1. C/DVD Models

1.1. General

1.2. Features

Features are sets of commands, mode pages, and behaviors or operations specified for a logical unit. Each feature must be implemented entirely to its standard description in order to claim compliance with the feature. Except as explicitly identified, all commands, mode pages, and behaviors within a feature are mandatory.

Features were designed primarily to support multi-function devices that could only function as one device at a time, e.g. CD-R drives act as either a CD-R or CD-ROM depending on the medium. Virtually all removable medium devices are in effect multi-function devices: they can use their medium when present, but cannot perform any media operations when no medium is present.

Mode pages described and required by features shall always be present if the Feature is reported by the Logical Unit, regardless of whether or not the Feature is current. For example, the CD Audio parameters page shall be available for reading and writing if the CD Audio feature is supported by the device, even if no audio media is present. The current values and changeable masks shall not change, even across morphing. Default values may change when morphing occurs. De-fault values shall always reflect a usable set of values for the loaded medium. Changes to the default values shall not generate a Unit Attention condition.

The use of features allows generic host drivers to use logical units that have among their many features some core functionality.

For example, the Random Readable feature may be reported by a very large variety of devices: magnetic disk, CD, DVD, or Magneto-Optical. A common driver to read data would be usable with all of these devices; special code would be needed only to manage extensions unique to each technology.

Features implemented by a logical unit are reported to the host via the GET CONFIGURATION command. This command should be used to identify all possible features, and those features that are current. A feature shall not be current if any of its mandatory commands or behaviors are not available. For example, a logical unit with writable media loaded and a mechanical write protect active shall not report any writable features as available. A DVD-ROM logical unit with a non-protected DVD-ROM loaded shall not report the DVD-CSS feature as being available. A logical unit with removable medium shall have no read or write or other medium dependent features active. Commands within a feature that is not current may still operate normally, especially when those commands are described in more than one feature.

The introduction of features are not intended to change device behavior. The use of commands that are not current will generate the same errors as legacy devices. Features simply provide a method for avoiding errors and avoids using errors to convey state information. When features are used properly by the host, the host should see only true medium errors and not need to do any informational discovery through error codes.

This standard also specifies techniques for the logical unit to notify the host of changes in the list of current features. In addition, a technique for preventing changes until host approval is granted is defined. The GET EVENT/STATUS NOTIFICATION command is used for notification of changes or change requests; the Persistent Prevent and Send Event com-mands are used to notify the logical unit of a host control request and for the host to notify the logical unit of permission to change.

For a Feature to be considered current, all commands and behaviors described by that Feature should be availalble to the host. Even if a Feature is not current, its components should function if appropriate for the logical unit's state. Commands received by a logical unit that are a member of a supported Feature that is not current shall either execute normally or return an appropriate error (i.e. incompatible medium, medium not present, etc.). Logical Units shall not terminate any Command that is a member of any supported Feature with CHECK CONDITION status, ILLEGAL REQUEST, INVALID COMMAND OPERATION CODE. For example, if the Formattable Feature is implemented, the READ FORMAT CAPACITIES command should return valid data regardless of whether or not the Formattable Feature is Current.

An attempt to format a medium that cannot be formatted by the logical unit may return CHECK CONDITION status, ILLEGAL REQUEST, INCOMPATIBLE MEDIUM INSTALLED.

Each Feature Descriptor may contain information specific to that feature. The Feature specific information in the Feature Descriptor may not be valid if the Feature is not current.

Commands, pages, and behavior not described by a Feature may exist in the Logical Unit.

See “GET CONFIGURATION Command” on page 133. for more information on the individual features.

1.3.Implementation of Features

1.3.1.What is a Feature?

This specification introduces Features. Features were designed to be atomic units of functionality. On the first level, Features are only a description in a document. Traditional drivers work without modification with logical units that implement features. Features were a part of the documentation in SFF 8020, SFF 8090, and MMC; however they were not comprehensive, typically documenting only optional behavior. This specification associates all normal functionality with Features. Detection of a whole group of functions (a “Feature”) was typically accomplished by the host by issuing a command unique to that Feature and examining the completion status of that command.

The SFF and T10 (MMC) groups have been conciously trying to avoid using errors as a method for status detection. Error handling code is typically one of the more complex parts of implementing drivers; reducing the number of cases that need to be handled helps implementations by reserving error status for only true errors. Status information is reported via explicit status reporting commands such as GET EVENT/STATUS NOTIFICATION and GET CONFIGURATION.

The descriptions of Features in this specification appear complex, and they are. However, these descriptions describe almost nothing new; they are simply the descriptions of existing legacy behavior. The only new parts are the descriptors themselves, which are either static identification blocks or groups of information that the drive must already have to operate, even in a legacy behavior. For example, a drive must internally identify whether or not a PLAY AUDIO command may succeed; Features are simply a way to let the host in on the secret.

Previously, new devices had to make a choice: to look completely like an old device with added functionality, or as a new device not compatible with old drivers. Feature and Profiles, a host can first determine if the “right” driver is available by examining the profiles. If “the” right driver isn’t available, the host can identify operable subsets when multiple profiles are reported. Finally, the host can identify basic functions to use the device via the Feature reporting

1.3.2. History

The separation of status and error reporting is very important in multitasking environments. Typically, the operating system needs to constantly be aware of the status of the drive. Various applications, operating through a variety of OS interfaces, may also need to be aware of drive status. Reporting of status via errors breaks down in this environment; only one process is made aware of state changes via the error, while other processes cannot obtain the same state information because the error (status change) has already been reported to the host (according to the Logical Unit).

Features do not replace legacy behavior. Features, in most cases, define a subset of legacy behavior. Several Features, taken together, are generally equivalent to legacy devices of the same type. Error and status reporting in legacy host environments is the same as legacy devices, without any special mode setting.

The Features described in this specification add something new: reporting. Legacy devices, while implementing the content of the Features, did not have any mechanism to report specifically the drive’s capabilities. The closest mechanism that has existed is a command that reported implemented commands. Implemented mode pages are also reportable via standard mechanisms. However, a command is more than an operation code (opcode). A whole set of commands, mode pages, and behavior needs to be grouped together to be useful. For example, write once MO, hard disk drives, and CD-R all use the WRITE command, but it is impossible to use the same strategies for writing these three media. Typically, different drivers or fragments or drivers are used for each kind of media. The previous mechanism would only identify that the WRITE command was implemented, but could not identify how to use it.

The capabilities of a particular drive may change at arbitrary times. The most common example of this is seen in a removable medium device. Even a basic removable magnetic medium device changes: from a random read/write device to a virtually functionless device when the medium is removed. Multi-function devices can change their behavior even more radically when they accept a variety of physical and logical formats.

Before features, hosts had to use a trial and error method for determining what would or would not function. Medium codes became outdated even before publication of the relevant standard, and still were not adequate to describe all media.

The Profiles, also introduced in this specification, provide an equivalent to the medium type. However, the profile does not indicate exact capabilities for the drive/medium system, only a generic identification of core capabilities.

Feature reporting is not completely new. Operating systems first identify a driver via the device type. The device type implied a core set of functions, e.g. a CD-ROM drive would support READ, READ TOC, etc. However, even these commands would not work if no medium were loaded. A driver would determine media status by trying a few commands and examining the error codes. After determining that media was present, a driver would have to probe to find out about additional features such as audio or medium changers. Features were “reportable,” but each feature had a different mechanism, and many of the mechanisms relied on the success or failure of special “key” commands.

1.3.3. Implementation of Features

There are only two requirements to fully implement features. The first is the GET CONFIGURATION command. This command is a very basic reporting command that reports some very static information; only a few featres have any dynamic fields; most features have only one bit that changes. The command is a form of Inquiry: a technique for the host to identify the device on the bus. The GET CONFIGURATION command simply provides more detail, and the information reported is expected to be dynamic.

Implementation of Feature reporting via the GET CONFIGURATION command is simple: the image of the result data can be copied from device ROM to its buffer, a few fields set with information already known to the drive (such as the block size), and a few bits set according to already existing flags in the firmware (i.e. DVD vs. CD, audio tracks present, etc.). Devices with non-removable media may have a completely static image that is reported. If a starting point other than the beginning is requested, the drive walks the table to find the first requested feature, subtracts the offset from the data length, and transfers data starting at the same offset.

The second part of Features is reporting when the Features change. As it is important for the host to know what operations will function with the drive at any given moment, pre-emptive reporting of Feature changes greatly eases host implemenations by reducing the number of error conditions that must be handled. The GET EVENT/STATUS NOTIFICATION command is used for status change reporting (an “Event.”) In many drives, implementation simply requires recording an event whenever a UNIT ATTENTION is generated, and having the GET EVENT/STATUS NOTIFICATION command clear the UNIT ATTENTION when the command completes.

As mentioned earlier, Features are not new; their reporting is. This reporting has become very important in modern environments.

Multiple drivers are talking to the same device, doing different tasks. For example, a DVD-ROM drive may use the basic CD-ROM driver when a CD is installed, and another driver when a DVD is installed, and both a basic DVD driver and a separate copy protection process when copy protected media is mounted. All of these processes must interact well to provide seamless and solid support. Feature reporting provides a method for clean interaction.

1.3.4.1Compatibility

Logical Units implementing Feature reporting are fully compatible with legacy systems.

The GET CONFIGURATION changes no behavior of the drive; it simply reports existing state information. Repeated GET CONFIGURATION commands will report the same information (unless the user inserts or removes the medium, etc.). GET CONFIGURATION never changes any state information in the drive, including UNIT ATTENTION conditions.

The GET EVENT/STATUS NOTIFICATION command changes legacy behavior only slightly, and not at all in a legacy environment. In a legacy environment, UNIT ATTENTION conditions are reported as done in the past. In a new environment, completion of the GET EVENT/STATUS NOTIFICATION command clears the UNIT ATTENTION. In a legacy environment, it would be cleared anyway; there are two differences: 1) the error is reported as an event, rather than as an error, and 2) in a queued environment, the GESN command will complete before anything else, because it was idle in the drive, awaiting completion. In this environment, UNIT ATTENTION reporting will be very rare or non-existent.

1.3.5. Summary

Features do not radically modify any legacy behavior or functionality. The only new parts involve reporting of behavior, and typically reflect state information already required of any firmware implementation, via two new commands. One command reports status, and the other notifies the host that the status may have changed.

The benefits include easier coding of highly robust drivers, fewer error conditions, and forward and backward compatibility with operating system drivers.

1.4. Morphing commands and functionality

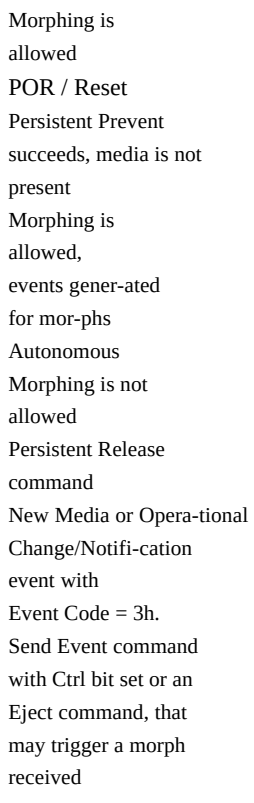
The GET CONFIGURATION command is used to discover a logical unit's behavior. The result data of the GET CONFIGURATION command may be dynamic. A Morph occurs whenever the data that would be returned to a GET CON-FIGURATION command changes.

The GET EVENT/STATUS NOTIFICATION command shall be supported. Asynchronous GESN operation may be supported.

If supported, the Async bit in the Feature Descriptor shall be set to one, otherwise the Async bit shall be set to ze-ro. The PREVENT/ALLOW command and the Persistent Prevent bit shall be supported. When a persistent prevent is in place, the Logical Unit shall not allow, to the limit of its design, non-host events to change the operational behavior of the device. Devices with a mechanical eject may not be able to prevent ejecting the media. When a persistent prevent is in place, events are reported to the host via the Get Event/Status Notification command instead of causing action within the logical unit. For example, if the user presses the eject button while a persistent prevent is in effect, the only action is to report the button press to the host. The logical unit shall behave as shown in *"Figure 30 - Morphing States"* on page 113.

