GA26-1589-2

Systems

# Reference Manual for IBM 2835 Storage Control and IBM 2305 Fixed Head Storage Module

IBM

# Preface

The 2835 Storage Control and 2305 Fixed Head Storage Module form a large capacity, high speed direct access storage facility for general purpose data storage and system residence. It attaches to the central processing unit through a block multiplexor channel, and operates under direct program control of the CPU.

For experienced programmers, this manual provides readily-accessible reference material related to channel command words, sense bytes, track format, track capacities, and error recovery.

Less experienced programmers will find sufficient information to create channel programs to best utilize the standard and special features of the facility.

A complete description of the switches and indicators is provided for systems installation operators.

Programmers should be familiar with the information contained in IBM System/360 Principles of Operation, Order Number GA22-6821 and IBM System/370 Principles of Operation Order Number GA22-7000. Operators should be familiar with the material presented in the system summary for the parent system. Order numbers for system summary and other related publications can be found in IBM System/360 and System/370 Bibliography, Order Number GA22-6822.

*Third Edition (August 1971)*

Significant changes or additions to the specifications contained in this publication are continually being made. Before using this publication in connection with the operation of IBM equipment, contact the local IBM Branch for revisions.

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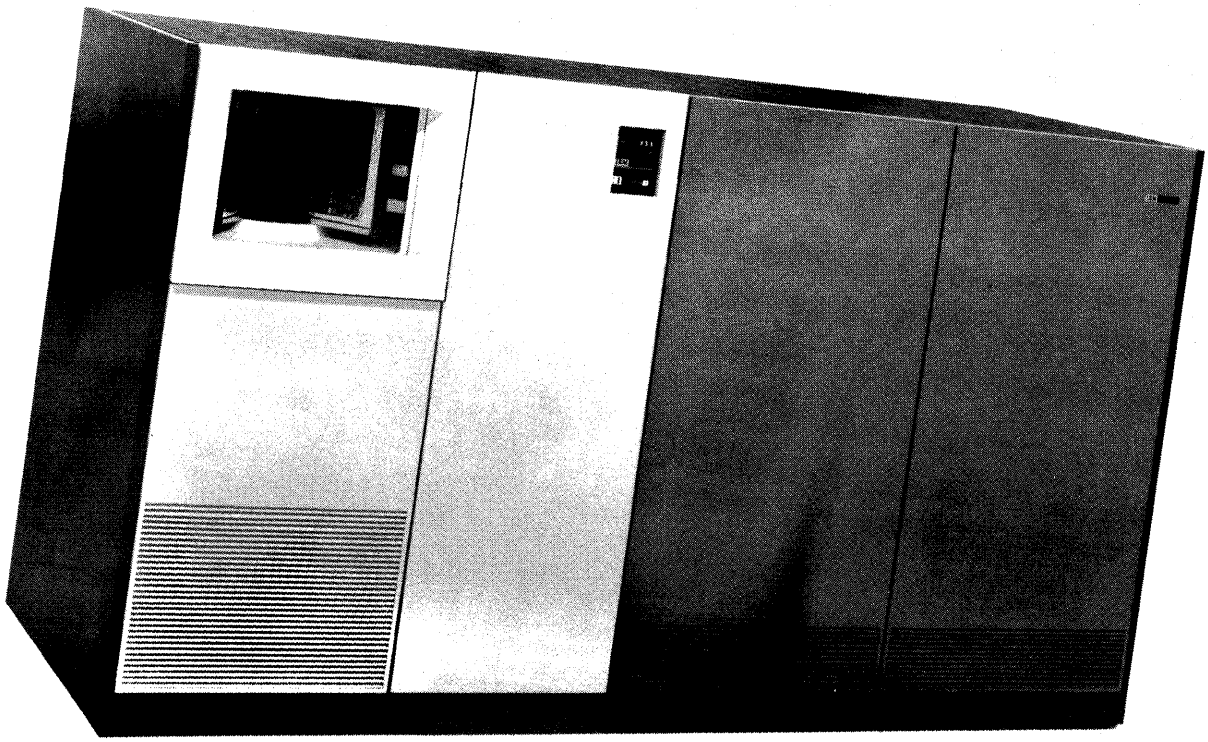

IBM 2835 Storage Control and 2305 Fixed Head Storage Module

## General Characteristics of the Facility

The IBM 2835 Storage Control and the IBM 2305 Fixed Head Storage module (briefly and collectively known as the "2305 Facility") provide for attachment of fast access, fixed head storage units to the IBM System/360 Model 85 and Model 195, and to the IBM System/370 Model 145, Model 155, Model 165 and Model 195.

Two types of the 2305 facility are available. Both consist of a single 2835 Storage Control and one or two 2305 Fixed Head Storage Modules. In the one type (Model 1) each 2305 utilizes two parallel recording paths, with two recording elements per path. In the other type, (Model 2) each 2305 is equipped with a single recording path and a single recording element per path.

When one or more 2305's are attached to a 2835, the model numbers of all units must match. For example, a 2835 model 1 may control two 2305 model 1's, and 2835 model 2 may control two 2305 model 2's.

## 2835 Storage Control

Capabilities

The IBM 2835 Storage Control provides the following capabilities:

1. Interpret and execute file commands.
2. Translate and check the integrity of all data moving between the channel byte interface and the module bit interface.
3. Furnish facility status information to the using system.
4. Perform diagnostic evaluation of the facility.

### *Data Handling*

DATA LINES: In the 2835 model 1, two parallel data lines carry information between the 2835 and the 2305. In the 2835 model 2, a single line is used for this purpose. In both models, reading and writing are performed as described in subsequent paragraphs.

WRITING: The byte(s) received from the channel is serialized and transferred bit-by-bit to the module over the data line(s). Parity is not recorded on the disk. A sync bit, generated by the control unit, is added to each byte for clocking purposes later when the data is read.

READING: The sync bit is stripped off, and the data bits are assembled into bytes. Parity is generated and added to the data before transmission to the channel.

## Microprograms

The control unit contains a miniature direct access device which provides read-only storage for microprogram backup and storage of nonresident microdiagnostics. The recording medium is an inexpensive Mylar*-coated disk cartridge. This cartridge can be mailed to the customer engineer when changes are required in the functional or maintenance microprogram.

## 2305 Fixed Head Storage Module, Models 1 and 2

The IBM 2305 Fixed Head Storage Module is a prime system residence device on large systems that require low access time and high data rates. It meets the requirements of large systems for high speed, high availability auxiliary storage. The 2305 provides capabilities qualitatively similar to those of the IBM 2301 Drum Storage, but both models of the 2305 offer faster access and larger capacity than does the 2301.

Unique features of the 2305 include error correction, vary sensing, alternate track sparing, rotational position sensing, command retry, and multiple requesting, all of which are described in this publication. The sum of these characteristics is a device well adapted for high performance direct access storage applications such as systems residence, paging, index residence, high priority data residence, and high speed work storage.

The functional description of each unit in a basic system configuration is shown in Figure 1.

## 2305 Fixed Head Storage Module, Model 1

### *General Description*

The IBM 2305 Fixed Head Storage Module, Model 1, is a high speed auxiliary storage device that provides fast access time and a high speed data rate.

The storage module is a fixed head disk drive module that uses multiple element recording heads. Six disks, permanently mounted in each disk storage module, provide 432 recording tracks; 384 of these tracks are addressable and 48 are spares. Two recording elements are located over each of the 384 recording tracks. Average access time is 2.5-millisecond; disk rotational speed is 6000 rpm.

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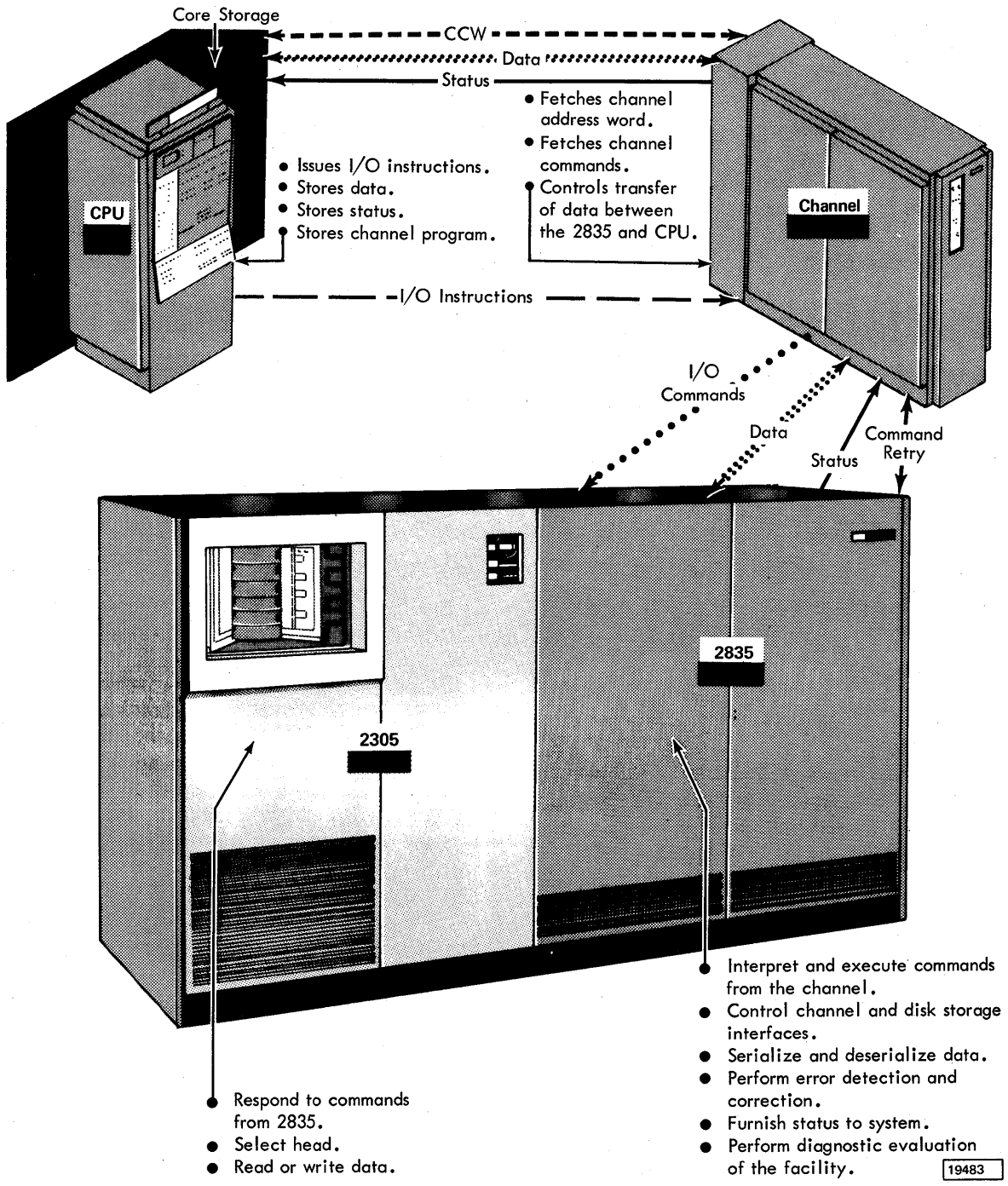



Figure 1. Functional Description

Data is transferred serially by bit (on parallel paths) to the control unit at the rate of 3.0 million bytes/second.

