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5074/8494 Disk Subsystem

Programming Reference Manual

December 1987

Printed in U S America
UP-11627

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PUBLICATIONS RELEASE

General

5074/8494 Disk Subsystem

Programming Reference Manual

UP-11627

This Library Memo announces the release of the *5074/8494 Disk Subsystem Programming Reference Manual*, UP-11627.

The 5074/8494 Disk Subsystem is a single cabinet disk subsystem consisting of one disk control unit and two 308 million byte disk drives. It can be expanded to two disk control units and eight disk drives in one cabinet.

The 5074/8494 disk subsystem can operate on either a block multiplexer channel (5074-00) or a System 80 10/20 selector channel (5074-01).

This manual is intended as a reference for experienced programmers and systems analysts.

Copies of this manual may be ordered from your Unisys representative.

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About This Manual

Purpose

This manual provides a detailed reference to the hardware functions and characteristics that affect the programming of the 5074/8494 Disk Subsystem.

Scope

This manual describes the channel commands and gives programming information for the disk subsystem. It describes in detail the subsystem components and operations, channel I/O operations, channel commands, status information, sense information, and hardware error detection and recovery procedures.

Audience

This manual is primarily a reference for experienced systems analysts and systems programmers.

Prerequisites

The audience for this manual needs experience on the Unisys Series 1100 Executive system and Unisys disk subsystems.

How To Use This Document

This manual is a reference manual that can be used with the ***OS 1100 Exec System Software Executive Requests Programming Reference Manual,*** UP-4144, and the ***OS 1100 Exec System Software Operations Reference Manual,*** UP-7928.

Organization

This manual contains seven sections, an appendix, a glossary, and an index.

- **Section 1. Introduction**

  This section describes the subsystem hardware components, characteristics, features, and configurations.

- **Section 2. Subsystem Operations**

  This section describes the following subsystem operations.

  - Control unit selection
  - Control unit addressing
  - Disk drive addressing
  - Track format

- **Section 3. Channel I/O Operations**

  This section describes the channel interface operations, including I/O interface lines and interface signal sequences.

- **Section 4. Channel Command Description**

  This section describes the channel command set for both the block multiplexer channel and the System 80 Models 10/20 selector channel.

- **Section 5. Status Information**

  This section describes the subsystem status formats.

- **Section 6. Sense Information and Error Logging**

  This section describes the subsystem sense byte formats and the error logging operation.

- **Section 7. Hardware Error Detection and Recovery Procedures**

  This section describes the subsystem error recovery procedures.

- **Appendix A. Error Condition and System Recovery Action Summary**

  This appendix summarizes the error condition information and the system recovery actions from Section 7.

Related Product Information

- ***OS 1100 Exec System Software Executive Requests Programming Reference Manual,*** **UP-4144**

  This manual describes Executive Requests (ERs) in the areas of Activity and Program Control, Symbiont Control, I/O Control, File Control, and Communications Control. It also gives a general overview of the operating system.

- ***OS 1100 Exec System Software Operations Reference Manual,*** **UP-7928**

  This manual discusses operation concepts and operator responsibilities, and lists keyin formats, system messages, and error codes.

- ***5074/8494 Disk Subsystem Operations Guide,*** **UP-11626**

  This manual provides information for an operator to power up the 5074/8494 Disk Subsystem.

Refer to the ***Series 1100 and 2200/200 Systems Product Documentation Library Directory,*** **UP-7893 Rev. 1** for the current applicable version of these manuals.

Contents

2. Subsystem Operations

3. Channel Input/Output Operations

4. Channel Command Description

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Tables

1. Introduction

This section describes the subsystem hardware components, characteristics, features, and configurations.

1.1. Components and Features

The 5074/8494 disk subsystem (Figure 1-1) can operate on either a block multiplexer channel (5074-00) or a System 80 10/20 selector channel (5074-01). It is a freestanding subsystem with the following components and features. Table 1-1 provides a summary of the subsystem's major components and features.

Components

The disk subsystem includes a disk control unit and disk drives. Up to two disk control units and eight disk drives can be in the freestanding cabinet. The disk control unit contains a 32K byte buffer to smooth variations in data transfer. The disk control unit can have one or two (optional feature) host I/O channel interfaces.

The disk drives have a formatted data capacity of 308 million bytes and an average access time of 22.6 milliseconds. An optional dual-access feature is available for connecting the disk drives to a second disk control unit.

Configurations

A minimum subsystem consists of a single cabinet that contains a disk control unit and two disk drives. A maximum configuration consists of a single cabinet, two disk control units, and eight disk drives. Two disk drives is the minimum required when expanding the number of disk drives in the subsystem.

Storage Capacity

The minimum subsystem (two disk drives) provides 606 million bytes of data storage on the block multiplexer channel subsystem and 616 million bytes of data storage on the selector channel subsystem. The maximum subsystem (eight disk drives) provides 2.42 billion bytes of data storage on the block multiplexer channel subsystem and 2.46 billion bytes of data storage on the selector channel subsystem.

Table 1-1. Subsystem Components and Features

Name	Description
Disk Subsystem Cabinet	The disk subsystem cabinet contains a disk control unit with a 32K byte buffer for single access/single I/O channel, power supplies, and power control. This cabinet can contain one disk control unit expansion feature, up to eight disk drives, and a remote power-on feature (used on System 80 only). The disk subsystem cabinet is available for use on a block multiplexer channel or a System 80 selector channel.
Disk Control Unit Expansion Feature	Adds a second disk control unit to the subsystem cabinet for dual access. This feature contains a disk control unit with a 32K byte buffer, power supply, and interfaces for up to eight disk drives.
Disk Drive Expansion Feature	Disk drive expansion requires two disk drive expansion features.
Remote Power-on Feature (System 80 only)	Provides two remote power interfaces for connection to one or two host systems.
Channel Expansion Feature	Provides a second channel interface for each disk control unit.

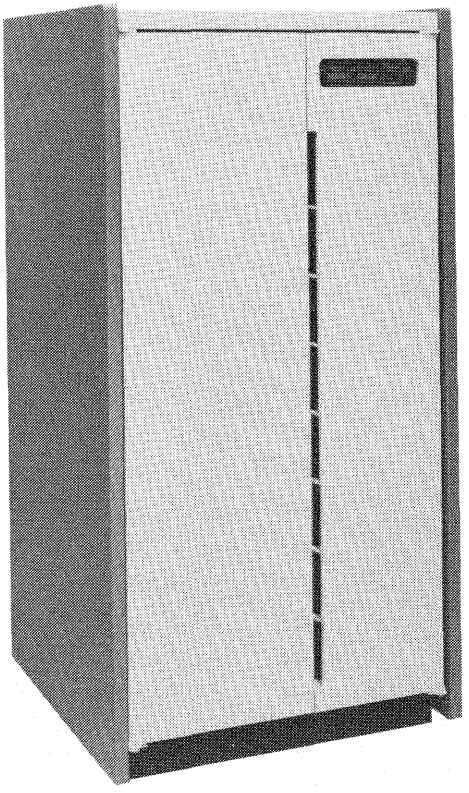


Figure 1-1. 5074/8494 Disk Subsystem

1.2. Performance Characteristics

Table 1-2 summarizes the subsystem performance characteristics.

Table 1-2. Subsystem Performance Characteristics

Type	Parameter	Block Multiplexer Channel	Selector Channel
Format	Bytes/track	30,240	30,240
	Bytes/sector	504	512 (Two 256 byte sectors)
	Sectors/track	50	100
	Primary sectors/cylinder	495	990
	Alternate sectors/cylinder	5	10
Drive Specifications	Primary cylinders	1215	1215
	Customer engineer cylinders	2	2
	Sectors/drive	608,500	1,217,000
	Primary Sectors	601,425	1,202,850
	Primary formatted storage capacity (bytes)	303,118,200 (67,359,600 36-bit words)	307,929,600
Head Positioning Time	Minimum seek (1 cylinder)	5 ms*	5 ms*
	Average seek	14.33 ms	14.33 ms
	Maximum seek	35 ms	35 ms
Rotational Latency	Average	8.33 ms	8.33 ms
	Maximum	16.8 ms	16.8 ms
Transfer Rate	Channel data transfer rate #	3 MB/sec.**	3 MB/sec.**
	Bit data transfer to drive	1.82 MB/sec.	1.82 MB/sec.

ms - milliseconds
**MB/sec - million bytes per second
#Data streaming mode

1.3. Subsystem Cabinet

The disk subsystem cabinet can contain up to two disk control units and up to eight disk drives. It also contains power supplies, a power control, and for the System 80 only an optional remote power on feature. The remote power on feature controls power to the cabinet from the host system.

A circuit breaker located at the rear of the disk subsystem cabinet provides control of the main AC input power.

1.4. Disk Control Unit

This subsection describes the disk control unit operational features.

Operation

The disk control unit operates at 3 million bytes per second in the data streaming mode, and at 1.82 million bytes per second in the interlock mode on a block multiplexer or selector channel.

Buffering

The disk control unit buffer synchronizes the difference in transfer rates between the disk drive and the I/O channel. The disk control unit transfers 64K byte blocks of data without overrun.

Features

The disk control unit significant features are:

- Rotational position sensing
- 32K byte speed matching buffer
- Error recovery operation
- Retry hard errors
- Power on confidence (POC) test
- Two channel attachments per disk control unit
- Parity protection on all data paths
- Parity or check characters for all memory devices

Error Checking

The disk control unit performs internal tests to check all hardware functions. The subsystem performs these tests automatically when powering up the subsystem. The operator can perform these tests from the operator's control panel.

1.5. Disk Drives

The disk drive is a random-access, fixed-media disk drive. It consists of a sealed module assembly and the required support electronics. These features provide write/read, servo/motor control, and interface operations.

Track Format

The disk drive has 30,240 bytes per track divided into 50 sectors for the block multiplexer channel, and 100 sectors for the selector channel. Each sector contains 603 bytes and a 90-byte end-of-track gap.

Reliability

The disk drive has the following reliability features:

- A dedicated head landing zone outside of the data recording area
- A sealed module assembly with its own closed loop air filtration system that contains the disk drive heads, media, and actuator

Availability

The availability features for the disk drive include:

- Dual-access
- High-performance access to data at an average rate of 22.66 milliseconds
- Automatic recovery without operator intervention after AC power loss

Maintainability

The maintainability features for the disk drive include:

- No required scheduled maintenance other than cleaning or replacement of air filters
- Built-in self test during the power up sequence

- Offline diagnostics run from a Status/Control Panel
- Automatic carriage lock/unlock on power down/up

1.6. Configurations

The 5074/8494 Disk Subsystem can be configured as a single-access subsystem or as a dual-access subsystem. Either configuration is available for use on a block multiplexer channel or a System 80 selector channel.

Single-Access Disk Subsystem

A single-access configuration (see Figure 1-2) provides the host with one access path to any disk drive in the subsystem. This configuration consists of one disk control unit and two to eight disk drives.

Dual-Access Disk Subsystem

The dual-access configuration (see Figure 1-3) has two access paths to each disk drive from the host system. This provides simultaneous operation on any two disk drives in the subsystem. A minimum configuration of a dual-access 5074/8494 Disk Subsystem consists of two disk control units and two to eight disk drives in one subsystem cabinet.

Additional Features

Additional expansion features include:

- Remote Power-On Feature (Used on System 80 only)

  This feature provides two Federal Information Processing Standard (FIPS) 61 remote power interfaces that connect to one or two host systems.

- Channel Expansion

  This feature provides attachment to one or two disk control units to a second I/O channel.

- Channel Port Expander

  This feature provides two additional channel ports to one disk control unit. Only one feature can be used on a disk control unit.

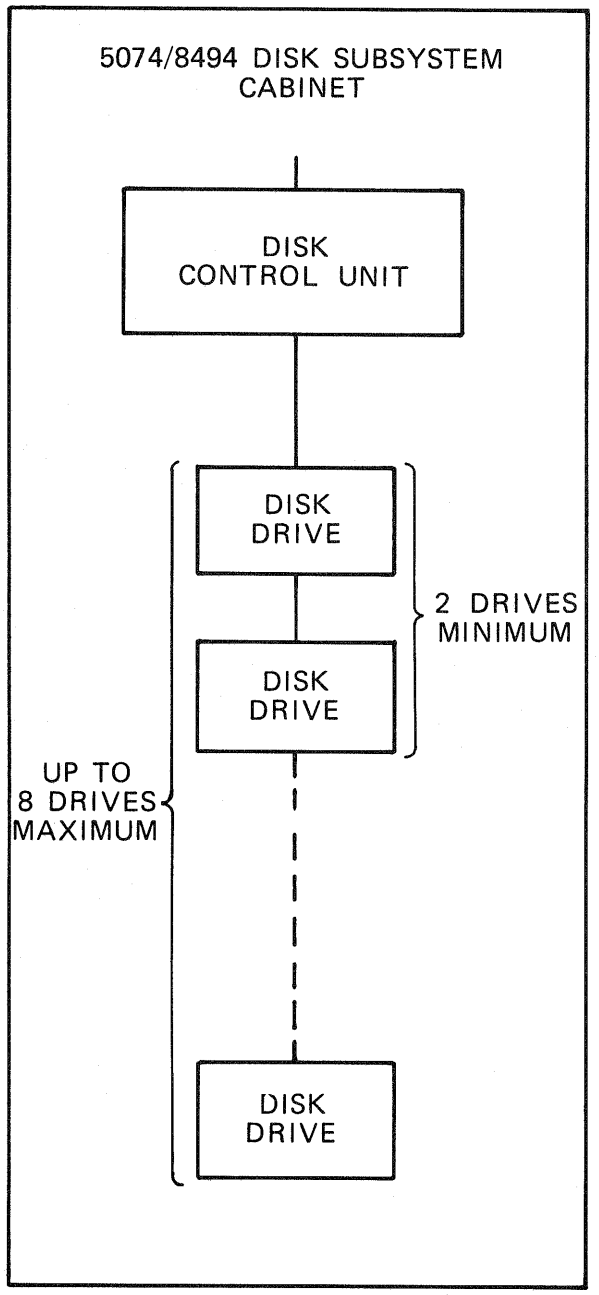


Figure 1-2. Single-Access 5074/8494 Disk Subsystem Configuration

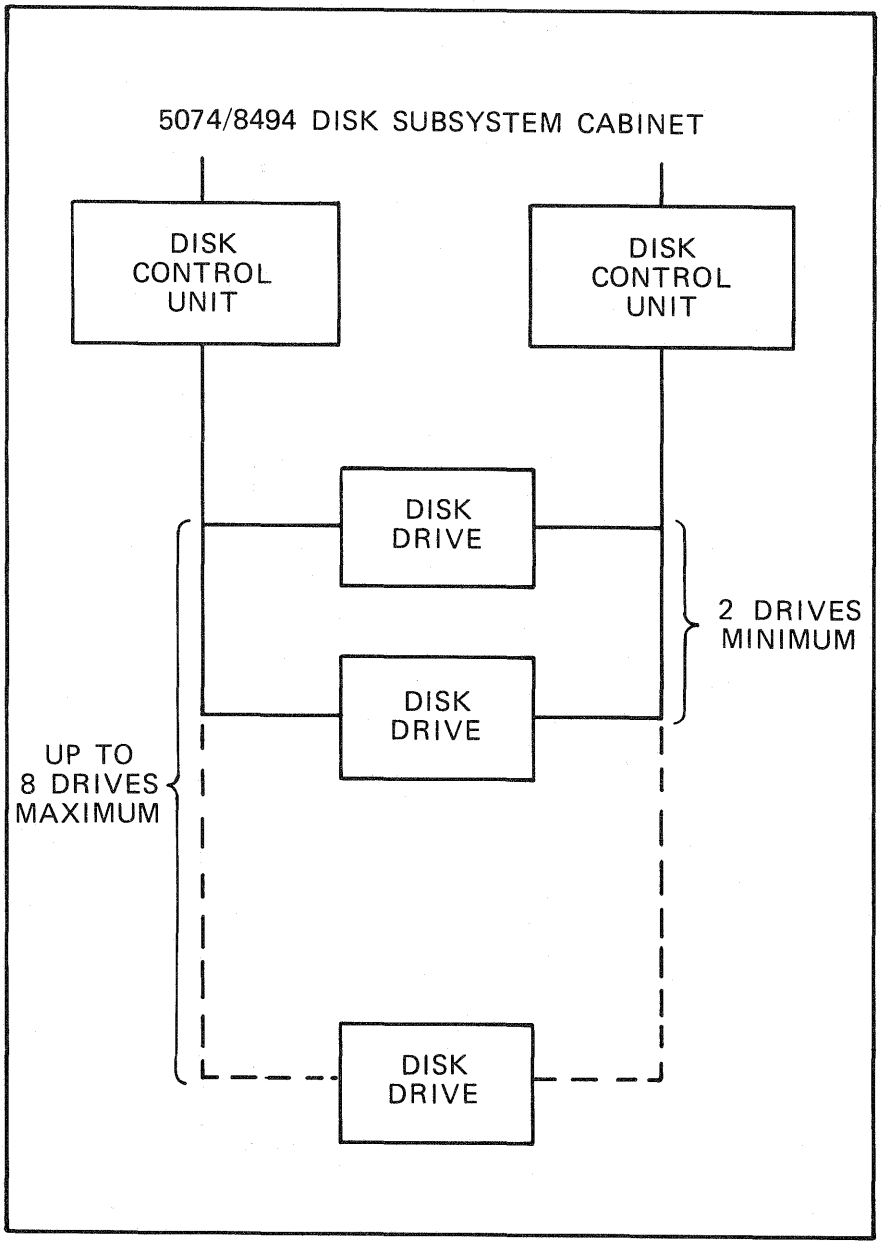


Figure 1-3. Dual-Access 5074/8494 Disk Subsystem Configuration

2. Subsystem Operations

This section describes control unit selection and addressing, disk drive addressing, and the track format.