The SEND EVENT command shall be supported for any GESN class 1 events that the device may generate. This command is used to tell the logical unit to perform an action that was previously requested by the drive via a Class 1 GESN response. The host, after receiving a Class 1 notification, prepares for a possible logical unit change by notifying its drivers and flushing buffers as needed. After the host is prepared for a possible device change, it sends the Class 1 event descriptor back to the logical unit for processing.

Figure 30 - Morphing States



A: External event requiring attention is serviced by logical unit.

B: Host requested operation is executed normally.

C: Host requested operation that cannot cause a morph is

executed normally.

D: External event requiring attention generates event to be reported to the host.

E: Non-preventable morph generates event to be reported to the host.

Morphing due to completion of requested operation is allowed

B

Operation complete; morph occurrs if appropriate

Command requesting possible morph re-ceived: mor-ph occurs if appropriate

D, E

1.4.1. Morphing Operation

The host may issue a PREVENT/ALLOW command with the Persistent Prevent bit set to indicate to the logical unit that it shall not change its behavior without host notification for any preventable action. This will, for example, prevent any front panel buttons from causing an eject, play, or other operation that affects device operation.

When the Persistent Prevent state is entered, the media shall remain locked in the Logical Unit and the Logical Unit shall not change its behavior, until the host issues an eject request, or a power on or hard reset condition occurs. The Persistent Prevent state shall be maintained after the eject request. New media that is inserted into the Logical Unit shall be locked in the Logical Unit after the logical unit reports the NEW MEDIA event. Prior to reporting the NEW MEDIA event, the logical unit may eject media without an explicit eject command from the host. This allows the user to remove incorrectly inserted media without having to wait for host intervention. In this condition neither the new media event nor the eject event should be reported by the logical unit.

While in the Persistent prevent state, the logical unit shall generate Events upon receipt of a User Eject request. The logical unit shall not eject the media on receipt of these requests, if the logical unit has already reported a NEW MEDIA event for this media. When the host receives the Eject Request, and determines that it is safe to eject the medium, an START/STOP UNIT command with the LoEj bit set will be issued, at which time the logical unit shall ***eject*** the medium.

The Persistent Prevent state shall be retained.

The logical unit shall only generate MSEN (EJECT REQUEST) events after reporting a MSEN (NEW MEDIA) event, and prior to reporting a MSEN (MEDIA REMOVAL) event for the given media.

In the Polling Mode of Event Notification, the host shall repeatedly issue GESN commands with an immediate bit of 1. The interval should be sufficiently short to provide quick user feedback but long enough to avoid performance impacts within the system. The logical unit shall complete these commands upon receipt, supplying the host with information on the most recent event occurrences, as described in the GESN command. If an event occurrence of the class(es) requested is not in the logical unit event queue, the Logical Unit shall complete the GESN command, and shall set the NEA bit to 1. This shall not be deemed an error.

If command queuing is supported, the host may issue a GESN command with an immediate bit of 0. The command shall not complete until an event occurrence of the class(es) requested is either in the event queue, or occurs.

The logical unit shall maintain a separate queue for each class of Event Notification(s) supported. Events that are generated shall be placed at the tail of the event queue. The depth of the queue(s) is vendor specific, although it shall be at least one. If an overflow occurs, the logical unit shall maintain the most recent Events in the queue.

Each GESN command shall report only one event. If multiple Event Classes are requested and multiple events are available, the logical unit shall report the Event in the Event Class with the lowest Notification Class ordinal.

1.4.2. Morphing Compatibility Considerations

To maintain compatibility with existing BIOS implementations and operating systems, the logical unit shall default to Persistent Prevent disabled. When the host enables the support using the PREVENT/ALLOW command, the logical unit shall respond as described in this specification. When the host disables this feature, the logical unit must default to normal operating modes. A power on or hard reset shall cause the logical unit to the default Persistent Prevent state.

If the Logical Unit is unable to maintain media status information across a reset or power cycle, the Logical Unit shall generate a NEW MEDIA event.

Commands must be processed exactly the same as they would be if Persistent Prevent was not enabled. For compatibility reasons, UNIT ATTENTION status conditions must still be returned. However, the logical unit shall not return the UNIT ATTENTION status on a GESN command. For example, if the user inserts a new medium and the logical unit is accessed with a command, the CHECK CONDITION with UNIT ATTENTION shall be reported, but the logical unit shall also report the NEW MEDIA Event with the next available GESN (Media Status) command. If the GESN command is received after a Unit Attention condition is generated, and before it is reported to the host, the GESN command shall report the event and clear the Unit Attention state.

1.5. Vendor Unique

All Vendor Unique Features shall be a multiple of 4 bytes in length. Use of Reserved fields in the Feature Descriptor Header is prohibited. Vendors are encouraged to take steps to choose a Feature number unique among all products.

The Logical Unit's Vendor ID and Product ID shall be used to qualify which set of Vendor Unique Features may be available.

9.0 Profiles

Profiles define a base set of functions for logical units. Logical units that list a profile as current shall support all Fea-tures required by that Profile, but not all Features may be current. Logical units may support Features in addition to those required by the Profile. A single device may implement more than one Profile, and more than one Profile may be active at any given time. All required features may not be current, depending on the medium installed. If a Not Ready response would be given to a TEST UNIT READY command, no Profile shall be current.

For example, a logical unit with unformatted media may not be able to read or write, and the corresponding Features would not be current, but the Profile corresponding to the logical unit/media system may be current. i.e. a DVD-RAM drive with unformatted media loaded may claim compliance to the DVD-RAM profile; A DVD-RAM drive with no media loaded shall claim no Profile as current.

1.6. Profile 2: Removable disk

Logical units identifying profile 2 as current shall support the features listed in Table 1.

Table 1 – Mandatory Features for Removable Disks

Feature Number	Feature Name	Description
0000h	Profile List	A list of all profiles supported by the device
0001h	Core	Mandatory behavior for all devices
0002h	Morphing	Ability to notify host about operational changes and accept host requests to prevent operational changes.
0003h	Removable Medium	The medium may be removed from the device
0010h	Random Readable, PP=1	Read ability for storage devices with random addressing.

0020h	Random Writable	Write support for randomly addressed writes
0023h	Formattable	Support for formatting of media
0024h	Defect Management	Ability of the drive/media system to provide an apparently defect-free space
0100h	Power Management	Host and device directed power management
0101h	S.M.A.R.T.	Self Monitoring Analysis and Reporting Technology (Failure prediction)
0105h	Timeout	Ability to respond to all commands within a specific time

1.7. Profile 8: CD-ROM

Logical units identifying profile 8 as current shall support the features listed in Table 2.

Table 2 – Mandatory Features for CD-ROM

Feature Number	Feature Name	Description
0000h	Profile List	A list of all profiles supported by the device
0001h	Core	Mandatory behavior for all devices
0002h	Morphing	Ability to notify host about operational changes and accept host requests to prevent operational changes.
0003h	Removable Medium	The medium may be removed from the device
0010h	Random Readable, PP=1	Read ability for storage devices with random addressing.
001Eh	CD Read	The ability to read CD specific structures
0100h	Power Management	Host and device directed power management
0105h	Timeout	Ability to respond to all commands within a specific time

9.3 Profile 10h: DVD-ROM

Logical units identifying profile 10h as current shall support the features listed in Table 3.

Table 3 – Mandatory Features for DVD-ROM

Feature Number	Feature Name	Description
0000h	Profile List	A list of all profiles supported by the device
0001h	Core	Mandatory behavior for all devices
0002h	Morphing	Ability to notify host about operational changes and accept host requests to prevent operational changes.
0003h	Removable Medium	The medium may be removed from the device
0010h	Random Readable, PP=1	Read ability for storage devices with random addressing.
001Fh	DVD Read	The ability to read DVD specific structures
0100h	Power Management	Host and device directed power management
0105h	Timeout	Ability to respond to all commands within a specific time
0107h	Real-Time Streaming	Ability to read using host requested performance parameters

9.4 Profile 12h: DVD-RAM

Logical units identifying profile 12h as current shall support the features listed in Table 4.

Table 4 – Mandatory Features for DVD-RAM

Feature Number	Feature Name	Description
0000h	Profile List	A list of all profiles supported by the device
0001h	Core	Mandatory behavior for all devices
0002h	Morphing	Ability to notify host about operational changes and accept host requests to prevent operational changes.
0003h	Removable Medium	The medium may be removed from the device
0010h	Random Readable, PP=1	Read ability for storage devices with random addressing.
001Fh	DVD Read	The ability to read DVD specific structures.
0020h	Random Writable	Write support for randomly addressed writes
0023h	Formattable	Support for formatting of media
0024h	Defect Management	Ability of the drive/media system to provide an apparently defect-free space
0100h	Power Management	Host and device directed power management
0101h	S.M.A.R.T.	Self Monitoring Analysis and Reporting Technology (Failure prediction)
0105h	Timeout	Ability to respond to all commands within a specific time
0107h	Real-Time Streaming	Ability to read and write using host requested performance parameters.

1.8. Profile FFFFh: Logical Units Not Conforming to a Standard Profile

Logical units identifying profile FFFFh as current shall support the features listed in Table 5.

Table 5 - Mandatory Features for Logical Units Not Conforming to a Standard Profile

Feature Number	Feature Name	Description
0000h	Profile List	A list of all profiles supported by the device
0001h	Core	Mandatory behavior for all devices

1.8.1. CD address reporting formats (MSF bit)

Several CD commands can report addresses either in logical block address or in MSF format (see Table 6). The READ HEADER, READ SUB-CHANNEL, and READ TOC/PMA/ATIP commands have this feature.

Table 6 - MSF Address format

Bit / Byte	7	6	5	4	3	2	1	0
0	Reserved							
1	M field							
2	S field							
3	F field							

An MSF bit of zero requests that the logical block address format be used for the CD absolute address field or for the offset from the beginning of the current track expressed as a number of logical blocks in a CD-ROM track relative address field. This track relative logical block address (TRLBA) value is reported as a negative value in twos-complement notation for transition areas that have decreasing MSF encoded relative addresses.

An MSF bit of one requests that the MSF format be used for these fields. In certain transition areas, the relative MSF addresses are decreasing positive values. The absolute MSF addresses are always increasing positive values.

The M, S, and F fields are expressed as binary numbers. The values match those on the media, except for the encoding.

NOTE: For a logical block size of 512 bytes, the MSF address returned is that for the physical block containing the specified logical blocks.

1.8.2. Logical Blocks

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

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

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

The location of a logical block on the medium does not have a relationship to the location of any other logical block. However, in a typical Logical Unit the logical blocks are located in an ascending order. The time to access the logical block at address [x] and then the logical block at address [x+1] need not be less than time to access [x] and then [x+100].

1.8.3. RESETS

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

- Power On Reset

- Hard Reset

- Device Reset

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

1.8.3.1. Power On Reset

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

1.8.3.2. Hard Reset

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

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

1.8.3.3. Device Reset

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

- Reset host interface circuitry.
- Perform hardware initialization and device-internal diagnostics only if necessary.
- Do not revert to default conditions, including ATAPI master/slave address, SCSI Device Number, Logical Unit Number or TOC information.
- Stay in the current Power State.
- Persistent Prevent state is unchanged.
- Key management shall be reset to the default state.

1.8.3.4. Mapping of reset functions

Table 7 shows how the different reset functions specified in the various ATAPI and SCSI specifications are used in this specification. Note that this table is not intended to show all possible resets or their mapping.