*Speed and Capacity*

The following table summarizes 2305 model 1 speed and capacity:

| | |
|---|---|
| Number of tracks | 384 |
| Bytes per track (R0 no key) | 14,576 |
| Bytes per track (R1 no key) | 14,136 |
| Bytes per module (R1 no key) | 5,428,224 |
| Rotation time | 10 ms |
| Access time (maximum) | 5.1 ms |
| Access time (average) | 2.5 ms |
| Transfer rate | 3.0 megabytes/sec |

*Operational Description*

There are two parallel data lines between the control unit and the model 1 disk module. During write operations, the two bytes received in parallel from the channel are serialized and transferred to the disk module. Parity is not recorded. During reading, the two channels of serial data are deskewed and assembled into bytes. Parity bits are generated and added before transmission to the channel.

Two recording heads, separated by 180°, are located over each of 384 recording tracks. A recording track contains two logical track segments, each occupying a 180° arc of the recording track. Two of the logical track segments, from opposing disk surfaces, are paired and operated in parallel with their recording heads to form 384 system-addressable tracks. When a track is addressed, the disk module dynamically selects the pair of recording heads that is currently nearest the desired addressed track.

There are 48 spare tracks that can be wired in by the customer engineer to replace defective addressable tracks. One pair of spare tracks is available for alternate track sparing under system control. To activate one or more of the 48 spare track addresses, an IBM customer engineer manually wires the necessary logic into circuits provided for this purpose. If the 2835 attempts to select a read/write head that has been jumpered out in this manner, the normal address sent by the 2835 is automatically switched to the selected spare head.

## 2305 Fixed Head Storage Module, Model 2

*General Description*

The IBM 2305 Fixed Head Storage Module, Model 2, has the same physical characteristics as the model 1, except that the model 2 has a single head per track. Therefore, there are 768 recording tracks, with an average access time of 5.0 milliseconds.

*Speed and Capacity*

The following table summarizes the speed and capacity provided by the model 2 disk module:

| | |
|---|---|
| Number of addressable tracks | 768 |
| Bytes per track (R0 no key) | 14,866 |
| Bytes per track (R1 no key) | 14,660 |
| Bytes per module (R1 no key) | 11,258,880 |
| Rotation time | 10 ms |
| Access time (maximum) | 10.25 ms |
| Access time (average) | 5.0 ms |
| Transfer rate | 1.5 megabytes/sec |

*Operational Description*

The operation is the same as on the model 1, except that bytes are transferred to the channel serially rather than by two bytes in parallel.

There are 864 recording tracks in each module, of which 768 are operational and 96 are spares. Each address is processed through a single data channel.

# Data Characteristics

The basic unit of information recorded on the 2305 facility is eight bits long and is called a byte. A group of bytes separated by a special gap recognized by the 2835 is called an area. Areas of related data are combined to make a record, the logical unit of information.

## Record Format

A record consists of the following four areas: address marker (AM) area, count area, key area, and data area.

*Address Marker Area*

This area is written and used by the 2835 to denote the beginning of a record. The address marker is followed by a gap (G4).

*Count Area*

The 2305 uses self-formatting records; i.e., records which contain information defining their length and format. The count area containing this information is written at the time the record is originally written; this area is not changed until the entire record is rewritten. The process of writing an entire record, including the count area, is called formatting. The size of a record is determined at the time a record is formatted. The count area consists of the following sub-areas and is followed by a gap (G2).

| | |
|---|---|
| Flag (F) | 2 bytes (model 1)<br>or<br>1 byte (model 2) |
| Identifier (ID) | 5 bytes |
| Key Length (KL) | 1 byte |
| Data Length (DL) | 2 bytes |
| Error Correction Code Bytes (ECC) | |

FLAG: The first byte of the count area contains the flag. The flag is propagated from record to record by the 2835. The function or setting of each bit in the first flag byte is given in the following list.

0 - Unused, written as 0.
1 - On if the logical record continues on the next track. On for each segment of an overflow record except the last.
2-5 - Unused, written as 0.
6 - Used for alternate track sparing; bit is not written on track.
7 - Unused, written as 0.

The second flag byte is present only on the model 1, and is unused; it is written only because of the parallel recording technique.

IDENTIFIER: This subarea is used to uniquely identify a record regardless of the content of that record. Because the identifier is not necessarily related to the physical location of the record, is it not considered an address. However, the track address is usually included as a part of the identifier (ID) area. Each ID on a track is usually unique to ensure that each record can be processed without knowledge of its content. The first four bytes of the ID usually consist of the track address; the fifth byte is unique for each record on the track.

KEY LENGTH: This byte defines the length of the key area. This area is always present; however, it may contain 0, in which case the key area and its gap are omitted.

DATA LENGTH: These two bytes define the length of the data area. It is always present. If set to 0, it represents the end of the logical file.

ERROR CORRECTION CODE BYTES: These bytes are used for error detection and correction in reading the count area.

KEY AREA: The length of this area is defined by the key length (KL) subarea. Because correction code bytes are added to this area, it is actually longer than the length given in the key length. Once the area is formatted, its contents, (but not its length) can be altered.

The key area is used to identify the information recorded in the data area of a record. If the key area is altered, the data area of the record must be rewritten as well. The key area is followed by a gap (G2).

*Data Area*

The length of this area is defined by the data length (DL) subarea. Because correction code bytes are added to this area, it is actually longer than the

length given in the data length. Once the area is formatted, its contents, but not its length, can be altered. The data can be altered without affecting any other area in the record. The data area is followed by a gap (G3 or G5).

*Track Format*

A track (Figure 2) is the smallest physically addressable recording area on the 2305. Each addressable track has a unique physical address. One or more records are written on each track. The first record following the index point is always record zero (R0).

The 2305 does not record a home address area between the index point and R0. However, for compatibility with other similar storage devices, it does accept and emulate Write Home Address, Read Home Address, and Search Home Address commands.

Record Zero

Record zero may be used as a normal data record. However, it is usually reserved by the operating system for nonuser functions. R0 differs from all other records in the following ways:

1. Every addressable track contains only one R0.
2. R0 is always the first record on a track following index.
3. Special commands are provided which operate only on R0.
4. R0 is not preceded by an address marker.

*Data Records (R1-Rn)*

One or more data records may follow R0 on a track. Count areas make each record self-formatting for maximum data organization, flexibility, and efficiency.

*Gaps*

The record gap is a string of bytes written by the 2835 to delimit records and areas within records. Gaps are not accessible to the using system nor under its control. There are five gap types, designated G1 through G5. G5 is variable in length; the other four are fixed in length.

GAP 1: This gap is written between index and the R0 count area.

GAP 2: This gap is written between the count area and the key area, and between the key area and the data area.

GAP 3: This gap is written between the data area of one record and the address marker of the following record.

GAP 4: This gap is written between the address marker and the count area of every record except R0.

GAP 5: This gap is written following the data area of the last record on the track. It is variable in length and extends to the index point.

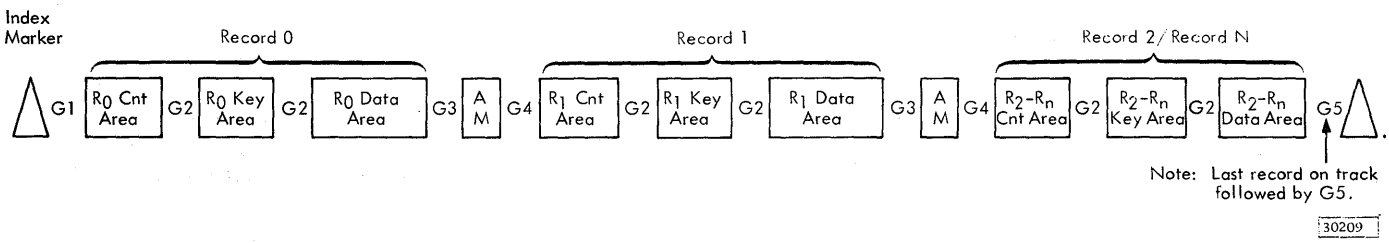



Figure 2. Track Format

# Error Detection and Corrections

## CPU Parity

To check data accuracy, a parity bit is associated with each byte within the CPU and channel. When a byte is formed, the parity bit is set to either 1 or 0 to maintain an odd number of 1 bits within the byte (odd parity). Each byte of data to be written is checked for correct parity as it is received by the 2835.

## Error Correction Code

As data is being transferred from the channel to the disk storage (written), the storage control removes the parity bit associated with each byte. It then computes error correction code bytes which are written after each recorded area. The correction code bytes are coded to represent the data in the recorded area, and are used for both error detection and correction.

As the data is being transferred from the disk storage to the channel (read), each area is inspected by the storage control and the error correction code bytes are recalculated for each area. The 2835 correction code can detect single burst errors of 470 bits or less, and correct single bursts of 11 bits or less.

The correction code bytes are removed and proper parity is generated by the storage control before the data is transferred to the channel.

If a correctable data error is detected in the count or key areas, the storage control internally executes the error correction function through use of command retry. (See "Command Retry.") If a correctable data error in a data area is detected, the operation is terminated and the correction function is performed by the system error recovery procedures. (See "Error Recovery Procedures.")

## Data Integrity

Unless corrected immediately, soft write errors may cause hard read errors. Therefore, where data integrity is required, verification should be incorporated within the program. Then, in the event of soft errors, the record can be rewritten and verified before the original data has been destroyed.

Two methods can be used for verification; the full read-back check and the correction code check.

FULL READ-BACK CHECK: All of the data just written is read back into main storage and compared with the original information byte for byte.

CORRECTION CODE CHECK: A read operation is performed with the skip bit on. In this method the control unit checks the validity of the record by using the error correction code bytes.

## GENERAL DESCRIPTION

I/O operations, initiated by I/O instructions in the CPU program, are controlled by commands fetched from main storage by the channel. Arithmetical and logical decision operations are performed while the processing unit is in the problem state; I/O operations require the processing unit to be in the supervisor state.

The processing unit is changed from problem to supervisor state when a supervisor call instruction is executed or an I/O interrupt occurs. The status of the system existing at the time of the change is stored in the program status word. See "Program Status Word."

In the supervisor state, the CPU can execute the following I/O instructions:

- Start I/O -- Initiates an I/O operation if the addressed channel, storage control, and device address are available.