2.1. Interface Types and Features

The 5074/8494 disk subsystem is a fixed-block rotating mass storage subsystem. The subsystem can attach to a block multiplexer I/O channel or a System 80 10/20 selector I/O channel. The disk subsystem uses the Federal Information Processing Standards (FIPS) 60-2 I/O channel interface. The FIPS interface is the communication link between the host I/O channel and the disk subsystem. The host system performs the following functions through the I/O channel:

- Addresses the subsystem and disk drives
- Transfers the channel commands (see Section 4) to the subsystem
- Reads and writes data from and to the subsystem
- Receives the status indications (see Section 5) and sense information (see Section 6) from the subsystem

The subsystem consists of one or two disk control units connected to one or two I/O channels. The disk control unit can control two to eight disk drives.

2.2. Control Unit Selection

More than one I/O channel interface can access each disk control unit. If channel *x* selects a control unit that is already in use by channel *y*, the control unit presents busy status to channel *x*. If both channels select the same control unit, it may delay the selection sequence on one channel until the requirements of the other channel are determined. Then, the system either continues the selection sequence or indicates busy status on the channel that was delayed.

2.3. Control Unit Addressing

The factory assigns an address to each control unit with backpanel jumpers. A customer engineer can change the address at the customer sites. The addresses follow.

For block multiplexer channel systems:

- First disk control unit - 0, 2, 4, 6
- Second disk control unit - 1, 3, 5, 7

For System 80 10/20 selector channel systems:

- First disk control unit - 8, A, C, E
- Second disk control unit - 9, B, D, F

2.4. Disk Drive Addressing

The factory sets the disk drive addresses. These addresses are from the top to the bottom of the cabinet, 0 through 7. An operator or a customer engineer can change the addresses by pressing the ADDR (logical address) switch on the disk drive operator's panel until the desired address is reached.

2.5. Track Format

Sectors make up the format of each track. Each sector is 603 bytes long, and there are a total of 50 sectors in each track. A one-to-two correspondence exists between sectors for block multiplexer channel systems and System 80 selector channels. Physical sector marks define the start of each sector. In the description that follows, the term *sector* refers to a logically addressable element starting at zero and ending at the maximum for the entire disk. The term *sector* refers to the physical partitioning of a track starting at sector zero and ending at sector 49.

Disk Capacity

The disk drive has 1217 cylinders and 10 heads (cylinders 1215 and 1216 are customer engineer cylinders). The following disk capacities are based on 512 byte data fields.

Sectors per track	50/100*
Sectors per cylinder	500/1000*
Alternate sectors per cylinder	5
Sectors per device	608,500/1,217,000*
Primary sectors per device	601,425/1,202,850*
Formatted storage capacity in bytes	303,118,200/307,929,600*

* *Items marked with an asterisk are capacities for System 80 10/20 systems only.*

Sector Definition

A sector format contains the following fields:

- Three gap fields
- An identification (ID) field
- Two error correction code (ECC) fields
- A data field

Each sector begins and ends with a sector (index) mark and is 603 bytes long. Gaps separate the ID field and data field. An ECC field follows each of these fields. The sector format is:

Sector Format - 603 bytes

Gap 1 30 bytes	ID 6 bytes	ECC 4 bytes	Gap 2 34 bytes	Data 512 bytes	ECC 7 bytes	Gap X 10 bytes

Gap Fields

The gap fields allow the control unit time to set up the hardware and microcode parameters. These parameters are necessary for system operatation on the next ID or data field.

Gap 1 is a variable length field (30 bytes maximum). The length depends on whether the ID field that follows is to be moved to avoid a track defect. The Gap 1 format is:

Gap 1 Format - 30 bytes

Zeros 2 bytes	Zeros A 15 bytes*	Zeros 12 bytes	Sync 1 byte

Index Mark or Sector Mark

*These numbers are for ID in normal position.

For displaced ID: A is 113, Gap 1 is 158
For extended displacement: A is 271, Gap 1 is 286

Gap 2 contains a midgap write splice (write turn on or turn off point) to update data field write operations that follow. The Gap 2 format is:

Gap 2 Format - 34 bytes

Zeros 2 bytes	Zeros 17 bytes	Zeros 2 bytes	Zeros 12 bytes	Sync 1 byte

Gap X is for end of sector tolerance. The Gap X format is:

Gap X Format - 10 bytes

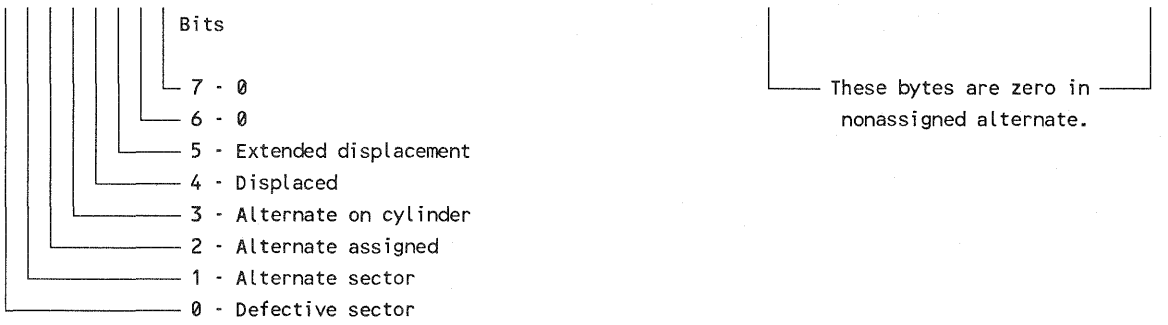
Zeros 2 bytes	Zeros 8 bytes

Identification (ID) Field

The ID field contains the physical address of the sector and the address of any assigned alternate sector. The ID field format is:

Primary or Nonassigned Alternate ID Field Format - 6 bytes

Byte 0	Byte 1	Byte 2		Byte 3	Byte 4	Byte 5	
		Physical	Physical			Alt Cyl	Alt Sector
Flags 00	Physical Cyl Low	Cyl High	Head	Sector	Alternate Cyl	High	Offset
0 1 2 3 4 5 6 7		0 1 2	3 4 5 6 7		Low	0 1 2	3 4 5 6 7



NOTE: Byte 0, bit 0 is the most significant byte and bit.

Assigned Alternate ID Field Format - 6 bytes

Byte 0	Byte 1	Byte 2		Byte 3	Byte 4		Byte 5
		Physical	Sector		Def Cyl	Defective	
Flags 00	Physical Cyl Low	Cyl High	Offset	Defective	High	Head	Defective
defined above		0 1 2	3 4 5 6 7	Cylinder Low	0 1 2	3 4 5 6 7	Sector

The disk control unit uses the physical cylinder, head, and sector to verify positioning. The flag byte (byte 0) defines the type of sector, whether it's a defective sector, and whether an alternate sector has been defined. Flag bits 0 and 1 are defined below:

Bits 0 and 1		Sector Definition
0	0	Primary
1	0	Defective primary
0	1	Alternate
1	1	Defective alternate

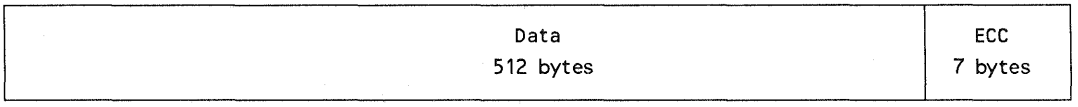
- Bit 2 indicates the flagged alternate sector is assigned to a defective primary. A defective alternate cannot be assigned.
- Bit 3 is adjusted in the defective primary when the alternate is assigned. If set, the disk control unit does not cause accessor motion to locate the alternate.
- Bit 4 indicates that the ID is written in the displaced position
- Bit 5 indicates the extended displaced position. If bit 5 is set, bit 4 is *don't care*. If either bit 4 or bit 5 is set then bit 0 must be set.

The alternate sector offset is the displacement from the start of the alternate area on that cylinder to the alternate sector.

Data and ECC Fields

The data field is 512 bytes long and is followed by 7 ECC bytes. Application programs that use normal read and write commands use the data field. The ECC field can correct error bursts up to 11 bits long. The data field format is:

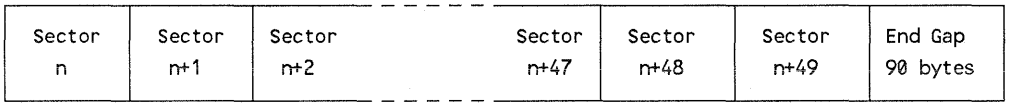
Data Field Format - 512 bytes + 7 ECC bytes



Track Definition

A track contains 50 equal sectors aligned on physical sector boundaries. The track also contains a 90 byte end-of-track gap used for head switching when the disk performs multiple track operations. The track sector format is:

Track Sector Format - 50 sectors



Cylinder Definition

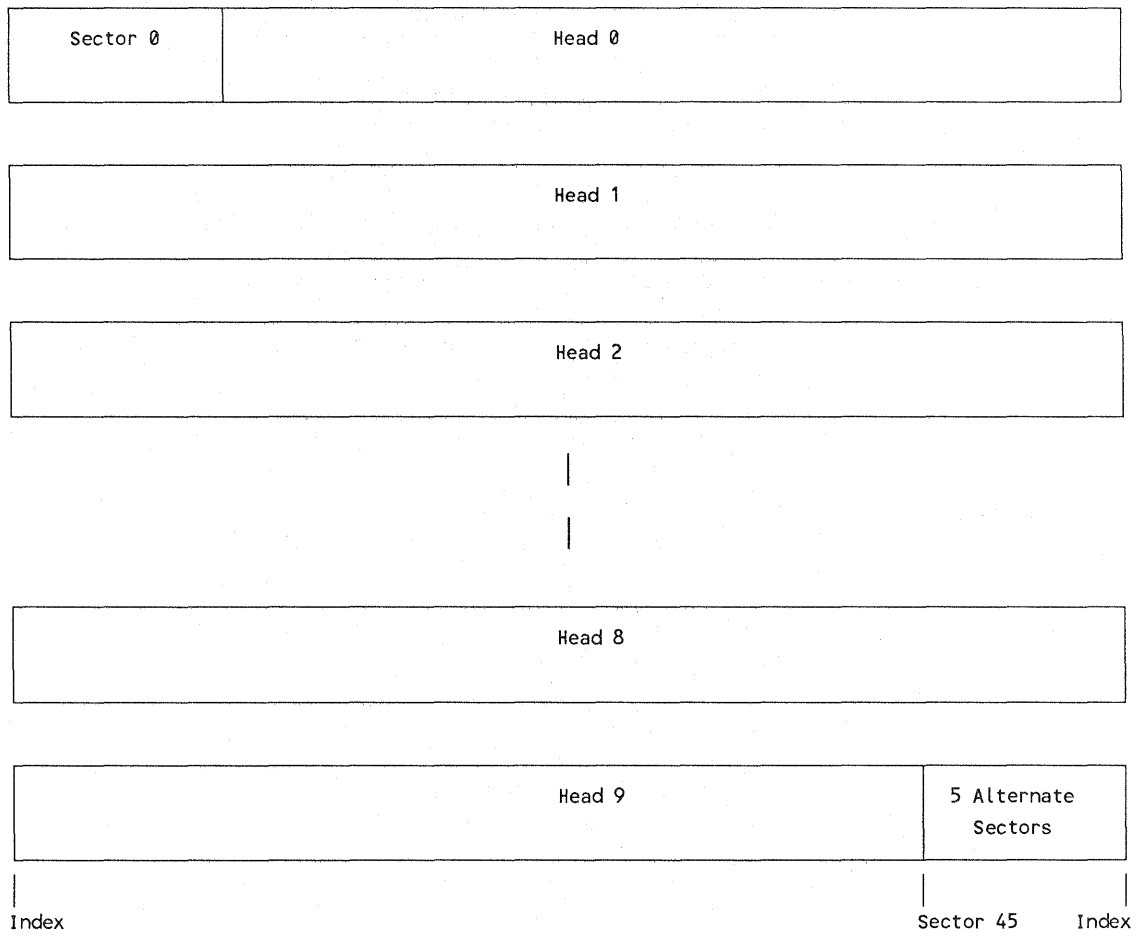
The disk drive has 10 heads and 1217 cylinders. Each cylinder has 495 primary sectors and 5 alternate sectors as shown in the formats below.

The first sector in the even numbered cylinders is in sector 0 of head 0, and in sector 25 of head 0 in the odd numbered cylinders. This arrangement allows a single track to occur when a disk encounters a cylinder boundary during a multiple sector operation without losing an entire disk revolution.