Table 7 - Example Reset Function Mapping in ATAPI and SCSI

Reset Type	ATAPI	SCSI
Power-On Reset	Same as Power-On Reset	Same as Power-On Reset
Hard Reset	Hard Reset	TARGET RESET task management function
	ATA SRST. This is a channel reset and as such is treated as a Hard Reset. However the SRST shall not reset any mode parameters to the default state.	SAM Reset events. Note that this is SCSI protocol dependent.
		SPI Reset Signal
Device Reset	Device Reset in ATA/ATAPI-4	ABORT TASK SET task management function
	ATAPI Soft Reset in SFF8020	CLEAR TASK SET task management function

1.8.4. Error reporting

If any of the conditions in Table 8 occur during the execution of a command, the target shall return CHECK CONDITION status. The appropriate sense key and additional sense code should be set. The following list illustrates some error conditions and the applicable sense keys. The list does not provide an exhaustive enumeration of all conditions that may cause the CHECK CONDITION status.

Table 8 - Sense key responses for error reporting

Condition	Sense Key
Invalid Logical Block Address	ILLEGAL REQUEST
Unsupported option requested	ILLEGAL REQUEST
Attempt to read a blank block	ILLEGAL REQUEST
Attempt to play a data block as audio	ILLEGAL REQUEST
Target reset or medium change since last command	UNIT ATTENTION
Self diagnostic failed	HARDWARE ERROR
Un-recovered read error	MEDIUM ERROR/HARDWARE ERROR
Recovered read error	RECOVERED ERROR
Overrun or other error that might be resolved by repeating the command	ABORTED COMMAND

In the case of an invalid logical block address, the sense data information field shall be set to the logical block address of the first invalid address.

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

There are other special error situations for CD devices. In the following cases the sense key shall be set to ILLEGAL REQUEST and the additional sense code set to END OF USER AREA ENCOUNTERED ON THIS TRACK:

a) a pre-gap area is encountered (i.e. a block with index equal to 0).

b) a post-gap area is encountered.

c) The information type (data vs. audio) changes.

When the command is other than an audio playback operation, the command shall be terminated with CHECK CONDITION status if the Logical Block Address requested is not within a data track. The sense key shall be set to ILLEGAL REQUEST and the additional sense code set to ILLEGAL MODE FOR THIS TRACK. This applies to audio-combined and audio media.

1.8.5. Deferred Errors

Error code 70h indicates that the CHECK CONDITION status returned is the result of an error or exception condition on the I/O process that returned the CHECK CONDITION status. This includes errors generated during execution of the command by the actual execution process. It also includes errors not related to any command that are first observed during execution of a command. Examples of this latter type of error include disk servo mechanism, off track errors, and power-up test errors.

Error code 71h (deferred error) indicates that the CHECK CONDITION status returned is the result of an error or exception condition that occurred during execution of a previous command for which GOOD status has already been returned. Such commands are associated with use of the immediate bit, with some forms of caching, and with multiple command buffering. C/DVD Logical Units that implement these features are required to implement deferred error reporting.

The deferred error may be indicated by returning CHECK CONDITION status to the Host Computer as described below. The subsequent execution of a REQUEST SENSE command shall return the deferred error sense information.

If an I/O Command terminates with CHECK CONDITION status and the subsequent sense data returns a deferred error, that I/O command shall not have been executed. After the C/DVD Logical Unit detects a deferred error condition on a Logical Unit, it shall return a deferred error according to the rules described below:

1. If a deferred error can be recovered with no external system intervention, a deferred error indication shall not be posted unless required by the error handling parameters of the MODE SELECT command. The occurrence of the error may be logged if statistical or error logging is supported.

2. If a deferred error can be associated with a particular function or a particular subset of data, and the error is either un-recovered or required to be reported by the mode parameters, a deferred error indication shall be returned to the Host Computer.

Deferred errors may indicate that an operation was unsuccessful long after the command performing the data transfer returned GOOD status. If data that cannot be replicated or recovered from other sources is being stored using buffered write operations, synchronization commands should be performed before the critical data is destroyed in the host computer. This is necessary to be sure that recovery actions can be taken if deferred errors do occur in the storing of the data.

1.8.6. Removable medium

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

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

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

1.9. CD Device Model

CD devices permit reading data from a removable rotating media. Data transfer can begin with any of the consecutively numbered logical blocks. Some CD devices support a separate information stream (e.g. audio and/or video but referred to as audio in this clause) transmitted via a connection other than the attached physical interface. This standard defines commands for controlling these other information streams.

C/DVD drives are designed to work with any disc that meets IEC. Many new drives read C/DVD data discs, digital audio discs, and audio-combined discs (i.e. some tracks are audio, some tracks are data).

The writing of a CD-R/RW disc requires the Initiator read a set of parameters from the Logical Unit, selecting the parameters to be used, setting those parameters in the write parameters of the Logical Unit and then using the normal SCSI-3 Write Command. Once the write process has begun, data is streamed from the initiator to the Logical Unit.

1.9.1. CD media organization

The formats written on the CD and CD-DA (Digital Audio) media require special interfacing considerations.

> Note: This sub-clause contains a number of terms that have special meanings peculiar to CD technology or that may be unfamiliar to many readers of this standard. The glossary, sub-clause **Error! Reference source not found.**, defines these terms.

Discs may contain either audio, data or a mixture of the two. Table 9 gives an example of a mixed mode disc to illustrate the relationship between the logical block addresses reported in SCSI and the MSF address encoded on the media.

> NOTE: The term frame is used in two different ways in the CD media standard. The intended meaning can only be determined from the context. Whenever possible, this description replaces the larger data unit with the more familiar term sector. The primary exception to this policy is the use of frame when referring to the MSF address. In the MSF context, one frame (F field unit) equals one sector. On a typical two channel CD-DA media, each frame (F field unit) is played in 1/75th of a second.

The physical format defined by the CD media standards provides 2352 bytes per sector. For usual computer data applications, 2048 bytes are used for user data, 12 bytes for a synchronization field, 4 bytes for a sector address tag field and 288 bytes - the auxiliary field - for L-EC (CD data mode 1). In less critical applications, the auxiliary field may also be used for user data (CD data mode 2). The user data portion of a CD sector contains 2048, 2332, 2340, or 2352 bytes.

Table 9 - Example of Mixed Mode CD Disc Layout

Block Description	Logical Address (Decimal)	Track Relative logical address	Absolute M/S/F Address[1]	Track / Index	Track Relative M/S/F Address	Sector Contains Info or Pause	Mode Audio or Data	CD Data Mode[2]
Lead-in Area	---	---	---	0 /-	---	---	Audio	---
Pre-gap	---	---	00/00/ 00	1 / 0	00/02/ 00[7]	Pause	Data	Null
1st Track data	0000[4]	0	00/02/ 00[5]	1 / 1	00/00/ 00	Info	Data	L-EC
2nd track data	6000[4]	0	01/22/ 00[5]	2 / 1	00/00/ 00	Info	Data	L-EC
	7500	1500	01/42/ 00	2 / 2	00/20/ 00	Info	Data	L-EC
Post gap	9000	3000	02/02/ 00	2 / 3	00/40/ 00	Pause	Data	Null
Pause-silence	9150	-150[6]	02/04/ 00	3 / 0	00/02/ 00[7]	Pause	Audio	---
3rd track audio	9300[8]	0	02/04/ 00[9]	3 / 1	00/00/ 00	Info	Audio	---
	1400	2250	02/34/ 00	3 / 2	00/03/ 00	Info	Audio	---
4th track audio	21975[8]	0	04/53/ 00[9]	4 / 1	00/00/ 00	Info	Audio	---
Pre-gap part 1	30000	-225[6]	06/40/ 00	5 / 0	00/03/ 00[7]	Pause	Audio	---
Pre-gap part 2	300075	-150	06/41/ 00	5 / 0	00/02/ 00[7]	Pause	Data	Null
5th track data	30225	0	06/43/ 00	5 / 1	00/00/ 00	Info	Data	L-EC
Last Information	263999[10]	233 774	58/39/ 74	5 / 1	51/56/ 74	Info	Data	L-EC
Post-gap	---	233 775	58/40/ 00	5 / 2	51/57/ 00	Pause	Data	Null
Lead-out area	264000[11]	0	58/42/ 00	AA /-	00/00/ 00	Pause	Audio	---

Lead-out area	264000[11]	0	58/42/00	AA/-[13]	00/00/00	Pause	Audio	---

Notes:

1. Absolute MSF address repeated in the header field of data blocks.
2. The CD data mode is stored in the header of data tracks. This indicates that the block is part of a data pre-gap or post gap (null), that this is a data block using the auxiliary field for L-EC symbols (ECC-CD data mode one), or that this is a data block using the auxiliary field for user data (CD data mode 2.)
3. Table of Contents information is stored in the sub-channel of lead-in area. The lead-in area is coded as track zero. Track zero and the initial 150 sector pre-gap (or audio pause) are not accessible with logical addressing.
4. Exact value returned by READ TOC/PMA/ATIP Command.
5. Value stored in Table of Contents with zero tolerance.
6. Track relative logical addresses are negative in the pre-gap areas.
7. Track relative MSF value decreases to 0 in the pre-gap areas.
8. Value returned by READ TOC/PMA/ATIP Command plus or minus 75 blocks.
9. Value stored in Table of Contents plus or minus 75 sectors.
10. Minimum value returned by READ C/DVD RECORDED CAPACITY: exact value depends on encoding of this track and the lead-out track and whether this is derived from the TOC data.
11. Value returned by READ TOC/PMA/ATIP Command; exact if lead-out track is encoded as data, or plus or minus 75 blocks if encoded as audio.
12. Value stored in Table of Contents; exact if lead-out track is coded as data, or plus or minus 75 blocks if coded as audio.
13. Lead-out track number field is defined as AAh.

For data and mixed mode media (those conforming to ISO/IEC 10149), logical block address ZERO shall be assigned to the block at MSF address 00/02/00. For audio media (those conforming only to IEC 908), logical block address ZERO shall be assigned to the actual starting address of track 1. This may be approximated by using the starting address of track 1 contained in the table of contents (TOC) or by assigning logical block address ZERO to the block at MSF ad-dress 00/02/00.

Logical addressing of CD information may use any logical block length. When the specified logical block length is an exact divisor or integral multiple of the selected number of bytes per C/DVD sector, the device shall map (one to one) the bytes transferred from C/DVD sectors to the bytes of logical blocks. For instance, if 2048 bytes are transferred from each C/DVD sector, and the logical block length is 512 bytes, then each C/DVD sector shall map to exactly four logical blocks. This standard does not define the mapping of logical block lengths which do not evenly divide or are not exact multiples of the selected number of bytes per CD-ROM sector.

A track may be viewed as a partition of the CD address space. A CD media contains from one to ninety-nine tracks. All information sectors of a track are required to be of the same type (audio or data) and mode. Each change in the type of information on the disc 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.

The tracks of a CD media are numbered consecutively with values between 1 and 99. However, the first information track may have a number greater than 1. Tracks have a minimum length of 300 sectors plus any transition area that is part of a track.

The CD media standards require transition areas between tracks encoded with different types of information. In addition, transition areas may be used at the beginning or end of any track. For audio tracks the transition areas are called pause areas. For data tracks, transition areas are called pre-gap and post-gap areas. See Table 6 for an example. The IEC 908 and ISO/IEC 10149 standards specify minimum time duration for these areas. Maximum time duration’s are not specified.

Transition areas are formatted and the logical address continues to increment through transition areas. Some media (i.e. discs with only one track) may not have transition areas. The means to determine the location of the transition areas is vendor or application-specific and is addressed by other standards (e.g. ISO 9660).

C/DVD is a unique logical unit in the respect that some logical blocks on a disc may not be accessible by all commands. SEEK commands may be issued to any logical block address within the reported capacity of the disc. READ commands cannot be issued to logical blocks that occur in some transition areas. Audio commands cannot be issued to logical blocks within a data track.

CD media have lead-in and lead-out areas. These areas are outside of the user-accessible area as reported in the READ C/DVD RECORDED CAPACITY data. The lead-in area of the media is designated track zero. The lead-out area is designated track AAh. The Q sub-channel in the lead-in track contains a Table of Contents (TOC) of the disc.

NOTE: The READ C/DVD RECORDED CAPACITY command returns the logical block address of the last block prior to the lead-out area. This location may be in a transition area and therefore not a valid address for read operations.