- Start I/O Fast Release -- Initiates an I/O operation if the addressed channel is available. The storage control and device address are assumed to be available. If they are not, an I/O interrupt occurs to indicate the busy condition.

- Halt I/O -- Terminates the operation in progress at the channel, and the storage control is disconnected from the channel.

- Halt Device -- Terminates the operation in progress at the storage control without interfering with other I/O operations at the channel. This instruction should be used instead of Halt I/O to terminate an operation on a device attached to an IBM 2880 Block Multiplexor channel.

- Test I/O -- Sets the condition code in the program status word to indicate the status of the addressed channel, sub-channel, storage con trol and storage module.

After the specified instruction has been executed, the CPU can return to the problem state and continue the interrupted program by reloading the program status word stored when the program entered the supervisor state.

The format for I/O instructions is shown in Figure 3.

## CHANNEL OPERATION

After successful execution of an I/O instruction, the channel selects and governs the addressed storage control and drive. Reserved main storage locations contain information and instructions that enable the channel to perform the functions necessary to complete the operation.

### Channel Address Word

Issuing a start I/O or start I/O fast release instruction causes the channel to fetch the channel address word from main storage location 72. Bits 0 through 3 of the channel address word form the protection key for all commands associated with the I/O instruction. The protection key establishes the right of access (whether data can be stored or fetched) to the particular main storage locations.

The command address in bits 8 through 31 designates the address of the first channel command word. The three low order bits of the command address must be zero to specify the channel command word on integral boundaries for double words.

Fetching of channel address words is a hardware function of the channel. The information must be set up in main storage location 72 prior to issuing the I/O instruction.

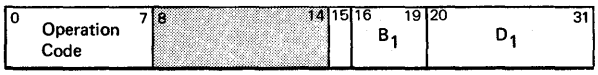
The format for the channel address word is shown in Figure 4.

### Channel Command Word

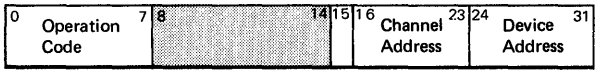
The channel fetches the first channel command word (CCW) from the address specified in the channel address word. The channel command word specifies the operation to be performed, the main storage location to be used, and the action to be taken when the operation is completed.

If the channel is available when it receives the channel command word, it attempts to select the device specified in the I/O instruction by sending the address to all attached control units. If the addressed device is attached to the channel and has power on,

**I/O Instruction Format**




| Bit Position | Field Designation | Function |
|---|---|---|
| 0-7 | Operation (OP) Code | Designates the operation to be performed. |
| 8 - 14 | Not Used | |
| 15 | | Set to 1 for start I/O fast release and halt device. |
| 16 - 19 | Base Address Register Location ($B_1$) | Designates the address of a general register in the CPU. The register is 32 bits in length, but only the low order 24 bits are used. |
| 20 - 31 | Displacement ($D_1$) | Bits 16-31 of the sum obtained by the addition of the contents of the register at $B_1$ and the contents of the $D_1$ field identifies the channel and the device addressed by the instruction. The result has the following format: |




| Bit Position | Field Designation | Function |
|---|---|---|
| 0 - 7 | Operation (OP) Code | Designates the operation to be performed. |
| 8 - 14 | Not Used | |
| 15 | | Set to 1 for start I/O fast release and halt device. |
| 16 - 20 | Must be Zero | |
| 21 - 23 | Channel Address | |
| 24 - 28 | Control Unit Address | |
| 29 - 31 | Device Address | |

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Figure 3. I/O Instruction Format

**Channel Address Word**


Channel Address Word

CAW fields are allocated for the following purposes:

| CAW Bit Position | Field Designation | Function |
|---|---|---|
| 0-3 | Protection Key | Forms the Storage Protection key for all commands associated with Start I/O. This key must match the storage key. |
| 4-7 | | Always zero. |
| 8-31 | Command Address | Designates the location of the first CCW in main storage. |

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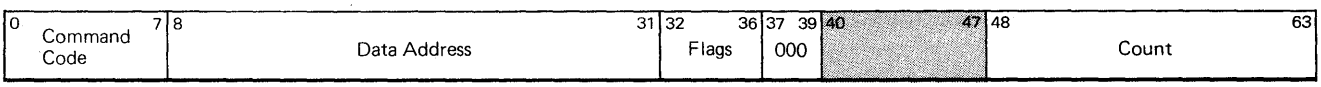
Figure 4. Channel Address Word

the command code portion of the channel command word is sent to the storage control. The storage control responds with an initial status byte to the channel.

The start I/O instruction is now finished, releasing the CPU to perform the next instruction or return to the problem state. The results of the attempt to initiate execution of the command are indicated by the condition code in the program status word. If the I/O operation was not started, new status information to show why is normally set in the channel status word.

The format for the channel command word is shown in Figure 5.

**Channel Command Word**




| CCW Bit Position | Field Designation | Function |
|---|---|---|
| 0-7 | Command Code | Specify the operation to be performed. The two low-order bits, or when these bits are 00, the four low-order bits of the command code identify the operation to the channel. The channel distinguishes the operations: write, control, read, sense, or transfer in channel. Commands that initiate I/O operations cause all eight bits to be transferred to the control unit. |
| 8-31 | Data Address | Specifies the location of 2 bytes in main storage. This is the address of the area associated with data transfer operations. |
| 32 | Chain Data | When set to one, specifies chaining of data. Make sure the data rate of the I/O device permits chaining by the particular system model before using. |
| 33 | Chain Command (CC) Flag | When set to one, and when the CD flag is zero, specifies chaining of commands. It causes the operation specified by the command code in the next CCW to be initiated on normal completion of the current operation. |
| 34 | Suppress Length Indicator (SLI) | When set to one, an incorrect length condition is suppressed (except when the CCW count is not exhausted, channel end is present and data chaining is indicated). Should be set to one for restore, recalibrate, no-op and some space count commands. |
| 35 | Skip Flag | When set to one, specifies suppression of a transfer of information to storage during a read or sense operation. Checking takes place as though the information had been placed in storage. When bit 35 is zero, normal transfer of data takes place. |
| 36 | Program Control-Interruption | When set to one, causes the channel to generate an interruption condition upon fetching the CCW. When bit 36 is zero, normal operation takes place. |
| 37-39 | | Bit positions 37-39 of every CCW other than one specifying transfer in channel must contain zeros. Violation of this restriction generates the program-check condition. |
| 40-47 | | Not used. |
| 48-63 | Count | Specify the number of 8-bit byte locations in the storage area designated by the data address. |

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Figure 5. Channel Command Word

## Channel Status Word

The channel status word, stored at main storage location 64, informs the program of the status of an I/O device or the conditions under which an I/O operation was terminated. The channel status word (CSW) is formed or changed during I/O interruptions and during execution of I/O instructions. Status stored in the CSW remains unchanged until a subsequent interrupt occurs or a new I/O instruction is processed.

The format for the channel status word is shown in Figure 6.

*Status Presentation*

Status is presented twice (initial status and ending status) for all commands except immediate commands not chained from write commands.

Immediate commands present channel end and device end in initial status. An immediate command chained from a write command causes channel end status to be presented in initial status and device end is presented in ending status when the write operation is finished.

INITIAL STATUS: The initial status byte is zero for test I/O and all non-immediate commands unless one or more of the following conditions exists.

1. The storage control is busy.
2. A status condition is pending. See "Pending Status."
3. A unit check condition exists.
4. Command retry is required. See "Command Retry."

ENDING STATUS: In most cases channel end and device end are presented as the normal ending sequence for an operation.

If an error has occurred during the operation, unit check will accompany the channel end-device end status.

PENDING STATUS: A pending status condition may exist for either the storage control or a device.

Status is pending for the storage control if:

1. A halt I/O was signaled after a command was issued, but before channel end status was accepted.
2. Busy, channel end, or unit check status was stacked by the channel.
3. Zero status in response to a test I/O was stacked by the channel.
4. Control unit busy was presented to the channel. (Control unit end is pending.)
5. Unit check was detected for an operation after device end had been cleared.

Status pending for the storage control (except for control unit end) causes the storage control to appear busy for all devices except the device for which the status condition exists. Unless it is busy, the storage control will request service to clear the pending status condition. Status is cleared when presented to, and accepted by, the channel.

Status is pending for a device if:

1. Channel end was presented alone.
2. Busy status was presented.
3. The drive has gone from not ready to ready.

Status pending for a device causes the storage control to request service when both the storage control and device are not busy. The status is cleared when presented to, and accepted by, the channel.

CONTINGENT CONNECTION: A contingent connection is established in the storage control after the channel accepts a status byte containing unit check. It lasts until a command other than test I/O or no-op receives an initial status byte of zero for the storage control and exposure that generated the unit check or a selective or system reset occurs.

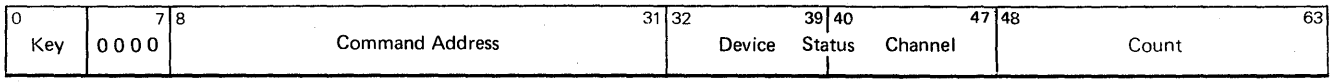
During the contingent connection state, the storage control appears busy to all device addresses other than the address for which the contingent connection was established.

## Program Status Word

Two program status words are associated with facility interrupt conditions: an "old" PSW which contains the status information of the system existing at the time of the interrupt, and a current or "new" PSW which is used to control instruction sequencing and to hold the status of the system in relation to the program being executed.

By storing the current PSW during an interruption, the status of the CPU is preserved for subsequent inspection by the program. By loading a new PSW, the state of the CPU can be initialized or changed to branch to a new instruction sequence. If, at the

Channel Status Word




| CSW Bit Position | Field Designation | Function |
|---|---|---|
| 0-3 | Protection Key | Form the storage protection key used in the chain of operations. |
| 4-7 | Not Used | Always zero. |
| 8-31 | Command Address | Form an address eight positions higher than the address of the last CCW used. |
| 32 | Attention | Not used by 3830. |
| 33 | Status Modifier | Set whenever a Search High, Search Equal, or a Search High or Equal command has been executed and the condition satisfied.<br>The status modifier is also set whenever the Control Unit is busy. This bit, in conjunction with the busy bit, signifies control unit busy.<br>Status modifier set with unit check and channel end (or channel end and device end) indicates that a retriable error has been encountered. The storage control automatically retries the command. |
| 34 | Control Unit End | Set if a control unit busy status has been generated previously and the busy condition has been terminated. |
| 35 | Busy | Indicates that the selected device is busy.<br>In conjunction with the status modifier bit indicates the control unit is busy. It is set when a new command chain is initiated while the storage control is causing a track to be erased following a Format Write command. |
| 36 | Channel End | Set at the end of each channel command. |
| 37 | Device End | Indicates that an access mechanism is free to be used. |
| 38 | Unit Check | Set whenever an unusual or error condition is detected.<br>A Sense I/O command may then be used to identify the condition. |
| 39 | Unit Exception | Indicates an end-of-file has been detected during a read RO, read IPL, read CKD, read KD, read D, write KD, or a write D operation. It results from a data length of zero being detected in the count area of a record. When this condition is detected no data is transferred from the data area. If the key length is not zero, the key area is transferred. |
| 40-47 | Channel Status | Indicate channel conditions as follows:<br>**Bit — Designation**<br>40 Program-controlled interruption<br>41 Incorrect length<br>42 Program check<br>43 Protection check<br>44 Channel data check<br>45 Channel control check<br>46 Interface control check<br>47 Chaining check |
| 48-63 | Count | The residual count from the last CCW used. |

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Figure 6. Channel Status Word

conclusion of an interrupt routine, there is an instruction to make the old PSW the current PSW, the system is restored to the state existing prior to the interruption, and the interrupted routine continues.

