CD-ROM DRIVE

SCSI INTERFACE MANUAL

MODEL CDU-541

SONY CORPORATION
CD-ROM Drive Division
Mechatronic Products Group

DOCUMENT REVISION: 1.00

FIRMWARE VERSION: S-1.0a

First Edition

This document is prepared for use by customers of Sony. It contains information for writing software for the drive. An operators manual includes the specifications and use of the CDU-541 CD-ROM drive is also available.

CHANGE LIST

REVISION 1.00 - First release

TABLE OF CONTENTS

LIST OF TABLES

1. Preface

This document details the implementation of a SCSI command set for a Read-Only device type (i.e. CD-ROM). This implementation complies with the ANSI X3.131-1986 standard. In addition several of the concepts proposed in the common command set document for direct-access devices have been incorporated. There are extensions to the SCSI interface included for audio control.

This implementation represents the best information available to Sony Engineering at the time. There is continuing work in the X3T9.2 committee to develop an SCSI-2 standard that will incorporate CD-ROM commands as well as extensions to the original SCSI standard. It is Sony Engineering's intention to comply with the proposed SCSI-2 document at the earliest feasible date. At this time it is expected that most of the current implementation will comply with SCSI-2. However the commands used for audio control are still controversial and most likely will change in a future firmware release. Information about the current status of the audio commands and the proposed SCSI-2 interface for CD-ROM can be obtained from Sony CD-ROM Engineering.

2. Introduction

This document covers the Sony CDU-541 CD-ROM drives. The CDU-541 is a half-height CD-ROM drive which embeds a drive, a SCSI controller and a audio/headphone circuit. Not only SCSI commands but also SCSI-2 commands which relate to the audio function are supported in this model. All commands supported are described in alphabetic order in this document.

3. Physical Characteristics

The Sony SCSI controller uses a single-ended asynchronous SCSI interface that complies with the physical characteristics of ANSI X3.131-1986 Section 4.0. Please refer to that standard for detailed information.

4. Logical Characteristics

The logical characteristics of the controller comply with ANSI X3.131-1986 for a single-ended asynchronous implementation. The controller supports disconnect/reselect. Several additional logical characteristics are discussed here to aid in understanding the operation of the drive and controller.

4.1. Conditions

This section describes certain conditions as they relate to the operation of the drive and the interface.

4.1.1. Power-on Condition

The power-on condition occurs when power is first applied to the unit. The controller performs power-on diagnostics. If a caddy is inserted the drive loads the caddy and attempts to read the table of contents. For the duration of the power-on condition the controller will return BUSY status. If a failure in power-on diagnostics occurs the controller will return CHECK CONDITION STATUS. If after the caddy is inserted it does not seat properly, or the drive is unable to focus, or the drive is unable to achieve spindle lock-up or the table of contents is not recovered the controller will return a CHECK CONDITION STATUS.

4.1.2. Reset Condition

The reset condition occurs whenever the RST signal is asserted, or a BUS DEVICE RESET message is received.

4.1.3. Unit Attention Condition

The unit attention condition occurs following a power-on condition, a reset condition, the insertion of a caddy with the successful recovery of the table of contents or the receipt of a MODE SELECT command from another initiator.

The unit attention condition will persist for each initiator until that initiator issues a command to the logical unit for which the controller returns a CHECK CONDITION status. If the next command from that initiator to the logical unit (following the CHECK CONDITION status) is REQUEST SENSE, then the UNIT ATTENTION sense key is returned. If any command other than REQUEST SENSE is received, the unit attention condition is lost.

If more than one unit attention condition occurs the unit attention condition with the highest priority will be reported. The priority is

1) Power on / reset
2) Not ready to ready transition (medium change)
3) MODE SELECT command issued from another initiator

If an INQUIRY command is received from an initiator with a pending unit attention condition the controller will perform the INQUIRY command and will not clear the unit attention condition.

If a REQUEST SENSE command is received from an initiator with a pending unit attention condition then the controller will discard any pending sense data, report UNIT ATTENTION sense key, and clear the unit attention condition for

that initiator. The additional sense code will be set to the appropriate value.

If an STOP UNIT command (with LoEj set) is received from an initiator with a pending unit attention condition the controller will perform the command and will not clear the unit attention condition.

If an initiator issues a command other than INQUIRY, REQUEST SENSE, or STOP UNIT (with LoEj set) while a unit attention condition exists for that initiator, the controller will terminate the command with a CHECK CONDITION status.

4.1.4. Ready Condition/Not Ready Condition

The ready condition occurs after a caddy is inserted and the table of contents has been recovered from the disc.

A not ready condition occurs for the following reasons:

1) There is no caddy inserted.
2) The drive is unable to load or unload the caddy.
3) The drive is unable to recover the table of contents.
4) The controller cannot select drive. (This can only occur if the controller was previously able to select the drive).

A check condition status will be returned for the drive not ready condition only for commands that require or imply a disc access. The following commands will not return a check condition status for the not ready condition. The value in parentatheses is the command code.

1) INQUIRY (12h)
2) MODE SELECT (15h)
3) RESERVE (16h)
4) RELEASE (17h)
5) MODE SENSE (1A)
6) STOP UNIT with LoEj bit set to one (1Bh)
7) ALLOW MEDIUM REMOVAL (1Eh)
8) READ BUFFER (3Ch)
9) WRITE BUFFER (3Bh)

The following commands will return a check condition status for the not ready condition. The value in parentatheses is the command code.

1) TEST UNIT READY (00h)
2) REZERO UNIT (01h)
3) READ (08h)
4) SEEK (0Bh)
5) START UNIT with Start bit set (1Bh)
6) RECEIVE DIAGNOSTIC RESULTS (1Ch)
7) SEND DIAGNOSTIC (1Dh)
8) PREVENT MEDIUM REMOVAL (1Eh)
9) READ CAPACITY (25h)
10) READ EXTENDED (28h)
11) SEEK EXTENDED (2Bh)
12) VERIFY (2Fh)
13) READ SUB-CHANNEL (42h)
14) READ TOC (43h)
15) READ HEADER (44h)
16) PLAY AUDIO (10)(45h)
17) PLAY AUDIO MSF (47h)
18) PLAY AUDIO TRACK/INDEX (48h)
19) PAUSE/RESUME (4Bh)
20) READ TOC (C1h)
21) READ SUB-CHANNEL (C2h)
22) READ HEADER (C3h)
23) PLAYBACK STATUS (C4h)
24) PAUSE (C5h)
25) PLAY TRACK (C6h)
26) PLAY MSF (C7h)
27) PLAY AUDIO (C8h)
28) PLAYBACK CONTROL (C9h)

4.1.5. ATTENTION Condition

The ATTENTION condition allows an initiator to inform the controller that the initiator has a message ready. The controller may get this message by performing a MESSAGE OUT phase.

The initiator creates the ATTENTION condition by asserting ATN at any time except during the ARBITRATION or BUS FREE phases.

The initiator will assert the ATN signal before releasing ACK for the last byte transferred in a bus phase for the ATTENTION condition to be honored before transition to a new bus phase. An ATN asserted later might not be honored until a later bus phase and then may not result in the expected action. A controller will respond with MESSAGE OUT phase as follows:

1. If ATN occurs during a COMMAND phase, MESSAGE OUT will occur after the transfer of all command descriptor block bytes has been completed.

2. If ATN occurs during a DATA phase, MESSAGE OUT will occur at the controller's convenience on a logical block boundary. The initiator must continue REQ/ACK handshakes until it detects the phase change.

3. If ATN occurs during a STATUS phase, MESSAGE OUT will occur after the status byte has been acknowledged by the initiator.

4. If ATN occurs during a MESSAGE IN phase, MESSAGE OUT phase will occur after the current MESSAGE IN byte has been acknowledged by the initiator.

5. If ATN occurs during a SELECTION phase and before the initiator releases the BSY signal, MESSAGE OUT will occur immediately after that SELECTION phase.

6. If ATN occurs during a RESELECTION phase, MESSAGE OUT will occur after the controller has successfully sent its IDENTIFY message for that RESELECTION phase.

The initiator shall keep ATN asserted if more than one byte is to be transferred. The initiator may negate the ATN signal at any time except it shall not negate the ATN signal while the ACK signal is asserted during a MESSAGE OUT phase. Normally, the initiator negates ATN while REQ is true and ACK is false during the last REQ/ACK handshake of the MESSAGE OUT phase.

4.2. Command Descriptor Block

The Command Descriptor Block (CDB) is a packet of six or ten bytes sent from the host computer during a command phase that requests the controller to perform some operation. The common parts of the CDB are described here.

4.2.1. Operation Code

The operation code is the first byte of the CDB and indicates whether a six or ten byte is being sent. Each command has a unique operation code.

4.2.2. Relative Address Bit

The relative address bit is applicable to some ten byte commands. This version of the controller does not implement relative addressing.

4.2.3. Starting Logical Address

The starting logical address specifies the logical block at which the requested read, verify or play operation is to begin. Not all CDB's have starting logical addresses.

4.2.4. Transfer Length

The transfer length specifies the number of logical blocks to be transferred. A transfer length value of zero has special meaning in some commands. The size of the logical blocks can be set using the MODE SELECT command.

4.2.5. Parameter Length

The parameter length specifies the exact number of bytes of sense data that the host will transfer to the controller.

4.2.6. Allocation Length

The allocation length specifies the maximum number of bytes that the initiator has allocated for returned sense data. An allocation length of zero indicates that no sense data will be transferred. This condition will not be considered as an error. The controller will terminate the DATA IN phase when allocation length bytes have been transferred or when all available sense data have been transferred to the initiator, whichever is less.

4.2.7. Flag and Link Bits

The link bit set to one indicates that the initiator requests a link to the next command upon successful completion of the current command. If the link bit is one, the controller will return INTERMEDIATE status upon successful termination of the command. The message sent depends on the flag bit.

The link bit set to zero indicates that the initiator does not want the commands linked. If the link bit is set to zero, the flag bit shall be set to zero .

If the link bit is set to one and the flag bit is set to zero, the controller will send LINKED COMMAND COMPLETE message if the current command completes successfully.

If the link bit is set to one and the flag bit is set to one, the controller will send LINKED COMMAND COMPLETE(WITH FLAG) message if the current command completes successfully.

4.3. Command Processing

Upon normal command completion (successful or unsuccessful), the controller returns a status byte to the initiator. Since most error and exception conditions cannot be adequately described with a single status byte, one status code, CHECK CONDITION, indicates that additional information is available. The initiator may issue a REQUEST SENSE command to retrieve this additional information.

An initiator should never send a second command to a logical unit until the command in progress is terminated. The command is normally terminated with a COMMAND COMPLETE message, but termination may result because of other events such as the RESET condition.

If the controller receives a selection from an initiator that has a command in progress (i.e. the controller has disconnected) the controller will abort the first command and not perform the second command. A CHECK CONDITION status is returned. The sense key is set to ABORTED COMMAND, and the additional sense code is set to OVERLAPPED COMMANDS ATTEMPTED.

The occurrence of an initiator sending a second command to a logical unit with a command in progress by the same initiator is considered a catastrophic failure from the controller's viewpoint.

4.4. Handling of Message Phase

The message phase is a term that references either a MESSAGE IN, or a MESSAGE OUT phase. Multiple messages may be sent during either phase. The first byte transferred in either of these phases shall be either a single-byte message or the first byte of a multiple-byte message. Multiple-byte messages shall be wholly contained within a single message phase.

4.4.1. MESSAGE IN Phase

The MESSAGE IN phase allows the target to request that message(s) be sent to the initiator from the controller.

The controller will assert C/D, I/O, and MSG during the REQ/ACK handshake(s) of this phase.

4.4.2. MESSAGE OUT Phase

The MESSAGE OUT phase allows the controller to request that message(s) be sent from the initiator to the controller. The controller may invoke this phase at its convenience in response to the ATTENTION condition created by the initiator.

The controller will assert C/D and MSG and negate I/O during the REQ/ACK handshake(s) of this phase. The controller will handshake byte(s) in this phase until ATN goes false, unless an error occurs.

If the controller detects one or more parity error(s) on the message byte(s) received, it may indicate its desire to retry the message(s) by asserting REQ after detecting ATN has gone false and prior to changing to any other phase. The initiator, upon detecting this condition, shall re-send all of the previous message byte(s) in the same order as previously sent during this phase. When re-sending more than one message byte, the initiator shall assert ATN prior to asserting ACK on the first byte and shall maintain ATN asserted until the last byte is sent.

The controller will act on messages as received as long as no parity error is detected and will ignore all remaining messages sent under one ATN condition after a parity error is detected. When a sequence of messages is re-sent by an initiator because of a target detected parity error, the target will not act on any message which it acted on the first time received.

If the target receives all of the message byte(s) successfully (i.e., no parity errors), it will indicate that it does not wish to retry by changing to any information transfer phase other than the MESSAGE OUT phase and transfer at least one byte. The target may also indicate that it has successfully received the message byte(s) by changing to the BUS FREE phase

Table 4-1: Message Codes

Code	Description	Direction	
00h	COMMAND COMPLETE	In	
02h	SAVE DATA POINTER	In	
03h	RESTORE POINTERS	In	
04h	DISCONNECT	In	
04h	DISCONNECT		Out
05h	INITIATOR DETECTED ERROR		Out
06h	ABORT		Out
07h	MESSAGE REJECT	In	Out
08h	NO OPERATION		Out
09h	MESSAGE PARITY ERROR		Out
0Ah	LINKED COMMAND COMPLETE	In	
0Bh	LINKED COMMAND COMPLETE (WITH FLAG)	In	
0Ch	BUS DEVICE RESET		Out
80h - FFh	IDENTIFY		Out

Key: In = Target to initiator, Out = Initiator to target.

4.4.3. Messages

The single byte messages (Table 4-1) are listed below along with their code values and their definitions.

COMMAND COMPLETE 00h. This message is sent from the controller to an initiator to indicate that the execution of a command (or series of linked commands) has terminated and that valid status has been sent to the initiator. After successfully sending this message, the controller will go to the BUS FREE phase by releasing BSY. The controller will consider the message transmission to be successful when it detects the negation of ACK for the COMMAND COMPLETE message with the ATN signal false.

