description	Opcode	Feature Set	Reference
FORMAT UNIT	04h	Recordable	section A-6 on page 267
FLUSH CACHE	35h	Core	section 9.1.1 on page 89
GET EVENT STATUS NOTIFICATION	4Ah	Event Notification	section 9.1.2 on page 91
INQUIRY	12h	Core	section 9.1.3 on page 97
LOAD/UNLOAD C/DVD	A6h	Embedded Changer	section 9.1.4 on page 101
MECHANISM STATUS	BDh	Core	section 9.1.5 on page 103
MODE SELECT (10)	55h	Core	section 9.1.6 on page 107
MODE SENSE (10)	5Ah	Core	section 9.1.7 on page 109
PAUSE/RESUME	4Bh	CD Audio	section 10.1.1 on page 177
PLAY AUDIO (10)	45h	CD Audio	section 10.1.2 on page 179
PLAY AUDIO MSF	47h	CD Audio	section 10.1.3 on page 182
PLAY CD	BCh	Digital Output	section 10.1.4 on page 185
PREVENT/ALLOW MEDIUM REMOVAL	1Eh	Core	section 9.1.9 on page 131
READ (12)	A8h	Core	section 9.1.10 on page 133
READ C/DVD CAPACITY	25h	Legacy	section 9.1.12 on page 141
READ CD	BEh	Core	section 10.1.5 on page 189
READ CD MSF	B9h	Core	section 10.1.6 on page 201
READ DISC INFORMATION	51h	Core	section 10.1.7 on page 203
READ DVD STRUCTURE	ADh	Core	section 9.1.11 on page 135
READ FORMATTED CAPACITIES	23h	Core	section 9.1.17 on page 159
READ HEADER	44h	CD Audio	section 10.1.8 on page 209
READ SUBCHANNEL	42h	CD Audio	section 10.1.9 on page 213
READ TOC/PMA/ATIP	43h	Core	section 10.1.10 on page 221
READ TRACK INFORMATION	52h	Core	section 10.1.11 on page 235
REPORT KEY	A4h	Key Exchange	section 9.1.15 on page 151
REQUEST SENSE	03h	Core	section 9.1.18 on page 163
SCAN	BAh	CD Audio (Optional)	section 10.1.12 on page 241
SEEK	2Bh	Core	section 9.1.19 on page 171
SEND KEY	A3h	Key Exchange	section 9.1.13 on page 143
SET READ AHEAD	A7h	Core	section 9.1.16 on page 157
START STOP UNIT	1Bh	Core	section 9.1.14 on page 147
STOP PLAY / SCAN	4Eh	CD Audio or Digital Output	section 10.1.13 on page 245
TEST UNIT READY	00h	Core	section 9.1.20 on page 173
VERIFY (12)	AFh	Recordable	section A-7 on page 271
WRITE DVD STRUCTURE	BFh	Recordable	section 9.1.11 on page 135
WRITE (12)	AAh	Recordable	section A-8 on page 273
WRITE and VERIFY (12)	AEh	Recordable	section A-9 on page 275

4.7 DVD Ready Condition/Not Ready Condition

The ready condition occurs after a disc is inserted and the Logical Unit has performed its initialization tasks. These 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 will be returned for the not ready condition only for commands that require or imply a disc access.

A not ready condition may occur for the following reasons:

1. There is no disc mounted, See “Removable medium” on page 52.

2. The Logical Unit is unable to load or unload the disc.

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

Any media access that occurs when the Logical Unit is not spinning shall spin the Logical Unit up and not generate an error. Note that accesses to the media can be satisfied from the Logical Unit’s cache and may not require the media to be spinning.

4.8 DVD Copy Protection

Any read by the host to a sector with a Title Key present in the sector, when the Authentication Success Flag (ASF) is set to zero shall be blocked. The command shall be terminated with a CHECK CONDITION and the Sense Key shall be set to 05 ILLEGAL COMMAND and the Sense Code and Qualifier set to 06Fh/03h READ WITHOUT VALID AUTHENTICATION.

For more information on the authentication process, See “Device Key Exchange and Authentication State Diagram” on page 152. For more information on the Authentication Success Flag, See “Authentication Flag Sequence” on page 153.