The format for the program status word is shown in Figure 7.

## Command Chaining

It is typical for the 2835/2305 to execute a series of channel commands as a result of a single start I/O instruction. This method of operation is called command chaining. Command chaining is initiated by turning on bit 33 in the channel command word. The channel fetches a new CCW, specifying a new I/O operation, on completion of the current CCW. The new I/O operation is automatically executed when the 2305 has completed the current operation and signaled device end to the channel.

The completion of the current CCW does not cause an I/O interrupt, and the count indicating the amount of data transferred is not available to the program.

Command chaining is normally used with all 2835/2305 channel programs. Time is made available to execute command chaining functions in the gap area between record areas.

Certain restrictions exist regarding sequences of commands within chains. These restrictions are discussed with the individual command descriptions in the "Channel Commands" section of this manual.

## Data Chaining

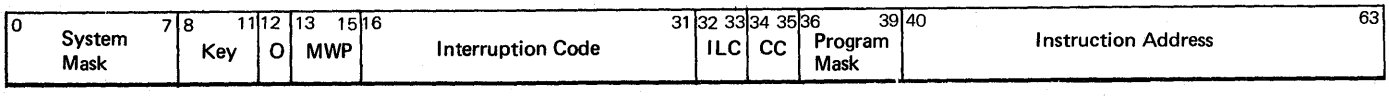
Data transferred between main storage and the 2305 may be chained. Data chaining permits blocks of data to be transferred to or from noncontiguous areas of main storage. When data chaining is specified (bit 32 of the channel command word on), the channel fetches a new CCW, specifying a new storage location, upon completion of data transfer for the current channel command. Unless the command code specifies transfer in channel, the command code of the new CCW is ignored.

Data chaining may be used to rearrange information as it is transferred between main storage and the 2305. It may also be used in conjunction with the skip flag to enable the program to place selected portions of a block of data in main storage.

Data chaining occurs immediately after the last byte of data designated by the current CCW has been transferred to main storage or been accepted by the 2305.

If both data chaining and command chaining are indicated in the channel command word, data chaining takes precedence and command chaining is ignored.

**Program Status Word**




| PSW Bit Position | Field Designation | |
|---|---|---|
| 0 | Channel 0 mask | System Mask |
| 1 | Channel 1 mask | |
| 2 | Channel 2 mask | |
| 3 | Channel 3 mask | |
| 4 | Channel 4 mask | |
| 5 | Channel 5 mask | |
| 6 | Channel 6 mask | |
| 7 | External mask | |
| 8-11 | Protection key | |
| 12 | Must be zero for System/370 | |
| 13 | Machine check mask (M) | |
| 14 | Wait state (W) | |
| 15 | Problem state (P) | |
| 16-31 | Interruption code | |
| 32-33 | Instruction Length code (ILC) | |
| 34-35 | Condition code (CC) | |
| 36 | Fixed-point overflow mask | Program Mask |
| 37 | Decimal overflow mask | |
| 38 | Exponent underflow mask | |
| 39 | Significance mask | |
| 40-63 | Instruction address | |

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Figure 7. Program Status Word

Note: Because of the high data rate of the 2305, read or write data chaining within record areas may cause unpredictable overruns or chaining checks. The following conditions are particularly sensitive.

- Simultaneous use of data chaining and PCI.
- Data chaining with small byte counts and the CCW data address not on a word boundary.
- On the model 1, data chaining with an odd byte count that is not equal to the length of a record area.

## Branching in Channel Programs

Normally, the next CCW in a chain of channel commands is taken from an address eight positions higher than the address of the current CCW. This sequence can be modified in either of two ways:

1. If command chaining is specified in a search command, and execution of the command results in a status modifier indication (search satisfied), the channel fetches the next CCW from a main storage location sixteen positions higher than the current channel command.
2. The transfer in channel command (TIC) may be used to modify the sequence of a chain of commands. The data address portion of the TIC CCW specifies the main storage location of the next channel command word. Therefore, the next CCW may be fetched from any valid main storage location.

These methods of modifying the sequence of a CCW chain provide branching capabilities within a channel program.

## Unit Selection and Device Addressing

The I/O unit address consists of an eight-bit byte. This information is used to specify the control unit number and the device number.

The four high-order bits specify the control unit number. Because the control unit address is plugged into an address card at installation time, these four bits may be any configuration.

The four low-order bits specify the device number. A maximum of two modules can be attached to the control unit. Therefore, the addresses are restricted to 0 and 8. However, to support multiple requesting, the device number may have any value from 0 to 15. A device number in the 0-7 group causes the control unit to select the module with physical address 0. An address in the group 8-15 selects the module with physical address 8.

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## CONTROL COMMANDS

Control commands do not involve a transfer of data records between the storage control and main storage. However, in certain operations, control bytes are transferred from main storage to the storage control to enable the operation to take place. The control bytes are parity checked during transfer.

## SEARCH COMMANDS

On all search commands, the channel operates in write mode while the disk storage operates in read mode. The storage control compares the data from main storage against the data from the drive. When the search criteria has been satisfied (compared equal, high, etc.) the storage control returns a status modifier bit with channel end and device end. The status modifier bit causes the channel to skip the next CCW in the chain and fetch the next command from a storage location 16 positions higher than the current CCW.

Each search command operates only on one record. To search another record, the search command must be reissued. This is normally done by chaining a transfer in channel command to the search command. The following is an example of this procedure:

```
Search Key Equal
TIC * -8
Read Data
```

As long as the search is unsuccessful, the transfer in channel command following the search command causes the search to be repeated. When the search is successful, the status modifier causes the TIC command to be skipped and the read data command is executed.

At the end of every field searched, the validity of the data read is verified by the correction code bytes following the search field. After the correction code check, appropriate ending status is generated and presented to the channel.

If a data overrun or data check is detected, the storage control attempts recovery through use of command retry. If command retry is unsuccessful, channel end, device end, and unit check status is presented.

## READ COMMANDS

A read command is used to transfer information from the disk storage to the central processing unit. Read commands may operate in either single track or multiple track mode.

> Note: Read IPL and read sector do not operate in multi-track mode.

For all read commands, the storage control checks the validity of each area of each record as it is transferred from the disk storage to the storage control. After the correction code bytes have been examined and the validity of the data is established, the storage control sends an ending status byte of channel end and device end to the channel.

If a data overrun or data check is detected, the storage control attempts recovery through use of command retry. If command retry is unsuccessful, or not used, channel end, device end, and unit check are presented to the channel.

## WRITE COMMANDS

### Formatting Write Commands

Formatting write commands are used to initialize tracks and records, and establish the length of the areas within each record. Error correction code bytes are calculated and written after each area of a record.

Formatting write commands are:

- Write home address.
- Write R0.
- Write count, key, and data.
- Write special count, key, and data.
- Erase.

The command prerequisites and file mask settings for these commands are very explicit and any violation prevents command execution.

Format write commands may be chained together if each satisfies the required prerequisites. After the last format write command in a chain has been completed, the storage control causes the remaining portion of the track to be erased.

If a command other than a format write command is chained from a format write command, it is executed after the track has been erased. If a new command chain is attempted before the end of the track is reached, a short control unit busy sequence (busy and status modifier bits) is presented to the channel. In this case, a control unit end signal is generated at the end of the track.

### Update Write Commands

Update (non-formatting) write commands are used to update existing records, and must operate on previously formatted tracks. Error correction code bytes are calculated and written after each key and/or data area in the record. Update write commands are:

- Write data.
- Write key and data.

If a data overrun occurs during an update, write operation, the storage control attempts recovery through use of command retry. If the retry is unsuccessful, channel end, device end, and unit check status is presented to the channel.

## SENSE/TEST I/O COMMANDS

These commands are used to determine the status of the 2305 facility, and identify the specific nature of errors or unusual conditions that have occurred.

> Note: Since the test I/O "command" is not the result of the channel executing a CCW, its operation is explained at this time instead of with the other channel commands. A test I/O command (command code 0000 0000) is not written by the programmer. A command code of all 0's is considered invalid and causes a program check.

The test I/O command is generated automatically by the channel when the channel requires status information, or it is the result of processing a test I/O instruction. In either case it appears to the storage control as a command byte of all 0's and is treated as an immediate command. It requests the storage control to send outstanding status information to the channel. Test I/O normally presents an all zero status byte. Stacked or pending status (if any) is presented in initial status.

| | COMMAND | COMMAND CODE | | | |
|---|---|---|---|---|---|
| | | Multiple Track OFF | | Multiple Track ON (if applicable) | |
| | | Hexadecimal | Binary | Hexadecimal | Binary |
| CONTROL | No Operation | 03 | 0000 0011 | | |
| | **Orient** | **2B** | **0010 1011** | | |
| | Recalibrate | 13 | 0001 0011 | | |
| | Seek | 07 | 0000 0111 | | |
| | Seek Cylinder | 0B | 0000 1011 | | |
| | Seek head | 1B | 0001 1011 | | |
| | Space Count | 0F | 0000 1111 | | |
| | Set File Mask | 1F | 0001 1111 | | |
| | Set Sector | 23 | 0010 0011 | | |
| | Restore | 17 | 0001 0111 | | |
| | Transfer in Channel | X8 | XXXX 1000 | | |
| | **Vary Sensing** | **27** | **0010 0111** | | |
| | Diagnostic Load | 53 | 0101 0011 | | |
| | Diagnostic Write | 73 | 0111 0011 | | |
| SEARCH | Home Address Equal | 39 | 0011 1001 | B9 | 1011 1001 |
| | Identifier Equal | 31 | 0011 0001 | B1 | 1011 0001 |
| | Idenfifier High | 51 | 0101 0001 | D1 | 1101 0001 |
| | Identifier Equal or High | 71 | 0111 0001 | F1 | 1111 0001 |
| | Key Equal | 29 | 0010 1001 | A9 | 1010 1001 |
| | Key High | 49 | 0100 1001 | C9 | 1100 1001 |
| | Key Equal or High | 69 | 0110 1001 | E9 | 1110 1001 |
| READ | Home Address | 1A | 0001 1010 | 9A | 1001 1010 |
| | Count | 12 | 0001 0010 | 92 | 1001 0010 |
| | Record 0 | 16 | 0001 0110 | 96 | 1001 0110 |
| | Data | 06 | 0000 0110 | 86 | 1000 0110 |
| | Key and Data | 0E | 0000 1110 | 8E | 1000 1110 |
| | Count, Key and Data | 1E | 0001 1110 | 9E | 1001 1110 |
| | IPL | 02 | 0000 0010 | | |
| | Sector | 22 | 0010 0010 | | |
| SENSE | Sense I/O | 04 | 0000 0100 | | |
| | **Read Buffered Log** | **24** | **0010 0100** | | |
| | Release * | 94 | 1001 0100 | | |
| | Reserve * | B4 | 1011 0100 | | |
| | Read Diagnostic Status 1 | 44 | 0100 0100 | | |
| WRITE | Home Address | 19 | 0001 1001 | | |
| | Record 0 | 15 | 0001 0101 | | |
| | Erase | 11 | 0001 0001 | | |
| | Count, Key and Data | 1D | 0001 1101 | | |
| | Special Count, Key and Data | 01 | 0000 0001 | | |
| | Data | 05 | 0000 0101 | | |
| | Key and Data | 0D | 0000 1101 | | |

Notes:
* Two-channel switch feature.
X Not significant. (Data addresses should not exceed storage capacity.)