The Table of Contents gives the absolute MSF location of the first information sector of each track. Control information (audio/data, method of audio encoding, etc.) for each track is also contained in the TOC. However, the TOC does not distinguish between the different modes of data tracks (i.e. CD data mode 1 vs. CD data mode 2).

The MSF locations pointing to the start of data tracks in the TOC are required to be accurate. However, the TOC values for audio tracks have a tolerance of plus or minus 75 sectors. Information from the TOC can be used to reply to a READ CD RECORDED CAPACITY command. When this is done, the device implementor should consider the possible tolerances and return a value that allows access to all information sectors.

An index is a partition of a track. Pre-gap areas are encoded with an index value of zero. Pause areas at the beginning of audio tracks are also encoded with an index value of zero. The first information sector of a track has an index value of one. Consecutive values up to 99 are permitted. Index information is not contained in the TOC. Not all sectors are encoded with the index value in the Q sub-channel data (the requirement is 9 out of 10). A sector without an index value is presumed to have the same index as the preceding sector.

Tracks and indexes are not defined to be any particular length, (except for a minimum track length of 300 sectors.) A CD disc may be created with a single information track that has a single index; or with 99 information tracks, each with 99 indexes.

The sub-channel information which is part of each sector includes a track relative MSF location value giving the distance from the first information sector of the track. On the media, this value decreases during the pre-gap area (sectors with index values of 0) and increases for the rest of the track. The data, returned by the READ SUB-CHANNEL command with MSF bit set to zero, converts this to a track relative logical block address (TRLBA). The TRLBA is continually increasing over the whole track, and pre-gap areas shall return negative values. When the MSF bit in the read sub-channel command is set to one, the MSF track relative location value from the media is reported without change.

1.9.2. CD Physical Data Format

The physical format of CD-ROM and CD-DA media uses a smaller unit of synchronization than the more familiar magnetic or optical recording systems. The basic data stream synchronization unit is a small frame. This is not the same large frame (sector) as referred to in the MSF unit. Each small frame consists of 588 bits (see Figure 1). A sector on CD media consists of 98 small frames.

1 synchronization pattern (24 + 3 bits)	1 byte of sub-channel data (14 + 3 bits)	12 bytes of data (12 x (14 + 3) bits	4 bytes of CIRC code (4 x (14 + 3) bits)	12 bytes of data (12 x (14 + 3) bits	4 bytes of CIRC code (4 x (14 + 3) bits)
588 bits					

Figure 1 - Small Frame layout and definition

Data, sub-channel and CIRC bytes are encoded with an 8-bit to 14-bit code; then three merging bits are added. The merging bits are chosen to provide minimum low-frequency signal content and optimize phase lock loop performance.

1.9.3. Frame Format for Audio

Each small frame of an audio track on a two-channel CD-DA or CD-ROM media consists of six digitized 16-bit samples of each audio channel. These 24 bytes of data are combined with a synchronization pattern, CIRC bytes and a sub-channel byte to make a frame. Each frame takes approximately 136.05 μs to play. This gives a sampling rate of 44.1 kHz for each channel. The sub-channel information creates the higher level sector grouping for audio tracks.

1.9.4. Sector Format for Data

The data bytes of 98 small frames comprise the physical unit of data referred to as a sector. See Figure 2. (98 small frames times 24 bytes per small frame equals 2352 bytes of data per sector.)

The physical format defined by the CD-ROM media standard provides 2352 bytes per sector. For usual computer data applications, 2048 bytes are used for user data, 12 bytes for a synchronization field, 4 bytes for a sector address tag field and 288 bytes - the auxiliary field - for L-EC (CD-ROM data mode 1). In less critical applications, the auxiliary field may also be used for user data (CD-ROM data Mode 2/Form 2).

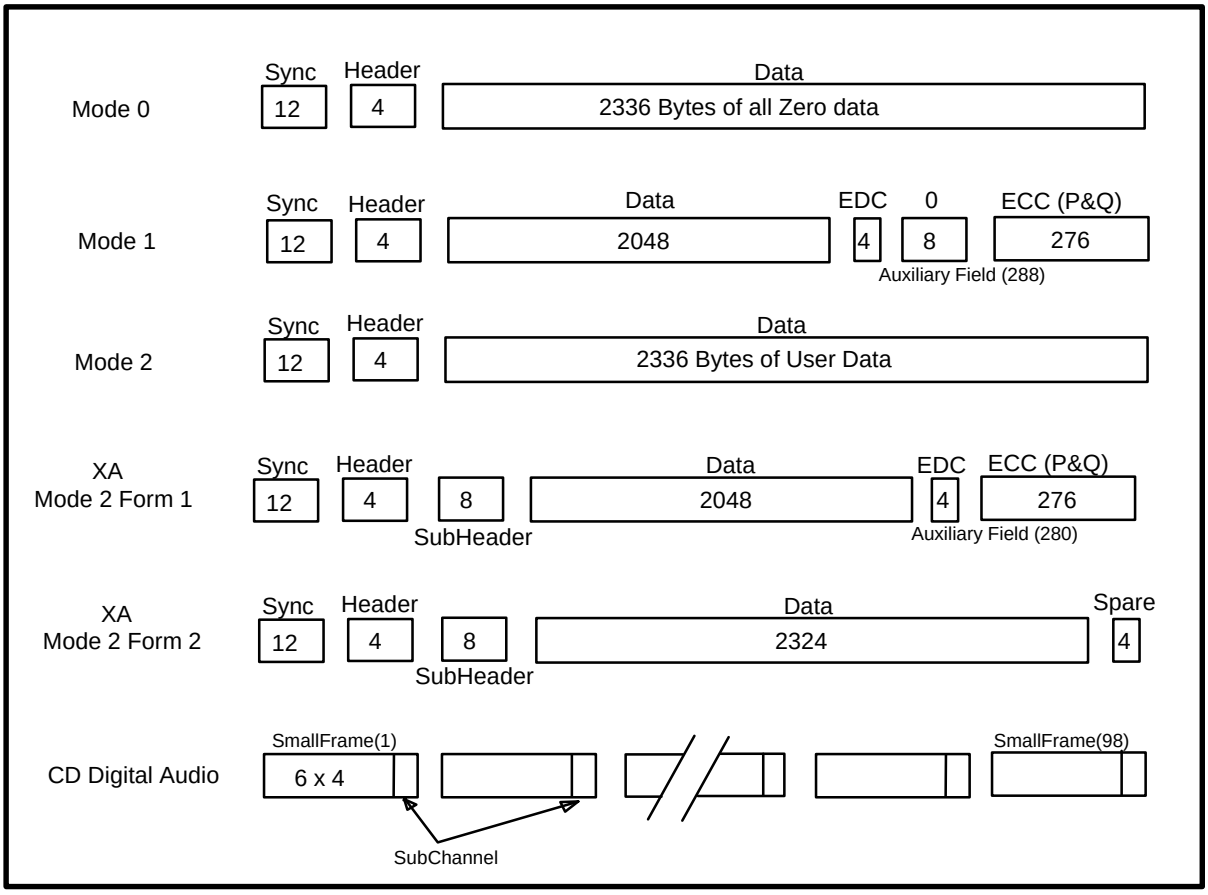


Figure 2 - CD-ROM Sector Formats

A CD physical sector size is 2048, 2052, 2056, 2324, 2336, 2340, or 2352 bytes per sector. These values correspond to the user data plus various configurations of header, sub-header and EDC/ECC.

> NOTE: Many drives are capable of returning CD-ROM data Mode 1 data in a CD-ROM data Mode 2 format. This allows the user to investigate the error detection and error correction codes. However data encoded as CD-ROM data Mode 2 cannot be read as CD-ROM data Mode 1 data.

1.9.4.1. Multi Session Format

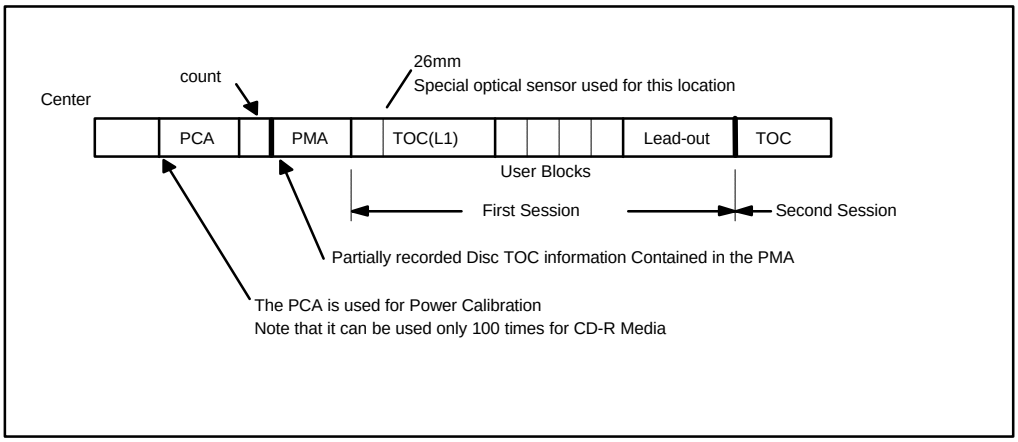


Figure 3 - CD-R/RW Disc Layout

1.9.5. Supported Block Sizes

Supported block sizes (see Table 10) include 2048, 2056, 2324, 2332, 2352, 2368, and 2448 bytes. Table 10 shows the implementation of the various block sizes. These definitions apply for reading with the Read commands.

Table 10 - Block Sizes for Read

Size	Readable block types
2048	Mode 1 or Mode 2 Form 1.
2332	Mode 2, form 1 or 2 data. The drive shall operate as specified for 2048 byte blocks except: Both forms send 2332 byte blocks. Form 1 blocks return the third layer ECC with the user data.
2336	Mode 2 data The drive shall operate as specified for 2048 byte blocks lengths. This mode will include all data, including Yellow Book Mode 2 sectors and Form 1 and Form 2.
2352	Audio or raw blocks. The drive shall operate as specified for 2048 byte blocks. Reads of data mode sectors shall return de-scrambled data.
2448 or 2368	Audio or raw blocks with raw sub-channel. The drive shall not perform the data de-scrambling operation.

1.9.6. Frame format for audio

Each small frame of an audio track on a two-channel CD-DA or CD-ROM media consists of six digitized 16-bit samples of each audio channel. These 24 bytes of data are combined with a synchronization pattern, CIRC bytes and a sub-channel byte to make a frame. Each frame takes approximately 136.05 μs (1/75th of a second) to play. This gives a sampling rate of 44.1 kHz for each channel. The sub-channel information creates the higher level sector grouping for audio tracks.

1.9.7. Q sub-channel information formats

Q sub-channel has a higher level of structure. All the Q sub-channel bits of a sector define the Q sub-channel information block. (For audio tracks, decoding the Q sub-channel is the only way to distinguish sector boundaries.)

The Control, ADR, DATA-Q, and CRC fields contain 96 bits of information defined in Figure 4.

Field name	Definitions
S0, S1	Sub-Channel Synchronization
CONTROL	The Control Field has 4 bits that define the type of information within a track: 00x0b = 2 audio channels without pre-emphasis 00x1b = 2 audio channels with pre-emphasis of 50/15 µs 10x0b = audio channels without pre-emphasis (reserved in CD-R/RW) 10x1b = audio channels with pre-emphasis of 50/15 µs (reserved in CD-R/RW) 01x0b = Data track, recorded uninterrupted 01x1b = Data track, recorded incremental 11xxb = reserved xx0xb = digital copy prohibited xx1xb = digital copy permitted The bits of the control field (except for the copy bit) can change during an actual pause (X=00) of at least 2 seconds and during the lead-in area only.
ADR	4 bits of control for DATA-Q.
DATA Q	72 bits of data
CRC	A 16 bit CRC for the Control, ADR, and DATA-Q Fields. On the disc the parity bits are inverted. The remainder has to be checked at zero. Polynomial = $P(X)=X^{16}+X^{12}+X^{5}+1$

Figure 4 - Q sub-channel Information Block

Three codes are defined for DATA-Q: MODE-1, MODE-2, and MODE-3.