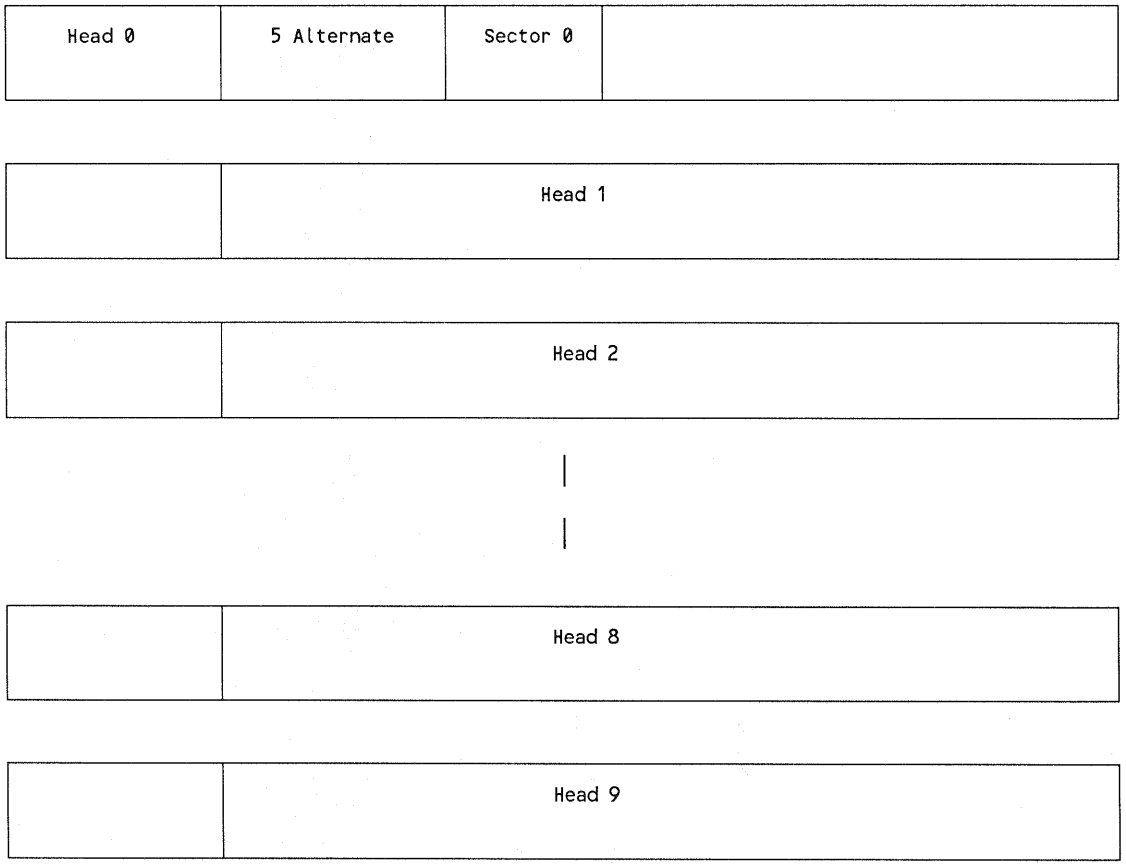
The five alternate sectors start after the last logical sector on the cylinder. The last 20 logical sectors on an odd numbered cylinder start at sector 0 on head 0.

The even and odd numbered cylinders formats are:

Even Numbered Cylinders Format



Odd Numbered Cylinders Format



Track Defect Handling

Track defects are handled using alternate sectors. There are five alternate sectors for each cylinder. The alternate sectors need not be on the same cylinder as the defect if all alternate sectors on that cylinder are already assigned.

The format defective sector operation of the locate command searches for an unassigned alternate sector on the cylinder of the defective sector. Alternate sectors are assigned in ascending order from sector 45, head 9 on even numbered cylinders. On odd numbered cylinders, alternate sectors are assigned in ascending order from sector 45, head 0. If there is no available alternate sector on the cylinder, the search continues on the defective sector's cylinder +1, then -1, then +2, then -2. This scheme minimizes accessor motion when a read or write command encounters a defective sector.

3. Channel Input/Output Operations

This section describes the channel interface signals and signal sequences.

3.1. Interface Line Definition

The input/output (I/O) interface lines (Figure 3-1) provide the disk subsystem with a common information format and signal sequence. The disk control unit decodes the commands received from the host. Then, the disk control unit interprets the commands for the device and provides the signal sequences to execute the operation.

Except for signals that establish priority among disk control units, all interface signals travel over multiplex lines. Only one disk control unit at a time logically connects to the interface. After selection, it remains logically connected to the interface until one of the following operations occur:

- The disk control unit transmits the required information
- The disk control unit receives the required information
- The channel signals the disk control unit to disconnect

The signals transmitted over the interface are interlocked with the corresponding responses, making the interface applicable to a wide variety of data rates.

Each disk control unit contains a wired address that indicates its interface address. Two disk control units on the same interface cannot have the same address. To begin an I/O operation, the channel must transmit the address of the desired disk control unit.

The disk control unit converts interface line sequences and coded commands to the control functions necessary to operate and establish communications between the disk control unit and the interface.

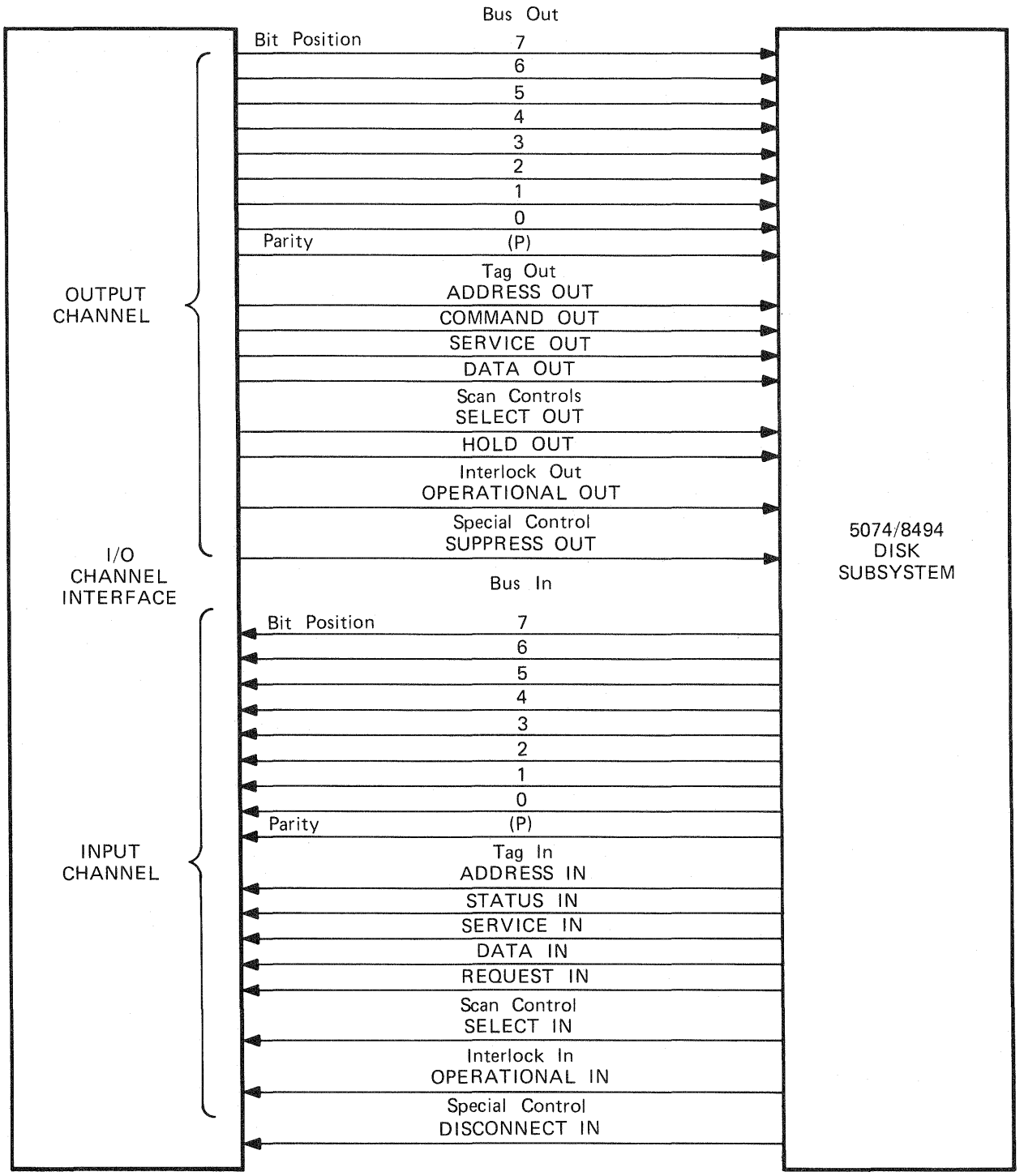


Figure 3-1. Input/Output Interface Lines

Bus Lines

The bus lines consist of a set of nine bus-out and nine bus-in lines. Each group of nine consists of eight data lines and one parity line.

Except for control signals, all data transmitted between the host and the disk subsystem travels on the bus lines. Any signal the channel provides is common to all disk control units. However, only one disk control unit at a time can logically connect to the channel.

The bus-out lines carry addresses, commands, and data information from the channel to the disk control unit. The bus-in lines carry addresses, data, status, and sense information from the disk control unit to the channel. A simultaneous signal on the appropriate control line indicates the type of information contained on the bus-out and bus-in lines.

Bit position 7 is the low-order value of a byte on a bus. Bit position 0 is the high-order value, with intervening bits in descending order. When it is necessary to transmit less than eight data bits, the bits must be in the highest numbered adjoining bit positions of the bus. All unused lines must be low numbered lines (bit position 0 and adjoining bit positions). The parity bit must always be the result of odd parity.

Selection Controls and Tag Lines

When an operation starts, the channel applies a signal to the select-out line. The SELECT OUT signal passes serially through all disk control units in order of priority. The SELECT OUT signal travels to the disk subsystem with the highest priority. The selection priority is (1) all control units on the select out lines in order of attachment from the channel to the end of the string of control units, followed by (2) all control units on the select in lines in order of attachment from the end of the string to the channel (see Figure 3-2.).

If the address is not that of the addressed unit or the unit does not require service, the SELECT OUT signal travels to the disk subsystem with the next highest priority. This operation continues until the SELECT OUT signal travels to the addressed or requesting disk subsystem. When the disk subsystem accepts the address or is the requesting unit, it captures the interface by applying a signal to the operational-in line. This signal inhibits passage of the SELECT OUT signal to the next lower priority disk subsystem.

Normally, the disk subsystem retains control of the interface for a short interval (execution of immediate commands or transfer of a single byte of data) and relinquishes control by passing the SELECT OUT signal to the next lower priority unit. During the next initiation of the SELECT OUT signal, the operation is repeated. That is, another data byte is transferred. This process is repeated until the transfer operation is complete and the subsystem notifies the channel of this status.

If none of the disk control units recognize the address or require servicing, the lowest priority disk control unit sends the SELECT IN signal to the channel.

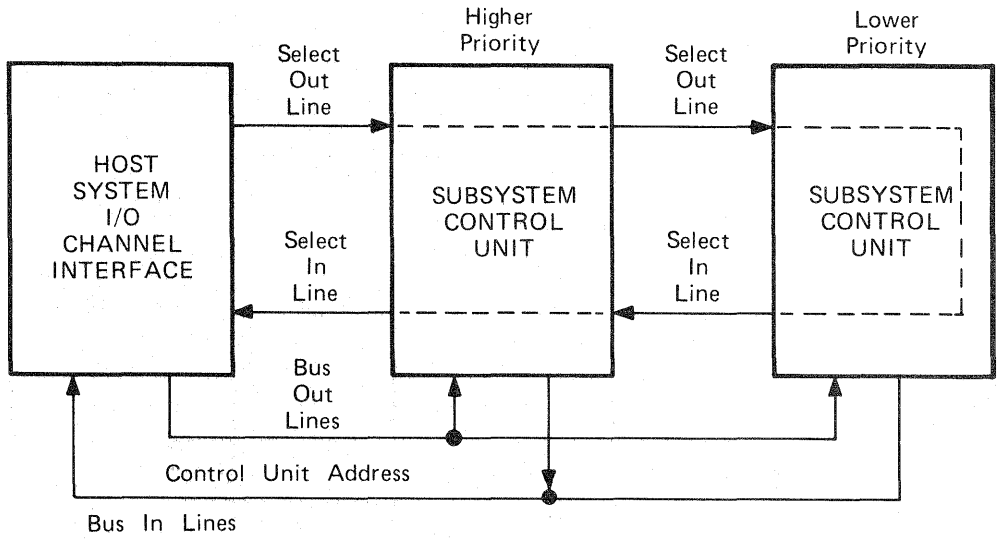


Figure 3-2. I/O Interface Priority Selection

Table 3-1 gives the signal name, its origin, its purpose, and the effect of each for each group of lines.

Table 3-1. Summary of Input/Output Interface Signals

Signal	Origin	Purpose
		Tag Lines
ADDRESS IN	Control Unit	Indicates that the address of the currently selected disk control unit requiring service is on bus-in lines.
STATUS IN	Control Unit	Indicates that a status byte is present on bus-in lines.
SERVICE IN	Control Unit	Signals the channel when the selected disk control unit is ready to transmit or receive a byte of information. The type of information depends on the operation. The channel responds with a SERVICE OUT, COMMAND OUT, or an ADDRESS OUT (during a disconnect) signal.

Table 3-1. Summary of Input/Output Interface Signals (cont)

Signal	Origin	Purpose
DATA IN	Control Unit	Indicates the disk control unit is ready to receive data on the bus-out lines or that it is transmitting data on the bus-in lines.
REQUEST IN	Control Unit	Indicates the disk control unit is prepared to transmit status or data, and requests a selection sequence.
ADDRESS OUT	Channel	Signals the disk control unit to decode disk control unit address present on bus-out lines. The addressed disk control unit responds with an OPERATIONAL IN signal.
COMMAND OUT	Channel	Indicates that a command byte is present on bus-out lines. The command byte notifies the selected disk control unit to start, continue, or stop an operation. Response to an ADDRESS IN signal means start the operation. Response to a SERVICE IN signal means stop the operation. Response to a STATUS IN signal means stack (retain status information at disk control unit until next selection sequence).
SERVICE OUT	Channel	Acknowledges receipt of a SERVICE IN or STATUS IN signal from a disk control unit. Indicates to the selected disk control unit that the channel has received a data byte.
DATA OUT	Channel	Response to a DATA IN signal. Indicates receipt of data on the bus-in lines or indicates data is available on the bus-out lines.
Scan Controls		
SELECT OUT	Channel	Establishes communications with a disk control unit whose address is on bus-in lines.
SELECT IN	Control Unit	Indicates the address byte is not recognized by a control processor (completes the path of the SELECT OUT signal).
HOLD OUT	Channel	Indicates that the SELECT OUT signal will begin. This signal is present only for the time the SELECT OUT signal is present and ends when a disk control unit seizes the interface.

Table 3-1. Summary of Input/Output Interface Signals (cont)

Signal	Origin	Purpose
		Interlocks
OPERATIONAL IN	Control Unit	Indicates that a disk control unit was selected and will be present for the entire period of time that data is being transmitted to the channel.
OPERATIONAL OUT	Channel	Allows operations between the disk control units and channel. When this signal is not present, all lines to the channel are made inoperable.
		Special Controls
SUPPRESS OUT	Channel	Informs the disk control units not to generate a service request in an attempt to seize the interface. This signal suppresses any subsequent data or status transfer.
DISCONNECT IN	Control Unit	Indicates to the channel that the selected disk control unit has detected a malfunction that prevents it from signaling properly over the I/O interface.

3.2. Interface Signal Sequences

Each I/O operation between the host I/O channel and the disk control unit requires a certain sequence of events to occur that the I/O channel controls. A system of interlocking inquiry and response signals through signal lines (see Figure 3-2) controls an orderly flow of data between the channel and the disk control unit.

Interface signal sequences control the transfer of information between the channel and the disk control unit. The following subsections describe these sequences.

Initial Selection Sequence

The initial selection sequence initiates an I/O operation. When the disk control unit is the output device, this sequence activates a group of signals in a particular sequence. Initially, the channel places the disk control unit address on the bus-out lines. After a predetermined delay, the channel raises the ADDRESS OUT signal. The ADDRESS OUT signal causes the disk control unit control circuit to compare the address on the bus-out lines with its own assigned address. The disk control unit can respond only if parity is correct.

After the address comparison is complete, the channel raises the SELECT OUT signal. It then waits for a response from the disk control unit. Disk control unit responses are: SELECT IN, STATUS IN, and OPERATIONAL IN signals.