Table 7 - Not Ready Error & Time-out Unit Attention Reporting (by Command)

Command	Opcode	Returns Ready Status	Time-out	Comment
BLANK	A1h	Yes	Group 2	Recordables only
CHANGE DEFINITION	40h	No	Not Allowed	SCSI only
CLOSE AREA/SESSION	5Bh	Yes	Group 2	Recordables only
COMPARE	39h	Yes	Group 1	SCSI only
COPY	18h	Yes	Group 2	SCSI only
COPY AND VERIFY	3Ah	Yes	Group 2	SCSI only
FLUSH CACHE	35h	Yes	Group 1	
FORMAT UNIT	04h	Yes	Group 2	Erasables only
GET EVENT STATUS NOTIFICATION	4Ah	Yes	Not Allowed	
INQUIRY	12h	No	Not Allowed	
LOAD/UNLOAD C/DVD	A6h	Yes	Group 1	
LOCK/UNLOCK CACHE	36h	No	Group 2	SCSI only
LOG SELECT/SENSE	4Ch, 4Dh	No	Group 1	SCSI only
MECHANISM STATUS	BDh	No	Group 1	
MODE SELECT	55h, 15h	No	Group 1	
MODE SENSE	5Ah, 1Ah	No	Group 1	
PLAY AUDIO/MSF	45h, 47h	Yes	Group 1	
PLAY CD	BCh	Yes	Group 1	
PREFETCH	34h	Yes	Group 1	SCSI only
PREVENT/ALLOW MEDIUM REMOVAL	1Eh	See *Table 78 - Prevent/Allow Medium Removal Support* on page 132	Group 1	
READ(12)	A8h	Yes	Group 1	
READ BUFFER	3Ch	No	Group 1	SCSI only
READ C/DVD CAPACITY	25h	Yes	Group 1	
READ DISC INFORMATION	51h	Yes	Group 1	
READ HEADER	44h	Yes	Group 1	
READ SUB-CHANNEL	42h	Yes	Group 1	
READ FORMATED CAPACITY	23h	No	Group 1	
READ CD	BEh	Yes	Group 1	
READ CD MSF	B9h	Yes	Group 1	
READ DVD STRUCTURE	ADh	Yes	Group 1	
READ LONG	3Eh	Yes	Group 1	SCSI only
READ TOC/PMA/ATIP	43h	Yes	Group 1	
READ TRACK INFORMATION	52h	Yes	Group 1	
RECEIVE DIAGNOSTIC RESULTS	1Ch	No	Not Allowed	SCSI only
RELEASE	17h, 57h	No	Special	SCSI only
REPORT KEY	A4h	Yes	Group 1	
REPORT LUNS	A0h	No	Group 1	SCSI only
REQUEST SENSE	03h	No	Not Allowed	
RESERVE	16h, 56h	No	Special	SCSI only
RESERVE TRACK	53h	Yes	Group 2	Recordables only
REZERO	01h	Yes	Group 1	SCSI only
SCAN	BAh	Yes	Group 1	
SEEK	2Bh	Yes	Group 1	
SEND DIAGNOSTIC	1Dh	No	Not Allowed	SCSI only
SEND KEY	A3h	Yes	Group 1	
SEND OPC INFORMATION	54h	No	Group 1	Recordables only
SET READ AHEAD	A7h	Yes	Group 1	
SET C/DVD SPEED	B8h, BBh	No	Group 1	SCSI only
STOP PLAY/SCAN	4Eh	Yes	Group 1	
START STOP UNIT	1Bh	Yes	Group 1	
TEST UNIT READY	00h	Yes	Group 1	
VERIFY(12)	AFh	Yes	Group 1	
WRITE(10)	2Ah	Yes	Group 2	Recordables only
WRITE and VERIFY(12)	AEh	Yes	Group 2	Recordables only

Note that the references to SCSI only in the table are to indicate that these commands are currently only defined in the SCSI SPC, SBC and MMC standards. As these commands are not defined in this specification the usage and actual operation of these commands is specified elsewhere, their reference here are only recommendations to provide better compatibility.

For information on the Time-out groups see section "4.15 Time-out Model" on page 54.

4.9 Error Reporting

If any of the following conditions occur during the execution of a command, the 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 8 - Error Conditions and Sense Keys

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
C/DVD Logical Unit 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 the 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 the 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 that block shall be transferred.

4.10 Removable medium

Removable medium is sometimes contained within a cartridge to prevent damage to the recording surfaces. The combination of medium and optional cartridge is often called a volume.