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CONTROL

SEARCH

READ

SENSE

WRITE

# NO–OP

| 0 Command Code 7 | 8 Data Address 31 | 32 Flags 36 | 37 39 000 | 40 47 | 48 Count 63 |
|---|---|---|---|---|---|
| Binary **0000 0011** Hex **03** | Not checked for validity; should not exceed addressing capacity. | SLI flag (bit 34) should be on. | | | Must be non zero to avoid program check. |

Chaining and Special Requirements: See following description.

**NO–OP,** an immediate command; causes no action at addressed device.

**CHANNEL END** is presented in initial status.

**DEVICE END,** normally presented in initial status, is presented in ending status if device is completing a format write operation.

**INDISCRIMINATE USAGE** must be avoided; a no-op resets orientation information causing all or part of the records to be skipped.

**EXAMPLE:** a no-op inserted between read count and read data causes the following record's data to be read.

**EXAMPLE:** a no-op inserted between a command which reads the data field of record n-1 and a command which must process the count area of record n, may skip record n and process the count area of record n+1.

**NO-OP CCW** count field must not be zero.

**SLI FLAG** must be on to avoid incorrect length indication.

**ZERO COUNT** will set the program check bit (bit 42) in the CSW.

# ORIENT

| 0 Command Code 7 | 8 Data Address 31 | 32 Flags 36 | 37 39 | 40 47 | 48 Count 63 |
|---|---|---|---|---|---|
| Binary **0010 1011** Hex **2B** | Allows control of head selection during command execution. | SLI must be on. | 000 | | Must be non-zero to avoid program check. |

Chaining and Special Requirements: None



## MODEL 1

**ORIENT,** a data recovery tool; does not transfer data to or from the channel. This command allows control of head selection during command execution.

**INITIAL STATUS** is zero.

**COMMAND EXECUTION** initially orients the track at index with Head A selected; Head B is selected at next half rotation.

**READ R0 CCW** chained to Orient causes R0 to be read using Head A.

**CHANNEL END/DEVICE END** presented to channel after index is detected.

## MODEL 2

**COMMAND EXECUTION** causes no action.

**CHANNEL END/DEVICE END** presented in initial status.

**NOTE:** If command is chained from a format write command:

**CHANNEL END** is presented in initial status.
**DEVICE END** presented when index is detected.

## RECALIBRATE

| 0 Command Code 7 | 8 Data Address 31 | 32 Flags 36 | 37 39 000 | 40 47 | 48 Count 63 |
|---|---|---|---|---|---|
| Binary **0001 0011** Hex **13** | Not checked for validity, but should not exceed addressing capacity. | SLI flag (bit 34) should be on. | | | Must be non-zero to avoid a program check. |

Chaining and Special Requirements: None

**RECALIBRATE** causes no action - maintained for compatibility with other direct access storage devices.

**CHANNEL END/DEVICE END** presented in initial status.

**SLI BIT** must be on in Recalibrate CCW to avoid incorrect length indication.

**CCW COUNT FIELD** must not be zero.

# SEEK

| 0 Command Code 7 | 8 Data Address 31 | 32 Flags 36 | 37 39 | 40 47 | 48 Count 63 |
|---|---|---|---|---|---|
| Binary<br>**0000 0111**<br>Hex<br>**07** | Specifies main storage location of the seek address. | Used at discretion of programmer. | 000 | | Six |

Chaining and Special Requirements: None

**SEEK** transfers the six-byte seek address from channel to storage control.

**INITIAL STATUS** normally zero.

**STORAGE CONTROL** selects drive and proper head.

**CCW COUNT > SIX** transfers six bytes of address information.

**CCW COUNT < SIX:** Seek command is not executed; unit check, channel end and device end are presented in ending status. A subsequent sense command indicates command reject.

**VALID SEEK ADDRESS** checked by control unit.
**BYTES** 0, 1, 2, and 5 must be zero.
**BYTE** *4 must not exceed 96.
**BYTE** 6 must not exceed 7.

**INVALID SEEK ADDRESS:** seek command is not executed; unit check, channel end and device end are presented in ending status. A subsequent sense command indicates command reject.

**PARITY ERROR** detected in transfer of seek address: command is not executed; unit check, channel end and device end presented in ending status. A subsequent sense command indicates bus-out parity error.

**COMMAND EXECUTION** does not require preceding CCW.

**FILE MASK** must allow seeks.

**CHANNEL END/DEVICE END** presented after transfer of seek address.

* Cylinder 96, head 0 is alternate track spare.

## SEEK CYL

| 0 Command Code 7 | 8 Data Address 31 | 32 Flags 36 | 37 39 | 40 47 | 48 Count 63 |
|---|---|---|---|---|---|
| Binary **0000 1011** Hex **0B** | Specifies main storage location of the seek address. | Used at discretion of programmer. | 000 | | Six |

Chaining and Special Requirements: None

**SEEK CYLINDER** transfers the six-byte seek address from channel to storage control.

**INITIAL STATUS** normally zero.

**STORAGE CONTROL** selects drive and proper head.

**CCW COUNT > SIX** transfers six bytes of address information.

**CCW COUNT < SIX:** seek cylinder command is not executed; unit check, channel end and device end are presented in ending status. A subsequent sense command indicates command reject.

**VALID SEEK ADDRESS** checked by control unit.
Bytes 0, 1, 2, 5 must be zero.
* Byte 4 must not exceed 96 (decimal).
Byte 6 must not exceed 7 (decimal).

**INVALID SEEK ADDRESS:** seek cylinder command is not executed; unit check, channel end and device end are presented in ending status. A subsequent sense command indicates command reject.

**PARITY ERROR** detected in transfer of seek address: command is not executed; unit check, channel end and device end presented in ending status. A subsequent sense command indicates bus-out parity error.

**COMMAND EXECUTION** does not require preceding CCW.

**FILE MASK** must allow seek cylinder commands.

**CHANNEL END/DEVICE END** presented after transfer of seek address.

* Cylinder 96, head 0 is alternate track spare.

# SEEK HEAD

| 0 Command Code 7 | 8 Data Address 31 | 32 Flags 36 | 37 000 39 | 40 47 | 48 Count 63 |
|---|---|---|---|---|---|
| Binary **0001 1011** Hex **1B** MT Binary | Specifies main storage location of seek address. | Used at discretion of programmer. | | | Six |

Chaining and Special Requirements: None

**SEEK HEAD** transfers seek address from channel to storage control.

**INITIAL STATUS** normally zero.

**CCW COUNT > SIX** transfers six bytes of address information.

**CCW COUNT < SIX:** seek cylinder command is not executed; unit check, channel end and device end are presented in ending status. A subsequent sense command indicates command reject.

**VALID SEEK ADDRESS** (Six byte) required; however, only the head address specified in the sixth byte is significant; i.e. another cylinder address is ignored.

Bytes 0, 1, 2, 5 must be zero.
*Byte 4 must not exceed 96 (decimal).
Byte 6 must not exceed 7 (decimal).

**INVALID SEEK ADDRESS:** seek head command is not executed; unit check, channel end and device end are presented in ending status. A subsequent sense command indicates command reject.

**PARITY ERROR** detected in transfer of seek address; command is not executed; unit check, channel end and device end presented in ending status. A subsequent sense command indicates bus-out parity error.

**COMMAND EXECUTION** does not require preceding CCW.

**FILE MASK** if preceding seek must be set to allow head seeks.

**CHANNEL END/DEVICE END** presented after transfer of seek address.

* Cylinder 96, head 0 is alternate track spare.

## SPACE COUNT

| 0 Command Code 7 | 8 Data Address 31 | 32 Flags 36 | 37 000 39 | 40 47 | 48 Count 63 |
|---|---|---|---|---|---|
| Binary **0000 1111** Hex **0 F** | Specifies main storage location of the key and data lengths of record to be recovered. | Used at discretion of programmer. | | | 3 |

Chaining and Special Requirements:
1. Cannot be chained from a format write or erase command.
2. Must not be followed by a write, erase, or set file mask command in the same chain.

**SPACE COUNT** allows bypassing a defective count area on a track for recovering data in key and/or data areas following the defective area.

**DATA TRANSFERRED FROM CHANNEL** is used by the storage control as the key length (first byte) and data length (last two bytes) of the record to be recovered.

**CCW COUNT > THREE:** three bytes are transferred.

**CCW COUNT < THREE:** specified number of bytes is transferred.

**NO BYTES TRANSFERRED:** storage control assumes a value of zero.

**CHAINING REQUIREMENTS** must be met; otherwise channel end, device end, and unit check are presented to the channel.

# SET FILE MASK

| 0 Command Code 7 | 8 Data Address 31 | 32 Flags 36 | 37 000 39 | 40 47 | 48 Count 63 |
|---|---|---|---|---|---|
| Binary **0001 1111** Hex **1F** | Specifies main storage location of mask byte. | Used at discretion of programmer. | | | One |

Chaining and Special Requirements: **One set file mask command permitted in a CCW chain.**

**SET FILE MASK** sets the write and seek masks which provide protection for 2305 data and defines command retry-PCI interaction.

**COMMAND EXECUTION** is allowable only once within a CCW chain. An attempt to issue more than one set file mask in a CCW chain causes a unit check in initial status.