Control Unit Busy Sequence

The disk control unit busy sequence occurs when a disk control unit is addressed during an initial selection sequence and any one of the following conditions is true.

- The disk control unit is busy executing a previously initiated command.
- The disk control unit is erasing a track after a format write.
- The channel initiated an interface disconnect sequence, and either the operation has not completed or it has not accepted ending status.
- The disk control unit is performing a command retry function on another channel interface.
- The disk control unit is holding a contingent connection for another channel or for a disk drive other than the one addressed.
- Stacked status (other than control unit end or device end) for another channel or for a disk drive, other than the one addressed, is being held in the disk control unit.
- The disk control unit is performing a timing countdown for another channel interface.

Control Unit Initiated Sequence

When the disk control unit is not currently assigned to the interface, it can request a selection sequence. The disk control unit raises the REQUEST IN signal to alert the channel of the need to communicate for the following conditions:

- The disk control unit is not busy.
- The ADDRESS OUT signal is not active on the channel interface.
- The status present in the disk control unit is not suppressed.

When its incoming SELECT OUT signal rises and the ADDRESS OUT signal is inactive, the disk control unit captures the interface. The disk control unit then, performs the following operations:

- Blocks the propagation of the SELECT OUT signal
- Raises the OPERATIONAL IN signal

- Places a device address on the bus-in lines
- Activates the ADDRESS IN signal

The channel acknowledges receipt of the device address by activating the COMMAND OUT signal. This allows the disk control unit to drop the device address and the ADDRESS IN signal. The disk control unit is now logically connected to the channel. It remains connected until it drops the OPERATIONAL IN signal.

Data Transfer Sequence

Data byte transfers occur on a request-acknowledge basis (that is, service in and service out). For input data transfers, the connected disk control unit performs the following operations:

- Places an input data byte on the bus-in lines
- Activates the SERVICE IN signal
- Waits for a SERVICE OUT or COMMAND OUT signal response from the channel

A SERVICE OUT response indicates acceptance of the data byte information. A COMMAND OUT response indicates rejection of the data byte information.

For output data transfers, the connected disk control unit activates the SERVICE IN signal and waits for a SERVICE OUT response from the channel. A SERVICE OUT response indicates that the channel received the data byte information.

Termination Sequence

Either the channel or the disk control unit ends an operation. The channel signals an end of transfer (stop) by responding to a SERVICE IN signal with a COMMAND OUT signal.

When the disk control unit ends an operation, regardless of the reason, it transmits the status byte to the channel unless the STATUS IN signal has been inhibited. Initiating a selection sequence presents the status byte to the channel. When the disk control unit is connected to the channel, it places the status byte on the bus-in lines and raises the STATUS IN signal.

Selective Reset Sequence

The selective reset sequence disconnects the disk control unit from the interface and resets the status. The disk control unit performs the following operations after receiving this sequence:

- Clears the status register

- Stops any data transfer sequence in progress
- Immediately disconnects from the interface

However, any command in progress may be completed if the selective reset occurred after the channel end status was stored in the status register.

If the disk control unit receives the selective reset sequence during a data transfer sequence, the disk control unit performs the following operations:

- Ends a data transfer
- Presents unit check status alone in the next initial selection sequence (next start I/O)
- Constructs Format 3 sense information

Interface Disconnect Sequence

Operation of the interface disconnect sequence is similar to the selective reset sequence except that the status register is not cleared. Holding the ADDRESS OUT signal high while the SELECT OUT signal is low causes the channel to force the disk control unit to drop the OPERATIONAL IN signal and release the interface. The channel maintains this condition until the OPERATIONAL IN signal drops, causing the channel to drop the ADDRESS OUT signal which completes the sequence. Operations in the disk control unit proceed normally except that the disk control unit does not transfer any data bytes. The disk control unit may initiate a selection sequence to transmit status condition.

System Reset Sequence

The system reset sequence causes the disk control unit control section to enter a cleared state in which the disk control unit can accept any valid command. A system reset sequence occurs when the channel is powered up. The following conditions occur in this operation:

- The channel holds the OPERATIONAL OUT and SUPPRESS OUT signals low concurrently
- The disk control unit is reset
- The OPERATIONAL IN signal drops

Command Chaining

Command chaining indicates that another command for the current disk drive immediately follows device end status. This indication occurs as long as no unusual conditions have occurred during the current operation. The SUPPRESS OUT and SERVICE OUT signals in response to the STATUS IN signal indicate command chaining.

If command chaining is active when device end status is presented, it will be active until reselection is made or until the SUPPRESS OUT signal falls (minimum down-level to be sure of break is 250 nanoseconds). Reselection of any other I/O device attached to the control unit resets the chained-command condition in the disk control unit. Status conditions such as unit check, control unit end, or attention will end command chaining in the channel.

A multidevice disk control unit that is to operate on more than one subchannel must not:

1. Reset the chained-command condition on an address other than the one being selected.

2. Present control unit end status with command chaining on an address.

If command chaining is active when a disk control unit shared by two or more devices operating on a single subchannel presents channel end status without device end status, the I/O device that presents channel end status must be the next device from that disk control unit to present device end status, unless the disk control unit is addressed in the meantime on the same interface.

If command chaining is active when device end status is presented, the control unit must ensure that the path to the device remains available until the command chaining operation is initiated or until command chaining is no longer active. Also, unless command chaining is being canceled by the channel, the immediately following sequence must be a reselection of the device presenting device end status.

If command chaining is active on an I/O device shared between more than one disk control unit or channel, the I/O device must remain available until the command chaining operation is initiated or until command chaining is no longer active.

To ensure that the disk control unit recognizes command chaining, the SUPPRESS OUT signal must be up at least 250 nanoseconds before the SERVICE OUT signal appears in response to the STATUS IN signal and must not fall before the STATUS IN signal. If command chaining is not active, the SUPPRESS OUT signal must be down at least 250 nanoseconds before the rise of the SERVICE OUT signal and must not rise before the fall of the STATUS IN signal.

4. Channel Command Description

This section describes the channel command set for both the block multiplexer channel and the System 80 Models 10/20 selector channel.

4.1. Channel Command Set

This subsection shows the types of commands, and lists them by type in Table 4-1 and alphabetically in Table 4-2.

Types of Commands

The channel command set consists of the following types of commands:

- Control
- Read
- Write
- Search (System 80 Model 10/20 selector channel only)
- Sense

Subsection 4.2 describes each command. The description for each command contains the following information:

- Command name and hexadecimal code
- Functional description of the command
- Parameters for the command
- Error conditions that can occur during command operation
- Chaining requirements for the command
- Status indications that may be presented for the command

Command Listing by Type

Table 4-1 lists the commands by types.

Table 4-1. Channel Command Set Listing by Type

Type	Command	Command Code (Hexadecimal)
Control	No Operation	03
	Test I/O	00
	Define Extent	63
	Locate	43
Read	Read	42
	Read Initial Program Load	02
Write	Write	41
Search*	Search Equal	09
	Search Equal/High	0D
Sense	Sense Input/Output	04
	Sense Input/Output Type	E4
	Read and Reset Buffered Log	A4
	Read Device Characteristics	64
	Device Reserve	B4
	Device Release	94
	Unconditional Reserve	14

**Only the System 80 Model 10/20 system uses the search commands.*

Alphabetical Command Listing

Table 4-2 lists the commands alphabetically.

Table 4-2. Channel Commands Arranged Alphabetically

Name	Code	Binary
Define Extent	63	0110 0011
Device Release	94	1001 0100
Device Reserve	B4	1011 0100
Diagnostic Control	F3	1111 0011
Diagnostic Sense/Read	C4	1100 0100
Locate	43	0100 0011
No Operation	03	0000 0011
Read	42	0100 0010
Read and Reset Buffered Log	A4	1010 0100
Read Device Characteristics	64	0110 0100
Read Initial Program Load	02	0000 0010
Read WT Segments	62	0110 0010
Search Equal*	09	0000 1001
Search Equal/High*	0D	0000 1101
Sense Input/Output	04	0000 0100
Sense Input/Output Type	E4	1110 0100
Set Diagnose	4B	0100 1011
Test I/O	00	0000 0000
Unconditional Reserve	14	0001 0100
Write	41	0100 0001

**Only the System 80 Model 10/20 system uses the search commands.*

4.2. Control Commands

The control commands transfer only control information to the disk subsystem. These commands do not transfer stored data to or from the disk subsystem. This information can include subcommands that specify certain actions that are performed by the disk control unit or disk units, or other parameters required by the command.

Control Commands

No Operation (03_{16})

The no operation command is an immediate command; it causes no action at the addressed device. It is used to maintain the channel connection during I/O operations.

Parameters

There are no parameters passed by this command.

Error Conditions

The disk control unit detects equipment check conditions.

Chaining Requirements

There are no chaining requirements specified for this command.

Status Indications

The status indications for the no operation command are: channel end and device end presented in initial status.

Test I/O (00_{16})

The test I/O command releases the addressed I/O path of pending status information.

Parameters

There are no parameters passed by this command.

Error Conditions

The disk control unit detects equipment check conditions.

Chaining Requirements

There are no chaining requirements specified for this command.

Status Indications

This command normally presents an all-zero status byte. The initial status indication contains any stacked or pending status.

Define Extent (63_{16})

The define extent command defines:

- Operations allowed by following chained commands
- The size of data blocks in bytes (512 bytes for Series 1100 and 256 bytes for System 80)
- A contiguous extent of data blocks that can be accessed by subsequent chained commands
- A relative displacement in data blocks from the start of a data set to the extent. Subsequent chained commands may access this relative displacement.

Parameters

This command transfers 16 bytes of parameters from the channel to the disk control unit. The disk control unit retains the define extent parameters until the end of command chaining. Table 4-3 describes each define extent parameter byte.

Error Conditions

The following error conditions can occur during a define extent command operation:

- Insufficient parameter bytes were transferred
- Invalid parameters were transferred
- Another define extent command in the chain preceded the command.
- Equipment check conditions detected by the disk control unit.

Chaining Requirements

A define extent command must not be preceded by another define extent command in the same chain.

Status Indications

The following are status indications for the define extent command:

- Initial status is usually zero.
- Channel end and device end are presented after the parameters were transferred to the disk control unit and checked for validity.
- Error conditions end the command with channel end, device end, and unit check status.

Table 4-3. Define Extent Parameter Bytes

Byte Number and Name	Description
Byte 0 - Mask Byte	The mask byte determines which operations are inhibited in subsequent chained commands. The bit functions are: Bits — Function 0, 1 - 00 — Inhibit format write operations - 01 — Inhibit all write operations - 10 — Invalid, must not be used - 11 — Permit all write operations 2, 3 - 00 — Must be 00 or parameters are invalid 4 - 00 — Indicates data area - 01 — Indicates CE area, for maintenance use only 5 - 00 — Inhibit diagnostic commands 01 — Allow diagnostic commands 6, 7 - 00 — Must be 00 or parameters are invalid
Byte 1 - reserved	Byte 1 must be set to zero or the parameters are invalid.
Bytes 2 and 3 - Block size	The block size bytes define the logical block size. This disk subsystem block size is 504 bytes for block multiplexer channel systems and 256 bytes for the System 80 selector channel.
Bytes 4 thru 7 - Physical Extent Offset	The physical extent offset bytes define the offset, from block zero of the logical device, of the first block of the extent that permits access by subsequent chained locate commands.
Bytes 8 thru 11 - First Extent Displacement	The first extent displacement bytes define the relative displacement, in blocks, from the beginning of the data set to the first block of the extent that permits access by subsequent chained commands.
Bytes 12 thru 15 - Last Extent Displacement	The last extent displacement bytes define the relative displacement, in blocks, from the beginning of the data set to the last block of the extent. The extent begins at the first extent displacement and ends at the last extent displacement.

Locate (43_{16})

The locate command defines the location and amount of data processed by an immediately following chained read or write command. It positions the device to the first data block processed. This command does not transfer recorded data.

In the System 80, the locate command may use the locate disconnect mode (operation code bit 3) of operation to pre-position the device to the addressed block. After device positioning starts, the disk control unit presents channel end status. This allows the channel to become available to start other operations. The channel performs a device reserve command on the device to prevent another path from modifying the device position. After device positioning is completed, the disk control unit presents device end status. The implicit reserve is reset on any subsequent I/O operation for the device on the path that caused the initial reserve.

Parameters

The locate command transfers eight bytes of parameters from the channel to the disk control unit. Table 4-4 defines the locate command parameter bytes.

Error Conditions

The following errors can occur during a locate command operation:

- Insufficient parameter bytes were transferred
- Invalid parameters were transferred
- The command was not preceded by a read initial program load or a define extent command in the command chain
- The command specifies a write operation and the device is write protected
- Data, access, or other device related errors when the command specifies format defective block
- Equipment check conditions detected by the disk control unit

Chaining Requirements

A locate command must be preceded by a read initial program load or a define extent command in the same command chain, or the disk control unit rejects the locate command. A status indication of channel end, device end, and unit check is presented.

Table 4-4. Locate Command Parameter Bytes

Byte Number and Name	Description
Byte 0 - Operation Code	The operation code specifies the type of operation performed: ▪ Block multiplexer channel modifier bits (0-3): Bits 0 - 3 are reserved and must be zero or the command will be ended with device end and unit check status. ▪ System 80 selector channel modifier bits (0-2): Bits 0 - 2 are reserved and must be zero or the command will be ended with device end and unit check status. ▪ System 80 selector channel modifier bit (3): Modifier bit 3 indicates a locate disconnect operation. ▪ Operation code bits (4-7): Bits 4 - 7 define the following operations: Value Operation 0100 Format defective block 0001 Write data data 0101 Write and check data 0010 Read replicated data 0110 Read data 0111 Search data and read data (System 80 selector channel only) Any other values are invalid and cause the command to end with channel end, device end, and unit check status. Data transfers between the channel and disk subsystem associated with these operations do not occur during the execution of the locate command, but are initiated by an immediately-following chained read, write, or search (System 80 only) command. A description of the operations specified above follows: ▪ Format defective block (0100): The format defective block operation operates on only one logical block (physical sector in System 80). This operation causes the disk control unit to flag the logical block (physical sector in System 80) at the address specified as defective by bytes 4 through 7. The disk control unit assigns an alternate logical sector and establishes

Table 4-4. Locate Command Parameter Bytes (cont)

Byte Number and Name	Description
	appropriate pointers so that the specified alternate sector is accessed whenever subsequent commands attempt to access the sectors specified by bytes 4 through 7. If all alternate space is used, the disk control unit presents unit check and device end status, and, if not already presented, channel end status. If the mask specified in the Define Extent command inhibits format write operations, or if the device is in read-only mode, the locate command is ended with channel end, device end, and unit check status. If an unused alternate block (sector for System 80) is located, the disk control unit saves the alternate block (sector for System 80) pointer and initiates access to the defective block (sector for System 80) specified in bytes 4 through 7 of the parameters, verifies the correct positioning, and formats the block (sector for System 80) identification with the defective flag bit on and the appropriate block (sector for System 80) pointer. Format defective block operates on only one logical sector. During a format defective block operation, there is no data transfer between the channel and the disk control unit. The disk control unit internally generates all written data. Only ID areas of the defective and alternate logical sectors are written. After the format defective block operation, a locate command that specifies a write data operation is issued to write the data field of the logical block. Write Data (0001): This operation code prepares the disk control unit to write one or more blocks of data. The number of blocks to be written is specified in the block count parameters (bytes 2 and 3) of the locate command. If the mask specified in the define extent command inhibits all write operations, or if the device is locally set in read-only mode, the locate command is ended with channel end, device end, and unit check status.