SAVE DATA POINTER 02h. This message is sent from the controller to direct the initiator to save a copy of the present active data pointer for the currently attached logical unit.

RESTORE POINTERS 03h. This message is sent from the controller to direct the initiator to restore the most recently saved pointers (for the currently attached logical unit) to the active state. Pointers to the command, data, and status locations for the logical unit shall be restored to the active pointers. Command and status pointers shall be restored to the beginning of the present command and status areas. The data pointer shall be restored to the value at the beginning of the data area in the absence of a SAVE DATA POINTER message or to the value at the point at which the last SAVE DATA POINTER message occurred for that logical unit.

DISCONNECT 04H. This message is sent from the controller to inform an initiator that the present physical path is going to be broken (the target plans to disconnect by releasing BSY), but that a later reconnect will be required in order to complete the current operation. This message shall not cause the initiator to save the data pointer. After successfully sending this message in, the controller will go to the BUS FREE phase by releasing BSY. The controller will consider the message transmission to be successful when it detects the negation of ACK for the DISCONNECT message with the ATN signal false. If DISCONNECT messages are used to break a long data transfer into two or more shorter transfers, then a SAVE DATA POINTER will be issued before each DISCONNECT message.

This message may also be sent from an initiator to the controller to instruct the controller to disconnect from the SCSI bus. After the DISCONNECT message is received, the controller will switch to MESSAGE IN phase, send the DISCONNECT message to the initiator preceded by SAVE DATA POINTER message, and then disconnect by releasing BSY. After releasing BSY, the controller will not participate in another ARBITRATION phase for at least a disconnection delay. If the controller cannot disconnect at the time when it receives the DISCONNECT message from the initiator, it will respond by sending MESSAGE REJECT message to the initiator.

INITIATOR DETECTED ERROR 05h. This message is sent from an initiator to inform the controller that an error (e.g., parity error) has occurred that does not preclude the controller from retrying the operation. Although present pointer integrity is not assured, a RESTORE POINTERS message or a disconnect followed by a reconnect, shall cause the pointers to be restored to their defined prior state.

ABORT 06h. This message is sent from the initiator to the controller to clear the present operation. If a logical unit has been identified, all pending data and status for the issuing initiator from the affected logical unit will be cleared, and the controller will go to the BUS FREE phase. Pending data and status for other initiators is not cleared. If a logical unit has not been identified, the controller will go to the BUS FREE phase. No status or ending message will be sent for the operation. It is not an error to issue this message to an logical unit that is not currently performing an operation for the initiator.

MESSAGE REJECT 07h. This message is sent from either the initiator or controller to indicate that the last message it received was inappropriate or has not been implemented.

In order to indicate its intentions of sending this message, the initiator shall assert the ATN signal prior to its release of ACK for the REQ/ACK handshake of the message that is to be rejected. If the target receives this message under any other circumstance, it shall reject this message.

When the controller sends this message, it will change to MESSAGE IN phase and send this message prior to requesting additional message bytes from the initiator. This provides an interlock so that the initiator can determine which message is rejected.

NO OPERATION 08h. This message is sent from an initiator in response to a the controller's request for a message when the initiator does not currently have any other valid message to send.

MESSAGE PARITY ERROR 09h. This message is sent from the initiator to the controller to indicate that one or more bytes in the last message it received had a parity error.

In order to indicate its intentions of sending this message, the initiator shall assert the ATN signal prior to its release of ACK for the REQ/ACK handshake of the message that has the parity error. This provides an interlock so that the controller can determine which message has the parity error. If the controller receives this message under any other circumstance, it will signal a catastrophic error condition by releasing the BSY signal without any further information transfer attempt.

LINKED COMMAND COMPLETE 0Ah. This message is sent from the controller to an the initiator to indicate that the execution of a linked command has completed and that status has been sent. The initiator shall then set the pointers to the initial state for the next linked command.

LINKED COMMAND COMPLETE (WITH FLAG) 0Bh. This message is sent from the controller to an initiator to indicate that the execution of a linked command (with the flag bit set to one) has completed and that status has been sent. The initiator shall then set the pointers to the initial state of the next linked command. Typically this message would be used to cause an interrupt in the initiator between two linked commands.

BUS DEVICE RESET 0Ch. This message is sent from an initiator to direct the controller to clear all current commands on that SCSI device. This message forces the SCSI device to an initial state with no operations pending for any initiator. Upon recognizing this message, the controller will go to the BUS FREE phase.

IDENTIFY 80h to FFh. These messages are sent by either the initiator or the controller to establish the physical path connection between an initiator and controller for a particular logical unit. The logical unit number addresses one physical drive attached to the controller.

Bit 7. This bit shall be set to one to distinguish these messages from the other messages.

Bit 6. This bit is only set to one by the initiator to grant the the privilege of disconnecting. If this bit is zero, the controller will not disconnect. This bit is set to zero when the identify message is sent by the controller.

Bits 5-3. Reserved.

Bits 2-0. These bits specify the logical unit number in the controller.

Only one logical unit number shall be identified for any one selection sequence; a second IDENTIFY message with a new logical unit number shall not be issued before the bus has been released (BUS FREE phase). The initiator may send one or more IDENTIFY messages during a selection sequence. However, the logical unit number in any additional IDENTIFY messages shall be the same as the logical unit number specified in the first IDENTIFY message sent by the initiator.

When sent from the controller to an initiator during reconnection, an implied RESTORE POINTERS message shall be performed by the initiator prior to completion of this message.

4.5. Handling of Status Phase

The controller will always follow the selection phase with a command phase. If exception handling requires a status phase it will occur after the command phase. (Example: A reservation conflict or busy status.)

A status byte will be sent from the controller to the initiator during the STATUS phase at the termination of each command unless the command is cleared by an ABORT message, by a BUS DEVICE RESET message, an assertion of the RST signal, or by an unexpected BUS FREE condition.

4.5.1. Status Byte Description

GOOD (00h). This status indicates that the controller has successfully completed the command.

CHECK CONDITION (02h). This status indicates that an error, exception, or abnormal condition has caused the sense key or additional sense code to be set. The REQUEST SENSE command should be issued following a CHECK CONDITION status, to determine the nature of the condition.

BUSY (08h). This status indicates that the controller is busy. The controller is unable to perform a command from an otherwise acceptable initiator. The normal initiator recovery action is to issue the command again at a later time.

INTERMEDIATE (10h). This status indicates that a command in a series of linked commands has completed successfully. This status is returned for every linked command in a series of linked commands except the last command, unless an error, exception, or abnormal condition causes a CHECK CONDITION status or a RESERVATION CONFLICT status to be returned. If the intermediate status is not returned, the chain of linked commands is broken; no further commands in the series are executed.

RESERVATION CONFLICT (18h). This status indicates that the initiator attempted to access a logical unit that is reserved for to another SCSI ID. The normal initiator recovery action is to issue the command again at a later time.

4.6. Disconnect/Reconnect

If the disconnect privilege is granted, and the Disconnect/Reconnect parameters are in the default setting, the controller will disconnect after the command phase for any command that requires a seek operation.

The controller will attempt to reselect the initiator after a disconnect has occurred. A minimum delay of 200 milliseconds will elapse between each attempt. The reselection procedure will continue until the initiator reselected responds or until a BUS DEVICE RESET or COMMAND ABORT message is received from that initiator or until the RST signal is asserted.

4.7. Disc Compatibility

The controller is designed to work with any disc that meets the Sony-Philips "red-book" or "yellow-book" documents at the current revision level. The drive will read CD-ROM data discs in mode one or mode two, digital audio discs, and audio- combined discs (i.e. some tracks are audio, some tracks are data).

It is recommended for the efficient performance of the interface that post-gap areas be encoded as CD-ROM data in mode zero.

4.8. TOC Recovery Strategy

The recovery of the TOC data is required before a logical unit is ready and data can be read from the disc. The TOC data is written several times in the area set up for TOC data. The exact number of repetitions depends on the number of tracks on a disc. The following TOC recovery strategy attempts to maximize the chance of recovering the TOC data.

The drive attempts to recover the TOC as soon as a caddy is successfully loaded. The time maximum time to recover a TOC that is read without error is approximately five seconds. The repeated TOC data can be up to two minutes long. Following this strategy the drive will continue in its attempts to recover the TOC data until the end of the TOC data area is reached.

Any command received during the TOC read operation will be terminated with a CHECK CONDITION status. The sense key is set to NOT READY and the additional sense code is set to TOC READ IN PROGRESS.

If the drive reaches the end of the TOC data area without successfully recovering the TOC data the controller will respond to all subsequent commands that imply a disc access with a CHECK CONDITION status (see 4.1.4). The sense key is set to NOT READY and the additional sense code is set to UNABLE TO RECOVER TOC.

4.9. Audio Playback Implementation Rules

The rules for audio playback operations:

1) The starting audio address must be specified before a playback operation can occur. The controller will set the ending audio address if any audio tracks exist on the disc to the address of the next track index one minus one block. If a playback operation is requested and no audio tracks exist the playback operation will be terminated with CHECK CONDITION status. The sense key will be set to ILLEGAL REQUEST and the additional sense code set to AUDIO ADDRESS NOT VALID.

2) The audio addresses will be valid until a reset condition, a medium change occurs or until another command is received with a new audio address.

3) The audio addresses must be within an audio track. If the audio address is not within an audio track the command will be terminated with a CHECK CONDITION status. The sense key will be set to ILLEGAL REQUEST and the additional sense code set to ILLEGAL MODE FOR THIS TRACK.

4) If a change in bit one of the control field is detected the playback operation will be terminated with a CHECK CONDITION status. The sense key will be set to ILLEGAL REQUEST and the additional sense code set to END OF USER AREA ENCOUNTERED ON THIS TRACK.

If any of the following conditions occur and the drive has not detected the ending audio address audio play operation will continue on the next track.

a) an index equal zero is detected (i.e. pre-gap detected).
b) a track number change is detected (i.e. lead-out).

The ending audio address may be set while audio play is in progress. If the ending address requested is not greater than the current address the audio play operation will stop and the drive will enter the hold track state.

5) The audio play operation will not be interrupted by the following commands received by the controller. The value in parentheses is the command code.

TEST UNIT READY	READ CAPACITY
REQUEST SENSE	WRITE BUFFER
INQUIRY	READ BUFFER
RESERVE	READ TOC (C1h)
RELEASE	READ TOC (43h)
MODE SELECT	READ SUB-CHANNEL (C2h)
MODE SENSE	READ SUB-CHANNEL (42h)
RECEIVE DIAGNOSTIC RESULTS	PLAYBACK STATUS
	PAUSE with Pause bit=0

The actual starting audio address will be within four q-subcode addresses of the requested starting audio address. The reason is the reliability of reading the q-subcode address. The current audio players carry through if they miss a q-subcode address.

5. CD-ROM Devices

This section has five parts; a model of the CD-ROM, a command set used to control the drive, a part detailing the implemented pages, a part listing the additional sense codes, and a glossary.

5.1. CD-ROM Model

IMPLEMENTORS NOTE: The model described is based on CD-ROM technology, however the command set is designed to be usable by all read-only devices. The model is provided as a means to understand the implementation of the command set. As such the model description does not impose any mandatory requirements.

CD-ROM drives are designed to work with any disc that meets the Sony-Philips "red-book" or "yellow-book" documents at the current revision level. Most drives will read CD-ROM data discs in mode one or mode two, digital audio discs, and combined-mode discs (i.e. some tracks are audio, some tracks are data).

The CD-ROM disc has the same physical size and properties as the CD-AUDIO disc. The discs have two sizes, 120 millimeter diameter and 80 millimeter diameter. These correspond to 5-1/4 inch and 3-1/2 inch footprint drives.

The disc is single sided containing approximately 600 megabytes of data or 74 minutes of audio in the larger diameter. The smaller diameter has a capacity of 200 megabytes of data or 23 minutes of audio. A disc may contain both audio and data, a so called combined mode disc.

A disc contains from one to ninety-nine tracks. Each change in the type of information on the disc (audio or data) requires a change in track number. A disc containing both audio and data would have at least two tracks, one for audio and one for data.

A track has a minimum length of four seconds or 300 sectors. The first track number on a disc may be any track number from one to ninety-nine. The following track numbers, if any, are in contiguous and ascending order.

A transition area occurs between each track. Seek operations can be performed to the transition area. However read or play operations cannot be performed in the transition area. The transition area is structured and the logical addressing sequence continues to increment through the transition area.

There also exits a lead-in and a lead-out area on the disc. This allows for overshoot during seek operations. These areas are outside of the user defined area as reported in the READ CAPACITY data.

Each track can be subdivided by indexes. Every track has at least index one, and may have up to ninety-nine indexes. The user information starts at index one within a track. The index numbers are contiguous and ascending.

Each disc has a table of contents (TOC). The TOC contains information on the number of tracks on a disc, and the starting location of the user information within the track. The starting location is given in MSF or LBA address format. The TOC also indicates which tracks are audio and which tracks are data. Note though, that the TOC does not contain information to distinguish between CD-ROM Mode one and CD-ROM Mode two data.

The recovery of the TOC data is necessary before a drive is ready and data can be read from the disc. The TOC data is written several times in the area set up for TOC data. The exact number of repetitions depends on the number of tracks on a disc.

The drive attempts to recover the TOC as soon as a caddy is successfully loaded. The time maximum time to recover a TOC that is read without error is approximately five seconds. The repeated TOC data can be up to two minutes long.

A frame has 588 bits. A frame must be EFM decoded by the drive before the bit stream contains recognizable data. Fourteen bits are used to represent each eight-bit byte. Three merging bits are added to each fourteen bits.