1.9.7.1. Q sub-channel Mode-1

ADR = 1 (0001b)
Mode-1 occupies at least 9 out of 10 successive sub-coding blocks. Two different data formats are possible in Mode-1. The data format during the lead-in track is shown in Figure 5.

ADR	DATA-Q								
0001	TNO	POINT	MIN	SEC	FRAME	ZERO	PMIN	PSEC	PFRAME

Figure 5 - Q sub-channel Mode-1 Format recorded in lead-in

The format during the data and audio and lead-out tracks on a disc is shown in Figure 6.

ADR	DATA-Q								
0001	TNO	INDEX	MIN	SEC	FRAME	ZERO	AMIN	ASEC	AFRAME

Figure 6 - Q sub-channel Mode-1 Format recorded in Program Area and lead-out

TNO (Track number) on the media is expressed in 2 BCD digits.

00bcd	Lead-in. The end of the lead-in is at the starting diameter of the program area.
01 - 99bcd	Track numbers. A track can be preceded by a pause with the same track number. The track numbering once set, shall increment by one.
AAh	Lead-out . The lead-out starts at the end of the last track on a disc, without a preceding pause encoding.

The INDEX (Index to TNO) on the media is 2 BCD digits.

00bcd	Pause encoding.
01 - 99bcd	Sub-division numbers. During the lead-out track INDEX is 01. Within an audio track (TNO = 01 - 99 and X not equal to 00) the first value of INDEX is 01. The value of INDEX can only be incremented by one. In a data track it shall have a value of 01.

The ZERO field contains a value of ZERO. (00000000 b)

Min, Sec, Frame fields contain the running time within a track expressed in 6 BCD digits. Min, Sec, and Frame are each two digits. The time is set to zero at the start of a track. Time increases in the track and decreases in the pause/pregap, ending with the value zero at the end of the pause/pregap. In the lead-in and the lead-out tracks the time increases.

The minutes are stored in Min, the seconds in Sec. One second is subdivided into 75 Frames (running from 00 to 74).

AMIN, ASEC, AFRAME fields contain the absolute address expressed in 6 BCD digits. AMIN, ASEC, and AFRAME are each two digits. At the starting diameter of the program area the running time is set to zero and TNO takes the value of the first track on the disc.

The minutes are stored in AMIN, the seconds in ASEC. One second is subdivided into 75 AFRAMEs (running from 00 to 74).

Bytes in the Q-sub-channel that contains bcd contents may also contain illegal BCD values. Then values start with 0A0h and continue to 0FFh. No conversion of these to hex for transmission to/from the initiator is performed. Refer to **Error! Reference source not found.** for more information.

The POINT, PMIN, PSEC, and PFRAME contain the Table of Contents during the lead-in. This Table of Contents is continuously repeated in the lead-in (TNO = 0). In each Table of Contents, the individual items are repeated three times. At the end of the lead-in, the Table of Contents can be ended with any value of point.

The value of PMIN, PSEC, and PFRAME gives the starting point of the track number pointed to by POINT. These values give the start position of the track on the absolute time scale (AMIN, ASEC, and AFRAME) with an accuracy of +/- one second. The start position of a track is the first position with the new track number and X not equal to 00.

If POINT = A0h, the value of PMIN gives the track number of the first piece of audio on the disc, PSEC and PFRAME are zero.

If POINT = A1h, the value of PMIN gives the track number of the last track on the disc, PSEC and PFRAME are zero.

If POINT = A2h, PMIN, PSEC, and PFRAME contains the starting point of the lead-out.

1.9.7.2. Q sub-channel Mode-2

ADR = 2(0010b)

If Mode-2 is present, and occupies at least 1 out of 100 successive sub-coding blocks. Mode-2 data format is shown in Figure 7 - Q sub-channel Mode-2 Format.

ADR	DATA-Q														
0010	N1	N2	N3	N4	N5	N6	N7	N8	N9	N10	N11	N12	N13	ZERO	AFRAME

Figure 7 - Q sub-channel Mode-2 Format

The DATA-Q field is 52 bits long and is defined as:

N1 - N13 is the Catalog number of the disc expressed in 13 BCD digits. Used in the UPC/EAN coding. The catalog number does not change on a disc. In case no catalog number is encoded according to the UPC/EAN code, N1 - N13 are all zero, or Mode-2 can be deleted from the disc.

The ZERO field contains 12 bits of zero. (000000000000b)

AFRAME is defined in Q sub-channel Mode-1 (two BCD digits running from 00 to 74). During the lead-in (TNO = 00), these 8 bits are zero.

1.9.7.3. Q sub-channel Mode-3

ADR = 3 = (0011b)

If Mode-3 is present, it occupies at least 1 out of 100 successive sub-coding blocks. Mode-3 is used to give a unique number to a audio track, This is done by means of the International Standard Recording Code (ISRC). The ISRC, as recorded on the media, is defined in Table 11. If no ISRC is used, Mode-3 must be deleted. During the lead-in and lead-out, Mode-3 is not present on the disc. The ISRC can only change immediately after the track number (TNO) has been changed. The Mode-3 data format is shown in Figure 8.

ADR	DATA-Q															
0011	I1	I2	I3	I4	I5	0	0	I6	I7	I8	I9	I10	I11	I12	ZERO	AFRAME

Figure 8 - Q sub-channel, Mode-3 Format

I1 - I12 define the ISRC, and is 60 bits in length.

The Country-Code is given in fields I1 through I2, the owner-code in fields I3 - I5, The year of recording in fields I6 - I7 and the I8 through I12 contain the serial number of the recording. The characters I1 - I5 are formatted as shown in Table 11. The characters I6 - I12 are coded in 4 bit BCD numbers.

The ZERO field contains 4 bits of zero. (0000b)

AFRAME is defined in Q sub-channel Mode-1 (two BCD digits running from 00 to 74). During the lead-in area (TNO = 00), these 8 bits are zero.

The 6 bit character coding map is shown in Table 11.

Table 11 - ISRC 6 bit character codes (in hexadecimal)

CHAR	CODE	CHAR	CODE	CHAR	CODE
0	00	G	17	W	27
1	01	H	18	X	28
2	02	I	19	Y	29
3	03	J	1A	Z	2A
4	04	K	1B		
5	05	L	1C		
6	06	M	1D		
7	07	N	1E		
8	08	O	1F		
9	09	P	20		
A	11	Q	21		
B	12	R	22		
C	13	S	23		
D	14	T	24		
E	15	U	25		
F	16	V	26		

1.9.7.4. Q sub-channel Mode-5

ADR = 5 = (0101b)

1.9.8. CD Audio error reporting

PLAY commands with the immediate bit set in the audio control mode return status as soon as the command has been validated (which may involve a seek to the starting address). The playback operation continues and may complete without notification to the initiator. Error termination of audio operations shall be reported to the initiator by returning immediate CHECK CONDITION status to the next command (except for REQUEST SENSE and INQUIRY). The deferred error

sense data (reference SCSI Block Commands standard) is used to indicate that the error is not due to the current command.

The status of the play operation may be determined by issuing a REQUEST SENSE command. The sense key is set to NO SENSE and the audio status (see **Error! Reference source not found.**) is reported in the additional sense code qualifier field.

1.9.9. CD ready condition/not ready condition

The ready condition occurs after a disc is inserted and the drive has performed its initialization tasks. These tasks may include reading the Table of Contents from the media. Table 12 defines the Not Ready Error reporting for each command. A not ready condition shall occur only for the following reasons:

a) There is no medium mounted.
b) The drive is unable to load or unload the medium.
c) The drive is unable to recover the Table of Contents.
d) The controller cannot select the drive.

Table 12 - Not Ready Error Reporting (by command)

Command Name	Operation Code	Return Ready Status	Time-out	Comment
BLANK	A1h	Yes	Group 2	Recordable only
CHANGE DEFINITION	40h	No	Not Allowed	SCSI only
CLOSE AREA/SESSION	5Eh	Yes	Group 2	Recordable only
COMPARE	39H	Yes		SCSI only
COPY	18h	Yes	Group 2	SCSI only
COPY AND VERIFY	3Ah	Yes	Group 2	SCSI only
FLUSH CACHE	36h	Yes		
FORMAT UNIT	04h	Yes	Group 2	Recordable only
GET EVENT/STATUS NOTIFICATION	4Ah	Yes	Not Allowed	
INQUIRY	12h	No	Not Allowed	
LOAD/UNLOAD CD	A6h	Yes	Group 1	
LOCK/UNLOCK CACHE	38h	No	Group 2	SCSI only
LOG SELECT/SENSE	4Ch,4Dh	No	Group 1	SCSI only
MECHANISM STATUS	BDh	Yes	Group 1	
MODE SELECT	55h, 15h	No	Group 1	
MODE SENSE	5Ah, 1Ah	No	Group 1	
PAUSE/RESUME	4Bh	Yes	Group 1	
PLAY AUDIO (10)	45h	Yes	Group 1	
PLAY AUDIO (12)	A5h	Yes	Group 1	
PLAY AUDIO MSF	47h	Yes	Group 1	
PLAY CD	BCh	Yes	Group 1	
PREFETCH	34h	Yes	Group 1	
PREVENT/ALLOW MEDIUM REMOVAL	1Eh	No	Group 1	
READ (10)	28h	Yes	Group 1	
READ (12)	A8h	Yes	Group 1	
READ BUFFER	3Ch	No	Group 1	SCSI only
READ C/DVD RECORDED CAPACITY	25h	No	Group 1	
READ CD	BEh	Yes	Group 1	
READ CD MSF	B9h	Yes	Group 1	
READ DISC INFORMATION	51h	Yes	Group 1	
READ DVD STRUCTURE	A0h	Yes	Group 1	
READ FORMATTED CAPACITY	23h	No	Group 1	
READ HEADER	44h	Yes	Group 1	
READ LONG	3Eh	Yes	Group 1	SCSI only
READ SUB-CHANNEL	42h	Yes	Group 1	

Table 12 (cont.) - Not Ready Error Reporting (by command)

Command Name	Operation Code	Return Ready Status	Time-out	Comment
READ TOC/PMA/ATIP	43h	Yes	Group 1	
READ TRACK INFORMATION	52h	Yes	Group 1	
RECEIVE DIAGNOSTIC RESULTS	1Ch	No	Not Allowed	SCSI only
RELEASE	17h, 57h	No	Special	SCSI only
REPORT KEY	AAh	Yes	Group 1	
REPORT LUNS	A0h	No	Group 1	SCSI only
REQUEST SENSE	03h	No	Not Allowed	
RESERVE	16h, 56h	No	Special	SCSI only
RESERVE TRACK	53h	Yes	Group 2	Recordable only
REZERO	01h	Yes	Group 1	SCSI only
SCAN	BAh	Yes	Group 1	
SEEK	2Bh	Yes	Group 1	
SEND DIAGNOSTICS	1Dh	No	Not Allowed	SCSI only
SEND KEY	A3H	Yes	Group 1	
SEND UPC INFORMATION	54h	No	Group 1	Recordable only
SET C/DVD SPEED	B8h, BBh	No	Group 1	SCSI only
SET READ AHEAD	A7h	Yes	Group 1	
START/STOP UNIT	1Bh	Yes	Group 1	
STOP PLAY/SCAN	4Eh	Yes	Group 1	
TEST UNIT READY	00h	Yes	Group 1	
VERIFY (12)	A2h	Yes	Group 1	
WRITE (10)	2Ah	Yes	Group 2	Recordable only
WRITE (12)		Yes	Group 2	Recordable only
WRITE AND VERIFY (12)	A7h	Yes	Group 2	Recordable only

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

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

1.9.10. Sensing support for CD-audio commands.

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.

1.10. DVD Model

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

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

A DVD Logical Unit may be capable of reading CD-ROM, CD-R and possibly CD-RW media. This backwards compatibility will allow a DVD Logical Unit to replace a CD-ROM Logical Unit in most systems. Although the DVD Logical Unit will be capable of reading the older CD media, it will support the same commands as the CD-ROM Logical Unit today.