**COMMAND REJECT** is indicated by a subsequent sense command.

**FILE MASK RESET** to 0's at end of CCW chain.

**WRITE COMMANDS** that violate file mask are not executed.

**UNIT CHECK** is presented in initial status.
**COMMAND REJECT** is indicated by a subsequent sense command.

**SEEK COMMANDS** that violate the file mask are not executed.

**UNIT CHECK** is presented in initial status.
**FILE PROTECTED** is indicated by a subsequent sense command.

**MULTI-TRACK/OVERFLOW** operations that violate the file mask indicate unit check and file protected.

**CHANNEL END/DEVICE END** are presented to the channel at completion of mask byte transfer.

**SYSTEM OR SELECTIVE RESET** resets the file mask to 0's.

**START I/O** executed after a reset without a set file mask CCW permits seek and write commands (except write home address and write R0).

# SET SECTOR

| 0 7 Command Code | 8 31 Data Address | 32 36 Flags | 37 39 000 | 40 47 | 48 63 Count |
|---|---|---|---|---|---|
| Binary **0010 0011** Hex **23** | Specifies main storage location of desired sector. | Used at discre-tion of program-mer. | | | One |

Chaining and Special Requirements: None

**SET SECTOR,** used on block multiplexor channels; eliminates the necessity to maintain channel end storage control connection during rotational delay.

**COMMAND EXECUTION** transfers a sector number from main storage control.

**SECTOR VALUES** are checked for validity by the 2835.

* **VALID ARGUMENT** (Model 1) (0-89):
**VALID ARGUMENT** (Model 2) (0-179):

1. Storage control presents channel end and disconnects.
2. Device end is signaled when angular position is reached and channel re-connects to continue chain.
3. If reconnection does not occur, the storage control attempts reconnection on subsequent revolutions.

**ZERO ARGUMENT:**

Storage control attempts reconnection prior to index.

Channel end, device end and unit check presented in ending status.

**ARGUMENT = 255:**

1. Command is treated as a no-op.
2. Channel end/device end presented in ending status.
3. Track orientation is destroyed.

* All valid arguments are adjusted by the storage control to compensate for channel reselection delay.

# RESTORE

| 0 Command Code 7 | 8 Data Address 31 | 32 Flags 36 | 37 39 | 40 47 | 48 Count 63 |
|---|---|---|---|---|---|
| Binary **0001 0111** Hex **17** | Not checked for validity; must not exceed addressing capacity. | SLI flag (bit 34) must be on. | 000 | | Must be non-zero to avoid a program check. |

Chaining and Special Requirements: None

**RESTORE** is maintained primarily for compatibility with other IBM Direct Access Storage Devices. No action is performed at the 2305.

**CHANNEL END/DEVICE END** presented in initial status.

**SLI BIT** must be on in the restore CCW since there is no data transfer.

# TRANSFER IN CHANNEL (TIC)

| 0 Command Code 7 | 8 Data Address 31 | 32 Flags 36 | 37 000 39 | 40 47 | 48 Count 63 |
|---|---|---|---|---|---|
| Binary **XXXX 1000** Hex **X8** | Specifies storage location from which next CCW will be taken. | Ignored | | | Ignored |

Chaining and Special Requirements:
1. Cannot be first CCW designated by channel address word.
2. One TIC command cannot transfer directly to another.

**TRANSFER IN CHANNEL** provides chaining capabilities for CCW's not located in adjacent main storage locations.

**TIC DATA ADDRESS FIELD** specifies address of next CCW to be fetched.

**COMMAND EXECUTION** does not initiate I/O operations or signal I/O device.

**PROGRAM CHECK SIGNAL** is generated when chaining requirements are not met or an invalid address is specified. (TIC CCW data address filed does not specify a double word boundary.)

**ERROR DETECTION** terminates data chaining operations. Causes I/O interrupt during command chaining.

**BIT POSITIONS** 0-3 and 32-63 are ignored; bits 29-31 must be zero for double word boundary requirements.

**NOTE:** TIC is the only CCW that allows a zero count field; an incorrect length indication cannot occur since flags and count are ignored.

**ASSEMBLER LANGUAGE** notation TIC * -8 indicates an unconditional branch to the TIC storage address (*) minus a count of eight. TIC * -16 indicates an unconditional branch to the TIC storage address (*) minus a count of 16.

# VARY SENSING

| 0 Command Code 7 | 8 Data Address 31 | 32 Flags 36 | 37 39 | 40 47 | 48 Count 63 |
|---|---|---|---|---|---|
| Binary **0010 0111** Hex **27** | Contains control information to vary read sensing level. | Used at discretion of programmer. | 000 | | One |

Chaining and Special Requirements: None

**VARY SENSING** attempts data recovery following an uncorrectable data check.

**INITIAL STATUS** is zero.

**COMMAND EXECUTION** causes one byte of data to be transferred from the system to storage control.

**STORAGE CONTROL** sends clip level and clip path to module.

**BYTE FORMAT:**

| BIT(s) | FUNCTION |
|---|---|
| 0-2 | Unused |
| 3 | Clip plus (clip minus if zero) |
| 4,5,6 | Reserved |
| (Model 1) 7 | Path 1 (path 0 if zero) |
| (Model 2) 7 | Zero |

**CHANNEL END/DEVICE END** presented to channel after byte is transferred.

# DIAGNOSTIC LOAD

| 0 Command Code 7 | 8 Data Address 31 | 32 Flags 36 | 37 39 | 40 47 | 48 Count 63 |
|---|---|---|---|---|---|
| Binary **0101 0011** Hex **53** | Specifies main storage location of control byte. | Used at discretion of programmer. | 000 | | One |

Chaining and Special Requirements: None

**DIAGNOSTIC LOAD** transfers a 512 byte block of data from storage control read-only storage to storage control buffer.

**DATA BLOCK** transferred is a functional microprogram diagnostic test.

**INITIAL STATUS** normally zero.

**CONTROL BYTE** specifying diagnostic microprogram ID number, is transferred from main storage to storage control.

* **TRACK ADDRESS** (0-31) is specified by bits 0-4.
* **SECTOR NUMBER** (0-7) is specified by bits 5-7.

**STORAGE CONTROL** transfers diagnostic test to buffer.

**DATA TRANSFER COMPLETE** causes storage control to request service and present device when polled.

**COMMAND EXECUTION** allows any drive address to be used with the storage control address.

**READ DIAGNOSTIC STATUS 1** command transfers the diagnostic test from storage control buffer to main storage.

* Track address and sector number are references to the read only storage device attached to the 2835, not to a 2305 disk drive.

# DIAGNOSTIC WRITE

| 0 Command Code 7 | 8 Data Address 31 | 32 Flags 36 | 37 39 | 40 47 | 48 Count 63 |
|---|---|---|---|---|---|
| Binary **0111 0011** Hex **73** | Specifies main storage location of diagnostic test. | Used at discretion of programmer. | 000 | | 512 |

Chaining and Special Requirements: Must be preceded in the chain by a Set File Mask command with bit 5 of the mask byte set to 1.

**DIAGNOSTIC WRITE** transfers a 512 byte diagnostic test from main storage to storage control.

**INITIAL STATUS** normally zero.

**DATA TRANSFER COMPLETE:** test execution begins.

**TEST COMPLETE:** 16 byte error code message is stored in storage control buffer.

**CCW COUNT > 512:** only 512 bytes are transferred.

**CCW COUNT < 512:** only the specified number of bytes are transferred, command is terminated and channel end, device end and unit check are presented in ending status. A subsequent sense command indicates command reject.

**ERROR CODE MESSAGE** (16 bytes) is transferred from storage control buffer to main storage by subsequent read diagnostic status 1 command.

**CHANNEL END & DEVICE END** presented after test complete.

**CAUTION:** This command is intended for maintenance purposes only. Any use other than that provided by IBM diagnostic programs may yield unpredictable results.

# SEARCH HOME ADDRESS EQUAL

| 0 Command Code 7 | 8 Data Address 31 | 32 Flags 36 | 37 39 | 40 47 | 48 Count 63 |
|---|---|---|---|---|---|
| Binary **0011 1001** Hex **39** MT Binary **1011 1001** **B9** | Specifies main storage location of a cylinder number (CC) and head number (HH). | Used at discretion of programmer. | 000 | | Four |

Chaining and Special Requirements: None

**INITIAL STATUS** normally zero.

**CYLINDER/HEAD NUMBERS** from main storage and current head address are compared by storage control immediately. Storage Control then searches for index before presenting final status.

**COMPARISON EQUAL:** channel end/device end and status modifier are presented to the channel.

**COMPARISON UNEQUAL:** channel end/device end are presented to the channel. If Multiple Track bit is on, search continues on next track if command is reissued. Multiple Track will not cross cylinder boundary.

**CCW COUNT > FOUR BYTES:** search is completed when four bytes are received by storage control; command is terminated with channel end/device end (and status modifier if comparison was equal).

**CCW COUNT < FOUR BYTES:** comparison of storage bytes and head address continues until CCW count is decremented to zero. Channel end/device end are presented to channel when 2835 count reaches zero. Status modifier is presented with channel end and device end if search was satisfied on short field.

**BUS OUT PARITY** detected; channel end, device end, and unit check presented in ending status.

# SEARCH ID EQUAL

| 0 Command Code 7 | 8 Data Address 31 | 32 Flags 36 | 37 000 39 | 40 47 | 48 Count 63 |
|---|---|---|---|---|---|
| Binary **0011 0001** Hex **31** MT Binary **1011 0001** **B1** | Specifies main storage location of a five-byte record identifier (CC HH R). | Used at discretion of programmer. | | | Five |

Chaining and Special Requirements: None

**SEARCH ID EQUAL** compares the main storage ID and the count area ID. ID to be compared is next ID on the track.

**INITIAL STATUS** normally zero.

**COMPARISON EQUAL:** channel end/device end/status modifier presented to the channel.

**COMPARISON UNEQUAL:** channel end/device end presented to the channel.

**CCW COUNT > FIVE:** only first five bytes used.

**CHANNEL END/DEVICE END** presented to terminate command.

**STATUS MODIFIER** presented if comparison was equal.

**CCW COUNT < FIVE:** comparison of main storage and track data continues until CCW count is zero.

**CHANNEL END/DEVICE END/UNIT CHECK** presented to channel when ID and correction code bytes are read and checked.

**STATUS MODIFIER** presented if search is satisfied on the short field.

**MULTI-TRACK NOT USED:** search is confined to one track; search is repeated (as long as channel repeats command) until search condition is satisfied or two index points are detected.

**CHANNEL END/DEVICE END/UNIT CHECK** presented to channel upon detection of second index.

**MULTI-TRACK USED:** causes search to continue (as long as channel repeats command); head number automatically increments at index until search condition is satisfied or head number reaches 8.