A block contains 98 frames.

```
FRAME BYTES
============================
 1 (24 + 3)  Synchronization
 1 (14 + 3)  Sub-Channels    =-> 1 eight-bit sub-channel P,Q,R,S,T,U,V,W
24 (14 + 3)  Data Symbols    --> 24 eight-bit bytes of data
 8 (14 + 3)  CIRC Symbols    Cross Interleaved Reed Solomon Code
-----------  ---------------
 588 bits total
============================
```

The sub-channel byte is assigned one bit for each sub-channel. One byte contains a bit for sub-channels P,Q,R,S,T,U,V,W. Sub-channel P is used for audio muting control. Sub-channels R,S,T,U,V,W are not used in CD-ROM. Sub-channel Q contains the following:

```
 2 bits Sync
 4 bits Control
 4 bits ADR
72 bits Sub-channel Q data (9 bytes)
16 bits CRC
-------------------------
98 bits total (one bit from the sub-channel byte of each frame in a block).
```

The Sub-channel Q data contains the following:

```
 4 bits Reserved
 4 bits Control Field
 8 bits Track Number Field in bcd format
 8 bits Index Number Field in bcd format
 8 bits Relative Minute Field in bcd format
 8 bits Relative Second Field in bcd format
 8 bits Relative Frame Field in bcd format
 8 bits Absolute Minute Field in bcd format
 8 bits Absolute Second Field in bcd format
 8 bits Absolute Frame Field in bcd format
----------------------------------------
72 bits total sub-channel Q data
```

The data symbols make up the block of data that is returned to the user during a read operation. A block of data is made up of 98 frames, so there are (98 x 24) 2352 bytes of data in a block. A block of data contains the following if the CD-ROM Mode field has a value of one:

```
   12 bytes Synchronization
    4 bytes CD-ROM data header
            Absolute Minute Field in bcd format
            Absolute Second Field in bcd format
            Absolute Frame Field in bcd format
            CD-ROM Mode Field
 2048 bytes user defined data
    4 bytes Error Detection Code
    8 bytes zero
  276 bytes Layered Error Correction Code
```

A block of data contains the following if the CD-ROM Mode field has a value of two:

```
   12 bytes Synchronization
    4 bytes CD-ROM data header
            Absolute Minute Field in bcd format
            Absolute Second Field in bcd format
            Absolute Frame Field in bcd format
            CD-ROM Mode Field
 2336 bytes user defined data
```

NOTE: Many drives are capable of returning CD-ROM Mode one data in a CD-ROM Mode two format. This allows the user to investigate the error detection and error correction codes. However if the data is encoded as CD-ROM Mode two it cannot be read as CD-ROM mode one data.

The address in the CD-ROM Header field is usually the same as the address in the sub-channel Q data for a particular sector. However a tolerance of ± one second is allowed.

The address in the TOC for the start of user data in track has a tolerance of ± 0 second.

5.2. CD-ROM Command Descriptions

The following table lists the commands implemented in the controller. This list is written by the alphabetical order. The command descriptions are in alphabetical order by command name.

Table 5-1: Implemented Commands

Command Name	Command Code	Type	Section
INQUIRY	12h	M	5.2.1.
MODE SELECT	15h	M	5.2.2.
MODE SENSE	1Ah	M	5.2.3.
PAUSE	C5h	V	5.2.4.
PAUSE/RESUME	4Bh	O	5.2.5.
PLAY AUDIO	C8h	V	5.2.6.
PLAY AUDIO(10)	45h	O	5.2.7.
PLAY AUDIO MSF	47h	O	5.2.8.
PLAY AUDIO TRACK/INDEX	48h	O	5.2.9.
PLAY MSF	C7h	V	5.2.10.
PLAY TRACK	C6h	V	5.2.11.
PLAYBACK CONTROL	C9h	V	5.2.12.
PLAYBACK STATUS	C4h	V	5.2.13.
PREVENT/ALLOW MEDIUM REMOVAL	1Eh	M	5.2.14.
READ	08h	M	5.2.15.
READ BUFFER	3Ch	O	5.2.16.
READ CAPACITY	25h	M	5.2.17.
READ EXTENDED	28h	M	5.2.18.
READ HEADER	C3h	V	5.2.19.
READ HEADER	44	O	5.2.20.
READ SUB-CHANNEL	C2h	V	5.2.21.
READ SUB-CHANNEL	42h	O	5.2.22.
READ TOC	C1h	V	5.2.23.
READ TOC	43h	O	5.2.24.
RECEIVE DIAGNOSTIC RESULT	1Ch	O	5.2.25.
RELEASE	17h	M	5.2.26.
REQUEST SENSE	03h	M	5.2.27.
RESERVE	16h	M	5.2.28.
REZERO UNIT	01h	M	5.2.29.
SEEK	0Bh	M	5.2.30.
SEEK EXTENDED	2Bh	M	5.2.31.
SEND DIAGNOSTIC	1Dh	M	5.2.32.
START/STOP UNIT	1Bh	M	5.2.33.
TEST UNIT READY	00h	M	5.2.34.
VERIFY	2Fh	O	5.2.35.
WRITE BUFFER	3Bh	O	5.2.36.

M: Mandatory O: Optional V: Vendor Unique

5.2.1. INQUIRY Command

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation Code (12h)							
1	Logical Unit Number			Reserved				
2	Reserved							
3	Reserved							
4	Allocation Length							
5	Control Byte							

The INQUIRY command requests that information regarding parameters of the controller and its attached peripheral device be sent to the initiator.

The INQUIRY command will be terminated with a BUSY status when the controller is performing power-on diagnostics or the reading of the table of contents is occurring.

The INQUIRY command will be terminated with a CHECK CONDITION status only then the controller has detected a catastrophic error.

If an INQUIRY command is received from an initiator with a pending unit attention condition (before the controller reports CHECK CONDITION status), the controller will perform the INQUIRY command and will not clear the unit attention condition.

Table 5-2: Inquiry Data

Bit / Byte	7	6	5	4	3	2	1	0
0	Peripheral Device Type (05h)							
1	RMB	Device-Type Qualifier						
2	ISO Version		ECMA Version			ANSI-Approved Version		
3	Reserved					Response Data Format		
4	Additional Length (n - 4)							
5	Reserved							
6	Reserved							
7	Reserved							
8 - 15	(MSB) Vendor Identification (LSB)							
16 - 31	(MSB) Product Identification (LSB)							
32 - 35	(MSB) Product Revision Level (LSB)							

The peripheral device type code is set to 05h if the logical unit is present. If the logical unit is not present the peripheral device type code is set to 7Fh.

The RMB bit is set to one because the disc is removable.

The device-type qualifier is a set to zero.

The response data format is set to one.

The additional length is set to 31h. If the allocation length of the command descriptor block is too small to transfer all of the parameters, the additional length will not be adjusted to reflect the truncation.

The vendor identification field contains eight bytes of ASCII data identifying the vendor of the product as follows:

Byte	08	09	10	11	12	13	14	15
ASCII	S	O	N	Y	sp	sp	sp	sp
Code	53h	4Fh	4Eh	59h	20h	20h	20h	20h

The product identification field contains sixteen bytes of ASCII data defined as follows:

Byte	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
ASCII	C	D	-	R	O	M	sp	C	D	U	-	x	x	x	x	sp
Code	43h	44h	2Dh	52h	4Fh	4Dh	20h	43h	44h	55h	2Dh	3xh	3xh	3xh	3xh	20h

The product revision level field contains four bytes of ASCII data which indicate the revision level of the controller firmware defined as follows:

Byte	32	33	34	35
ASCII	x	.	x	X
Code	3xh	2Eh	3xh	6Yh

X - is lower case letter indicating revision
Y - is corresponding hex code for letter

Byte 32 - A value of three indicates that this is a production release of the firmware. A value of two indicates a beta test version of the firmware. A value of one indicates an Engineering development version of the firmware.

Byte 33 - is a period.

Byte 34 - This byte indicates major revisions of, or additions to the firmware. The value of this byte is from zero to nine. This always implies a change in the implementation documentation.

Byte 35 - This byte indicates minor changes to the firmware, i.e. bug fixes, corrections for misunderstandings, etc. There is usually no change required, or very minor change in the implementation document.

5.2.2. MODE SELECT Command

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation Code (15h)							
1	Logical Unit Number			PF	Reserved			SP
2	Reserved							
3	Reserved							
4	Parameter List Length							
5	Control Byte							

The MODE SELECT command provides a means for the initiator to specify medium, logical unit, or peripheral device parameters to the controller.

The target does not check the value of PF bit.

The save parameters (SP) bit is set to zero because the CD-ROM cannot save parameters.

The parameter list length specifies the length in bytes of the MODE SELECT parameter list that will be transferred from the initiator to the controller. A parameter list length of zero indicates that no data will be transferred. This condition will not be considered as an error. The block descriptor and the pages which follow if any must be sent in their entirety. Truncation of a page due to an incorrect parameter list length will be considered an error. The command will be terminated with a CHECK CONDITION status. The sense key is set to ILLEGAL REQUEST and the additional sense code is set to INVALID FIELD IN PARAMETER LIST.

The MODE SELECT parameter list contains a four-byte header, followed by zero or one eight-byte block descriptor, followed by zero or more pages.

Table 5-3: Mode Select Parameter List

Bit / Byte	7	6	5	4	3	2	1	0
0	Reserved							
1	Medium Type							
2	Reserved							
3	Block Descriptor Length (00h or 08h)							
	Block Descriptor							
0	Reserved							
1	(00h)							
2	(00h)							
3	(00h)							
4	Reserved							
5	(MSB)							
6	Block Length							
7								(LSB)
	Page(s)							
0	Reserved			Page Code				
1	Page-Specific Parameter Length							
2								
- - -	- - Page-Specific Parameters - -							
n								

The medium type is set to zero to indicate the default disc is CD-ROM.

The block descriptor length shall be set to either 00h or 08h.

The block descriptor specifies the medium characteristics for the whole disc.

The block length requests that the controller use the logical block length specified for data transfers. The controller will accept the block lengths as shown in Table 5-4. Any other value will be considered an error. The command will be terminated with a CHECK CONDITION status. The sense key is set to ILLEGAL REQUEST and the additional sense code is set to INVALID FIELD IN PARAMETER LIST. The block length is applicable to the whole disc except the audio tracks.

Table 5-4: Block Lengths for CD-ROM

Block Length	Description
256	256 bytes of user data CD-ROM mode one data required
512	512 bytes of user data CD-ROM mode one data required
1024	1024 bytes of user data CD-ROM mode one data required
2048	2048 bytes of user data CD-ROM mode one data required
2336	2048 bytes of user data & 288 bytes ECC data if CD-ROM mode one data 2336 bytes of user data if CD-ROM mode two data
2340	4 byte header & 2048 bytes of user data & 288 bytes ECC data if CD-ROM mode one data 4 byte header & 2336 bytes of user data if CD-ROM mode two data

A block length of 2336 or 2340 can be specified for CD-ROM mode one or CD-ROM mode two data. If a read operation is requested on a track that is CD-ROM mode two data and L-EC is not disabled the command will be terminated with a CHECK CONDITION status. The sense key will be set to ILLEGAL REQUEST and the additional sense code set to ILLEGAL MODE FOR THIS TRACK.

Each page descriptor specifies parameters for the controller to use for subsequent operations on the specified logical unit. The page descriptors are specified in section 5.3. The parameter length field specifies the length in bytes of the parameters that follow for that page. The initiator shall set this value to the value that is returned in the parameter length field for the same page by the MODE SENSE command. If this condition is not met, the controller will terminate the command with a CHECK CONDITION status. The sense key is set to ILLEGAL REQUEST and the additional sense code is set to INVALID FIELD IN PARAMETER LIST.

5.2.3. MODE SENSE Command

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation Code (1Ah)							
1	Logical Unit Number			Reserved				
2	PC		Page Code					
3	Reserved							
4	Allocation Length							
5	Control Byte							

The MODE SENSE command provides a means for a controller to report parameters to the initiator. It is a complementary command to the MODE SELECT command.

The page control (PC) field defines the type of parameter values to be returned as shown below.

Table 5-5: Page Control Bit Definition

DB(7)	DB(6)	Type of Parameter Values
0	0	Current Values
0	1	Changeable Values
1	0	Default Values
1	1	Default Values

5.2.3.1. Current Values

A PC field value of 0h requests the controller return the current values for the page code specified. The current values returned are either the parameters set in the last successful MODE SELECT command or the default values if a MODE SELECT command has not been executed.

5.2.3.2. Changeable Values

A PC field value of 1h requests the controller return the changeable values for the page code specified. The page requested will be returned with the bits that are allowed to be changed set to one. Parameters that are not changeable will be set to zero. If any part of a field is changeable all bits in that field are set to one.

The page descriptor as defined in this document will always be returned even if none of parameters are changeable within the page.

5.2.3.3. Default Values

A PC field value of 2h requests the controller return the default values for the page code specified. The page requested will be returned with the default parameters set.

The page code specifies which page or pages to return. The page codes are described in Section 5.3. If the page code specified is not implemented the command will be terminated with a CHECK CONDITION status. The sense key will be set to ILLEGAL REQUEST and the additional sense code set to ILLEGAL VALUE IN CDB. If the page code is 3Fh, all implemented pages are requested to be returned by the controller. The pages are returned in ascending order.

The MODE SENSE parameter list contains a four-byte header, followed by one eight-byte block descriptor, followed by zero or more pages.

Table 5-6: Mode Sense Parameter List

Bit / Byte	7	6	5	4	3	2	1	0
0	Sense Data Length							
1	Medium Type							
2	Reserved							
3	Block Descriptor Length (08h)							
	Block Descriptor							
0	Reserved							
1	(MSB)							
2	Number of Blocks							
3								(LSB)
4	Reserved							
5	(MSB)							
6	Block Length							
7								(LSB)
	Page(s)							
0	Reserved			Page Code				
1	Page-Specific Parameter Length							
2 - n	Page-Specific Parameters							

The medium type is set to zero to indicate the default disc is CD-ROM.

The block descriptor length is set to 08h.

The block descriptor specifies the medium characteristics for the whole disc.

The number of blocks field indicates the number of contiguous logical blocks that have the block length specified in the block descriptor. A value of zero indicates the whole disc has the block length specified.