A disc has an attribute of being mounted or de-mounted on a suitable transport mechanism. A disc is mounted when the C/DVD Logical Unit is capable of performing read operations to the medium. A mounted disc may not be accessible by a host if it is reserved by another Host. A disc is de-mounted at any other time (e.g. during loading, unloading, or storage).

A host may check whether a disc is mounted by issuing a TEST UNIT READY command. In addition there now exists the MEDIA STATUS NOTIFICATION feature. This allows the host to prevent the removal of any media, as well as sensing requests from the user to remove media.

The PREVENT ALLOW MEDIUM REMOVAL command allows a host to restrict the un-mounting of the disc. This is useful in maintaining system integrity. If the C/DVD Logical Unit implements cache memory, it must ensure that all logical blocks of the medium contain the most recent data prior to permitting un-mounting of the disc. If the Host issues a

START STOP UNIT command to eject the disc, and the is prevented from un-mounting by the PREVENT ALLOW MEDIUM REMOVAL command, the START STOP unit command is rejected by the C/DVD Logical Unit.

4.11 Logical blocks

Blocks of data are stored on the medium along with additional information that the controller uses to manage the storage and retrieval. The format of the additional information is unique and is hidden from the Host during normal read or write operations. This additional information is often used to identify the physical location of the blocks of data and the ad-dress of the logical block, and to provide protection against the loss of the user data.

The address of the first logical block is zero. The address of the last logical block is [n-1], where [n] is the number of logical blocks available on the medium. A READ C/DVD CAPACITY command may be issued to determine the value of [n-1]. If a command is issued that requests access to a logical block not within the capacity of the medium, the command is terminated with CHECK CONDITION.

The number of bytes of data contained in a logical block is known as the block length. Each logical block has a block length associated with it. The block length shall not be different for each logical block on the medium. The block descriptor in the MODE SENSE data describes the block length that is used on the medium. Note that the block descriptor will not be present for an ATAPI C/DVD Logical Unit. In addition the Block Descriptor for ATAPI Logical Units has been made Obsolete in this specification.

The location of a logical block on the medium does not have a relationship to the location of any other logical block. However, in a typical Logical Unit the logical blocks are located in an ascending order. The time to access the logical

block at address [x] and then the logical block at address [x+1] need not be less than time to access [x] and then [x+100].

4.12 Data cache

Some C/DVD Logical Units implement cache memory. A cache memory is usually an area of temporary storage in the C/ DVD Logical Unit with a fast access time that is used to enhance performance. It exists separately from the blocks of data stored and is normally not directly accessible by the Host. Use of cache memory for write or read operations typically reduces the access time to a logical block and can increase the overall data throughput.

During read operations, the C/DVD Logical Unit uses the cache memory to store blocks of data that the Host may request at some future time. The algorithm used to manage the cache memory is not part of this specification. However, parameters are provided to advise the C/DVD Logical Unit about future requests, or to restrict the use of cache memory for a particular request.

Sometimes the Host may wish to have the blocks of data read from the medium instead of from the cache memory. The force unit access (FUA) bit is used to indicate that the C/DVD Logical Unit shall access the physical medium. For a write operation, setting FUA to one causes the C/DVD Logical Unit to complete the data write to the physical medium before completing the command. For a read operation, setting FUA to one causes the logical blocks to be retrieved from the physical medium.

Commands may be implemented by the C/DVD Logical Unit that allow the Host to control other behavior of the cache memory:

The MODE SELECT command defines a page for the control of cache behavior and handles certain basic elements of cache replacement algorithms.

4.13 Seek

The SEEK command provides a way for the Host to position the Logical Unit in preparation for access to a particular Page 54 Proposal for a Draft logical block at some later time. Since this positioning action is implicit in other commands, the SEEK command may not be useful with some C/DVD Logical Units.

4.14 Error reporting

If any of the following conditions occur during the execution of a command, the target shall return CHECK CONDITION status. The appropriate sense key and additional sense code should 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.

In the 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 the case of an attempt to read a blank or previously unwritten block, the information field shall be set to the logical block address of the first blank block encountered. The data read up to that block shall be transferred.

4.15 Time-out Model

Currently, it is difficult for an operating system to determine a correct time-out value to use when issuing commands to a Logical Unit. Specifically, in instances of commands that may take a long time complete, but usually complete in a relatively short time. An example would be a read command after the Logical Unit has entered a low power state, and the media must spin up before completing the request. This model allows for a method for the Logical Unit to complete the request with an error that indicates to the host operating system that the request should be retried, but with a longer time-out.