Table 4-4. Locate Command Parameter Bytes (cont)

Byte Number and Name	Description
	The write data operation establishes write orientation in the disk control unit for the addressed device. The disk control unit initiates access to the first block to be processed. The relative displacement of the first block (bytes 4 through 7) is converted to the appropriate physical values for the addressed device. When access to the block is complete, the device presents device end status. Write and Check Data (0101): The disk control unit performs the same functions as described for the write data operation code and also performs a read back check on the data just written following a chained write operation. Read Replicated Data (0010): This operation code prepares the disk control unit to read one or more blocks of data from a range of replicated data. The number of blocks to be read is specified in the block count parameters (bytes 2 and 3). This operation establishes read orientation in the disk control unit for the addressed device. Read Data (0110): This operation code prepares the disk control unit to read one or more blocks of data. The number of blocks to be read is specified in the block count parameters (bytes 2 and 3). Search Data and Read Data (0111): This operation code prepares the disk to search one or more blocks of data. The number of blocks to be searched is specified in the block count parameters (bytes 2 and 3).
Byte 1 - Replication Count	To minimize rotational delays, the disk control unit positions the device at the beginning of a unit of replicated data. This operation occurs only if the operation code (byte 0) specifies read replicated data (bytes 4 through 7 equals 0010). The replication count specifies a range of blocks containing replicated data. The block count (bytes 2 and 3) specifies the number of blocks in a unit of replicated data. If the replication count is less than the bock count or if the replication count is not a multiple of the block count, the locate command is ended with channel end, device end, and unit check status. If the replicated count equals the block count, the disk control unit treats the read replicated data operation as a read data operation.

Table 4-4. Locate Command Parameter Bytes (cont)

Byte Number and Name	Description
Bytes 2 and 3 - Block Count	Bytes 2 and 3 specify the number of sequential blocks to be processed by the command immediately following the Locate command. These bytes must not be zero or the locate command will terminate with channel end, device end, and unit check status.
Bytes 4 thru 7 - Relative Displacement	Bytes 4 through 7 specify the relative displacement, in blocks, from the beginning of the data set to the first block to be processed. The offset, from block zero of the logical device to the first block to be accessed, is computed by the disk control unit as follows: First Block Accessed = Relative Displacement - First Extent Displacement + Physical Extent Offset The disk control unit compares the displacement of the blocks to be processed to the valid Extent range determined by the First_Extent_Displacement and the Last_Extent_Displacement. If the blocks are within the valid Extent, the disk control unit processes the locate command. If any block is not within the valid extent range, the locate command terminates with channel end, device end and unit check status. NOTE: First Extent Displacement, Physical Extent Offset, and Last Extent Displacements are parameters of the define extent command.

Status Indications

The following are status indications for the locate command:

- Initial status is normally zero.
- Channel end status is presented after the parameters are transferred and checked for validity.
- Error conditions end the command with channel end, device end, and unit check status.
- The disk control unit presents device end status after completion of the format operation for a locate command with valid parameters and an operation code of 0100 (format defective block).
- The disk control presents device end status after the device is properly positioned to begin processing the first data block for a locate command with valid parameters and an operation code of 0001 (write data), 0110 (write and check data), or 0010 (read or read replicated data).

4.3. Read commands

The disk subsystem has two basic read commands: read and read initial program load.

Read commands transfer data from disk storage to the channel through the disk control unit. Data is buffered in the disk control unit before connection is made. This reduces the connection time with the channel. This buffered operation ensures that no service or command overruns occur in the disk control unit.

Read (42_{16})

The read command transfers recorded data from the disk control unit to the I/O channel. A read command normally is chained from an immediately preceding locate command which has specified an operation code of read data or read replicated data, the location of the first data block to be read, and the number of blocks to be read. The read command itself is initiated when device end status is returned for the locate command, indicating that the device is properly positioned to read the first data block.

In the System 80, the read command may also be preceded by and chained from a search command. In this operation, the disk control unit transfers the remaining bytes of the addressed block that caused the search hit. The read command is valid in this situation even though the locate command did not specify a read operation.

When the read command is executed, the disk control unit reads the block ID and verifies the correct positioning. After the positioning is verified, the following data block is read and transferred to the channel.

If the read command is not chained to a search command, the disk control unit continues reading and transferring data to the channel, including data from subsequent blocks, until one of the following events occur:

- The disk control unit detects an error.
- The number of blocks specified in the block count parameter of the preceding locate command were transferred to the channel.
- The channel signals stop.

If the read command is chained to a search command, the disk control unit continues reading and transferring data to the channel from the block of the search hit until one of the following events occur:

- The disk control unit detects an error.
- All the remaining bytes in the block of the search hit were transferred to the channel.
- The channel signals stop.

Parameters

The read command does not pass parameters to the disk control unit.

Error Conditions

The following errors can occur during a read command operation.

- The read command was not immediately preceded in the command chain by a locate, search (System 80 only), or set diagnose command that transfers data to the channel.
- The preceding locate command did not specify a read or read replicated data operation code. For System 80 systems, the preceding locate command was not chained to a search command.
- Data, access, or other device related errors when the command specifies a data transfer data from the device.

Chaining Requirements

If the read command is not immediately chained from a locate or search (System 80 only) command that specifies an operation code parameter of read or read replicated data, then the read command is ended with channel end, device end, and unit check status.

Status Indications

The following are status indications for the read command:

- Initial status is usually zero.
- Channel end and device end status is presented after data transfer is completed.
- Status indications for data errors and access error are specified in Section 7.

Read Initial Program Load (02_{16})

Block Multiplexer Operation

The read initial program load (IPL) command causes the disk control unit to access and read block 0. This command must be the first command in its chain or must be chained from another read IPL command.

The read IPL command first causes the disk control unit to establish an extent of maximum allowable size with a Physical Extent Offset of zero and a mask byte of zero. Next the disk control unit goes to block 0 of the selected device and reads the entire block.

System 80 Selector Channel Operation

The IPL command causes the disk control unit to go to block 96 (decimal) and transfer all blocks until the channel signals stop or block 989 is reached. This command must be the first command in its chain or must be chained from another read IPL command.

Parameters

No parameters are passed to the disk control unit by the read IPL command. However, several parameters frequently passed by define extent commands are implicitly set by the read IPL command.

Error Conditions

The following error conditions can occur during a read IPL command operation.

- The read IPL command was not the first command in the chain or the preceding command was not a read IPL command.
- Data, access, and other device related errors occurs.
- The disk control unit detects equipment check conditions.

Chaining Requirements

The read IPL command must be the first command in a command chain or must be chained from another read IPL command. If this requirement is not met, the read IPL command is rejected with channel end, device end, and unit check status.

Status Indications

The following are status indications for the read IPL command:

- Initial status is usually zero.
- Channel end and device end status is presented after data transfer is completed.
- Status indications for data errors and access error are specified in Section 7.

4.4. Write Command

Write commands transfer data from the channel to disk storage via the disk control unit. The channel is reconnected before the actual first block written on the disk. Data is buffered in the disk control unit to reduce the connection time with the channel. This buffered operation makes sure that no service or command overruns will occur in the disk control unit.

Write (41_{16})

The write command transfers data from the channel to the disk control unit. The disk records the data in one or more data blocks selected by an immediately preceding, chained locate command. The channel initiates the write command when the disk control unit presents device end status for the locate command. Device end status indicates that the addressed device is positioned properly to write the first data block.

A locate command immediately precedes a write command. The write command must be chained from a locate command that specifies a write data or write and check data operation code.

When the write command is executed, the disk control unit reads the block ID and verifies the positioning. After verification, the data block that follows is written with data transferred from the channel. The disk control unit continues to write subsequent data blocks until one of the following conditions occur:

- The disk control unit detects an error.
- The number of blocks specified in the block count parameter of the preceding locate command were written.
- The channel signals stop.

If the channel signals stop before the disk writes all specified data blocks, the disk control unit fills the remainder of the current data block and the data blocks that follow with zeros.

If the disk control unit specifies a write and check data operation code, each recorded data block is verified.

Parameters

The write command does not pass parameters to the disk control unit.

Error Conditions

The following error conditions can occur during a write command operation.

- The write command was not preceded in the command chain with a locate or set diagnose command requiring a write operation.
- Data, access, and other device related errors occur when the command specifies data transfer with the device.
- Equipment check conditions are detected by the disk control unit.

Chaining Requirements

The write command must be immediately chained from a locate command that specifies an operation code of write data or write and check data. If this requirement is not met or if the device is set in read-only mode, the write command is ended with channel end, device end, and unit check status.

Status Indications

The following are status indications for the write command:

- Initial status is usually zero.
- If the preceding locate command specifies an operation code of write data, the disk control unit presents channel end status after data transfer with the channel is complete. The disk control unit presents device end status after data was written to the device.
- If the preceding locate command specifies an operation code of write and check data, the disk control unit presents channel end status after all data is transferred to the disk control unit. After all data blocks are read and checked, the disk control unit presents device end status.
- If the preceding locate command does not specify an operation code of write data or write and check data, the write command is ended with channel end, device end, and unit check status (see Chaining Requirements for this command).
- Section 7 gives status indications for data errors and access errors.

4.5. Search Commands (System 80 Only)

Only the System 80 uses search commands. The search commands transfer 1 to 127 data bytes from the I/O channel to the disk control unit. The disk control unit compares the data to the currently addressed data block. The locate command block count determines the search length. The search continues for the specified block count or until the search condition is met. If a read command is chained to the search command, the remaining data bytes are transferred to the I/O channel.

Search Equal (09_{16})

The search equal command transfers data from the I/O channel to the disk control unit. This command compares the transferred data against one or more data blocks selected by the immediately preceding chained locate command.

The search equal command is initiated when the disk control unit presents the device status for the locate command. Device status indicates the addressed device is positioned to search the first data block.

When the search equal command is executed, the disk control unit reads the block ID and verifies the correct positioning. After verification, the data block that follows is compared with the search argument for an exact comparison of the number of data bytes transferred as the search argument. The disk control unit continues to search subsequent data blocks until one of the following conditions occur:

- The disk control unit detects an error.
- The number of blocks specified in the block count parameter of the preceding locate command are searched.
- A data block that satisfies the search argument is found.
- The channel signals stop.

If access boundaries are encountered during the search, the disk control unit performs the appropriate access movement.

If the search argument is satisfied, the locate parameters of the block that satisfied the search are set in the sense bytes to be transferred by a subsequent sense command. This information overrides any sense information relating to a correctable error but is overwritten if a unit check status condition occurs.

Parameters

The search equal command does not pass parameters to the disk control unit.

Error Conditions

The following error conditions can occur during a search equal command operation.

- A locate or set diagnose command requiring a search operation did not precede the search equal command in the command chain.
- Data, access, and other device related errors occur when the command specifies data transfer with the device.
- The disk control unit detects equipment check conditions.

Chaining Requirements

The search equal command must be immediately precede by and chained from a locate command that specifies an operation code of search data. If this requirement is not met the search equal command is ended with channel end, device end, and unit check status.

Status Indications

The following are status indications for the search equal command:

- Initial status is usually zero.
- The disk control unit presents channel end status after data transfer with the channel is complete.
- The disk control unit presents device end status if the search argument is satisfied on one of the data blocks.
- The disk control unit presents device end and unit check status (sense bytes indicating no record found) if the search argument is not satisfied.
- Section 7 gives status indications for data errors and access errors.

Search Equal/High ($0D_{16}$)

The search high/equal command executes the same as the search equal command, except the comparison is different. The first data block that contains data equal to or greater than the search argument satisfies the search.

All parameters, errors, chaining requirements, and status indications are the same as for the search equal command.

4.6. Sense Commands

The sense command set has commands that transfer sense information, error information, and information about the disk control unit. The set also has commands that control device reserve, device release, and unconditional reserve operations.

Sense Input/Output (04_{16})

The sense input/output (I/O) command transfers 24 bytes of sense information from the disk control unit to the channel. (Section 6 defines the meaning of the sense information.)

Sense information describes the reason for unit check status, the status of the device that performed an operation, and system error recovery information.

A contingent connection state is established in the disk control unit after the channel accepts a status byte containing unit check condition. A unit check condition is always followed by a sense I/O command to reset the state of the disk control unit, whether the sense data is used.

Sense information is reset to zero after the sense data transfer is complete, or when an initial status byte of zero is given to any command except test I/O or no operation.

Parameters

The sense I/O command does not pass parameters to the disk control unit.

Error Conditions

No error conditions occur on sense commands. However, equipment check conditions are possible during data transfer with the channel.

Chaining Requirements

There are no chaining requirements for the sense I/O command.

Status Indications

The following are status indications for the sense I/O command:

- Initial status is usually zero.
- The disk control unit presents channel end and device end status after transferring the sense bytes.

Sense Input/Output Type ($E4_{16}$)

The sense input/output (I/O) type command transfers information from the disk control unit to the channel. This information identifies the type of disk control unit and device. The format is as follows:

Byte	Description
0	Always FF hexadecimal
1 to 3	Control unit type (50 74 00 hexadecimal)
4 to 6	Device type (49 59 00 hexadecimal)

If the device is available and not busy, the sense I/O type command is executed even if the device is not ready.

The sense information is reset to zero after the sense I/O type command is executed.

Sense Commands

Parameters

The sense I/O type command does not pass parameters to the disk control unit.

Error Conditions

No error conditions occur on sense commands. However, equipment check conditions are possible during data transfer with the channel.

Chaining Requirements

There are no chaining requirements for the sense I/O type command.

Status Indications

The following are status indications for the sense I/O type command:

- Initial status is usually zero.
- The disk control unit presents channel end and device end status after completion of information transfer.

Read and Reset Buffered Log ($A4_{16}$)

The read and reset buffered log command transfers 24 bytes of usage and/or error information from the disk control unit to the channel. The first eight bytes are sense bytes 0 through 7. The remaining 16 bytes are as specified in format 6 sense information.

The usage and/or error information provides information the logical device addressed. The information is reset to zero after data transfer is complete.

Parameters

The read and reset buffered log command does not pass parameters to the disk control unit.

Error Conditions

No error conditions occur on sense commands. However, equipment check conditions are possible during data transfer with the channel.

Chaining Requirements

There are no chaining requirements for the read and reset buffered log command.

Status Indications

The following are status indications for the read and reset buffered log command:

- Initial status is usually zero.
- The disk control unit presents channel end and device end status after completion of information transfer.

Read Device Characteristics (64_{16})

The read device characteristics command transfers 32 bytes of information from the disk control unit to the channel. The information transferred defines the characteristics of the addressed device. Table 4-5 gives the device characteristics format.

Table 4-5. Device Characteristics Format

Byte	Value	Description
0	20	Operation modes: non-overrunable, and burst mode
1	28	Features: shared device and movable access mechanism
2	00	Device class A
	80	Device class B
	40	Device class B (System 80 selector channel)
3	00	Unit type
4, 5	0200	Block size - 512 bytes (block multiplexer channel)
	01F8	
	0100	Block size - 256 bytes (System 80 selector channel)
6 - 9	00000032	Sectors/cyclical group - 50 (block multiplexer channel)
	00000064	Sectors/cyclical group - 100 (System 80 selector channel)
10 - 13	000001EF	Sectors/access position - 495 (block multiplexer ch.)
	000003DE	Sectors/access position - 990 (System 80 selector ch.)
14 - 17	00092D51	Sectors/mechanism - 601425 (block multiplexer channel)
	00125AA2	Sectors/mechanism - 1,202,850 (System 80 selector ch.)
18 - 23	00	Reserved, must be zeros
24, 25	03DE	Records in the CE area - 990 (block multiplexer channel)
	078C	Sectors in the CE area - 1980 (System 80 selector channel)
26 - 31	00	Reserved, must be zeros

Parameters

The read device characteristics command does not pass parameters to the disk control unit.