**CHANNEL END/DEVICE END/UNIT CHECK** presented to channel upon detection of end of cylinder.

# SEARCH ID HIGH

| 0 Command Code 7 | 8 Data Address 31 | 32 Flags 36 | 37 39 | 40 47 | 48 Count 63 |
|---|---|---|---|---|---|
| Binary<br>**0101 0001**<br>Hex<br>**51**<br>MT Binary<br>**1101 0001**<br>**D1** | Specifies main storage location of a five byte record identifier (CC HH R). | Used at discretion of programmer. | 000 | | Five |

Chaining and Special Requirements: None

**SEARCH ID HIGH** compares the main storage ID and the count area ID. ID to be compared is next ID on the track.

**INITIAL STATUS** normally zero.

**TRACK ID HIGHER** than main storage ID: channel end/device end/status modifier presented to the channel.

**TRACK ID EQUAL OR LOWER** than main storage ID: channel end/device end presented to the channel.

**CCW COUNT > FIVE:** only first five bytes used.

**CHANNEL END/DEVICE END** presented to terminate command.

**STATUS MODIFIER** presented if comparison was high.

**CCW COUNT < FIVE:** comparison of main storage and track data continues until CCW count is zero.

**CHANNEL END/DEVICE END** presented to channel when ID and correction code bytes are read and checked.

**STATUS MODIFIER** presented if search is satisfied on the short field.

**MULTI-TRACK NOT USED:** search is confined to one track; search is repeated (as long as channel repeats command) until search condition is satisfied or two index points are detected.

**CHANNEL END/DEVICE END/UNIT CHECK** presented to channel upon detection of second index.

**MULTI-TRACK USED:** causes search to continue (as long as channel repeats command); head number automatically increments at index until search condition is satisfied or end of cylinder is reached.

**CHANNEL END/DEVICE END/UNIT CHECK** presented to channel upon detection of end of cylinder.

# SEARCH ID EQUAL OR HIGH

| 0 7 Command Code | 8 31 Data Address | 32 36 Flags | 37 39 | 40 47 | 48 63 Count |
|---|---|---|---|---|---|
| Binary **0111 0001** Hex **71** MT Binary **1111 0001** **F1** | Specifies main storage location of a five byte record identifier (CC HH R). | Used at discretion of programmer. | 000 | | Five |

Chaining and Special Requirements: None

**SEARCH ID EQUAL OR HIGH** compares the main storage ID and the count area ID. ID to be compared is next ID on the track.

**INITIAL STATUS** normally zero.

**TRACK ID EQUAL OR HIGHER** than main storage ID: channel end/device end/status modifier presented to the channel.

**TRACK ID LOWER** than main storage ID: channel end/device end presented to the channel.

**CCW COUNT > FIVE:** only first five bytes used.

**CHANNEL END/DEVICE END** presented to terminate command.

**STATUS MODIFIER** presented if comparison was equal or high.

**CCW COUNT < FIVE:** comparison of main storage and track data continues until CCW count is zero.

**CHANNEL END/DEVICE END** presented to channel when ID and correction code bytes are read and checked.

**STATUS MODIFIER** presented if search is satisfied on the short field.

**MULTI-TRACK NOT USED:** search is confined to one track; search is repeated (as long as channel repeats command) until search condition is satisfied or two index points are detected.

**CHANNEL END/DEVICE END/UNIT CHECK** presented to channel upon detection of second index.

**MULTI-TRACK USED:** causes search to continue (as long as channel repeats command); head number automatically increments at index until search condition is satisfied or head number reaches 8.

**CHANNEL END/DEVICE END/UNIT CHECK** presented to channel upon detection of end of cylinder.

# SEARCH KEY HIGH

| 0 Command Code 7 | 8 Data Address 31 | 32 Flags 36 | 37 000 39 | 40 47 | 48 Count 63 |
|---|---|---|---|---|---|
| Binary **0100 1001** Hex **49** MT Binary **1100 1001** **C9** | Specifies main storage locations to which key is compared. | Used at discretion of programmer. | | | Equal to key length. |

Chaining and Special Requirements: None

**SEARCH KEY HIGH** compares main storage key to key area read from track. Key to be compared is next key on track.

**NOTE:** When command is chained from search ID or read count, key compared is in same record as ID or count.

**INITIAL STATUS** normally zero.

**TRACK KEY** higher than main storage key: channel end/device end/status modifier presented to the channel.

**TRACK KEY EQUAL OR HIGHER** than main storage key: channel end/device end presented to the channel.

**CCW COUNT > KL:** search operation completed when key area is read.
**CHANNEL END/DEVICE END** terminates command.
**STATUS MODIFIER** presented if comparison was high.

**CCW COUNT < KL:** track and main storage data comparison continues until CCW count is zero.
**CHANNEL END/DEVICE END** presented after key area and the following correction code bytes are read and checked.
**STATUS MODIFIER** presented if search was satisfied on the short field.

**MULTI-TRACK NOT USED:** search is confined to one track; search is repeated (as long as channel repeats command) until search condition is satisfied or two index points are detected.
**CHANNEL END/DEVICE END/UNIT CHECK** presented to channel upon detection of second index.

**MULTI-TRACK USED:** causes search to continue (as long as channel repeats command); head number automatically increments at index until search condition is satisfied or head number reaches 8.
**CHANNEL END/DEVICE END/UNIT CHECK** presented to channel upon detection of end of cylinder.

**COMMAND EXECUTION** on a record with zero KL does not set a status modifier. If followed by a chained read data command, the data area read is that of the next record.

# SEARCH KEY EQUAL

| 0 7 Command Code | 8 31 Data Address | 32 36 Flags | 37 39 | 40 47 | 48 63 Count |
|---|---|---|---|---|---|
| Binary<br>**0100 1001**<br>Hex<br>**29**<br>MT Binary<br>**1101 1001**<br>**A9** | Specifies main storage locations to which key is compared. | Used at discretion of programmer. | 000 | | Equal to key length. |

Chaining and Special Requirements: None

**SEARCH KEY EQUAL** compares main storage key to key area read from track. Key to be compared is next key on track.

**NOTE:** When command is chained from search ID or read count, key compared is in same record as ID or count.

**INITIAL STATUS** normally zero.

**COMPARISON EQUAL:** channel end, device end and status modifier presented to the channel.

**COMPARISON UNEQUAL:** channel end/device end presented to the channel.

**CCW COUNT > KL:** search operation completed when key area is read.
**CHANNEL END/DEVICE END** terminates command.
**STATUS MODIFIER** presented if comparison was equal.

**CCW COUNT < KL:** track and main storage data comparison continues until CCW count is zero.
**CHANNEL END/DEVICE END** presented after key area and the following correction code bytes are read and checked.
**STATUS MODIFIER** presented if search was satisfied on the short field.

**MULTI-TRACK NOT USED:** search is confined to one track; search is repeated (as long as channel repeats command) until search condition is satisfied or two index points are detected.
**CHANNEL END/DEVICE END/UNIT CHECK** presented to channel upon detection of second index.

**MULTI-TRACK USED:** causes search to continue (as long as channel repeats command); head number automatically increments at index until search condition is satisfied or head number reaches 8.
**CHANNEL END/DEVICE END/UNIT CHECK** presented to channel upon detection of end of cylinder.

**COMMAND EXECUTION** on a record with zero KL does not set a status modifier. If followed by a chained read data command, the data area read is that of the next record.

# SEARCH KEY EQUAL OR HIGH

| 0 Command Code 7 | 8 Data Address 31 | 32 Flags 36 | 37 000 39 | 40 47 | 48 Count 63 |
|---|---|---|---|---|---|
| Binary **0110 1001** Hex **69** MT Binary **1110 1001** **E9** | Specifies main storage locations to which key is compared. | Used at discretion of programmer. | | | Equal to key length |

Chaining and Special Requirements: None

**SEARCH KEY EQUAL OR HIGH** compares main storage key to key area read from track. Key to be compared is next key on track (excluding R0).

Note: When command is chained from search ID or read count, key compared is in same record as ID or count. Search key equal bypasses R0 unless chained from search ID command which successfully searched R0 ID.

**INITIAL STATUS** normally zero.

**TRACK KEY EQUAL OR HIGHER** than main storage key: channel end/device end/status modifier presented to the channel.

**TRACK KEY LOWER** than main storage key: channel end/device end presented to the channel.

**CCW COUNT > KL:** search operation completed when key area is read.
**CHANNEL END/DEVICE END** terminates command.
**STATUS MODIFIER** presented if comparison was equal or high.

**CCW COUNT < KL:** track and main storage data comparison continues until CCW count is zero.
**CHANNEL END/DEVICE END** presented after key area and the following correction code bytes are read and checked.
**STATUS MODIFIER** presented if search was satisfied on the short field.

**MULTI-TRACK NOT USED:** search is confined to one track; search is repeated (as long as channel repeats command) until search condition is satisfied or two index points are detected.
**CHANNEL END/DEVICE END/UNIT CHECK** presented to channel upon detection of second index.

**MULTI-TRACK USED:** causes search to continue (as long as channel repeats command); head number automatically increments at index until search condition is satisfied or head number reaches 8.
**CHANNEL END/DEVICE END/UNIT CHECK** presented to channel upon detection of end of cylinder.

**COMMAND EXECUTION** on a record with zero KL does not set a status modifier. If followed by a chained read data command, the data area is that of the next record.

# READ HOME ADDRESS

| 0 7 Command Code | 8 31 Data Address | 32 36 Flags | 37 39 | 40 47 | 48 63 Count |
|---|---|---|---|---|---|
| Binary **0001 1010** Hex **1A** MT Binary **1001 1010** **9A** | Specifies main storage location where data from 2835 is to be stored. | Used at discretion of programmer. | 000 | | Five |

Chaining and Special Requirements: None

**READ HOME ADDRESS** transfers the five bytes of data to main storage.

Bytes 0, 1, and 3 are always zero.

Byte 2 = cylinder address

Byte 4 = head address

**INITIAL STATUS** normally zero.

**TRACK DATA** is not transferred.

**DATA TRANSFER COMPLETE** causes 2305 to search for index.

**CHANNEL END/DEVICE END** presented when index is detected.

**NOTE:** No home address written on track. Command maintained for compatibility with other direct access storage devices.

# READ COUNT

| 0 Command Code 7 | 8 Data Address 31 | 32 Flags 36 | 37 000 39 | 40 47 | 48 Count 63 |
|---|---|---|---|---|---|
| Binary<br>**0001 0010**<br>Hex<br>**12**<br>MT Binary<br>**1001 0010**<br>**92** | Specifies main storage locations where first byte of count data is to be transferred. | Used at discretion of programmer. | | | Eight |

Chaining and Special Requirements: None

**READ COUNT** transfers the eight bytes (CC HH R KL DL DL) of the next count area encountered on the track (excluding R0) from disk storage to main storage.