The block length specifies, in bytes, the logical block size in use by the controller. This is applicable to whole disc except those tracks that are audio. The default block length is 2048 and is returned if default values are requested. The current block length is returned if current values are requested. A block length of FFh FFh FFh is returned if changeable values are requested. See Table 5-4 for valid values.

Pages are returned following the block descriptor if requested. Each page has a header defining the page code and the page length. Following the header are the page parameters. The page length value is the number of bytes that follow the page length byte and does not include the header. The pages are defined in Section 5.3.

5.2.4. PAUSE Command

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation Code (C5h)							
1	Logical Unit Number			Pause	Reserved			
2	Reserved							
3	Reserved							
4	Reserved							
5	Reserved							
6	Reserved							
7	Reserved							
8	Reserved							
9	Control Byte							

The PAUSE command requests that the target start/stop the current audio play operation.

A pause bit of one indicates the drive will enter the hold track state with the audio output muted after the current audio block is played. A pause bit of zero indicates the drive will release the pause and begin play at the block following the last block played.

5.2.5. PAUSE/RESUME Command

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation Code(4Bh)							
1	Logical Unit Number			Reserved				
2	Reserved							
3	Reserved							
4	Reserved							
5	Reserved							
6	Reserved							
7	Reserved							
8	Reserved							Resume
9	Control Byte							

The PAUSE/RESUME command requests that the target start or stop the current audio play operation. This command is used with some commands,such as PLAY AUDIO commands issued while the immediate bit of MODE SELECT PAGE CODE 9 is set to one.

A resume bit of zero indicates that the drive enter the hold track state with the audio output muted after the current audio block is played. A resume bit of one indicates that the drive release the pause and begin play at the block following the last block played.

This command is terminated with CHECK CONDITION status if the resume bit is zero and the audio play operation cannot be resumed (i.e. an audio play operation has not been requested, or the requested audio play operation has been completed.).

It shall not be considered an error to request a pause when a pause is already in effect or to request a resume when a play operation is in progress.

5.2.6. PLAY AUDIO Command

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation Code (C8h)							
1	Logical Unit Number			Reserved				
2	(MSB)							
3								
4	Logical Block Address							
5								(LSB)
6	Reserved							
7	(MSB)							
8	Transfer Length							(LSB)
9	Control Byte							

The PLAY AUDIO command requests that the target play audio starting at the specified logical block address for the specified transfer length. The audio is output as specified by the audio control parameters.

This command returns the status byte when the address requested is found. If the address is not found , or if the ready condition does not exist, or if the address is not within an audio track, a CHECK CONDITION status will be returned and the appropriate sense key set.

If the transfer length is zero this command seeks to the specified logical block address and enters the hold track state. The drive is in a pause condition, issuing a PAUSE command with the pause bit set to zero will begin audio play.

5.2.7. PLAY AUDIO(10) Command

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation Code (45h)							
1	Logical Unit Number			Reserved				
2	(MSB)							
3								
4				Starting Logical Block Address				
5								(LSB)
6	Reserved							
7	(MSB)							
8				Transfer Length				(LSB)
9	Control Byte							

The PLAY AUDIO command requests that the target play audio starting at the specified logical block address for the specified transfer length. The audio is output as specified by the audio control parameters MODE SELECT PAGE CODE 9.

The status returning condition depends on the Immd bit of MODE SELECT page code 9. The Immd bit in MODE SELECT page code 9 of one requests that this command return the status byte when the address requested is found. The Immd bit in MODE SELECT page code 9 of zero requests that this command return the statuas byte when reading operation of data transfer length specifird byte 7 and 8 above is completed, or an error occurs.

If the address is not found , or if the ready condition does not exist, or if the address is not within an audio track, a CHECK CONDITION status will be returned and the appropriate sense key set.

If the transfer length is zero this command seeks to the specified logical block address and enters the hold track state.

If any commands related to audio operations are implemented then the PLAY AUDIO command shall be implemented to allow a method for the initiator to determine if audio operations are supported. A target responding to a PLAY AUDIO command which has a transfer length of zero with CHECK CONDITION status and setting the sense key to ILLEGAL REQUEST does not support audio play operations.

The logical block address field specifies the logical block at which the audio play back operation shall begin.

The transfer length field specifies the number of contiguous logical blocks that shall be played. A transfer length field of zero indicates that no audio operation shall occur. This condition shall not be considered as an error. Any other value indicates the number of logical blocksthat shall be played.

NOTE: A logical block length not equal to the sector size may cause the starting logical block address and the transfer length to be adjusted by the target. In most targets, a starting logical address that occurs within a sector causes audio play to start at the beginning of that sector. Many targets play any partial audio sector beyond the end of the requested transfer length.

NOTE: When the immideate bit in MODE SELECT PAGE CODE 9 is set to one, the command will be terminated at the address specified by the starting logical block address. When it is set to zero, the command will be terminated at the stop address, or an error makes the command be terminated.

5.2.8. PLAY AUDIO MSF Command

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation Code (47h)							
1	Logical Unit Number			Reserved				
2	Reserved							
3	Starting Minutes							
4	Starting Seconds							
5	Starting Frame							
6	Ending Minutes							
7	Ending Seconds							
8	Ending Frame							
9	Control Byte							

The PLAY MSF command requests that the target output the audio signals starting at the specified starting address and continue the audio play operation until the specified ending address is detected. The audio signals are output as specified by the audio control parameters in MODE SELECT PAGE CODE 9. The number in these fields is hexadecimal.

The Starting minutes, seconds, frame specify the starting address in absolute time. The Ending minutes, seconds, frame specify the ending address in absolute time. If the ending address is less than the starting address a CHECK CONDITION status is returned. The sense key is set to ILLEGAL REQUEST and the additional sense code is set to ILLEGAL VALUE IN COMMAND DESCRIPTOR BLOCK.

The status returning condition depends on the Immd bit of MODE SELECT page code 9. The Immd bit in MODE SELECT page code 9 of one requests that this command return the status byte when the address requested is found. The Immd bit in MODE SELECT page code 9 of zero requests that this command return the statuas byte when reading operation of data transfer length specifird byte 7 and 8 above is completed, or an error occurs.

If the address is not found , or if the ready condition does not exist, or if the address is not within an audio track, a CHECK CONDITION status will be returned and the appropriate sense key set.

If the starting address equals the ending address this command this command seeks to the specified address and enters the hold track state. The drive is in a pause condition, issuing a PAUSE command with the pause bit set to zero will begin audio play.

5.2.9. PLAY AUDIO TRACK/INDEX Command

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation Code (48h)							
1	Logical Unit Number			Reserved				
2	Reserved							
3	Reserved							
4	Starting Track							
5	Starting Index							
6	Reserved							
7	Ending Track							
8	Ending Indexe							
9	Control Byte							

The PLAY TRACK/INDEX command requests that the target play audio starting at the specified starting track and index for the specified ending track and index. The audio is output as specified by the audio control parameters in MODE SELECT PAGE CODE 9.

The starting track field specifies the track number of the starting audio track. The starting index field specifies the index number within starting track at which the audio play operation shall begin. Valid values for the track are 1h to 63h(1 to 99) and for the index are only 1

NOTE: The current firmware in the controller only supports a starting index of one.

The ending track field specifies the track number of the ending audio track. The ending index specifies the index number within the track after which the audio play operation shall stop. The ending track of FFh is valid, and the play operation continues until the lead-out or non-audio track is detected, or an error occurs.

IMPLEMENTORS NOTE: A typical audio track for music has only one index number (i.e. the number of indexes is equal to one.) The number of indexes within a track in not obtainable from data in the table of contents.

The status returning condition depends on the Immd bit of MODE SELECT page code 9. The Immd bit in MODE SELECT page code 9 of one requests that this command return the status byte when the address requested is found. The Immd bit in MODE SELECT page code 9 of zero requests that this command return the statuas byte when reading operation of data transfer length specifird by byte 7 and 8 above is completed, or an error occurs.

If the address is not found , or if the ready condition does not exist, or if the address is not within an audio track, a CHECK CONDITION status will be returned and the appropriate sense key set.

If the starting track is greater than the ending track, a check condition status will be returned. The sense key will be set to ILLEGAL REQUEST. If both are equal, the play operation is executed on the track only.

5.2.10. PLAY MSF Command

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation Code (C7h)							
1	Logical Unit Number			Reserved				
2	Reserved							
3	Starting Minutes							
4	Starting Seconds							
5	Starting Frame							
6	Ending Minutes							
7	Ending Seconds							
8	Ending Frame							
9	Control Byte							

The PLAY MSF command requests that the target output the audio signals starting at the specified starting address and continue the audio play operation until the specified ending address is detected. The audio signals are output as specified by the audio control parameters.

The Starting minutes, seconds, frame specify the starting address in absolute time. The Ending minutes, seconds, frame specify the ending address in absolute time. If the ending address is less than the starting address a CHECK CONDITION status is returned. The sense key is set to ILLEGAL REQUEST and the additional sense code is set to ILLEGAL VALUE IN COMMAND DESCRIPTOR BLOCK.

This command returns the status byte when the address requested is found. If the address is not found , or if the ready condition does not exist, or if the address is not within an audio track, a CHECK CONDITION status will be returned and the appropriate sense key set.

If the starting address equals the ending address this command this command seeks to the specified address and enters the hold track state. The drive is in a pause condition, issuing a PAUSE command with the pause bit set to zero will begin audio play.

5.2.11. PLAY TRACK Command

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation Code (C6h)							
1	Logical Unit Number			Reserved				
2	Reserved							
3	Reserved							
4	Starting Track							
5	Starting Index							
6	Reserved							
7	Reserved							
8	Number of Indexes							
9	Control Byte							

The PLAY TRACK command requests that the target play audio starting at the specified starting track and index for the specified number of indexes. The audio is output as specified by the audio control parameters.

The starting track field specifies the track number of the audio track. The starting index field specifies the index number within starting track to begin the audio play operation.

NOTE: The current firmware in the controller only supports a starting index of one.

The number of indexes specifies the duration of the audio play operation. If the value in the number of indexes field exceeds the number of indexes within the track the play operation will continue until the end of the track request. A value of FFh requests that the play operation continue until the lead-out track or a non-audio track is detected.

IMPLEMENTORS NOTE: A typical audio track for music has only one index number (i.e. the number of indexes is equal to one.) The number of indexes within a track in not obtainable from data in the table of contents.

This command returns the status byte when the address requested is found. If the address is not found , or if the ready condition does not exist, or if the address is not within an audio track, a CHECK CONDITION status will be returned and the appropriate sense key set.

If the number of the starting address specified is the same as that of the ending address, the audio data on the track is output.

5.2.12. PLAYBACK CONTROL Command

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation Code (C9h)							
1	Logical Unit Number			Reserved				
2	Reserved							
3	Reserved							
4	Reserved							
5	Reserved							
6	Reserved							
7	(MSB)							
---	---			Parameter Length				---
8								(LSB)
9	Control Byte							

The PLAYBACK CONTROL command requests that the target set the audio play as specified.

If the drive is not in the ready condition the command will be terminated with a CHECK CONDITION status. The sense key will be set to NOT READY and the appropriate additional sense code set.

The parameter length specifies the number of bytes of data to be sent during the data out phase.

Table 5-7: Audio Control Data Format

Bit / Byte	7	6	5	4	3	2	1	0
0	Reserved							
1	Reserved							
2	Reserved							
3	Reserved							
4	Reserved							
5	Reserved							
6	Reserved							
7	Reserved							
8	Reserved							
9	Reserved							
10	Reserved				Channel 0 Output Selection			
11	Channel 0 Volume							
12	Reserved				Channel 1 Output Selection			
13	Channel 1 Volume							
14	Reserved				Channel 2 Output Selection			
15	Channel 2 Volume							
16	Reserved				Channel 3 Output Selection			
17	Channel 3 Volume							

The channel output selection specifies where the audio for that channel will be output. Channel output selection and volume control of channel 0 and 1 is valid in this command. The valid values of volume control are 00h through FF in the channel volume field, and a value of zero indicates the output is muted and a value of FFh indicates maximum volume level. Channel output selection is defined as follows.

Table 5-8: Channel Output Selection

Channel output selection field	description
Bit No. 3 2 1 0	
0 0 0 0	muted
0 0 0 1	output to channel 0
0 0 1 0	output to channel 1
0 1 0 0	output to channel 2 (Not supported)
1 0 0 0	output to channel 3 (Not supported)

NOTE: The current firmware supports only channel 0 and 1. Attempting to set channel to 2 or 3 will result in the command being terminated with a CHECK CONDITION status. The sense key will be set to ILLEGAL REQUEST.

5.2.13. PLAYBACK STATUS Command

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation Code (C4h)							
1	Logical Unit Number			Reserved				
2	Reserved							
3	Reserved							
4	Reserved							
5	Reserved							
6	Reserved							
7	(MSB) Allocation Length							
8	(LSB)							
9	Control Byte							

The PLAYBACK STATUS command requests that the target return the status data of the current audio block.

If the drive is not in the ready condition the command will be terminated with a CHECK CONDITION status. The sense key will be set to NOT READY and the appropriate additional sense code set.

Table 5-9: Audio Status Data Format

Bit / Byte	7	6	5	4	3	2	1	0
0	Reserved							
1	Reserved							
2	(MSB) Audio Status Data Length							
3								(LSB)
4	Audio Status							
5	Reserved				Control			
6	CD Address							
7								
8								
9								
10	Reserved				Channel 0 Output Selection			
11	Channel 0 Volume							
12	Reserved				Channel 1 Output Selection			
13	Channel 1 Volume							
14	Reserved				Channel 2 Output Selection			
15	Channel 2 Volume							
16	Reserved				Channel 3 Output Selection			
17	Channel 3 Volume							

The audio status bits are defined in Table 5-10.

Table 5-10: Audio Status

Status	Description
00h	Audio play operation in progress.
01h	Audio pause operation in progress.
02h	Audio muting on.
03h	Audio play operation successfully completed.
04h	Error occurred during audio play operation.
05h	Audio play operation not requested.