There will be some simplifications to the command set supported. Commands that were necessary only for legacy support for the existing CD-ROM drivers have been removed.

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

A DVD Logical Unit will look different to the Host, depending on the type of media that is currently being used. The host system will now need to deal with a Logical Unit that changes the commands that are possible, based on the type of media that is currently in the Logical Unit. This type of operation will be handled via the use of Features and Profiles.

This new concept will allow the Logical Units to implement various capabilities. The Host will detect and configure the Logical Unit given the various capabilities that are possible.

1.11. DVD Media Organization

The DVD media is currently specified by the Physical sections of the DVD Books.

- DVD Media can contain information on one side (Single Sided) or on both sides (Double Sided).
- DVD-ROM disc has two types of layer structure, single layer and double layer.
- Each Layer on either side contains a spiral track. This track contains a Lead-in, Data Area, an optional Middle Area and a Lead-out.
- Double layer discs have two types of track path, Parallel Track Path and Opposite Track Path. In the case of the Parallel Track Path, there each layer is treated separately.
- The user Sector size is 2048 bytes only.
- One ECC-BLOCK, having 37856 bytes, consists of 16 sectors.
- There is no concept of TOC or Sub-channel data.
- Only general data is defined. There is no concept of AUDIO or VIDEO data.
- Addressing from the Host is LBA (Logical Block Address) only.
- Information concerning error correction that has been performed is not usually returned to the Host.
- Some data on DVD Media is used only inside of the DVD Logical Unit and is not transferred to the Host Computer.
- This is due in part because the Physical Addresses (PSN) that the DVD uses is not allowed across the Interface.
- The Host READ & WRITE unit is 2 Kilobytes (2048 Bytes).

1.12. DVD Specifications

Table 13 - General Parameters of DVD Discs

Specification	DVD-ROM Single Layer	DVD-ROM Double Layeer	DVD-R	DVD-RAM
User Capacity (120 mm disc)	4.70 Gbytes	8.45 Gbytes	3.95 Gbytes	2.6 Gbytes
User Capacity (80 mm disc)	1.46 Gbytes	2.66 Gbytes	1.23 Gbytes	
Wave length for read	635/650 nm			
Wave length for write	n.a.		635 nm	650 nm
NA of Objective Lens	0.60			
Data bit length	0.267 um	0.293 um	0.293 um	0.409 to 0.435 um
Channel bit length	0.133 um	0.147 um	0.147 um	0.205 to 0.218 um
Min Pit/Mark length	0.400 um	0.440 um	0.440 um	0.614 to 0.653 um
Max Pit/Mark length	1.866 um	2.054 um	2.054 um	2.863 to 3.045 um
Track Pitch	0.74 um		0.80 um	0.74 um
User data per sector	2048 bytes			
Error correction code	RS (208,192,17) x RS(182,172,11)			
ECC Constraint Length	16 sectors			
Correctable burst error length	6.0 mm	6.5 mm	6.5 mm	9.2 mm
Scan velocity (Ref.)	3.49 m/s	3.84 m/s	3.84 m/s	5.96 to 6.35 m/s
Channel bit rate	26.16 Mbps			
User data bit rate	11.08 Mbps			

The ranged values for DVD-RAM reflect its Zoned CLV format.

1.12.1. Track Structure

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

ED NOTE: the concept of "tracks" in CD and DVD world are different and needs to be cleared up.

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

ED NOTE: change "Physical Sector Number" to "Physical Block Number."