Error Conditions

No error conditions occur on sense commands. However, equipment check conditions are possible during data transfer with the channel.

Chaining Requirements

There are no chaining requirements for the read device characteristics command.

Status Indications

The following are status indications for the read and reset buffered log command:

- Initial status is usually zero.
- The disk control unit presents channel end and device end status after the information bytes are transferred.
- If the address device is available and not busy, but in the not-ready state, this command is not executed and unit check status is presented in initial status.

Device Reserve ($B4_{16}$)

The device reserve command reserves the addressed device to the channel that issued the command. This command also transfers all the sense bytes to the channel.

The device reserve command is executed regardless of device status conditions (except for device busy situations). The device may be inoperable but must be powered up.

Device reservation is maintained until the reserving channel successfully completes a device release command addressed to the reserved device. While a device reservation is in effect for a channel, busy status is used to reject access to the reserved device from a different channel access path.

If two device reserve commands are issued for a device by the same channel, without an intervening device release command, then the second device reserve is rejected with channel end, device end, and unit check status.

Parameters

The device reserve command does not pass parameters to the disk control.

Error Conditions

The following errors can occur during a device reserve command operation:

- The command was preceded by a define extent command in the same chain.
- Equipment check is possible during the data transfer.

Chaining Requirements

The device reserve command must not be preceded by a define extent command in the same chain, or the command will be rejected with channel end, device end, and unit check status.

Status Indications

The following are status indications for the device reserve command:

- Initial status is usually zero.
- Device busy status is possible.
- The disk control unit presents channel end and device end status after the information bytes are transferred.
- Error conditions cause channel end, device end, and unit check status with the sense condition stored in the disk control unit for a subsequent sense command.

Device Release (94_{16})

When a channel that previously issued a device release command issues a device release command to the same device, the reservation established by the device reserve command is ended. A device release command issued for an unreserved device has no effect on the addressed device.

In addition to ending the reservation of the addressed device, the device release command transfers the sense bytes to the channel.

The device release command is executed regardless of device status conditions.

Parameters

The device release command does not pass parameters to the disk control unit.

Error Conditions

The following errors can occur during a device release command operation:

- A define extent command preceded this command in the same chain.
- Equipment check is possible during the data transfer.

Chaining Requirements

The device release command must not be preceded by a define extent command in the same chain, or the command will be rejected with channel end, device end, and unit check status.

Status Indications

The following are status indications for the device release command:

- Initial status is usually zero.
- Device busy status is possible.
- The disk control unit presents channel end and device end status after the information bytes are transferred.
- Error conditions cause channel end, device end, and unit check status with the sense condition stored in the disk control unit for a subsequent sense command.

Unconditional Reserve (14_{16})

The unconditional reserve command recovers from hardware malfunctions whenever the channel establishes a reservation that fails to release the reservation with a device release command.

This command breaks any existing device allocation to the original primary (failing) path. If there are multiple access paths to the same device, the unconditional reserve command reserves the device for the current alternate path in the same system. If the device was reserved previously or in use by the primary path, the unconditional reserve command reserves the device for the alternate path. The reservation and pending status or sense information in the primary path is reset in the device and disk control unit through which the command was issued. Information in any disk control units not in the alternate connection path is not reset.

To release device reservations established by the unconditional reserve command, use the device release command. The unconditional reserve command then transfers the sense bytes to the channel.

Parameters

The unconditional reserve command does not pass parameters to the disk control unit.

Error Conditions

The following errors can occur during an unconditional reserve command operation:

- A command reject occurs if the unconditional reserve command is not the first command in the command chain.
- Equipment check is possible during the data transfer

Chaining Requirements

The unconditional reserve command must be the first command in a chain. If not the command is rejected with channel end, device end, and unit check status.

Status Indications

The following are status indications for the unconditional reserve command:

- Initial status is usually zero.
- Device busy status is possible.
- The disk control unit presents channel end and device end status after the sense bytes are transferred.
- Error conditions cause channel end, device end, and unit check status with the sense condition stored in the disk control unit for a subsequent sense command.

5. Status Information

This section describes the subsystem status information.

5.1. Status Conditions

The disk control unit or the disk drives generate the status conditions. The disk control unit transmits these conditions to the I/O channel in a status byte. If the initial status byte is zero for any command, except test I/O or no operation, all sense information is reset to zero.

5.2. Status Byte

The disk control unit transmits the status byte to the I/O channel during the initial selection sequence and for the following situations:

- To present channel end status when the data transfer operation is terminated
- To present the device end status condition and any associated conditions to the I/O channel
- To present control unit end or device end status to indicate the disk control unit or device that was busy is now free
- To indicate that a device has gone to a ready condition from a not-ready condition.

A description of each status bit is shown in Table 5-1.

Status Byte Definition

Table 5-1. Status Byte Bit Description

Bit Position	Designation	Description
P	Parity	Parity bit for the status byte.
0	Attention (System 80 only)	Indicates that the device has gone from a not-ready to ready status. Attention status is presented when the power-on sequence is complete.
1	Status Modifier	Presented with busy status and indicates that the disk control unit is busy.
2	Control Unit End	Control unit end status is a noncommand response to control unit busy (status modifier with busy). If control unit busy was presented during initial selection, the disk control unit, when free presents control unit end as unsolicited status to the channels that received control unit busy.
3	Busy	The disk control unit presents busy status only as initial status for the following conditions: ▪ Device Busy ▪ Control Unit Busy ▪ Busy with Other Status
4	Channel End	Channel end status is presented for each command and indicates that data transfer is complete. Channel end status is also presented for commands that have no data transfer after the operation is started. Device end is either included with channel end or is presented alone at a later time.
5	Device End	Device end status is presented at the completion of each command. Device end status may be presented with channel end status or alone at a later time. Device end status is also presented in response to device busy status (busy status alone) when the device becomes free.
6	Unit Check	Unit check status indicates an unusual or error condition on either the current or the prior command. After unit check is presented, the disk control unit constructs sense information detailing the error condition and enters a contingent connection state.

Table 5-1. Status Byte Bit Description (cont)

Bit Position	Designation	Description
7	Unit Exception	Unit check may appear alone (initial status) or with channel end and device end (ending status). If errors are detected after channel end is presented, device end is presented as normal. The next command receives the unit check in initial status. Unit exception indicates the device detected an unusual condition. The System 80 indicates that an ECC data error was detected and corrected.

5.3. Initial Status

Whenever the channel issues a command, the disk control unit presents initial status to the I/O channel. The initial status byte for the test I/O command and all nonimmediate commands is zero unless one or more of the following conditions exist:

- The path from the device or disk control unit to the channel is busy. The control unit signals busy whenever contention with another path blocks access to the selected device or whenever a previously initiated action is still incomplete at either the device or the control unit.
- Status is pending at the disk control unit or the device. For this condition, the disk control unit presents pending status as initial status. The disk control unit also presents busy status for all operations except test I/O. The pending status is cleared unless it is stacked.
- A unit check condition exists at either the disk control unit or device. For this condition, the disk control unit presents unit check status for all operations except sense I/O, which presents zero status.
- The disk control detects a command code parity error during a bus out operation.

5.4. Busy Status

The disk control unit presents busy status as control unit busy or device busy. Busy status indicates that the disk control unit or device cannot execute a command because of a busy condition at either the disk control unit or the device.

Control Unit Busy

Both busy and status modifier status occur together to indicate the control unit busy condition. Control unit busy occurs in response to an initial selection when:

- A disk control unit operation presents channel end status after transferring parameters or data, but before command processing is complete.
- A write operation is still in progress after command chaining is ended.
- The disk control unit is unable to execute the command because a control unit error recovery or diagnostic procedure is in progress.
- Status is pending in the disk control unit for a device other than the addressed device.
- The disk control unit establishes a contingent connection for some device other than the addressed device.
- Another channel attached to a multichannel disk control unit is using the addressed control unit.
- A system reset is in progress at the disk control unit.
- A disk control unit initiated connection is preferred to a channel initiated connection.

Device Busy

Busy status alone (without status modifier status) indicates the device busy condition. Device busy status is presented when:

- Device end status for the selected device is pending.
- The device is reserved for another channel or disk control unit.
- The disk control unit presents channel end status without device end status for the device.

5.5. Ending Status

Either the disk control unit or the I/O channel initiates an ending status procedure. Sometimes, the I/O channel initiates an ending status procedure before the disk control unit or device reaches its normal end point. Immediate commands present channel end and device end status in the initial status byte. A valid command can cause ending status to be presented to the channel twice. Channel end status is presented to the channel after the parameters are transferred and checked for validity. Device end status is presented again when the locate command is completed, and the disk control unit can accept another command for the device.

5.6. Pending Status

Pending status is status generated by the disk control unit or the device, but not presented to the I/O channel. Pending status is different from stacked status. Stacked status is status presented to but not accepted the channel.

When pending status is detected, the disk control unit begins a control unit initiated sequence. The pending status is presented as soon as the I/O channel, disk control unit, and device are not busy.

The types of pending status are:

- Status pending at the disk control unit.

  Status is pending at the disk control unit when:

  - Busy, channel end, or unit check status was stacked.
  - A test I/O command results in a zero status indication, which is stacked by the channel.
  - Disk control unit busy status was presented to the channel, and control unit end status is pending.
  - An interface disconnect condition occurs after a command is issued, but before channel end status is accepted. After the operation is complete, ending status remains pending at the disk control unit.
  - Status may be pending at the disk control unit when device end status from a command is stacked.

- Status pending at the device.

  Device end status is pending for the device when:

  - Channel end status was presented without device end, and the operation is now complete at the device.
  - Busy status was presented for the device, and the device is no longer busy.
  - The device condition changed from a not ready condition to a ready condition.
  - Device end status from a command is stacked, and status is not held pending at the disk control unit.

- Status pending in a control unit-initiated sequence.

  When a control unit initiated sequence presents pending status, several separate pending status conditions may exist within the disk control unit and attached devices. Pending status is presented in the following order:

  1. The highest priority is any status pending at the disk control unit, except control unit end status. During a contingent connection condition, control unit end status has the highest priority.
  2. Unsuppressible status
  3. Suppressible device end status
  4. Control unit end status

When a control unit initiated sequence presents status, the address is the address of a not-busy device within the range of addresses of the disk control unit.

5.7. Contingent Connection

A contingent connection condition is a special state maintained in the disk control unit after the control unit presents unit check status. The contingent connection condition ensures that sense information is not lost or destroyed by activity on other channels or devices. While in a contingent connection, the disk control unit appears busy (control unit busy) to all attached channels and devices, except to the specific device address associated with the unit check.

After the I/O channel accepts unit check status, a contingent connection condition is established in the disk control unit. This connection lasts until:

- A command other than test I/O or no operation receives an initial status byte of zero for the disk control unit and device address that generated the unit check.
- A selective reset occurs
- A system reset occurs

The disk control unit will be busy to all addresses other than the address that the contingent connection condition was established.

5.8. Multiple Status Indications

In cases where several different status indications are specified for a particular condition, these indications may not be presented together at one time. For example, where a condition calls for status indications of channel end, device end, and unit check status, the disk control unit may present channel end status first and then present device end and unit check status later.

6. Sense Information and Error Logging

This section describes the sense data format, each bit of the sense bytes, and the error logging operation.

6.1. Sense Information Construction

Sense information is constructed whenever unit check status is presented. This information must be retrieved by issuing a sense I/O command. Sense information is reset upon completion of the next command following presentation of unit check status and will be lost if that command is not a sense I/O.

The complete sense is twenty-four bytes in length and details the unit check condition. The following subsections define the sense information and indicate the system recovery action for equipment error conditions (such as, bus out parity) only. There are no recovery actions for error conditions for programming or operational problems (such as, end of cylinder or intervention required).

6.2. Sense Bytes 0 through 7

A description of sense bytes 0 through 7 bit positions follows.

Byte 0

The bit definitions for byte 0 are:

- Command Reject (0)

  Command reject is set by:

  - An invalid command code.
  - An invalid command sequence.
  - An invalid or incomplete argument transferred by any control command.
  - Issuing any write command when write operations are inhibited by local switch settings. Byte 1, bit 6 (write inhibited sense) is also set.

- Issuing a format write command that violates the define extent mask.
- Issuing a locate command with a format defective block specified in the operation byte and with space in the alternate area exhausted. The disk control unit also presents operation incomplete sense (byte 1, bit 7).
- Issuing a locate command with write data specified in the operation byte and the define extent mask inhibits all write operations.
- An invalid or incomplete argument transferred by diagnostic control commands.

- Intervention Required (1)

  Bit 1 is set by:

  - Addressing a drive that is not attached to the system
  - Addressing a drive that is not ready

- Bus Out Parity (2)

  Bit 2 is set when a parity error is detected during command transfer from the channel.

- Equipment Check (3)

  Equipment check indicates that an unusual hardware error condition occurred in the I/O channel, disk control unit, or device. This condition is described in more detail in sense bytes 7 through 23.

- Data Check (4)

  Data check indicates that the disk control unit detected a data error in the information received from the device. If the disk control unit presents data check with correctable sense, the data error is corrected.

- Bits 5 through 7 are not used and are set to zero.

Byte 1

The bit definitions for byte 1 are:

- Permanent Error (0)

  Bit 0 is set when internal error recovery is exhausted (by command retry) and unsuccessful, or when internal error recovery was not possible or desirable. The bit overrides any other bit settings and indicates that system error recovery procedures may not be required.

- Block Size Exception (1)

  Bit 1 is set when an invalid block size is specified in bytes 2 and 3 of a define extent command.

- Bit 2 is not used and is set to zero.

- Operator Message (3)

  Bit 3 is set with byte 0, bit 3 (Equipment Check) when reporting disk control unit control checks (format 3).

- Bit 4 is not used and is set to zero.

- File Protected (5)

  Bit 5 is set when a diagnostic control or locate command violates the logical extent limits established by a define extent command.

- Write Inhibited (6)

  Bit 6 is set when a write operation is attempted on a drive that is write inhibited. Byte 0, bit 0 (command reject) is also set.

- Operation Incomplete (7)

  Bit 7 is set when:

  - A correctable data check is detected in the data area of any block other than the last block. Byte 0, bit 4 (data check) and byte 2, bit 1 (correctable) are also set.

  - An uncorrectable data check is detected in the data area of any block other than the first block. Byte 0, bit 4 (data check) is also set.

  - A locate command is issued with a format defective block specified in the operation byte, and space in the alternate area is exhausted. Byte 0, bit 0 (command reject) is also set.

  - An access error is detected after the start of data transfer during a multitrack read or write operation.

Byte 2

The bit definitions for byte 2 are:

- Check Data Error (0)

  Bit 0 is set when an uncorrectable data check is detected during the read verification phase of a write command with write and check data specified in the preceding locate command.

- Correctable (1)

  Bit 1 is set when the data check condition indicated by byte 0, bit 4 (data check) is correctable.

- In the block multiplexer channel systems, bit 2 is not used and must be set to zero.

- In the System 80, bit 2 is the multiple corrections bit. This bit is set when multiple blocks are corrected by the disk control unit. Bit 1 must also be set.

- Environmental Data Present (3)

  Bit 3 is set when:

  - An error counter overflows.
  - The usage statistics require off loading.
  - A read and reset buffered log command is executed.

- Bits 4 through 7 are not used and must be set to zero.

Byte 3

The bit definitions for byte 3 are:

- High Order Cylinder Address (0 - 2)

  Bits 0 and 2 identify the high-order cylinder address of the most recent seek.

Byte 4

The bit definitions for byte 4 are:

- Low Order Cylinder Address (0 - 7)

  Bits 0 through 7 identify the low-order cylinder address of the most recent seek.

Byte 5

The bit definitions for byte 5 are:

- Head Address (0 - 7)

  Bits 0 through 7 identify the head address of the most recent seek. Operations involving head switching update this byte.