The control bits are defined in Table 5-24.

The CD address field specifies the current address. The format of the address is determined by the LBAMSF bit in the CD-ROM parameters. See Section 5.3.

The channel output selection indicates where the audio channel is output. See Table 5-8. A channel may be output to more than one channel (i.e., channel one may be output to channels one and two).

The channel volume control indicates the relative volume level of the audio output. A value of zero indicates the output is muted, a value of FFh indicates maximum volume level.

5.2.14. PREVENT/ALLOW MEDIUM REMOVAL Command

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation Code (1Eh)							
1	Logical Unit Number			Reserved				
2	Reserved							
3	Reserved							
4	Reserved							Prevent
5	Control Byte							

The PREVENT/ALLOW MEDIUM REMOVAL command requests that the controller enable or disable the removal of the caddy in the drive.

A prevent bit of one will inhibit the removal of the caddy by use of a command through the interface or by use of the eject button. The emergency release mechanism will not be overridden. A prevent bit of zero will allow removal of the caddy.

This prevention of caddy removal condition will terminate upon receipt of a ALLOW MEDIUM REMOVAL command (i.e. the prevent bit set to zero), or by the receipt of a BUS DEVICE RESET message from any initiator or by a reset condition.

If a PREVENT MEDIUM REMOVAL command is issued without the drive being in the ready condition command will be terminated with a CHECK CONDITION status. The sense key will be set to NOT READY and the appropriate additional sense code will be set.

A ALLOW MEDIUM REMOVAL command may be issued at any time by the initiator and will not be considered an error.

5.2.15. READ Command

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation Code (08h)							
1	Logical Unit Number			(MSB)				
2	Logical Block Address							
3								(LSB)
4	Transfer Length							
5	Control Byte							

The READ command requests that the controller transfer data to the initiator.
The data will be transferred in whole blocks without delays occurring during a block transfer on the bus. After completion of the read operation the drive will enter the hold track state for the duration of the inactivity time.

The logical block address specifies the logical block at which the read operation will begin.

The transfer length specifies the number of contiguous logical blocks of data to be transferred. A transfer length of zero indicates that 256 logical blocks will be transferred. Any other value indicates the number of logical blocks that will be transferred.

This command will be terminated with a RESERVATION CONFLICT status if any reservation conflict exists and no data will be read.

This command will be terminated with a CHECK CONDITION status for a number of reasons. The error recovery parameters determine when and how the data errors are reported. See Section 5.3.1.1. The data transfer will also be terminated with a CHECK CONDITION STATUS if any of the following events occur while a read operation is in progress. The sense key will be set to ILLEGAL REQUEST and the additional sense code set to END OF USER AREA ENCOUNTERED ON THIS TRACK.

1) A mode zero is detected (i.e. post-gap detected).
2) An index equal to 0 is detected (i.e. pre-gap detected).
3) A track number change is detected (i.e. lead-out, mode one <-> mode two).
4) A change in bit one of the control field is detected.

If the logical block address requested is not within a data track the command will be terminated with a CHECK CONDITION status. The sense key will be set to ILLEGAL REQUEST and the additional sense code set to ILLEGAL MODE FOR THIS TRACK.

If the logical block address plus the transfer length requested exceeds that reported by the READ CAPACITY data a CHECK CONDITION status will be returned. The sense key is set to ILLEGAL REQUEST and the additional sense code is set to LOGICAL BLOCK ADDRESS NOT VALID.

5.2.16. READ BUFFER Command

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation Code (3Ch)							
1	Logical Unit Number			Reserved			Mode	
2	Reserved							
3	(MSB)							
4	Buffer Offset							
5								(LSB)
6	(MSB)							
7	Transfer Length							
8								(LSB)
9	Control Byte							

The READ BUFFER command is used in conjunction with the WRITE BUFFER command as a diagnostic function for testing controller memory and the bus integrity. This command will not alter the medium.

The function of this command and the meaning of fields within the command descriptor block depend on the contents of the mode field. A mode field value of zero indicates that the buffer offset is zero. A mode field value of one indicates that the buffer offset is valid and the data will be placed in the buffer with that offset.

The buffer offset is the byte offset within the buffer where the data will be retrieved. If the controller is unable to accept the specified buffer offset, it will return CHECK CONDITION status and it will set the sense key to ILLEGAL REQUEST.

The data to be transferred is preceded by a four-byte READ BUFFER header.

Table 5-11: Read Buffer Header

Bit / Byte	7	6	5	4	3	2	1	0
0	Reserved							
1	(MSB)							
2	Available Length							
3								(LSB)

5.2.17. READ CAPACITY Command

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation Code (25h)							
1	Logical Unit Number			Reserved				
2	Reserved							
3	Reserved							
4	Reserved							
5	Reserved							
6	Reserved							
7	Reserved							
8	Reserved							
9	Control Byte							

The READ CAPACITY command a means for the initiator to request information regarding the capacity of the logical unit. The eight bytes of READ CAPACITY data is shown below. The capacity is based on the starting address of the lead-out area minus one.

Table 5-12: Read Capacity Data

Byte	Description
0	(MSB)
- - -	- - Logical Block Address - -
3	(LSB)
4	(MSB)
- - -	- - Block Length - -
7	(LSB)

The logical block address reports the address of the last user accessible block on the disc based on the block length specified in the MODE SELECT command. The default block length is used if a MODE SELECT command has not been issued.

The block length reported is based on the block size requested in the MODE SELECT command. The default block length default is reported if a MODE SELECT command has not been issued.

5.2.18. READ EXTENDED Command

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation Code (28h)							
1	Logical Unit Number			Reserved				
2	(MSB)							
3								
4				Logical Block Address				
5								(LSB)
6	Reserved							
7	(MSB)							
8				Transfer Length				(LSB)
9	Control Byte							

The READ EXTENDED command requests that the controller transfer data to the initiator. The data will be transferred in whole blocks without delays occurring during a block transfer.

The logical block address specifies the logical block at which the read operation will begin.

The transfer length specifies the number of contiguous logical blocks of data that will be transferred. A transfer length of zero indicates that no logical blocks will be transferred but the addressed drive will perform a seek operation to the specified address. This condition will not be considered as an error. Any other value indicates the number of logical blocks that will be transferred.

See the READ command for exception handling description.

5.2.19. READ HEADER Command

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation Code (C3h)							
1	Logical Unit Number			Reserved				
2	(MSB)							
3								
4				Logical Block Address				
5								(LSB)
6	Reserved							
7	(MSB)							
8				Allocation Length				(LSB)
9	Control Byte							

The READ HEADER command requests that the target return the CD-ROM data header for the specified logical block.

See the READ command for exception handling. If the logical block size is less than the physical block size the CD-ROM data header will be returned for the physical block which contains the logical block requested.

Table 5-13: Header Data Format

Bit / Byte	7	6	5	4	3	2	1	0
0	Absolute Minute							
1	Absolute Second							
2	Absolute Frame							
3	CD-ROM Mode							

The absolute minutes, seconds and frame fields specify the physical location from the beginning of the disc.

The CD-ROM Mode field specifies the CD-ROM mode of the physical block.

5.2.20. READ HEADER Command

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation Code (44h)							
1	Logical Unit Number			Reserved			MSF	Reserved
2	(MSB)							
3								
4				Logical Block Address				
5								(LSB)
6	Reserved							
7	(MSB)							
8				Allocation Length				(LSB)
9	Control Byte							

The READ HEADER command requests that the target return the CD-ROM data header for the specified logical block. In case of the block size smaller than 2048 bytes, the header date of the block including the specified logical block address will be returned. See the READ command for exception handling.

The logical block address field specifies the logical block at which the read header operation shall begin.

The address format returned is specified by MSF bit as follows.

o If MSF bit is equal to 1, it is minutes, second and frame format.

o If MSF bit is equal to 0, it is the logical block address format.

The CD-ROM data header format returned is defined as follows.

Table 5-14: Header Data Format

Bit / Byte	7	6	5	4	3	2	1	0
0	CD-ROM Data Mode							
1	Reserved							
2	Reserved							
3	Reserved							
4	(MSB)							
5	Absolute CD-ROM Address							
6								
7								(LSB)

The CD-ROM Data Mode field shall return the requested logical block data mode format which is defined as_follows.

Table 5-15: Logical Block Data Mode Format

CD-ROM Mode	User Data Field Contents (2048 bytes)	Auxialiary Field Contents (288 bytes)
00h	All bytes zero	All bytes zero
01h	User Data	EDC, L-EC symbols
02h	User Data	User Data
03h to FFh	Reserved	Reserved

5.2.21. READ SUB-CHANNEL Command

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation Code (C2h)							
1	Logical Unit Number			Reserved				
2	Reserved	Sub Q		Reserved				
3	Reserved							
4	Reserved							
5	Reserved							
6	Reserved							
7	(MSB)							
8	Allocation Length							(LSB)
9	Control Byte							

The READ SUB-CHANNEL command requests that the target return the requested sub-channel data of the current block. The data format returned is specified by the LBAMSF bit of MODE SELECT page code 8. The LBAMSF bit of zero indicates that the target will return LBA data format. The LBAMSF bit of one indicates that the target will return MSF data format.

The Sub Q bit set to one requests the target return the Q sub-channel data. The Sub Q bit set to zero requests that no data be returned.

NOTE: The other bits in this byte are reserved for use in requesting other sub-channel data. The bits occur in the sub-channel in P Q R S T U V W order. At present returning data from the other sub-channels is not permitted by the medium standards.

Table 5-16: Sub-Channel Q Data MSF Format

Bit / Byte	7	6	5	4	3	2	1	0
0	Reserved					Control		
1	Track Number							
2	Index Number							
3	Relative Minute							
4	Relative Second							
5	Relative Frame							
6	Absolute Minute							
7	Absolute Second							
8	Absolute Frame							

The control bits are defined in Table 5-24.

The Track Number specifies the current track number.

The Index Number specifies the index number in the current track.

The relative minutes, seconds and frame fields specify the relative physical location from the beginning of the current track.

The absolute minutes, seconds and frame fields specify the absolute physical location from the beginning of the disc.

Table 5-17: Sub-Channel Q Data LBA Format

Bit / Byte	7	6	5	4	3	2	1	0
0	Reserved						Control	
1	Track Number							
2	Index Number							
3	(MSB)							
4	Relative CD Address							
5								(LSB)
6	(MSB)							
7	Absolute CD Address							
8								(LSB)

The control bits are defined in Table 5-24.

The Track Number specifies the current track number.

The Index Number specifies the index number in the current track.

The relative CD address returns the equivalent logical address of the relative physical location from the beginning of the current track.

The absolute CD address returns the equivalent logical address of the absolute physical location from the beginning of the disc. If the first track on the disc is CD-ROM data the logical address returned is adjusted for the two second offset.

5.2.22. READ SUB-CHANNEL Command

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation Code (42h)							
1	Logical Unit Number			Reserved			MSF	Reserved
2	Reserved	Sub Q		Reserved				
3	Reserved							
4	Reserved							
5	Reserved							
6	Reserved							
7	(MSB)							
8	Allocation Length							(LSB)
9	MC	TC	Control Byte					

The READ SUB-CHANNEL command requests that the target return the requested sub-channel data of the current block, but only Sub-Q Channel data will be returned in current condition.

The Sub Q bit set to one requests the target return the Q sub-channel data. The Sub Q bit set to zero requests that no data be returned. This shall not be considered an error.

NOTE: The other bits in this byte are reserved for use in requesting other sub-channel data. The bits occur in the sub-channel in P Q R S T U V W order. At present, sub-channels R, S, T, U, V amd W are not used.

The relation between MC, TC bit and the returning data is defined as follows.

Table 5-18: MC, TC and Returning Data

MC	TC	Return SUB-Q Data
0	0	Time Data
0	1	Media Catalog Number (UPC/Bar Code)
1	0	Track International Standard Recording Code (ISRC)
1	1	Not used (Error)

Each returning format is defined as follows.

o The Format of Time Data (MC=0, TC=0)

Table 5-19: The Format of Time Data (MC=0, TC=0)

Bit / Byte	7	6	5	4	3	2	1	0
0	Reserved							
1	Audio Status							
2	Sub-Channel Data Length							
3								
4	Reserved							
5	Reserved					Control		
6	Track Number							
7	Index Number							
8	Absolute CD-ROM Address							
11								
12	Track Relative CD-ROM Address							
15								

The audio status field indicates the status of an audio play operation. The audio status values are defined as follows. Audio status values 03h and 04h return information on previous audio operations; they are returned only once after the condition has ocurred. If another audio play operation is not requested, the audio status returned for subsequent READ SUB-CHANNEL commands is 05h.

Table 5-20: Audio Status

Status	Description
00h	Audio play operation in progress.
01h	Audio pause operation in progress.
02h	Audio muting on.
03h	Audio play operation successfully completed.
04h	Error occurred during audio play operation.
05h	Audio play operation not requested.

The other data fields in the format of Time Data are the same as those of Group 6.

o The Format of Media Catalog Number (MC=0, TC=1)

Table 5-21: The Format of Media Catalog Number (MC=0, TC=1)

Bit / Byte	7	6	5	4	3	2	1	0
0	Valid	Reserved						
1	(MSB)							
---	Media Catalog Number (UPC/Bar Code)							
15								(LSB)

If the valid field is set to one, the data in byte 1 through 15 is available. The data is raw data read from the disc. "00h" is specified in the fields without data.

o The Format of Track International Standard Recording Code (MC=1, TC=0)

Table 5-22: The Format of Track International Standard Recording Code (MC=1, TC=0)

Bit / Byte	7	6	5	4	3	2	1	0
0	Valid	Reserved						
1	(MSB)							
---	Track International Standard Recording Code(ISRC)							
15								(LSB)

If the valid field is set to one, the data in byte 1 through 15 is available. The data is raw data read from the disc. "00h" is specified in the fields without data.