The Logical Unit will specify two time-out parameters in the C/DVD Time-out & Protect Page. The first parameter is the minimum time-out that an operating system must use for all commands in Group 1. The second parameter is the mini-mum time-out that an operating system must use for all commands in Group 2.

For commands in Group 1, the Logical Unit shall start an internal timer when the command is received. If the command is unable to complete before the time specified in the Group 1 Time-out field C/DVD Time-out & Protect Page, bytes 6

and 7), the Logical Unit may terminate the command, at any time before the Group 1 Time-out expires, with a Check Condition (Sense Key 06, UNIT ATTENTION, ASC 2Eh, ASCQ 00 INSUFFICIENT TIME FOR OPERATION) Additionally, the Logical Unit shall set the COMMAND SPECIFIC INFORMATION sense bytes (BYTES 8-11) to the value in seconds that corresponds to the minimum time-out that the host should use when retrying this command. Upon receiving this Check Condition, the operating system shall retry the command with the requested time-out.

> Note: a Logical Unit may return this check condition at any point after the command is received, it may even return prior to initiating command.

All commands in Group 2 are commands that may not be able to complete successfully if they are retried. Thus, the Host must ensure that it uses a time-out that is large enough to allow the command to complete under worst case scenarios. This time-out is specified by the Logical Unit in the Group 2 Time-out parameter of the C/DVD Time-out & Protect Page (Bytes 8-9).

For a complete list of command groupings see "Table 7 - Not Ready Error & Time-out Unit Attention Reporting (by Command)" on page 51.

4.16 Resets

Within this specification there are three resets defined. These resets will use the following names:

- Power On Reset

Page 55 Proposal for a Draft • Hard Reset

- Device Reset

These resets will be used differently in each physical interface used. For more information on the use in ATA/ATAPI and SCSI see the sections on implementation notes.

4.16.1 Power On Reset

When power is applied, the device executes a series of electrical circuitry diagnostics, resets Logical Unit specific parameters (mode pages) to default values, and if media is present, may spin up and make the logical unit ready for use. In addition power management and key management are reset to their default states.

4.16.2 Hard Reset

For each physical interface the detection of Hard Reset is different. The detection of Hard Reset for ATA/ATAPI and SCSI is defined in the implementation sections of this specification. The device executes a series of electrical circuitry diagnostics, resets Logical Unit specific parameters (mode pages) to default values, and if media is present, may spin up and make the logical unit ready for use. In addition power management and key management are reset to their default states. The behavior of the logical unit when Hard Reset is received is the same as for Power On Reset.

Hard Reset is used to reset devices or even a whole interface bus, not individual logical units.

4.16.3 Device Reset

For each physical interface the detection of Device Reset is different. The detection of Device Reset for ATA/ATAPI and SCSI is defined in the implementation sections of this specification. The Device Reset is used to bring a hung Logical Unit into a operable state. Device Reset is different from Power On or hard Reset. With the Device Reset the parameters being used by the Logical Unit are not set to the defaults. In some cases this may not be possible and the Logical Unit may need to reset to the default conditions. If a reset to default conditions occurs as a result of a Device Reset, a Unit Attention and Power Management Event Notification shall be generated. Logical Unit should:

- Reset host interface circuitry.

- Perform hardware initialization and device-internal diagnostics only if necessary.

- Do not revert to default conditions, including ATAPI master/slave address, SCSI Device Number, Logical Unit Number or TOC information.

- Stay in the current Power State.

- Persistent Prevent state is unchanged.

- Key management shall be reset to the default state.

4.16.4 Mapping of reset functions

The following table shows how the different reset functions specified in the various ATAPI and SCSI specifications are used in this specification. Note that this table is not intended to show all possible resets or their mapping.

Table 9 - Example Reset Function Mapping in ATAPI and SCSI

Reset Type	ATAPI	SCSI
Power-On Reset	Same as Power-On Reset	Same as Power-On Reset
Hard Reset	Hard Reset	TARGET RESET task management function
	ATA SRST. This is a channel reset and as such is treated as a Hard Reset. However the SRST *shall* not reset any mode parameters to the default state.	SAM Reset events. Note that this is SCSI protocol dependent
		SPI Reset Signal
Device Reset	Device Reset in ATA/ATAPI-4	ABORT TASK SET task management function
	ATAPI Soft Reset in SFF8020i	CLEAR TASK SET task management function