Byte 6

The bit definitions for byte 6 are:

- Block Number - (0 - 7) (block multiplexer channel)
- Sector Number - (0 - 7) (System 80 selector channel)

  Block number (sector number on System 80) sense identifies the block (sector) that was last processed. This byte is valid only when byte 7, bits 0 through 3 specify format 4, format 5, or format 0 when byte 1, bit 7 (operation incomplete) is set. Format 6, byte 6 identifies the disk control unit (hexadecimal 74).

Byte 7

The bit definitions for byte 7 are:

- Format Code (0 - 3)

  Bits 0 through 3 specify the format of sense bytes 8 through 23 as follows:

  - Format 0 program or system check
  - Format 1 device equipment check (customer engineer information)
  - Format 2 control unit equipment checks (customer engineer information)
  - Format 3 selective reset information (block multiplexer channel), control unit checks (System 80 selector channel)
  - Format 4 data check without displacement information (block multiplexer channel), uncorrectable data check (System 80 selector channel)
  - Format 5 data check with displacement information (block multiplexer channel), data check corrected (System 80 selector channel)
  - Format 6 usage statistics errors

  Formats 0 through 6 are described in 6.3.

- Message Code (4 - 7)

  Bits 4 through 7 describe error conditions for each of the above formats. The message table that accompanies the format specifies the function of the message bits.

6.3. Sense Bytes 8 through 23

The format of sense bytes 8 through 23 varies with the format decoded. The following subsections describe sense bytes 8 through 23 for formats 0 through 6.

Format 0 - Program or System Check

Format 0 is used when sense bytes 0 through 7 completely describe an error or unusual condition caused by a program or system error.

- Locate Parameters (Bytes 8 - 15)

  Bytes 8 through 15 contain the updated locate parameters when operation incomplete sense (byte 1, bit 7) occurs, and the error was not detected. At other times, these bytes are set to zero.

- Blocks Transferred (Bytes 16, 17)

  Bytes 16 and 17 contain the number of blocks transferred to the system (excluding the error block) when an operation incomplete (byte 1, bit 7) occurs, and the error was not detected. At other times, these bytes are set to zero.

- Bytes 18 through 20 are not used and are set to zero (block multiplexer channel).

- Search Hit Block Number (Bytes 18 - 20), System 80 only

  When the search argument is satisfied, bytes 18 through 20 contain the logical block number of the block that satisfied the search command.

- Disk Control Unit ID (Byte 21)

  Byte 21 contains the same disk control unit ID (hexadecimal 74) as byte 6.

- Microcode Revision and Patch Levels (Bytes 22, 23)

Format 1 - Device Equipment Check

Format 1 is generated when one of the following conditions occur:

- A device, device interface, or a disk control equipment check is detected. The equipment check bit (byte 0, bit 3) is also set.

- A permanent device seek check is detected. The equipment check bit (byte 0, bit 3) and permanent error bit (byte 1, bit 0) are also set.

- The online bit (byte 8, bit 4) is off. The permanent error bit (byte 1, bit 0) is also set.

Format 2 - Disk Control Unit Equipment Checks

Format 2 sense data indicates the following disk control unit equipment checks:

- Channel Interface (Byte 8)
- Control Board Parity (Byte 9)
- Device Driver Fault Code (Bytes 10 and 11)
- Bytes 12 and 13 are not used and are set to zero.
- T Bus Register Contents (Bytes 14 and 15)
- Status Register Contents (Bytes 16 and 17)
- Bytes 18 and 19 are not used and are set to zero.
- Device Interface (Byte 20)
- Control Unit Device Interface Unsafe (Byte 21)
- Bytes 22 and 23 are not used and are set to zero.

Format 3 - Disk Control Unit Control Checks

Format 3 sense data indicates the disk control unit state at the time of a hardware detected or microcode detected error, or diagnostic test error status as indicated by byte 8, bits 0 or 1.

Format 4 - Uncorrectable Data Check

Format 4 is named *Data Checks Without Displacement Information* for block multiplexer channels systems. For the System 80, format 4 is named *Uncorrectable Data Check.*

Format 4 is generated when errors that are not correctable by the error correction code (ECC) are detected in the ID or data field. The message code in sense byte 7 identifies the field.

- Locate Parameters (Bytes 8 - 15)

  Bytes 8 through 15 contain the updated locate parameters when an operation incomplete (byte 1, bit 7) occurs, and the error was not detected. At other times, these bytes are set to zero.

- Blocks Transferred (Bytes 16, 17)

  Bytes 16 and 17 contain the number of blocks transferred to the channel (excluding the error block).

- Offset (Bytes 18 - 21)

  Bytes 18 through 21 specify, in blocks, the offset of the error block from the beginning of the data set.

Format 5 - Data Checks With Displacement Information

Format 5 is named *Data Checks With Displacement Information* for block multiplexer channel systems. For the System 80, format 5 is named *Data Check Corrected.*

Format 5 is generated when ECC correctable data checks are detected in the data area of a record.

- Locate Parameters (Bytes 8 - 15)

  Bytes 8 through 15 contain the updated locate parameters when an operation incomplete (byte 1, bit 7) occurs and the error was not detected. At other times, these bytes are set to zero.

- Blocks Transferred (Bytes 16, 17)

  Bytes 16 and 17 contain the number of blocks transferred to the channel (excluding the error block).

- Error Displacement (Bytes 18, 19)

  Bytes 18 and 19 specify the data field location of the first data byte in error.

- Error Pattern (Bytes 20 - 23)

  Bytes 20 through 23 identify the bits in error when the data check is correctable.

Format 6 - Usage Statistics Errors

Format 6 is generated when a read and reset buffered log command is executed, and counter overflow requires usage and error statistics to be off loaded.

- Blocks Read (Bytes 8 - 10)

  Bytes 8 through 10 contain an accumulated count of blocks read during read operations.

- Correctable Data Checks (Bytes 11, 12)

  Bytes 11 and 12 contain an accumulated count of ECC-correctable data checks detected and corrected by the disk control unit.

- Uncorrectable Data Checks (Byte 13)

  Byte 13 contains the number of ECC-uncorrectable data checks retried by the disk control unit.

- Access Offset Involved (Byte 14)

  Byte 14 contains the number of ECC-uncorrectable data checks that involve access offset.

- Blocks Written With Verify (Bytes 15 - 17)

  Bytes 15 through 17 contain the number of blocks written with the check option specified.

- Byte 18 is not used and must be set to zero.

- Seeks (Bytes 19, 20)

  Bytes 19 and 20 contain the number of seeks processed by the disk control unit.

- Seek Errors (Byte 21)

  Byte 21 contains the number of seek errors that were retried by the disk control unit.

- Bytes 22 and 23 are not used and are set to zero.

6.4. Error Logging

The total number of blocks read and the access movements made by each disk drive are maintained in a blocks read counter and seek usage counter for each disk drive. These counters also maintain error counts for seek errors, uncorrectable data checks, and correctable data checks. The host issues a read and reset buffered log command to read the counters. Each of two disk control units maintain a set of counters for each disk drive in a dual-access configuration. The counters limits follow.

Usage Counters

Usage counters overflow at these values:

- Blocks read - 7FFFFF
- Blocks written with check data - 7FFFFF
- Access motions - 7FFF

Error Counters

Error counters overflow at these values:

- Corrected data checks - 512
- Uncorrectable data checks - 64
- Uncorrectable data checks with offset - 64
- Access errors - 8

Whenever any of the counters overflow, the next I/O sequence for the respective disk drive receives an immediate unit check status (environmental data, format 6). When a read and reset buffered log command is executed, the sense format for the overflow condition is the same as the format of the data received. Thus, for the overflow condition, a sense command is enough to read and reset the counters.

7. Hardware Error Detection and Recovery Procedures

This section describes the hardware error detection and recovery procedures. Subsection 7.1 describes error conditions detected by the disk control unit. This subsection also gives the system recovery action for each error condition. Subsection 7.2 describes each recovery action and gives the associated error conditions. Appendix A summarizes error conditions and recovery actions.

7.1. Error Conditions

The disk control unit reports only single error conditions and one single status condition at a time. After unit check status is presented (with or without other status), the disk control unit reports error conditions on a sense command.

When the disk control unit detects an error condition, it uses internal retry or command retry recover from the error condition. If the error persists or if retry is not possible, the disk control unit presents unit check status to the host system with or without other status bits. The host system then issues a sense command to retrieve the sense information that describes the error.

The following subsections describe the error conditions reported by the disk control unit in sense information. Subsection 7.2 explains the recovery actions referred to in this section.

Programming Errors or Unusual Conditions

The disk control unit detects the following channel programming errors and unusual conditions.

- Invalid Command Code

  The disk control unit detects this condition in the initial-selection sequence. The disk control unit ends the commands with unit check status.

  The disk control unit presents format 0 sense information with command reject sense (byte 0, bit 0) set.

  The system recovery procedure is recovery action 2.

- Invalid Command Sequence

  The disk control unit detects this condition during command execution. The disk control unit ends the commands with channel end, device end, and unit check status.

  The disk control unit presents format 0 sense information with command reject sense (byte 0, bit 0) set.

  The system recovery procedure is recovery action 2.

- Invalid or Incomplete Parameter

  The disk control unit detects invalid or incomplete parameters transferred on a define extent, locate, or diagnostic control command. The disk control unit ends the commands with channel end, device end, and unit check status.

  The disk control unit presents format 0 sense information with command reject sense (byte 0, bit 0) set.

  The system recovery procedure is recovery action 2.

- Violation of Define Extent Mask

  The disk control unit ends a diagnostic control command (with format ID subcommand) or a locate command (with write data specified) that violates the define extent mask with channel end, device end, and unit check status.

  The disk control unit presents format 0 sense information with command reject sense (byte 0, bit 0) set.

  The system recovery procedure is recovery action 2.

Write Inhibited

The disk control unit ends a locate command (with format defective block, write data, or write and check data subcommands) that is issued with the addressed drive in read-only mode with channel end, device end, and unit check status.

The disk control unit presents format 0 sense information with command reject sense (byte 0, bit 0) and write inhibited sense (byte 1, bit 6) set.

The system recovery procedure is recovery action 1.

Alternate Space Exhausted

The disk control unit ends a locate command that is issued with a format defective block operation byte and with space in the alternate area exhausted with device end and unit check status.

The disk control unit presents format 0 sense information with command reject sense (byte 0, bit 0) and operation incomplete (byte 1, bit 7) set.

The system recovery procedure is recovery action 1.

Drive Offline or Not On System

When there is no addressed drive attached to the disk control unit or the disk control unit is not ready, the command is ended with channel end (if not already presented), device end, and unit check status.

If the disk control unit detects this error in the initial-selection sequence, it presents check status alone.

The system recovery procedure is recovery action 3.

Bus Out Parity Error

When this condition occurs during a command transfer, the disk control unit ends the commands in the initial-selection sequence with unit check status alone.

When this condition occurs during a data transfer from the I/O channel to the disk control unit, the disk control unit ends the command with channel end, device end, and unit check status.

The disk control unit presents format 0 sense information with bus out parity sense (byte 0, bit 2) set.

The system recovery procedure is recovery action 3.

Drive Equipment Check

When this condition occurs during initial selection, the command is ended with unit check status alone.

When this condition occurs during command execution, the command is ended with channel end (if not already presented), device end, and unit check status.

If a permanent error occurs, the disk control unit generates format 1 sense information with equipment check sense (byte 0, bit 3) and permanent error sense (byte 1, bit 0) set. The system recovery procedure is recovery action 1.

If a permanent error does not occur, the disk control unit generates format 1 sense information with equipment check sense (byte 0, bit 3) only set. The system recovery procedure is recovery action 5.

Disk Control Unit Errors

The types of disk control unit errors are:

- No Response

  This error is not a unit check status condition. If the disk control unit does not respond to the system, the system responds with the following recovery procedures:

  1. Print console error message
  2. Issue a halt device instruction
  3. Retry the operation once

- Disk Control Unit Control Check

  This condition starts the disconnect-in tag to the subsystem, which requests a selective reset. When the disk control unit receives a selective reset, it does a state save operation and a reset sequence.

  The disk control unit presents unit check status alone in the next initial-selection sequence and generates format 3 sense information with equipment check sense (byte 0, bit 3) and operator message (byte 1, bit 3) set.

  The system recovery procedure is recovery action 4.

- Disk Control Unit Equipment Check

  When an equipment check condition other than control check occurs in the disk control unit during command execution, the disk control unit ends the command with channel end (if not already presented), device end, and unit check status.

  If the disk control unit detects this error during the initial-selection sequence, it presents unit check status alone.

  The disk control unit generates format 2 sense information with equipment check sense (byte 0, bit 3) set. The message code in sense byte 7 further identifies this error.

  The system recovery procedure is recovery action 5.

Data Check

When the disk control unit reads the data or ID fields from the disk drive, it checks for and detects data check errors. Data check errors are detected by failure to synchronize on a field (sync check) or by using the disk control unit error correction code (ECC) hardware. If ECC data check errors are correctable, the disk control unit generates a correction pattern to correct the invalid data as part of the format 5 sense information.

- Data Check in ID Field

  When the disk control unit reads the ID fields from the disk drive, it checks for data check errors. When a data check error is detected, the disk control unit tries recovery via internal retry up to 28 times, or less if the error is corrected.

  If the error is corrected, the operation continues. If the error cannot be corrected, the disk control unit ends the commands with channel end, device end, and unit check status. The disk control unit also generates format 4 sense information with data check sense (byte 0, bit 4) and permanent error sense (byte 1, bit 0) set.

  The system recovery procedure is recovery action 1.

- Correctable Data Check in Last Block

  When the disk control unit detects a correctable data check in the data field of the last block during a read operation, it presents retry status with or followed by device end status and then ends the command.

  The disk control unit presents unit check status as initial status when the system retries the failed command. The disk control unit also generates format 5 sense information with data check sense (byte 0, bit 4) and correctable sense (byte 2, bit 1) set.

  The system recovery procedure is recovery action 6.

- Correctable Data Check in Any Except Last Block

  When the disk control unit detects a correctable data check in the data field of any block except the last block during a read operation, it presents retry status with or followed by device end status and then ends the command.

  The status presented for this condition and the sense generated is the same as the Correctable Data Check in Last Block condition above, except operation incomplete sense (byte 1, bit 7) is also set.

  The system recovery procedure is recovery action 7.

- Uncorrectable Data Check in First Block

  When the disk control unit detects an uncorrectable data check (sync check or uncorrectable ECC error) in the data field of the first block during a read operation, the system tries recovery using command retry up to 28 times, or less if the error condition clears.

If retry is successful, the disk control unit continues the read operation. If retry is not successful, the disk control unit ends the command with channel end, device end, and unit check status. The disk control unit also generates format 4 sense information with data check sense (byte 0, bit 4) and permanent error sense (byte 1, bit 0) set.

The system recovery procedure is recovery action 1.

- Uncorrectable Data Check in Any Except First Block

  When the disk control unit detects an uncorrectable data check (sync check or uncorrectable ECC error) in the data field of any block except the first block for the command during a read operation, it presents retry status with or followed by device end status and then ends the command.

  The disk control unit presents unit check status as initial status on the retried command, and generates format 4 sense information with data check sense (byte 0, bit 4) and operation incomplete sense (byte 1, bit 7) set.

  The system recovery procedure is recovery action 8.

- Check Data Error

  If the disk control unit detects a correctable data check while reading a data field of any block during a write and check data operation, it continues the operation until all blocks written are checked.

  If the disk control unit detects an uncorrectable data check (sync check or uncorrectable ECC error) while reading a data field of any block during a write and check data operation, it ends the command with device end and unit check status. The disk control unit also generates format 4 sense information with check data error sense (byte 2, bit 0) set.