5.2.23. READ TOC Command

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation Code (C1h)							
1	Logical Unit Number			Reserved				
2	Reserved							
3	Reserved							
4	Reserved							
5	Track Number							
6	Reserved							
7	(MSB)							
---	---			Allocation Length				---
8								(LSB)
9	Control Byte							

The READ TOC command requests the transfer of the table of contents (TOC) data to the initiator.

The track number field specifies the first track number for which the TOC data will be returned. The data is returned in contiguous ascending order.

If the track number field is zero or is not valid for the disc inserted the command will be terminated with a CHECK CONDITION status. The sense key is set to ILLEGAL REQUEST. The additional sense code is set to ILLEGAL VALUE IN CDB.

Table 5-23: TOC Data Format

0	(MSB)	
1	TOC Data Length	(LSB)
2	First Track Number	
3	Last Track Number	
	TOC Track Descriptor	
0	Track Number	
1	Reserved | Control	
2		
3		
4	- CD Address	
5		

The starting track field specifies the starting track number for which the TOC data will be returned. The data is returned in contiguous ascending order. Valid values for the starting track field are 1h to 63h. A value of AAh requests that the starting address of the lead out area be returned.

The TOC data returned is a four byte header followed by one or more (up to 100) TOC track descriptors. The last track descriptor is for the lead-out area. The format of the CD Address is determined by the LBAMSF bit in the CD-ROM parameters page. See Section 5.3.1.4.

The TOC data length specifies the length in bytes of the available table of contents data. The value of TOC data length does not include itself. The maximum value is 602d (025Ah).

The first track number field indicates the first track number in the table of contents.

IMPLEMENTORS NOTE: A disc may start at any track number. The track numbers between the first track number and the last track number are in contiguous ascending order.

The last track number field indicates the last track number in the table of contents before the lead-out track number.

The track number field indicates the track number for the CD address that follows.

The control field indicates the attributes of the track. These are defined in Table 5-24.

Table 5-24: Definition of Control Field Bits

Bit	equal one	equal zero
0	With pre-emphasis	Without pre-emphasis
1	Digital copy permitted	Digital copy prohibited
2	Data track	Audio track
3	Four channel	Two channel

5.2.24. READ TOC Command

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation Code (43h)							
1	Logical Unit Number			Reserved			MSF	Reserved
2	Reserved							
3	Reserved							
4	Reserved							
5	Reserved							
6	Starting Track							
7	(MSB) Allocation Length							
8								(LSB)
9	Control Byte							

The READ TOC command requests the transfer of the table of contents (TOC) data to the initiator. Basically, this command is the same as TOC READ command of group 6, the format of returning data is different. The TOC data between the starting track number and the lead out area is returned by the specified MSF bit.

The starting track field specifies the starting track number for which the TOC data will be returned. The data is returned in contiguous ascending order. Valid values for the starting track field are 1h to 63h. A value of AAh requests that the starting address of the lead out area be returned.

If the track number field is zero or is not valid for the disc inserted the command will be terminated with a CHECK CONDITION status. The sense key is set to ILLEGAL REQUEST. The additional sense code is set to ILLEGAL VALUE IN CDB.

The Return Value Format of READ TOC Command is defined as follows.

Table 5-25: TOC Data Format

0	(MSB)	
1	TOC Data Length	(LSB)
2	First Track Number	
3	Last Track Number	
	TOC Track Descriptor(s)	
0	Reserved	
1	Reserved	Control
2	Track number	
3	Reserved	
4	(MSB)	
7	Absolute CD-ROM Address	(LSB)

The TOC data returned is a four byte header followed by one or more (up to 100) TOC track descriptors. The last track descriptor is for the lead-out area. The format of the CD Address is determined by the MSF bit in the CDB.

The TOC data length specifies the length in bytes of the available table of contents data. The value of TOC data length does not include itself. The maximum value is 602d (0322h).

The first track number field indicates the first track number in the table of contents.

IMPLEMENTORS NOTE: A disc may start at any track number. The track numbers between the first track number and the last track number are in contiguous ascending order.

The last track number field indicates the last track number in the table of contents before the lead-out track number.

The number of TOC Track Descriptors which are returned is the same as that of track number, maximum(99 tracks + Lead Out Track) 100 tracks.

The track number field indicates the track number for the CD address that follows.

The control field indicates the attributes of the track. These are defined as follows.

Table 5-26: Definition of Control Field Bits

Bit	equal one	equal zero
0	With pre-emphasis	Without pre-emphasis
1	Digital copy permitted	Digital copy prohibited
2	Data track	Audio track
3	Four channel	Two channel

The a bsolute CD-ROM address contains the address of the first block with user information for that track number as read from the table of contents. An MSF bit of zero indicates that the absolute CD-ROM address field contains a logical block address. An MSF bit of one indicates the absolute CD-ROM address field contains an MSF address.

5.2.25. RECEIVE DIAGNOSTIC RESULTS Command

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation Code (1Ch)							
1	Logical Unit Number			Reserved				
2	Reserved							
3	(MSB) Allocation Length							
4								(LSB)
5	Control Byte							

The RECEIVE DIAGNOSTIC RESULTS command requests analysis data be sent to the initiator after completion of a SEND DIAGNOSTIC command.

The RECEIVE DIAGNOSTIC data contains an eight-byte parameter list defined as follows.

Table 5-27: Receive Diagnostic Data

Bit / Byte	7	6	5	4	3	2	1	0
0	Reserved							
1	Parameter Length							
2	ROM Diagnostic							
3	RAM Diagnostic							
4	Data Buffer Diagnostic							
5	Interface Diagnostic							
6	Reserved							
7	Reserved							

The parameter length specifies the length in bytes of the following SEND DIAGNOSTIC parameters. The sense data length does not include itself.

A value of zero in any field indicates that the diagnostic if requested passed.

If the ROM Diagnostic field is set to one, it indicates that the controller ROM has failed. If the ROM Diagnostic field is set to two, it indicates that the drive control ROM has failed.

If the RAM Diagnostic field is set to one, it indicates that the controller RAM has failed. If the RAM Diagnostic field is set to two, it indicates that the drive control RAM has failed.

If the Data Buffer Diagnostic field is set to one, it indicates that the controller data buffer has failed. If the Data Buffer Diagnostic field is set to two, it indicates that the drive control data buffer has failed. If the Data Buffer Diagnostic field is set to four, it indicates that the drive control error RAM has failed.

If the Interface Diagnostic field is set to one, it indicates that the controller - drive control interface has failed. If the Interface Diagnostic field is set to two, it indicates that the drive control - mechanism control interface has failed.

5.2.26. RELEASE Command

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation Code (17h)							
1	Logical Unit Number			3rdPty	Third Party Device ID			Reserved
2	Reserved							
3	Reserved							
4	Reserved							
5	Control Byte							

The RELEASE command is used to release previously reserved logical units. It is not an error for an initiator to attempt to release a reservation that is not currently active. In this case, the controller returns GOOD status without altering any other reservation.

This command will cause the controller to terminate the logical unit reservation from the initiator

The third-party release for the RELEASE command allows an initiator to release a logical unit reserved using third-party reservation.

If the third-party (3rdPty) bit is zero, then the third-party release option is not requested. If the 3rdPty bit is one, the controller will release the specified logical unit only if the reservation was made using the third-party reservation option by the initiator that is requesting the release for the same initiator as specified in the third-party device ID field.

5.2.27. REQUEST SENSE Command

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation Code (03h)							
1	Logical Unit Number			Reserved				
2	Reserved							
3	Reserved							
4	Allocation Length							
5	Control Byte							

The REQUEST SENSE command requests that the controller transfer sense data to the initiator.

The sense data will be valid after a CHECK CONDITION status has been returned on the previous command. This sense data will be preserved by the controller for the initiator until

1) it is retrieved by a REQUEST SENSE command from that initiator.
2) the receipt of another command for the same logical unit from that initiator.
3) a reset condition occurs.

Note: The sense data will be cleared upon receipt of any subsequent command for the same logical unit from the initiator that was returned the CHECK CONDITION status. See Section 4.1.3.

The REQUEST SENSE command will return the CHECK CONDITION status only to report catastrophic errors for the REQUEST SENSE command. Following a catastrophic error on a REQUEST SENSE command, sense data may be invalid. For example:

1) A reserved bit is set the command descriptor block.
2) An unrecovered parity error occurs on the bus.
3) A controller malfunction prevents return of the sense data.

If an error occurs during the execution of the REQUEST SENSE command, but it is not catastrophic, the controller will return the sense data with GOOD status.

Table 5-28: Error Code 70h Sense Data Format

Bit / Byte	7	6	5	4	3	2	1	0
0	Valid	Error Code (70h)						
1	Reserved							
2	Reserved				Sense Key			
3 - 6	(MSB) Information Bytes (LSB)							
7	Additional Sense Length (8h)							
8 - 11	(MSB) Command Specific Information Bytes (LSB)							
12	Additional Sense Code							
13	Reserved							
14	Reserved							
15	Reserved							

A valid bit of zero indicates that the information bytes are not defined. A valid bit of one indicates the information bytes contain valid information as defined in this document.

The sense keys are described in Table 5-29. The additional sense codes are described in Section 5.4.

The contents of the information bytes are command specific and are defined under the appropriate command description. Unless specified otherwise, these bytes contain the unsigned logical block address associated with the sense key.

The additional sense length specifies the number of additional sense bytes to follow. If the allocation length of the command descriptor block is too small to transfer all of the additional sense bytes, the additional sense length is not adjusted to reflect the truncation.

The contents of the command specific information bytes are defined under the appropriate command description.

Table 5-29: Sense Key Descriptions

NO SENSE (0h). Indicates that there is no specific sense key information to be reported for the designated logical unit.

RECOVERED ERROR (1h). Indicates that the last command completed successfully with some recovery action performed by the controller. Details may be determinable by examining the additional sense bytes and the information bytes. (See Section 5.3.1.1.)

NOT READY (2h). Indicates that the logical unit addressed is not accessible. Operator intervention may be required to correct this condition.

MEDIUM ERROR (3h). Indicates that the command terminated with a unrecovered error condition that was probably caused by a flaw in the medium or an error in the recorded data. This sense key may also be returned if the controller is unable to distinguish between a flaw in the medium and a specific hardware failure (sense key 4h). (See Section 5.3.1.1.)

HARDWARE ERROR (4h). Indicates that the controller detected a unrecoverable hardware failure (for example, controller failure, device failure, parity error, etc.) while performing the command or during a self test.

ILLEGAL REQUEST (5h). Indicates that there was an illegal parameter in the command descriptor block or in the additional parameters supplied as data for some commands. If the controller detects an invalid parameter in the command descriptor block, then it will terminate the command without altering the medium. If the controller detects an invalid parameter in the additional parameters supplied as data, then the controller may have already altered the medium.

UNIT ATTENTION (6h). Indicates that the removable medium may have been changed or the controller has been reset. (See 4.1.3)

ABORTED COMMAND (Bh). Indicates that the controller aborted the command. The initiator may be able to recover by trying the command again.

5.2.28. RESERVE Command

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation Code (16h)							
1	Logical Unit Number			3rdPty	Third Party Device ID			Reserved
2	Reserved							
3	Reserved							
4	Reserved							
5	Control Byte							

The RESERVE command is used to reserve a logical units for the use of the initiator. The third-party reservation allows logical units to be reserved for another specified initiator. The RESERVE and RELEASE commands provide the basic mechanism for contention resolution in multiple-initiator systems.

This command will request that the entire logical unit be reserved for the exclusive use of the initiator until the reservation is superseded by another valid RESERVE command from the initiator that made the reservation or until released by a RELEASE command from the same initiator that made the reservation, by a BUS DEVICE RESET message from any initiator, by a "hard" RESET condition, or by a power off/on cycle. A logical unit reservation will not be granted if the logical unit is reserved by another initiator. It will be permissible for an initiator to reserve a logical unit that is currently reserved by that initiator.

If the logical unit, or any extent within the logical unit is reserved for another initiator, the controller will respond by returning a RESERVATION CONFLICT status.

If, after honoring the reservation, any other initiator then subsequently attempts to perform any command on the reserved logical unit other than an INQUIRY or a REQUEST SENSE command, the command will be rejected with RESERVATION CONFLICT status.

The third-party reservation for the RESERVE command allows an initiator to reserve a logical unit for another initiator.

If the third-party (3rdPty) bit is zero, then the third-party reservation option is not requested. If the 3rdPty bit is one then the specified logical unit will be reserved for the initiator specified in the third-party device ID field. The controller will preserve the reservation until it is superseded by another valid RESERVE command from the initiator that made the reservation or until it is released by the same initiator, by a BUS DEVICE RESET message from any initiator, or a reset condition. The controller will ignore any attempt to release the reservation made by any other initiator.

An initiator that holds a current reservation may modify that reservation by issuing another RESERVE command to the same logical unit. The superseding RESERVE command will release the previous reservation when the new reservation request is granted. The current reservation will not be modified if the new reservation request cannot be granted. If the superseding reservation cannot be granted because of conflicts with a previous active reservation (other than the reservation being superseded), then the controller will return RESERVATION CONFLICT status.

5.2.29. REZERO UNIT Command

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation Code (01h)							
1	Logical Unit Number			Reserved				
2	Reserved							
3	Reserved							
4	Reserved							
5	Control Byte							

The REZERO UNIT command requests that the controller position the optical pick-up at logical block address zero and enter the hold track state for the duration of the inactivity time.

If the disconnect privilege is granted the controller will disconnect before performing the seek operation.

If the ready condition does not exist a CHECK CONDITION status will be returned and the appropriate additional sense code set.

The MODE SELECT parameters will not be changed.

5.2.30. SEEK Command

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation Code (0Bh)							
1	Logical Unit Number		(MSB)					
2	Logical Block Address							
3								(LSB)
4	Reserved							
5	Control Byte							

The SEEK command requests that the controller position the optical pick-up at logical block address specified and enter the hold track state for the duration of the inactivity time.

A seek operation may be requested to any logical block address that is less than or equal to that reported by a READ CAPACITY command. If the logical block address is within a data track then the address will be verified against the header address. If the logical block address is within an audio track it is first converted into a Q sub-channel address and the seek is performed to that address. The Q sub-channel address has a tolerance of ± 75 blocks.