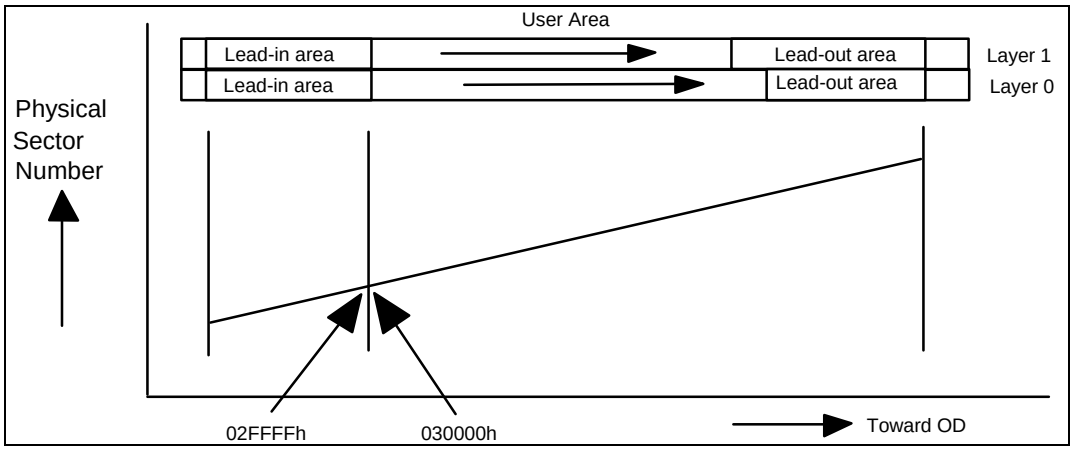


Figure 9 - Parallel Track Path Description

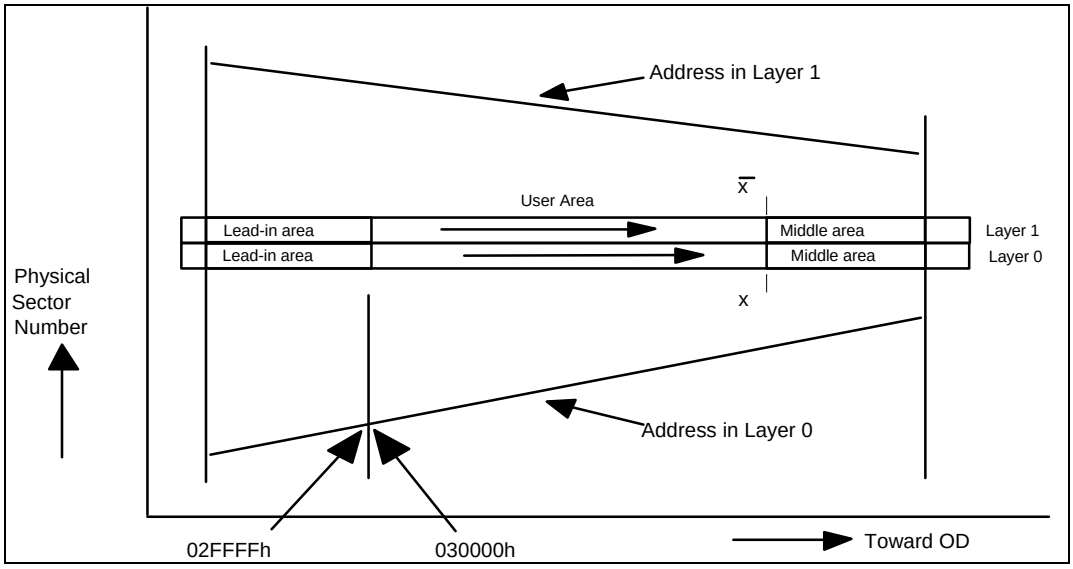


Figure 10 - Opposite Track Path Description

1.12.2. Header Layout

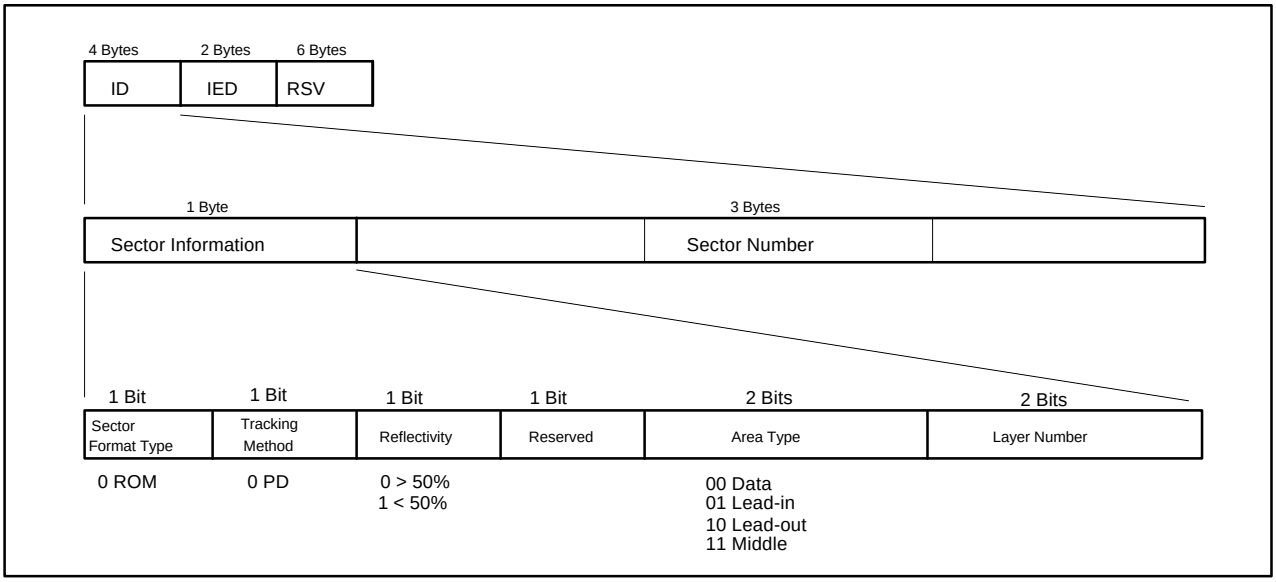


Figure 11 - Header Layout

1.12.3. Lead-in Contents

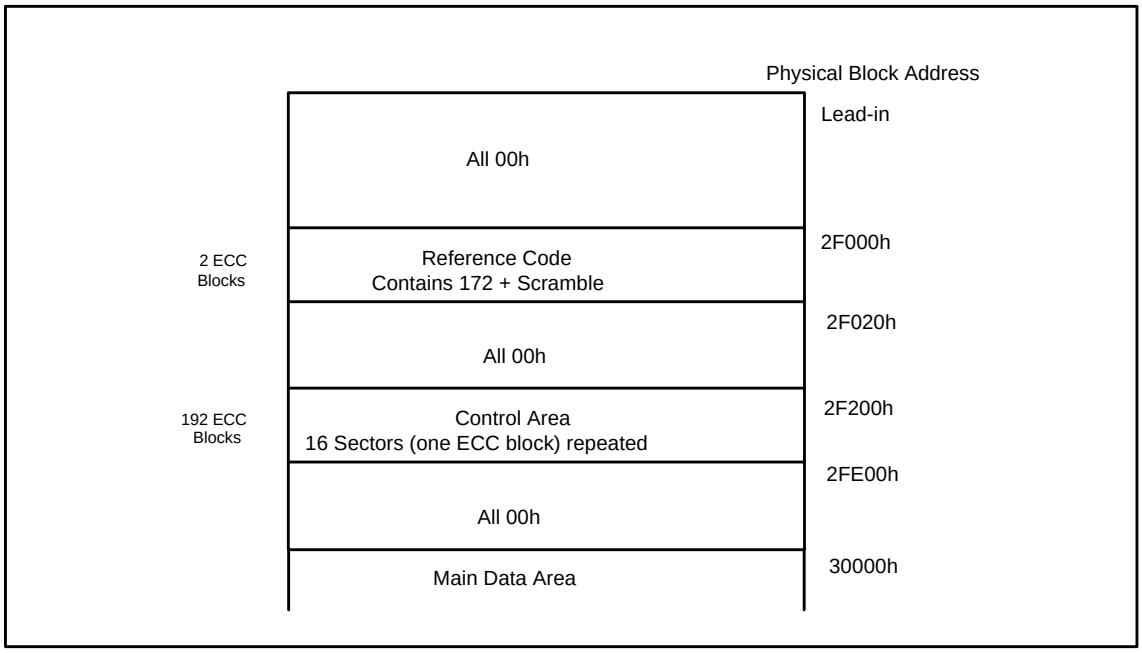


Figure 12 - Lead-in Contents

1.12.4. Sector Layout

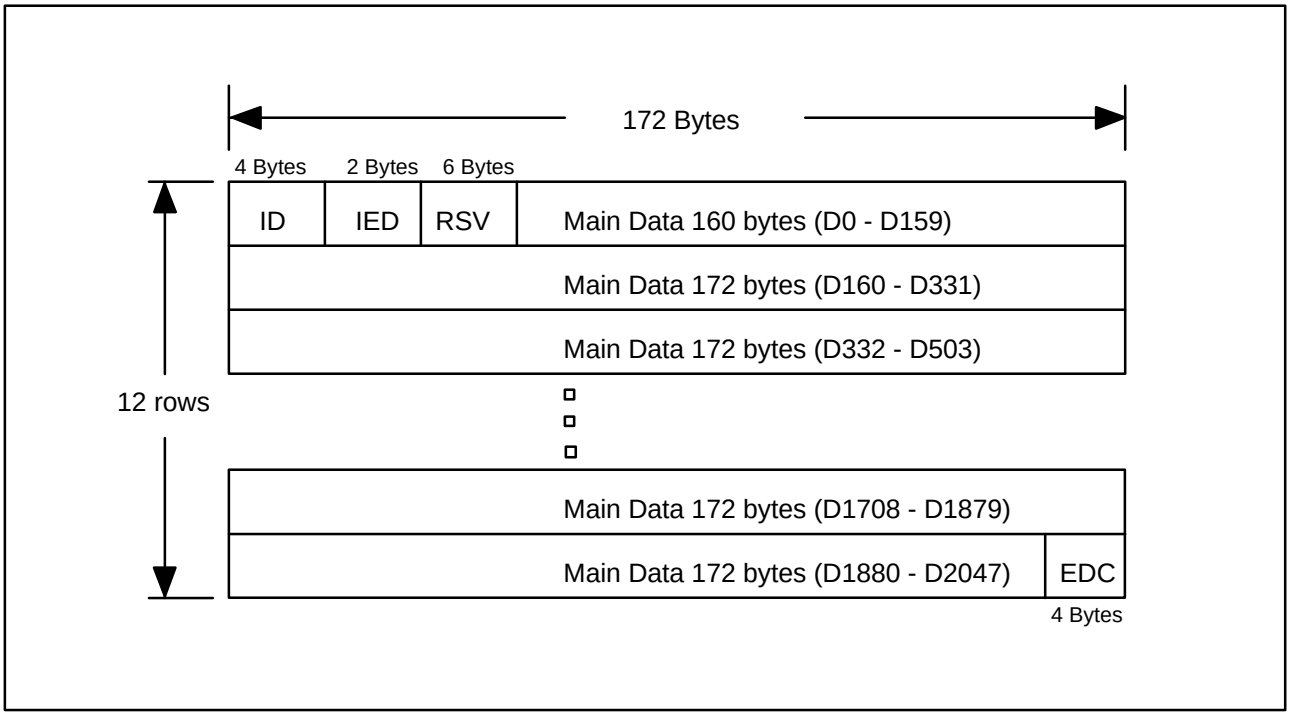


Figure 13 - Sector Layout

1.12.5. Control Area Data

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

Table 14- Control Area Definition

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

1.12.6. Control Area Sector Descriptions

Table 15 - Physical Format Definition

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

Table 16 - Recorded Area Allocation Definition

Byte	Single Layer	Parallel Track Path	Opposite Track Path
4	00h	00h	00g
5	Starting sector number of main data (030000h)	Starting sector number of main data (030000h)	Starting sector number of main data (030000h)
6			
7			
8	00h	00h	00h
9	End sector of main data	End sector of main data	End sector of main data
10			
11			
12	00h	00h	00h
13	000000h	000000h	End sector number in Layer 0
14			
15			

1.12.7. DVD Ready Condition/Not Ready Condition

The ready condition occurs after a disc is inserted and the Logical Unit has performed its initialization tasks. These may include reading the lead-in information from the media. A check condition status will be returned for the not ready condition only for commands that require or imply a disc access.

A not ready condition may occur for the following reasons:

1. There is no disc mounted, See “Removable medium” on page 52.
2. The Logical Unit is unable to load or unload the disc.

The Logical Unit shall spin up and make the disc ready for media accesses when a new disc is detected. Any media access that occurs when the Logical Unit is not spinning shall spin the Logical Unit up and not generate an error.

1.12.8. DVD Copy Protection

The DVD Copy Management is made up of two basic concepts. The first is to scramble the content of the data such that if it is available for copy operations, it would still be unusable. The data must be unscrambled before it can be used. The protection comes from an “Authentication” process that must exchange protected information (Keys) before the unscramble operation would be allowed. The second is to limit the playback of content to specific regions of the world. Both the scrambled content and regionalization are used only for discs that make use of the Content Scramble System (CSS).

1.12.9. Management of Protected Data

Any read by the host to a disc that contains scrambled content and a sector with a Title Key present, when the Authentication Success Flag (ASF) is set to zero shall be blocked. The command shall be terminated with a CHECK CONDITION and the Sense Key shall be set to 05 ILLEGAL COMMAND and the Sense Code and Qualifier set to 6Fh/03h READ WITHOUT VALID AUTHENTICATION.

1.12.10. Playback limitations by World Region

As part of the Authentication process the Region Code of the Media and that of the LOGICAL UNIT are checked by the LOGICAL UNIT. This process is performed during the Authentication Process. If the Regions allowed by the Media do not match the region of the LOGICAL UNIT, the authentication process will be terminated. The actual check of the region information is performed before the READ DVD STRUCTURE Command with Format = 02h is completed. When the command is received by the Logical Unit to return a Disc Key and the Region is not allowed the command shall be terminated with a CHECK CONDITION. The Sense Key shall be set to 05 ILLEGAL COMMAND and the Sense Code and Qualifier set to 6Fh/ 04h MEDIA REGION CODE IS MISMATCH TO LOGICAL UNIT REGION.

1.12.11. Authentication Process

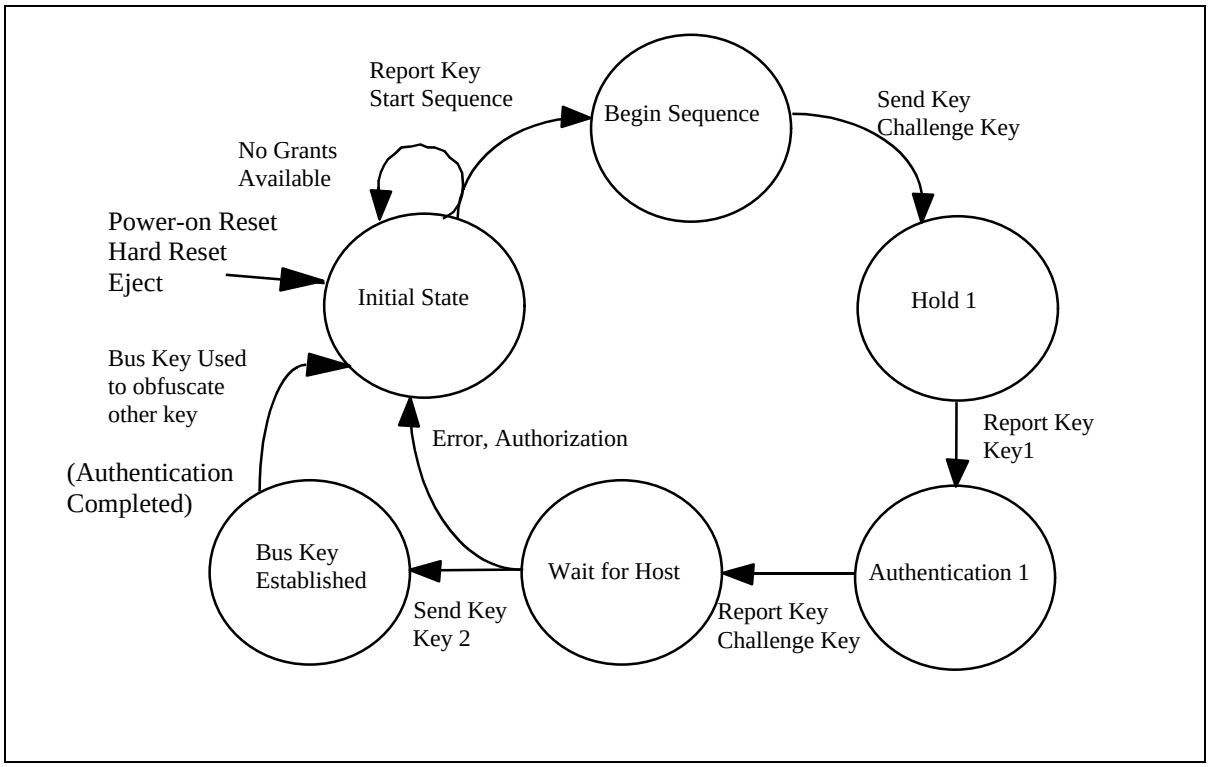


Figure 14 - Device Key Exchange and Authentication State Diagram

Note: The Initiator must reset a hung authentication process in the drive by invalidating the corresponding AGID. The Initiator may detect lost grants by refusal of the Start Authentication Process operation.

Figure 11 - Authentication Flag Sequence

1.13. Changer Model

The changer is a feature of a C/DVD device. It shall support two (2) additional commands, MECHANISM STATUS (BDh) and LOAD/UNLOAD CD (A6h).

A changer device provides a storage area for more than one CD Disc. This storage area contains multiple areas called slots. Each slot can contain just one disc. Once a disc has been placed into a given slot, it becomes locked in that position. This standard provides no capability to move a disc from one slot to another. Thus when a Disc has been moved from a given slot into the playing position, it can only be moved back into the slot that it came from. This shall be followed even if power is lost while a Disc is in the playing position or while it was being moved.

There are two basic types of changer mechanisms, one that has individually addressable eject and load capability and another that uses a cartridge to hold the discs. In the former, individual discs can be changed, while in the latter all the stored discs must be changed at one time.

Any time a disc or cartridge is removed or installed from the changer, the device shall generate an Unit Attention Condition. After the initiator detects the unit attention on a known changer device, the initiator may issue a MECHANISM STATUS Command. This will provide the initiator with information on what disc is present or was changed.