  The system recovery procedure is recovery action 5.

Service Overrun

When the disk control unit transfers many data blocks between it and a slow I/O channel, a service overrun condition can occur. The overrun is caused by a slow I/O channel that cannot transfer data at the data transfer rate of the disk drive.

The disk control unit contains a 32K byte channel buffer to prevent a service overrun condition. During a write transfer operation, the disk control unit prefills the buffer with data from the channel before beginning the write transfer to the disk drive.

If the channel fails to keep up with the transfer to or from the disk control unit or disk drive, an extra revolution of the disk occurs to permit the buffer to empty or fill as needed. The disk control unit does not report a service overrun condition to the channel.

Block Size Exception

When the define extent command specifies an invalid block size (bytes 2 and 3), the disk control unit ends the command with channel end, device end, and unit check status. The disk control unit also generates format 0 sense information with block size exception sense (byte 1, bit 1) set.

The system recovery procedure is recovery action 2.

File Protected

When a locate command violates the logical extent limits established by the define extent command, the disk control unit ends the command with device end and unit check status. The disk control unit also generates format 0 sense information with file protected sense (byte 1, bit 5) set.

The system recovery procedure is recovery action 10.

Access Error

The disk control unit detects access errors that occur during the disk drive access mechanism movement.

- Access Error Before Data Transfer

  The disk control unit attempts recovery using command retry one time if it detects an access error before data transfer occurs for read or update write operations, except for a write command specifying write and check data.

  If retry is successful, the disk control unit continues the operation.

  If retry is not successful, the disk control unit ends the command with channel end, device end, and unit check status. The disk control unit also generates format 1 sense information with equipment check sense (byte 0, bit 3) and permanent error sense (byte 1, bit 0) set.

  The system recovery procedure is recovery action 1.

- Access Error After Data Transfer

  If the disk control unit detects an access error after the data transfer has begun for all read or update write operations, except a write command specifying write and check data, the disk control unit ends the command with channel end, device end, and unit check status. The disk control unit also generates format 0 sense information with operation incomplete sense (byte 1, bit 7) set.

  The system recovery procedure is recovery action 9.

- Access Error During Write of Write and Check Data

  If the disk control unit detects an access error during a write operation of a write command that specifies write and check data, the disk control unit attempts recovery using command retry one time.

  If retry is successful, the disk control unit continues the operation.

  If retry is not successful, the disk control unit ends the command with channel end, device end, and unit check status. The disk control unit also generates format 1 sense information with equipment check sense (byte 0, bit 3) and permanent error sense (byte 1, bit 0) set.

  The system recovery procedure is recovery action 1.

- Access Error During Read of Write and Check Data

  If the disk control unit detects an access error during the read-back operation of a write operation that specifies write and check data, or when a format defective block subcommand of a locate command or a format ID subcommand of a diagnostics control command are executed, the disk control unit attempts recovery through internal retry one time.

  If internal retry is successful, the disk control unit continues the operation.

  If internal retry is not successful, the disk control unit ends the command with device end and unit check status. The disk control unit also generates format 1 sense information with equipment check sense (byte 0, bit 3) and permanent error sense (byte 1, bit 0) set.

  The system recovery procedure is recovery action 1.

Error Counter or Usage Counter Overflow

The disk control unit keeps track of the total count for the following items:

- Blocks read during read operations for each drive
- Access movements for each drive
- Blocks written by a write and check data subcommand for each drive
- Access errors retried by the disk control unit for each drive
- Correctable data checks detected by the disk control unit for each drive
- Uncorrectable data checks retried by the disk control unit for each drive
- Uncorrectable data checks retried by the disk control unit for each drive with offset

The error and usage counters overflow at the following values:

- Blocks read up to 8,388,608
- Access movements up to 65,536
- Blocks written with check data up to 8,388,608
- Access errors up to 8
- Correctable data checks up to 512
- Uncorrectable data checks - 64
- Uncorrectable data checks with offset - 64

Both disk control units in a dual-access configuration keep a set of counts. If a system reset or a counter off-load operation occurs, the counters are reset to zero.

When any of these counters overflow, the next command for the corresponding drive is ended with unit check status in the initial-selection sequence. The disk control unit generates format 6 sense information with environment data present sense (byte 2, bit 3) set.

Defective or Alternate Block

This error is not a unit check status condition. When the disk control unit reads an ID field from the disk drive, in preparation for a read or write operation on the corresponding data field, it checks for a defective or alternate block. If it detects a defective or alternate block, the disk control unit uses internal retry to access the corresponding defective or alternate block and continues the operation without an I/O interruption or channel assistance.

Disk Control Unit Offline

This error is not a unit check status condition. If the addressed disk control unit is not connected to the system, is powered off, or if a bus-out parity error occurs during the address byte transfer, the system receives the active select-in tag in the initial-selection sequence.

The system recovery procedure is:

- Print console error message
- Retry the operation one time

Use an alternate path (if available) if the error persists.

7.2. System Recovery Actions

This section provides a detailed description of the system recovery actions. Each description includes the name of the recovery action, associated error conditions for each recovery action, and whether the sense information should be logged in the system log file for customer engineer use.

Recovery Action 1

Print console error message

The error conditions that require recovery action 1 are:

- Command Reject (byte 0, bit 0) and Write Inhibited (byte 1, bit 6)

  The disk drive received a write command while the WRITE INHIBITED switch was in the read-only position. No sense information is put in the system log file.

- Command Reject (byte 0, bit 0) and Operation Incomplete (byte 1, bit 7)

  Alternate space is exhausted. No sense information is put in the system log file.

- Equipment Check (byte 0, bit 3) and Permanent Error (byte 1, bit 0)

  The equipment malfunctioned and retry is exhausted or not desirable. Sense information is put in the system log file.

- Data Check (byte 0, bit 4) and Permanent Error (byte 1, bit 0)

  An uncorrectable data check occurred and command retry is exhausted. Sense information is put in the system log file.

Since these errors are not recoverable, a console error message is printed to notify the operator.

Recovery Action 2

Exit with programming error or unusual condition indication.

The error conditions that require recovery action 2 are:

- Command Reject (byte 0, bit 0)

  A programming error occurred. No sense information is put in the system log file.

- Block Size Exception (byte 1, bit 1)

  An invalid block size is specified. No sense information is put in the system log file.

Since the error is a programming or unusual error and is not recoverable, the operation cannot be completed. Program abnormal exit routines could be used, if available.

Recovery Action 3

Repeat operation once and print console error message if error persists.

The error conditions that require recovery action 3 are:

- Intervention Required (byte 0, bit 1)

  The disk drive is offline or not on system. No sense information is put in the system log file.

- Bus Out Parity (byte 0, bit 2)

  The bus out parity error occurred. Sense information is put in the system log file.

- Environmental Data Present (byte 2, bit 3)

  Statistical usage or error log information is present. Sense information is put in the system log file.

Because the condition that caused the error may clear after one occurrence, repeat the operation. If the error condition continues, refer to recovery action 1 for further procedures.

Recovery Action 4

Print console error message and repeat the operation up to ten times if needed. Print console error message if error condition continues.

The error conditions that require recovery action 4 are:

- Equipment Check (byte 0, bit 3)
- Operator Message (byte 1, bit 3)

State save operation (format 3 sense) in reporting disk control unit. Sense information is put in the system log file.

Print a console error message to immediately notify the operator about this error condition. Refer to recovery action 5 for further procedures.

Recovery Action 5

Repeat operation up to ten times if needed and print console error message if error condition continues.

The error conditions that require recovery action 5 are:

- Equipment Check (byte 0, bit 3)

  Equipment malfunction. Sense information is put in the system log file.

- Check Data Error (byte 2, bit 0)

  An uncorrectable data check occurred during a check data operation. Sense information is put in the system log file.

Because error condition may be intermittent, repeat the operation up to ten times. If the error condition continues, refer to recovery action 1 for further procedures.

Recovery Action 6

Correct last block and continue chain.

The error conditions that require recovery action 6 are:

- Data Check (byte 0, bit 4)
- Correctable (byte 2, bit 1)

A correctable data check occurred in the last data area during a read operation. No sense information is put in the system log file.

Perform the following procedures:

1. The system recovery procedures use recovery action 6 as a step in recovering from a correctable data error that occurs in a block data area.

   When data check and correctable sense occurs (and possibly operation incomplete), sense bytes 18 through 23 (see 6.3) provide error pattern and displacement information. Error correction is done by aligning the error pattern in sense bytes 20 through 23 with the erroneous data in main storage. The location of the erroneous data is determined by the displacement information in sense bytes 18 and 19, and by the counts provided in the interrupted channel program.

   Bytes not transferred to main storage bypass the error correction function.

2. Simulate normal ending status for the channel command word that is completed when the error correction function is completed.

3. If the channel program is complete, the user program is notified of the completion. Issue a define extent command the same as the one in the interrupted channel program and command chain it to the next channel command word in the interrupted channel program, as determined from the simulated status to continue the channel program.

Recovery Action 7

Correct block (not last) and resume operation.

The error conditions that require recovery action 7 are:

- Data Check (byte 0, bit 4)
- Correctable (byte 2, bit 1)
- Operation Incomplete (byte 1, bit 7)

Correctable data check in the data area of any block except the last during a read operation. No sense information is put in the system log file.

Perform the following procedures:

1. The system recovery procedures use this error correction function as a step in recovering from a correctable data error that occurs in a block data area.

   When data check and correctable sense occurs (and possibly operation incomplete), sense bytes 18 through 23 (see 6.3) provide error pattern and displacement information. Error correction is done by aligning the error pattern in sense bytes 20 through 23 with the erroneous data in main storage. The location of the erroneous data is determined by the displacement information in sense bytes 18 and 19, and by the counts provided in the interrupted channel program.

   Bytes not transferred to main storage bypass the error correction function.

2. A read restart channel command word must be used to resume the operation starting with the block after the block erroneous data was corrected.

3. Complete the interrupted operation and continue the channel program by issuing a define extent command with the same parameters as the one in the interrupted channel program.

Recovery Action 8

Retry block (not first) and resume operation.

The error conditions that require recovery action 8 are:

- Data Check (byte 0, bit 4)
- Operation Incomplete (byte 1, bit 7)

An uncorrectable data check occurred in the data area of any block except the first during a read operation. No sense information is put in the system log file.

Perform the following procedures:

1. Use a read or write restart channel command word to retry the operation starting with the block in which the error occurred. Set the restart command code to a read command if sense byte 8, bit 7 equals 0. Otherwise, set it to a write command.
2. Complete the interrupted operation and continue the channel program by issuing a define extent command with the same parameters as the one in the interrupted channel program.

Recovery Action 9

Resume operation.

The error condition that requires recovery action 9 is:

- Operation Incomplete (byte 1, bit 7)

A seek error occurred after the start of data transfer during a read or update write (with check data modifier bit off) operation. No sense information is put in the system log file.

Perform the following procedures:

1. Use a read or write restart channel command word to resume the operation starting with the block after the point of interruption. Set the restart command code to a read command if sense byte 8, bit 7 equals 0. Otherwise, set it to a write command.
2. Complete the interrupted operation and continue the channel program by issuing a define extent command with the same parameters as the one in the interrupted channel program.

Recovery Action 10

Exit with programming error if blocks of user's data set or else correct extent limits and retry operation

The error condition that requires recovery action 10 is:

- File Protected (byte 1, bit 5)

Locate argument violated the define extent specifications. No sense information is put in the system log file.

If the blocks specified by the locate command are not in the user's data set perform recovery action 2. Otherwise, the host system software supplies correct extent limits. Complete the operation and continue the channel program. To do this issue a define extent command with the modified extent limit parameters and command chained to the locate channel command word in the interrupted channel program, as determined from the interrupt status.

Appendix A. Error Condition and System Recovery Action Summary

This appendix summarizes the error condition information and the system recovery actions from Section 7.

Error Condition from Sense Bytes				System Recovery Action		
Byte	Bit	Name	Description	Log	Action	Description
0	0	Command Reject	A programming error occurred.	No	2	Exit with the programming error or unusual condition indication.
0 1	0 6	Command Reject Write Inhibited	A write command was received with the WRITE PROT switch set for read-only operation.	No	2	Print the console error message.
0 1	0 7	Command Reject Operation Incomplete	The alternate space is exhausted.	No	1	Print the console error message.
0	1	Intervention Required	The disk drive is offline or not on subsystem.	No	3	Repeat the operation once. If the error persists, print the console error message.
0	2	Bus Out Parity	A bus out parity occurred.	Yes	3	Repeat the operation once. If the error persists, print the console error message.
0	3	Equipment Check	An equipment malfunction condition occurred.	Yes	5	Repeat the operation up to 10 times if needed. If the error persists, print the console error message.
0 1	3 0	Equipment Check Permanent Error	An equipment malfunction condition occurred and retry is exhausted or undesirable.	Yes	1	Print the console error message.

Error Condition and Recovery Action Summary

Error Condition from Sense Bytes				System Recovery Action		
Byte	Bit	Name	Description	Log	Action	Description
0 1	3 3	Equipment Check Operator Message	A state save operation (format 3 sense) exists in reporting disk control unit.	Yes	4	Repeat the operation up to 10 times if needed. If the error persists, print the console error message.
0 1	4 0	Data Check Permanent Error	An uncorrectable data check occurred and command retry is exhausted.	Yes	1	Print the console error message.
0 1	4 7	Data Check Operation Incomplete	An uncorrectable data check occurred in a data area of any block, except for the first block during a read operation.	No	8	Retry the block (not first block) and resume operation.
0 2	4 1	Data Check Correctable	A correctable data check occurred in the last data area during a read operation.	No	6	Correct the last block and continue the chain.
0 2 1	4 1 7	Data Check Correctable Operation Incomplete	A correctable data check occurred in the data area of any block, except the last block during a read operation.	No	7	Correct the block (not last) and resume operation.
1	1	Block Size Exception	An invalid block size was specified.	No	2	Exit with programming error or unusual condition indication.
1	5	File Protected	A locate argument violated the define extent specifications.	No	10	Exit with programming error if blocks out of user's data set or else correct extent limits and retry operation.
1	7	Operation Incomplete	A seek error occurred after the start of data transfer and during a read or update write with the check data modifier bit off.	No	9	Resume operation.
2	0	Check Data Error	An uncorrectable data check occurred during a check data operation.	Yes	5	Repeat the operation up to 10 times if needed. If the error persists, print the console error message.
2	3	Environmental Data Present	A statistical usage and/or error log information is present.	Yes	3	Repeat the operation once. If the error persists, print the console error message.

Glossary

A

access error

An error results from an access movement. Also called *seek error.*

B

block

See *Logical block.*

C

channel command word (CCW)

A CCW specifies the information necessary for the channel, control unit, and addressed drive to initiate an I/O operation.

channel program

A sequence of CCWs that control the operation of a subchannel

command chaining

Another command for the addressed drive immediately follows device end status.

command retry

A status indication that signals the I/O channel to retry a command without interrupting the system.

E

error correction code (ECC)

Bits appended to data and addresses that allows a device to detect double bit errors and correct single bit errors.

F

FIPS

Acronym for Federal Information Processing Standard. This is a National Bureau of Standards disk subsystem interface standard.

H

host system

The computer system to which the disk subsystem is attached.

L

logical block

A block of data that is the unit of information read or recorded during read or write operations.

P

positioning time

The time required for the accessor mechanism to move the read/write heads to the desired position.

R

recovery action

A code created by the control unit and transmitted to the host in an external interrupt word.

S

sector

A physical section of a track.

seek

An operation that positions the read/write heads to the addressed cylinder.

status

A byte of information presented to the I/O channel by the control unit that indicates the current condition of a device.

sense

Up to 24 bytes of information generated by the control unit to describe the condition of a device.

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