If the disconnect privilege is granted the controller will disconnect before performing the seek operation.

If the ready condition does not exist a CHECK CONDITION status will be returned and the appropriate additional sense code set.

If the logical block address requested exceeds that reported by the READ CAPACITY data a CHECK CONDITION status will be returned. The sense key is set to ILLEGAL REQUEST and the additional sense code is set to LOGICAL BLOCK ADDRESS NOT VALID.

If the drive is unable to complete the seek operation a CHECK CONDITION status will be returned. The sense key is set to MEDIUM ERROR and the additional sense code is set to ERROR OCCURRED DURING SEEK OPERATION.

5.2.31. SEEK EXTENDED Command

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation Code (2Bh)							
1	Logical Unit Number			Reserved				
2	(MSB)							
3								
4	Logical Block Address							
5								(LSB)
6	Reserved							
7	Reserved							
8	Reserved							
9	Control Byte							

The SEEK EXTENDED command requests that the controller position the optical pick-up at logical block address specified and enter the hold track state for the duration of the inactivity time.

See the SEEK command for further definition and exception handling.

5.2.32. SEND DIAGNOSTIC Command

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation Code (1Dh)							
1	Logical Unit Number			Reserved		SelfTest	Reserved	
2	Reserved							
3	(MSB)							
---	---			Parameter List Length				---
4								(LSB)
5	Control Byte							

The SEND DIAGNOSTIC command requests the controller to perform diagnostic tests on itself, on the attached peripheral devices, or on both. Except when the self-test bit is one, this command is usually followed by a RECEIVE DIAGNOSTIC RESULTS command.

A self-test bit of one directs the controller to complete its default self-test. If the self-test is requested, the parameter list length shall be set to zero. If the self-test bit is set to one and the parameter list length is not zero, the command will be terminated with CHECK CONDITION status. The sense key is set to ILLEGAL REQUEST and the additional sense code set to INVALID VALUE IN CDB. The controller will not disconnect during self-test.

If the self-test does not fail, the command will be terminated with a GOOD status; otherwise, the command will be terminated with CHECK CONDITION status and the sense key will be set to HARDWARE ERROR.

The parameter list length specifies the length in bytes of the parameter list that will be transferred during the DATA OUT phase. A parameter list length of zero indicates that no data will be transferred. This condition will not be considered as an error.

If the self-test is not requested the controller will return GOOD status upon receiving a valid command descriptor block and parameter list. The parameter list length is set to eight if user specified diagnostics are requested. The results of the diagnostic test are returned to the initiator by a RECEIVE DIAGNOSTICS RESULTS command.

The SEND DIAGNOSTIC data contains an eight-byte parameter list defined as follows.

Table 5-30: Send Diagnostic Data

Bit / Byte	7	6	5	4	3	2	1	0
0	Reserved							
1	Parameter Length							
2	ROM Diagnostic							
3	RAM Diagnostic							
4	Data Buffer Diagnostic							
5	Interface Diagnostic							
6	Reserved							
7	Reserved							

The parameter length specifies the length in bytes of the following SEND DIAGNOSTIC parameters. The sense data length does not include itself.

The ROM Diagnostic field if zero, requests that diagnostics not be performed on the ROM. The ROM Diagnostic field if one, requests that diagnostics be performed on the controller. The ROM Diagnostic field if two, requests that diagnostics be performed on the drive control.

The RAM Diagnostic field if zero, requests that diagnostics not be performed on the RAM. The RAM Diagnostic field if one, requests that diagnostics be performed on the controller. The RAM Diagnostic field if two, requests that diagnostics be performed on the drive control.

The Data Buffer Diagnostic field if zero, requests that diagnostics not be performed on the data buffer. The Data Buffer Diagnostic field if one, requests that diagnostics be performed on the controller. The Data Buffer Diagnostic field if two, requests that diagnostics be performed on the drive control data buffer. The Data Buffer Diagnostic field if four, request that diagnostics be performed on the drive control data error buffer.

The Interface Diagnostic field if zero, requests that diagnostics not be performed on the interfaces. The Interface Diagnostic field if one, requests that diagnostics be performed on the controller - drive control interface. The Interface Diagnostic field if two, requests that diagnostics be performed on the drive control - mechanism control interface.

5.2.33. START/STOP UNIT Command

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation Code (1Bh)							
1	Logical Unit Number			Reserved				Immed
2	Reserved							
3	Reserved							
4	Reserved						LoEj	Start
5	Control Byte							

The START/STOP UNIT command requests that the controller enable or disable the logical unit for further operations.

An immediate (Immed) bit of one indicates that status will be returned as soon as the operation is initiated. An Immed bit of zero indicates that status will be returned after the operation is completed.

A load/eject (LoEj) bit of zero indicates that no action is to be taken regarding loading or ejecting the disc. A LoEj bit of one indicates that the disc is to be unloaded if the start bit is zero.

A start bit of one requests the logical unit be made ready for use. A start bit of zero requests that the logical unit be stopped.

LoEj	Start	Description
0	0	spin down the disc, optical pick-up is not moved
0	1	spin up the disc, seek to last address requested
1	0	spin down the disc, eject the caddy
1	1	not supported

If a PREVENT MEDIUM REMOVAL command has been issued, a request to eject the disc will be terminated with a CHECK CONDITION status. The sense key will be set to ILLEGAL REQUEST, and the additional sense code set to PREVENT BIT SET.

5.2.34. TEST UNIT READY Command

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation Code (00h)							
1	Logical Unit Number			Reserved				
2	Reserved							
3	Reserved							
4	Reserved							
5	Control Byte							

The TEST UNIT READY command provides a means to check if the logical unit is in the ready condition. This is not a request for a self test.

If the ready condition does not exist a CHECK CONDITION status will be returned and the appropriate additional sense code set.

5.2.35. VERIFY Command

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation Code (2Fh)							
1	Logical Unit Number			Reserved				
2	(MSB)							
3								
4				Logical Block Address				
5								(LSB)
6	Reserved							
7	(MSB)							
8				Verification Length				(LSB)
9	Control Byte							

The VERIFY command requests that the controller verify the data on the disc based on the error recovery parameter settings. This command operates the same as a READ EXTENDED command except the data is not transferred to the initiator. The verification is performed according to the settings of the verification page (See Section 5.3.1.3.)

The logical block address specifies the logical block at which the verify operation will begin.

The verification length specifies the number of contiguous logical blocks of data that will be verified. A verification length of zero indicates that no logical blocks will be verified but the addressed drive will perform a seek operation to the specified address.. This condition will not be considered as an error. Any other value indicates the number of logical blocks that will be verified.

See the READ command for exception handling description.

5.2.36. WRITE BUFFER Command

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation Code (3Bh)							
1	Logical Unit Number			Reserved			Mode	
2	Reserved							
3	(MSB)							
4	Buffer Offset							
5								(LSB)
6	(MSB)							
7	Transfer Length							
8								(LSB)
9	Control Byte							

The WRITE BUFFER command is used in conjunction with the READ BUFFER command as a diagnostic function for testing controller memory and the bus integrity. This command will not alter the medium.

The function of this command and the meaning of fields within the command descriptor block depend on the contents of the mode field. A mode field value of zero indicates that the buffer offset is zero. A mode field value of one indicates that the buffer offset is valid and the data will be placed in the buffer with that offset.

The buffer offset is the byte offset within the buffer where the data will be stored. If the controller is unable to accept the specified buffer offset, it will return CHECK CONDITION status. The sense key is set to ILLEGAL REQUEST and the additional sense code is set to ILLEGAL VALUE IN CDB.

The data to be transferred is preceded by a four-byte header. The header consists of all reserved bytes. The transfer length specifies the maximum number of bytes that will be transferred during the DATA OUT phase. This number includes four bytes of WRITE BUFFER header, so the data length to be stored in the controller's buffer is transfer length minus four. If the transfer length minus four exceeds the capacity of the buffer the controller will return a CHECK CONDITION status. The sense key is set to ILLEGAL REQUEST and the additional sense code is set to ILLEGAL VALUE IN CDB.

If the buffer offset plus the transfer length minus four exceeds the buffer capacity, the controller will return a CHECK CONDITION status. The sense key is set to ILLEGAL REQUEST and the additional sense code is set to ILLEGAL VALUE IN CDB.

Table 5-31: Write Buffer Header

Bit / Byte	7	6	5	4	3	2	1	0
0	Reserved							
1	Reserved							
2	Reserved							
3	Reserved							

The WRITE BUFFER header is sent as part of the data transfer phase to the controller. The purpose is to make the READ BUFFER and WRITE BUFFER transfers equivalent in byte count.

5.3. CD-ROM Page Descriptions

5.3.1. MODE SELECT Pages

Table 5-32: Page Codes

Page Code	Description
01h	Read Error Recovery Parameters
02h	Disconnect/Reconnect Control Parameters
07h	Verify Error Recovery Parameters
08h	CD-ROM Parameters
09h	CD-ROM Audio Control Parameters

5.3.1.1. Page Code One

Table 5-33: Page Code One: Read Error Recovery Parameters

Bit / Byte	7	6	5	4	3	2	1	0
0	Reserved			Page Code (01h)				
1	Parameter Length (06h)							
2	Error Recovery							
3	Read Retry Count							
4	Reserved							
5	Reserved							
6	Reserved							
7	Reserved							

The implementation of error recovery procedures for CD-ROM devices is markedly different than those used for magnetic medium disc drives. At least one level of error correction (i.e. CIRC) is required to unscramble the data stream. Therefore the performance of the drive may differ substantially from what would be expected by sending the same error recovery parameters to a magnetic medium device.

The correlation of the error recovery parameter and the bit settings defined in common command set document is given in Table 5-33. The error recovery parameter is defined in Tables 5-34, 5-35, 5-36 and 5-37. If the error recovery parameter is set to any other value the command will be terminated with a CHECK CONDITION status. The sense key will be set to ILLEGAL REQUEST and the additional sense code set to ILLEGAL VALUE IN PARAMETER LIST.

The read retry count field specifies the number of times that the controller will attempt its read recovery algorithm. The default value is zero.

Table 5-34: Error Recovery Byte Bit Settings

value	Error Recovery							
			TB		EER	PER	DTE	DCR
00			0		0	0	0	0
01			0		0	0	0	1
04			0		0	1	0	0
05			0		0	1	0	1
06			0		0	1	1	0
07			0		0	1	1	1
20			1		0	0	0	0
21			1		0	0	0	1
26			1		0	1	1	0
27			1		0	1	1	1

A CIRC recovered data error is defined as a block for which the C2PO flag was set, but on a subsequent read operations it was not set. The number of subsequent read operations is limited to the read retry count. Layered error correction is not used.

A CIRC unrecovered data error is defined as a block for which the C2PO flag was set on all read operations up to the read retry count. Only read retries are used, layered error correction is not used.

An L-EC recovered data error is defined as a block for which the C2PO flag was asserted but the layered error correction was able to correct the block within the read retry count.

An L-EC uncorrectable data error is defined as a block which could not be corrected by layered error correction within the read retry count.

The error recovery procedures in Tables 5-35 and 5-36 are applicable only to CD-ROM mode one data. If one of the these error recovery parameters is

specified and CD-ROM mode two data is detected the read operation will be terminated with a CHECK CONDITION status. The sense key will be set to ILLEGAL MODE FOR THIS TRACK.

Table 5-35: Error Recovery Procedures - CD-ROM Mode One Data

Error Recovery Description
00h This is the default setting of the error recovery parameter on when a power-on or reset condition occurs. The maximum error recovery procedures are used. Only L-EC uncorrectable data errors are reported. If an L-EC uncorrectable data error occurs data transfer is terminated with a CHECK CONDITION status. The sense key is set to MEDIUM ERROR and the additional sense code is set to L-EC UNCORRECTABLE DATA ERROR. The information bytes are set to the address of the last block transferred to the initiator plus one.
04h The maximum error recovery procedures are used. L-EC recovered data errors are reported. If an L-EC recovered data error occurs data transfer is not terminated. However, when the data transfer has completed a CHECK CONDITION status is reported. The sense key is set to RECOVERED ERROR and the additional sense code is set to L-EC RECOVERED DATA ERROR. The information bytes are set to the address of the last block for which an L-EC recovered data error was detected. If an L-EC uncorrectable data error occurs data transfer is not terminated. However, when the data transfer has completed a CHECK CONDITION status is reported. The sense key is set to MEDIUM ERROR and the additional sense code is set to L-EC UNCORRECTABLE DATA ERROR. The information bytes are set to the address of the last block on which an L-EC uncorrectable error was detected.
06h The maximum error recovery procedures are used. L-EC recovered data errors are reported. If an L-EC recovered data error occurs data transfer is terminated with a CHECK CONDITION status. The sense key is set to RECOVERED ERROR and the additional sense code is set to L-EC RECOVERED DATA ERROR. The information bytes are set to the address of the last block transferred to the initiator plus one. If an L-EC uncorrectable data error occurs data transfer is terminated with a CHECK CONDITION status. The sense key is set to MEDIUM ERROR and the additional sense code is set to L-EC UNCORRECTABLE DATA ERROR. The information bytes are set to the address of the first block on which an L-EC uncorrectable error was detected.

Table 5-36: Error Recovery Procedures - CD-ROM Mode One Data

Error Recovery Description
20h The maximum error recovery procedures are used. Only L-EC uncorrectable data errors are reported. If an L-EC uncorrectable data error occurs data transfer is not terminated. However, when the data transfer has completed a CHECK CONDITION status is reported. The sense key is set to MEDIUM ERROR and the additional sense code is set to L-EC UNCORRECTABLE DATA ERROR. The information bytes are set to the address of the last block for which an L-EC uncorrectable data error was detected.
26h The maximum error recovery procedures are used. L-EC recovered data errors are reported. If an L-EC recovered data error occurs data transfer is not terminated. However, when the data transfer has completed a CHECK CONDITION status is reported. The sense key is set to RECOVERED ERROR and the additional sense code is set to L-EC RECOVERED DATA ERROR. The information bytes are set to the address of the last block transferred. If an L-EC uncorrectable data error occurs data transfer is terminated with a CHECK CONDITION status after the L-EC uncorrectable block is transferred. The sense key is set to MEDIUM ERROR and the additional sense code is set to L-EC UNCORRECTABLE DATA ERROR. The information bytes are set to the address of the block on which an the L-EC uncorrectable error occurred.