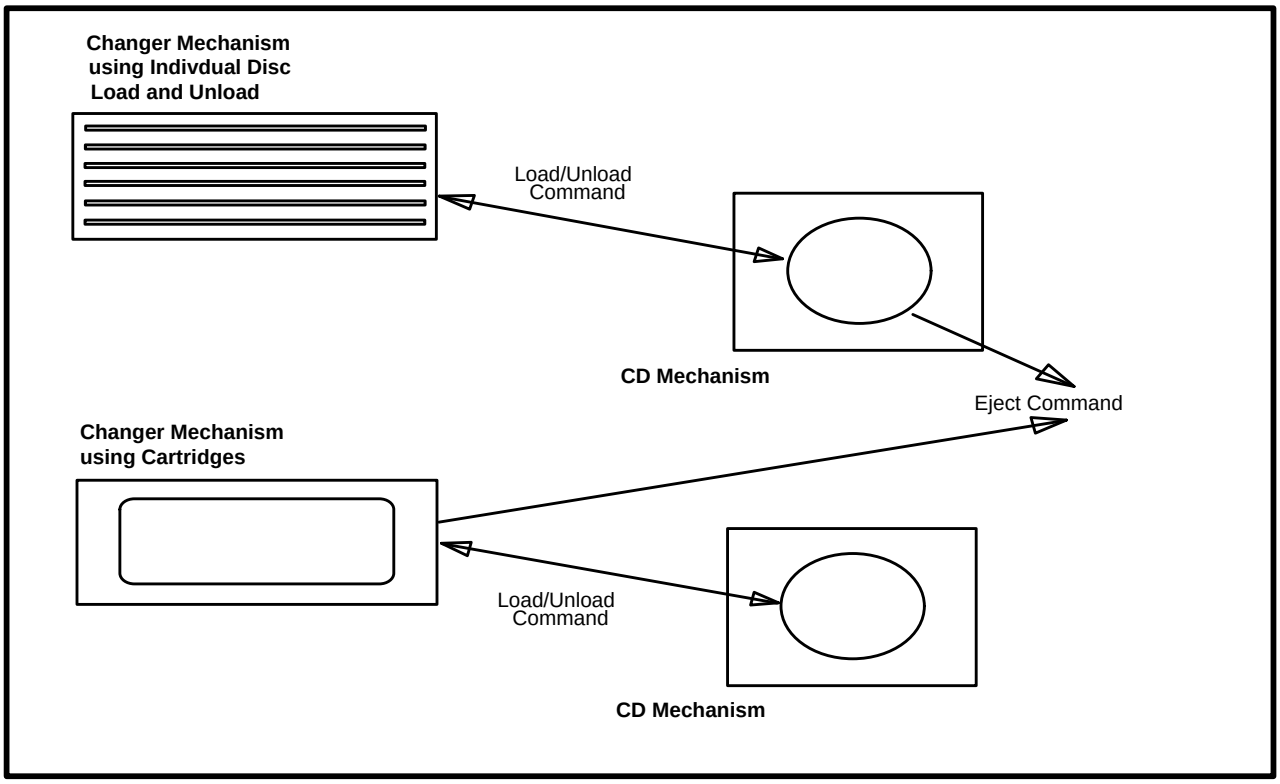


Figure 15 - Media Changer Mechanism Model

1.13.1. Side definition

As part of the DVD specifications, there is a type of media supported that includes data on more than one side of the Disc. This will allow devices that can automatically change sides to come into existence. Thus for C/DVD Devices, there is an optional capability to select each side of the Disc. Although this would not normally be thought of as a changer type of operation, the two sides to the Disc are independent and changer like functions are a good match for selecting sides. When the Logical Unit supports this functionality, each physical slot will have two logical slots. For example referencing slot 0 would be one side of the Disc, and slot 1 would then be the other side.

There are two fundamental techniques used to select each side of DVD media. The first is the most space efficient. It simply moved the Pick Up (laser unit used to read the disc) to the other side. This does add complexity to the laser

mechanism to be able to position it on either the bottom or top of the media. The second approach is to actually flip the media over. This type does not exist today, although it is possible. This type of Logical Unit will pose some problems making sure that the correct side is selected after a power on or hard reset condition. Some way to remember which side was selected when the power was removed would be needed.

For a Logical Unit that supports changing sides (see section 9.1.8.7, "C/DVD Capabilities and Mechanical Status Page", on page 126, “Side Change Capable”), the number of Slots reported shall be even, and every other slot shall be an alternating side.

1.13.1.1. Side Changing Only Logical Unit

There can exist a Logical Unit that is capable of changing the side of the Disc, but does not have separate Slots from the playing position. This type of Logical Unit reports that it has a Mechanism type that is not a changer, but also reports Side Change Capable. This style of Logical Unit will still make use of the LOAD/UNLOAD C/DVD command to change the currently selected side. This style Logical Unit shall report two slots available (see section Table 52 -, "Mechanism Status Header", on page 104).

A side effect of a Logical Unit that only has the capability to change sides is that when unloading a Disc does not actually perform any action. This will appear to the host as a Logical Unit with Delayed Load type of operation (See section 6.5, "Delayed Disc load operation", on page 70).

> Note that a DVD Logical Unit that supports changing sides will not be able to report if there is actually data on both sides until each side has been read.

1.13.1.2. Attention Conditions for Sided Discs

Devices that support changing sides shall only report Unit Attention Conditions for changes that involve movement of a Disc in/out of the Logical Unit. Changes of side shall not generate Unit Attention Conditions.

1.13.1.3. Error Conditions for Sided Discs

Devices that support changing sides of a Disc shall use the NO REFERENCE POSITION FOUND, Sense Key 02h NOT READY, ASC/ASCQ 06/00 to report when the currently selected side does not contain valid data.

1.13.1.4. Initialization

The Changer shall perform its initialization routine at power on or receipt of a hardware reset from the initiator.

“Initializing Changer” is a process that refers to gathering the information that is necessary to respond to the MECHANISM STATUS Command. If a changer is in the process of initializing when it receives a MECHANISM STATUS Command, it will respond immediately and provide no slot table information (Only the Header).

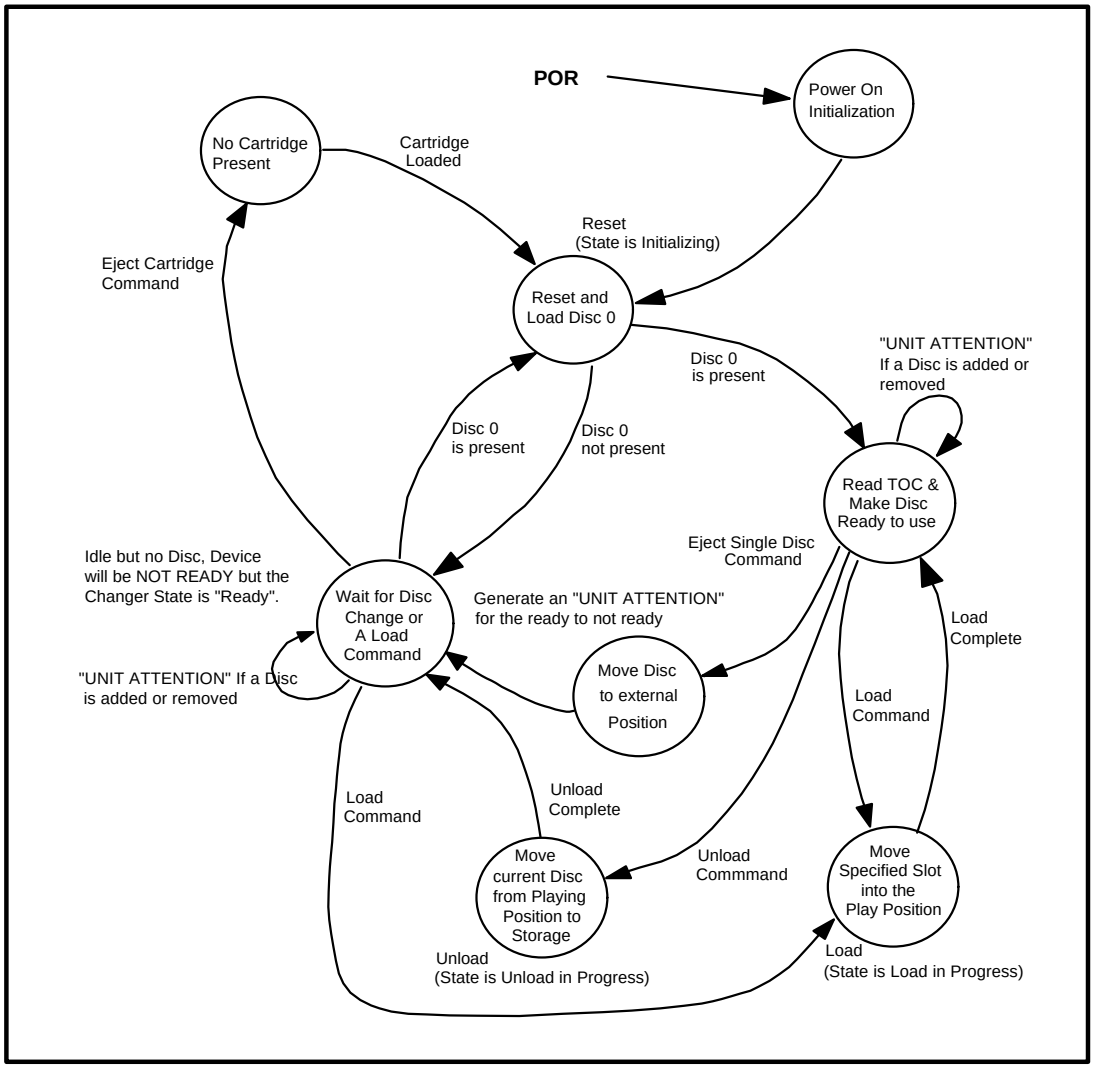


Figure 16 - Changer State Diagram

1.13.2. Changer Addressing

Several Changer specific commands use addresses called “Slots.”

If any commands related to Changer operations are implemented, then all the Changer commands shall be implemented. To determine if a drive is a changer type device, the Loading Mechanism Type field in the Capabilities page will contain one of the two changer type code (See **Error! Reference source not found.**) for individual disc or cartridge implementations.

1.13.3. Automatic Load and Unload Operations

After initialization is complete the changer shall have Disc 0 loaded into the play position. This enables drivers which are not changer aware to work with a changer device as if it were a normal single CD device. This also ensures compatibility with a Bootable CD. In support of this goal the changer shall also load and unload (Eject) default Disc 0 if the changer

supports loading and unloading (Ejecting) individual Discs unless otherwise commanded by the use of one of the changer specific Load/Unload commands.

When a LOAD Command is received and a Disc is present in the Playing position, it shall be unloaded automatically before the specified Load operation is performed.

1.13.4. Delayed Disc load operation

CD Changer Devices may either move a disc into the playing position immediately upon receipt of a LOAD command, or delay the loading of the disc until a media access command is received. It is recommended that the device not load discs into the playing position until data from a disc that is not cached is requested from the initiator.

Note that Initiator drivers should expect to encounter load mechanism delays on media accesses in addition to the spin up and seek delays normally introduced with these commands.

If the device supports delayed loading and the selected disc is not in the play position, then the commands listed in Table 17 shall move the selected disc into the play position when data that has not been cached has been requested by the initiator:

Table 17 - Commands that may cause delayed loads to occur

Command
Play Audio (10)
Play Audio MSF
Play CD
Read (10)
Read (12)
Read CD
Read CD MSF
Read CD-ROM Capacity
Read Header
Read Sub-Channel
Read TOC
Scan

If the device supports delayed loading and the selected disc is not in the play position, then the following commands shall load the selected disc into the play position before execution of the command. (See Table 18)

Table 18 - Commands that will cause delayed loads to occur

Command
Seek
Start/Stop Unit (LoEj=1)

If the device supports delayed loading and the selected disc is not in the play position, then the following commands shall not move the selected disc into the play position. (See Table 19)

Table 19 - Commands that should not cause delayed loads to occur

Command
Stop Play/Scan
Start/Stop Unit (LoEj=0)
Test Unit Ready
Inquiry
Mechanism Status
Mode Select
Mode Sense
Prevent/Allow Medium Removal
Request Sense
Set CD Speed

1.13.5. Prevent / Allow processing

There are two techniques for Prevent / Allow: either all the discs shall be prevented from being ejected by the user or each disc individually shall be prevented. If the device reports support for Software Slot Selection, then each slot shall be individually controlled by the Prevent / Allow command. Note that changer devices that use a Cartridge and not individually controlled slots should not report the Software Slot Selection capability.

1.13.6. Error Reporting for Changers

If any of the following conditions occur during the execution of a command, the Changer shall return CHECK CONDITION status. The appropriate sense key and additional sense code shall be set. Table 20 below list some error conditions and the applicable sense keys. The list does not provide an exhaustive enumeration of all conditions that may cause the CHECK CONDITION status.

Table 20 - Error Conditions and Sense Keys for Changer Mechanisms

Condition	Sense Key
Invalid Slot Number	ILLEGAL REQUEST
Unsupported option requested	ILLEGAL REQUEST
Load or Unload to invalid slot or no Disc in source location	ILLEGAL REQUEST
CD-ROM Drive reset or medium change since last command	UNIT ATTENTION
Self diagnostic failed	HARDWARE ERROR

In the case of an invalid Slot number, the sense data information field shall be set to the Slot number of the first invalid address.

Attempts to eject a Disc if the changer type is cartridge and there is a Disc in the playing position shall be rejected with a Sense Key 05, (ILLEGAL REQUEST) Sense Code 01 (MECHANICAL POSITIONING OR CHANGER ERROR).