Table 5-37: Error Recovery Procedures - CD-ROM Mode One or Two Data

Error Recovery Description
01h Only retries of the read operation are used (layer error correction is not used). Only CIRC unrecovered data errors are reported. If an CIRC unrecovered data error occurs data transfer is terminated with a CHECK CONDITION status. The sense key is set to MEDIUM ERROR and the additional sense code is set to CIRC UNRECOVERED DATA ERROR. The information bytes are set to the address of the last block transferred to the initiator plus one.
05h Only retries of the read operation are used (layer error correction is not used). CIRC recovered data errors are reported. If a CIRC recovered data error occurs data transfer is not terminated. However, when the data transfer has completed a CHECK CONDITION status is reported. The sense key is set to RECOVERED ERROR and the additional sense code is set to CIRC RECOVERED DATA ERROR. The information bytes are set to the address of the last block for which an CIRC recovered data error was detected. If an CIRC unrecovered data error occurs data transfer is not terminated. However, when the data transfer has completed a CHECK CONDITION status is reported. The sense key is set to MEDIUM ERROR and the additional sense code is set to CIRC UNRECOVERED DATA ERROR. The information bytes are set to the address of the last block on which an CIRC unrecovered error was detected.
07h Only retries of the read operation are used (layer error correction is not used). CIRC recovered data errors are reported. If a CIRC recovered data error occurs data transfer is terminated with a CHECK CONDITION status. The sense key is set to RECOVERED ERROR and the additional sense code is set to CIRC RECOVERED DATA ERROR. The information bytes are set to the address of the last block transferred to the initiator plus one. If an CIRC unrecovered data error occurs data transfer is terminated with a CHECK CONDITION status. The sense key is set to MEDIUM ERROR and the additional sense code is set to CIRC UNRECOVERED DATA ERROR. The information bytes are set to the address of the first block on which an CIRC unrecovered error was detected.

Table 5-38: Error Recovery Procedures - CD-ROM Mode One or Two Data

Error Recovery Description
21h Only retries of the read operation are used (layer error correction is not used). Only CIRC unrecovered data errors are reported. If a CIRC unrecovered data error occurs data transfer is not terminated. However, when the data transfer has completed a CHECK CONDITION status is reported. The sense key is set to MEDIUM ERROR and the additional sense code is set to CIRC UNRECOVERED DATA ERROR. The information bytes are set to the address of the last block for which a CIRC unrecovered data error was detected.
27h Only retries of the read operation are used (layer error correction is not used). CIRC recovered data errors are reported. If a CIRC recovered data error occurs data transfer is not terminated. However, when the data transfer has completed a CHECK CONDITION status is reported. The sense key is set to RECOVERED ERROR and the additional sense code is set to CIRC RECOVERED DATA ERROR. The information bytes are set to the address of the last block for which a CIRC recovered data error was detected. If an CIRC unrecovered data error occurs data transfer is terminated with a CHECK CONDITION status after the CIRC unrecovered block is transferred. The sense key is set to MEDIUM ERROR and the additional sense code is set to CIRC UNRECOVERED DATA ERROR. The information bytes are set to the address of the block on which the CIRC unrecovered error occurred.

5.3.1.2. Page Code Two

Table 5-39: Page Code Two: Disconnect-Reconnect Parameters

Bit / Byte	7	6	5	4	3	2	1	0
0	Reserved			Page Code (02h)				
1				Parameter Length (0Ah)				
2				Buffer Full Ratio				
3				Reserved				
4	(MSB)							
5				Bus Inactivity Limit				(LSB)
6	(MSB)							
7				Disconnect Time Limit				(LSB)
8	(MSB)							
9				Connect Time Limit				(LSB)
10				Reserved				
11				Reserved				

The Buffer Full Ratio indicates to the controller, on read operations, how full the buffer will be prior to attempting a reselection. The number of blocks available in the buffer when reselection is attempted for given Buffer Full Ratio is specified in Table 5-39. The default value is eight. The buffer full ratio is not applicable to audio tracks.

Table 5-40: Buffer Full Ratios

Value of Buffer Full Ratio	Number of 2048 byte blocks	Number of 2336/2340 blocks	Value of Buffer Full Ratio	Number of 2048 byte blocks	Number of 2336/2340 blocks
00h	32	28			
01h - 08h	1	1	81h - 88h	17	15
09h - 10h	2	2	89h - 90h	18	16
11h - 18h	3	3	91h - 98h	19	17
19h - 20h	4	4	99h - A0h	20	18
21h - 28h	5	5	A1h - A8h	21	19
29h - 30h	6	6	A9h - B0h	22	20
31h - 38h	7	7	B1h - B8h	23	21
39h - 40h	8	8	B9h - C0h	24	21
41h - 48h	9	8	C1h - C8h	25	22
49h - 50h	10	9	C9h - D0h	26	23
51h - 58h	11	10	D1h - D8h	27	24
59h - 60h	12	11	D9h - E0h	28	25
61h - 68h	13	12	E1h - E8h	29	26
69h - 70h	14	13	E9h - F0h	30	27
71h - 78h	15	14	F1h - F8h	31	28
79h - 80h	16	15	F9h - FFh	32	28

The Bus Inactivity Limit indicates the maximum time in 100 microsecond increments that the controller will assert the BSY signal without a REQ/ACK handshake. If the Bus Inactivity Limit is exceeded the controller will disconnect if the initiator has granted the disconnect privilege. The controller may round to its nearest capable value. A value of zero allows the controller to assert BSY until completion of the command. The default value of Bus Inactivity Limit is zero.

The Disconnect Time Limit indicates the minimum time in 100 microsecond increments that the controller will delay reselection. The controller may round to its nearest capable value. A value of zero allows the controller initiate a reselection without a delay. The default value of Disconnect Time Limit is zero.

The Connect Time Limit indicates the maximum time in 100 microsecond increments that the controller will use the bus before disconnecting if the initiator has granted the disconnect privilege. The controller may round to its nearest capable value. A value of zero allows the controller to determine if and when a disconnect occurs. The default value of Connect Time Limit is zero.

5.3.1.3. Page Code Seven

Table 5-41: Page Code Seven: Verify Error Recovery Parameters

Bit / Byte	7	6	5	4	3	2	1	0
0	Reserved			Page Code (07h)				
1	Parameter Length (06h)							
2	Error Recovery							
3	Verify Retry Count							
4	Reserved							
5	Reserved							
6	Reserved							
7	Reserved							

The implementation of error recovery procedures for verification operations is the same as for read operations on CD-ROM devices.

5.3.1.4. Page Code Eight

Table 5-42: Page Code Eight: CD-ROM Parameters

Bit / Byte	7	6	5	4	3	2	1	0
0	Reserved			Page Code (08h)				
1	Parameter Length (02h)							
2	Reserved							LBAMSF
3	Reserved				Inactivity Timer Multiplier			

The LBAMSF bit if zero indicates that the target will use the logical block addressing mode. The LBAMSF bit, if one, indicates that the target will use the minutes-seconds-frame addressing mode. The LBAMSF bit applies only to Group 6 commands implemented for the CD-ROM device type. The default value of the LBAMSF bit is zero.

Table 5-43: Logical Block Address Format

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB)							
1				Logical Block Address				
2								
3								(LSB)

Table 5-44: Minute Second Frame Format

Bit / Byte	7	6	5	4	3	2	1	0
0	Reserved							
1	Absolute Minute							
2	Absolute Second							
3	Absolute Frame							

The Inactivity Timer Multiplier sets the length of time that the drive will remain in the hold track state after completion of a seek or read operation. The default value is five.

Table 5-45: Inactivity Times

Inactivity Timer Multiplier	Minimum Time in Hold Track State	Inactivity Timer Multiplier	Minimum Time in Hold Track State
0h	infinite	8h	16 minutes
1h	2 minutes	9h	18 minutes
2h	4 minutes	Ah	20 minutes
3h	6 minutes	Bh	22 minutes
4h	8 minutes	Ch	24 minutes
5h	10 minutes	Dh	26 minutes
6h	12 minutes	Eh	28 minutes
7h	14 minutes	Fh	30 minutes

5.3.1.5 Page Code Nine

Table 5-46: Page Code Nine: CD-ROM Audio Control Parameters

Bit / Byte	7	6	5	4	3	2	1	0
0	Reserved			Page Code (09h)				
1	Parameter length (0Eh)							
2	Reserved					Immd	Reserved	
3 - 7	Reserved							
8	Reserved				Out port 0 ch. Select (1h)*			
9	Output port 0 Volume (FFh)*							
10	Reserved				Out port 1 ch. Select (2h)*			
11	Output port 1 Volume (FFh)*							
12	Reserved				Out port 2 ch. Select (0h)*			
13	Output port 2 Volume (00h)*							
14	Reserved				Out port 3 ch. Select (0h)*			
15	Output port 3 Volume (00h)*							

* Default value

If Immd(Immediate) bit is set to one, the command shall be terminated at the moment when the seek operation in audio commands of Group 2 , such as play audio, is completed. If this bit is set zero, the command shall not be terminated until the end address is found or an error occurs. Values in parentheses are default values.

Value 00 must be specified in ch.2 and ch.3 (byte 12 through 15) of the audio control parameters. If not, the command will be terminated with a CHECK CONDITION status.

5.3.2. MODE SENSE Pages

Table 5-47: Page Codes

Page Code	Description
01h	Read Error Recovery Parameters
02h	Disconnect/Reconnect Control Parameters
07h	Verify Error Recovery Parameters
08h	CD-ROM Parameters
09h	CD-ROM Audio Control Parameters
3Fh	Return All Implemented Pages

The MODE SENSE pages have the same format as MODE SELECT pages. The meanings of the fields within a page are the same, except that in MODE SENSE the settings are reported instead of being requested.

5.4. CD-ROM Additional Sense Codes

The following tables list the additional sense codes reported in Byte(12) of the REQUEST SENSE data.

Table 5-48: Additional Sense Code Descriptions

For Sense Key NO SENSE (0h):

Code	Description
00	No additional sense information

For Sense Key RECOVERED ERROR (1h):

Code	Description
17	CIRC recovered data error
18	L-EC recovered data error

For Sense Key NOT READY (2h):

Code	Description
04	Unit off line
B0	Caddy not inserted in drive
B1	Unable to recover TOC
B2	Caddy load/eject failed
B7	TOC read in progress

For Sense Key MEDIUM ERROR (3h):

Code	Description
02	Error occurred during seek operation
11	L-EC uncorrectable data error (L-EC on)
B3	CIRC unrecovered data error (L-EC off)

For Sense Key HARDWARE ERROR (4h):

Code	Description
08	Logical unit communication failure
09	Tracking servo failure
40	Controller data buffer failure
41	Data path failure (Sony bus data error)
42	Power on failure
44	Internal controller failure
47	Interface parity error
B4	Focus servo failure
B5	Spindle servo failure
B6	Caddy load mechanism failed

Table 5-49: Additional Sense Code Descriptions

For Sense Key ILLEGAL REQUEST (5h):

Code	Description
20	Invalid command operation code
21	Logical block address not valid
22	Illegal function for CD-ROM
24	Illegal value in command descriptor block other than the operation code or the logical block address
25	Invalid logical unit number
26	Invalid field in parameter list
80	Prevent bit is set
81	Logical unit is reserved
82	End of user area encountered on this track
84	Illegal mode for this track
85	Audio address not valid

For Sense Key UNIT ATTENTION (6h):

Code	Description
28	Not ready to ready transition (caddy inserted)
29	Power on, reset or BUS DEVICE RESET occurred
2A	Mode select parameters changed

For Sense Key ABORTED COMMAND (Bh):

Code	Description
43	Unsuccessful message retry
45	Reselect failure
48	Initiator detected error
49	Message out error
83	Overlapped commands attempted

5.5. CD-ROM Glossary

CD-ROM - Compact Disc Read Only Memory The CD-ROM was developed by N.V. Philips & Sony Corporation. The 'RED BOOK ' and 'YELLOW BOOK' documents describe the medium.

Sub-Channel - The signal from the compact disc consists of a main channel and a sub-channel. The sub-channel is divided into three parts. The P sub-channel is part one and is used with CD-Audio. The Q sub-channel is part three and contains useful information, such as the control field and MSF address. The R, S,T,U, V and W sub-channels collectively are treated as part three.

Control Field - Four bits in the Q sub-channel data that indicate whether the track is CD-ROM or CD-Audio. If the track is CD-Audio then three bits are used to indicate use of pre-emphasis, copy protection, and whether the audio is two or four channel.

TNO - Track Number. A disc has logical segments which are called tracks. The track numbers range from one to ninety-nine. The data within a track is always of the same type. A track can contain either CD-ROM or CD-Audio data. A disc can start at any track number.

TOC - The Table Of Contents has information on the type of each track and the starting address of the user data in a tracks. This information is encoded in the Sub-Q channel during the lead-in area of the compact disc.

MSF Address - The address on the disc in minutes, seconds and frame number. All three must be specified to determine a physical location on the disc.

Absolute MSF Address - The address encoded in the sub-channel (and header of CD-ROM) which is the elapsed time from the start of disc.

Relative MSF Address - The address encoded in the sub-channel which is the elapsed time from the start of a track.

Frame - One frame is equal to 1/75 second of elapsed time.

Block - A block commonly refers to the data contained in one frame. However there are other meanings attached to this term within the world of compact disc.

Hold Track State - When the drive enters the hold track state the optical pick-up of jumps one track towards the inside of the disc at the specified Sub-Q address. The optical pick-up traces the groove of the disc until detecting the address and again jumps one track towards the inside of the disc.

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END OF DOCUMENT

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CDSCSI.WS6