**INITIAL STATUS** normally zero.

**DATA VALIDITY** is verified by correction code bytes following the count area.

**SERVICE OVERRUN** detected: signaled at end of count area.

**COMMAND OVERRUN** detected: signaled immediately.

**CHANNEL END/DEVICE END/UNIT CHECK** presented for either of the above.

**PARITY BIT** is added to each byte prior to transferring byte to the channel.

**CHANNEL END/DEVICE END** are signaled to the channel at completion of the correction code check.

# READ R0

| 0 Command Code 7 | 8 Data Address 31 | 32 Flags 36 | 37 39 | 40 47 | 48 Count 63 |
|---|---|---|---|---|---|
| Binary **0001 0110** Hex **16** MT Binary **1001 0110** **96** | Specifies main storage location where first byte of R0 count data is to be transferred. | Used at discretion of programmer. | 000 | | Specifies number of count, key, and data bytes to be read. |

Chaining and Special Requirements: None

**READ R0** transfers count, key and data areas of R0 from disk storage to the channel.

**INITIAL STATUS** normally zero.

**STORAGE CONTROL** searches for index, clocks through gap 1.

**DATA TRANSFER** of the R0 count area is initiated by storage control.

**DATA VALIDITY** is verified by correction code bytes following each area.

**SERVICE OVERRUN is detected: signaled at end of area in which error occurred.**

**COMMAND OVERRUN** is detected: signaled immediately.

**CHANNEL END/DEVICE END/UNIT CHECK** status presented with either of above.

**PARITY BIT** is added to each byte prior to transferring byte to the channel.

**COMMAND EXECUTION** is accomplished immediately if read R0 is chained from a search home address or read home address command; the storage control will not search for index in these cases.

**CHANNEL END/DEVICE END** are presented to the channel at completion of the correction code check of the data area.

# READ DATA

| 0 Command Code 7 | 8 Data Address 31 | 32 Flags 36 | 37 000 39 | 40 47 | 48 Count 63 |
|---|---|---|---|---|---|
| Binary<br>**0000 0110**<br>Hex<br>**06**<br>MT Binary<br>**1000 0110**<br>**86** | Specifies main storage location where first byte of data is to be transferred. | Used at discretion of programmer. | | | Specifies number of bytes to be read. |

Chaining and Special Requirements: None

**READ DATA** transfers the data area of a record from disk storage to main storage.
The data transferred is:

1. data area read by search ID or search key command from which read command is chained.
2. data area read by read count command from which command is chained.
3. data area of record following next count area on the track (excluding R0).

**INITIAL STATUS** normally zero.

**DATA VALIDITY** is verified by correction code bytes following each area.

**SERVICE OVERRUN** detected - signaled at end of data area.

**COMMAND OVERRUN** detected - signaled immediately.
**CHANNEL END/DEVICE END/UNIT CHECK** presented with both of above.

**PARITY BIT** is added to each byte prior to transferring byte to the channel.

**CHANNEL END/DEVICE END** are presented to the channel at completion of the correction code check of the data area.

# READ KEY AND DATA

| 0 Command Code 7 | 8 Data Address 31 | 32 Flags 36 | 37 000 39 | 40 47 | 48 Count 63 |
|---|---|---|---|---|---|
| Binary<br>**0000 1110**<br>Hex<br>**0E**<br>MT Binary<br>**1000 1110**<br>**8E** | Specifies main storage location where first byte of key data is to be transferred. | Used at discretion of programmer. | | | Specifies the number of key and data area bytes to be read. |

Chaining and Special Requirements: None

**READ KEY AND DATA** transfers key and data areas of a record from disk storage to main storage. The key and data areas are:

1. key and data area of record read by search ID or read count command from which read key and data is chained.
2. key and data areas of record following next count area on the track (excluding R0).

**INITIAL STATUS** normally zero.

**DATA VALIDITY** is verified by correction code bytes following each area.

**SERVICE OVERRUN** detected - signaled at end of area in which error was detected.

**COMMAND OVERRUN** detected - signaled immediately.
**CHANNEL END/DEVICE END/UNIT CHECK** presented with either of above.

**KEY LENGTH = ZERO:** command operates as a read data command.

**PARITY BIT** is added to each byte prior to transferring byte to the channel.

**CHANNEL END/DEVICE END** are presented to the channel at completion of the correction code check of the data area.

# READ COUNT, KEY and DATA

| 0 Command Code 7 | 8 Data Address 31 | 32 Flags 36 | 37 39 000 | 40 47 | 48 Count 63 |
|---|---|---|---|---|---|
| Binary **0001 1110** Hex **1E** MT Binary **1001 1110** **9E** | Specifies main storage location where first byte of count data is to be transferred. | Used at discretion of programmer. | | | Specifies the number of count, key, and data bytes to be read. |

Chaining and Special Requirements: None

**READ COUNT, KEY AND DATA** transfers the next record encountered on the track from disk storage to main storage (excluding R0).

**INITIAL STATUS** normally zero.

**DATA VALIDITY** is verified by correction code bytes following each area.

**SERVICE OVERRUN** detected: signaled at end of area in which error occurred.

**COMMAND OVERRUN** detected: signaled immediately.

**CHANNEL END/DEVICE END/UNIT CHECK** presented with both of above.

**PARITY BIT** is added to each byte prior to transferring byte to the channel.

**CHANNEL END/DEVICE END** are signaled to the channel at completion of the correction code check of the data area.

# READ INITIAL PROGRAM LOAD

| 0 Command Code 7 | 8 Data Address 31 | 32 Flags 36 | 37 000 39 | 40 47 | 48 Count 63 |
|---|---|---|---|---|---|
| Binary **0000 0010** Hex **02** MT Binary | Specifies main storage location where first byte of data is to be transferred . | Used at discretion of programmer. | | | Specifies number of bytes to be transferred. |

Chaining and Special Requirements: Must not be preceded by a set file mask in the same chain.

**READ INITIAL PROGRAM LOAD** causes storage control to seek to cylinder 0, head 0 of selected drive and search for index.

**DATA AREA** read, after index is detected, is the first record after R0.

**COMMAND INITIATION** is normally accomplished by setting the direct access storage device address in the load unit switches and pressing IPL key on console.

**DATA VALIDITY** is verified by correction code bytes following the data area.

**CHANNEL END/DEVICE END** are signaled to the channel at completion of the correction code check.

**PARITY BIT** is added to each byte prior to transferring byte to the channel.

# READ SECTOR

| 0 Command Code 7 | 8 Data Address 31 | 32 Flags 36 | 37 39 | 40 47 | 48 Count 63 |
|---|---|---|---|---|---|
| Binary **0010 0010** Hex **22** | Specifies main storage location where sector number is to be stored. | Used at discretion of programmer. | 000 | | One |

Chaining and Special Requirements: None

**READ SECTOR** transfers one byte of data from storage control to main storage.

**INITIAL STATUS** normally zero.

**BYTE TRANSFERRED** contains angular position number required to access last record processed in the same chain.

**EXCEPTIONS:**

1. Set sector command intervened in the CCW chain.
2. Read, Write or Search CCW has not occurred in the CCW chain.

Either exception results in unpredictable angular position number returned to the channel.

**COMMAND EXECUTION** resets orientation information in the storage control.

**CHANNEL END/DEVICE END** presented after sector number is transferred.

# SENSE I/O

| 0 Command Code 7 | 8 Data Address 31 | 32 Flags 36 | 37 000 39 | 40 47 | 48 Count 63 |
|---|---|---|---|---|---|
| Binary **0000 0100** Hex **04** | Specifies storage location where bytes are to be transferred. | Used at discretion of programmer. | | | Twenty-four |

Chaining and Special Requirements: None

**SENSE I/O** transfers twenty-four bytes of sense information from the storage control to the channel.

**INITIAL STATUS** normally zero.

**DESCRIBES:**

**UNIT CHECK STATUS**

**CURRENT STATUS** of the device that performed operation, and

**SYSTEM ERROR RECOVERY** information.

**UNIT CHECK** should always be followed by a sense command, whether or not sense information is used; otherwise expected future interrupts may not occur and some I/O access paths may be unavailable.

**CHANNEL END/DEVICE END** presented after sense bytes are transferred.

See "Sense Bytes" for a description of the sense information pertaining to 2835/2305 operations.

# READ BUFFERED LOG

| 0 Command Code 7 | 8 Data Address 31 | 32 Flags 36 | 37 39 000 | 40 47 | 48 Count 63 |
|---|---|---|---|---|---|
| Binary **0010 0100** Hex **24** | Specifies main storage location of first error byte or usage information. | Used at discretion of programmer. | | | 128 |

Chaining and Special Requirements: None

**READ BUFFERED LOG** transfers 128 bytes of usage or error information from storage control to the channel.

**INITIAL STATUS** normally zero.

**USAGE/OVERRUN/ERROR INFORMATION** is generated by the overflow of the respective counters and makes up 15th and 16th bytes of buffered log. A start I/O with an error log full condition, to any device address, causes a unit check. The subsequent sense data (sense byte 2, bit 0) indicates that a read buffered log command should be issued.

**CHANNEL END/DEVICE END** presented after data transfer.

**CCW COUNT < 128:** specified number of bytes transferred, but log information not reset.

**CCW COUNT = or > 128:** 128 bytes transferred and log information reset to zero.

# DEVICE RELEASE

| 0 Command Code 7 | 8 Data Address 31 | 32 Flags 36 | 37 000 39 | 40 47 | 48 Count 63 |
|---|---|---|---|---|---|
| Binary **1001 0100** Hex **94** | Specifies main storage location where sense bytes are to be transferred. | Used at discretion of programmer. | | | Twenty-four |

Chaining and Special Requirements: Must be first command in a chain.

**DEVICE RELEASE** terminates reservation of the addressed logical device.

**INITIAL STATUS** normally zero.

**SENSE INFORMATION** (twenty-four bytes) is transferred to the channel.

**NORMAL BUSY** conditions cause command rejection; busy bit is set in the CSW.

**ABNORMAL FILE** status conditions (file unsafe, off-line, etc.) do not halt command execution.

**CHANNEL END/DEVICE END,** presented after sense bytes are transferred.

**UNIT CHECK,** causing command rejection, is presented if:
Two Channel Switch feature is not installed in storage control.
Command is not first CCW in the chain.

Note: The drive will remain reserved until all of its associated logical device addresses are released.

SENSE

# DEVICE RESERVE

| 0 Command Code 7 | 8 Data Address 31 | 32 Flags 36 | 37 39 000 | 40 47 | 48 Count 63 |
|---|---|---|---|---|---|
| Binary **1011 0100** Hex **B4** | Specifies main storage location where sense bytes are to be transferred. | Used at discretion of programmer. | | | Twenty-four |

Chaining and Special Requirements: Must be first command in a chain.

**DEVICE RESERVE** command reserves the addressed logical device to the channel issuing the command, and attempts to implicitly reserve all other logical devices on the same drive.

**INITIAL STATUS** normally zero.

**RESERVATION MAINTAINED** until either a device release command or a system reset is performed by the channel.

**SENSE INFORMATION** (twenty-four bytes) is transferred to the channel.

**NORMAL BUSY CONDITIONS** cause a command reject; busy bit is set in the CSW.

**ABNORMAL FILE STATUS** conditions (e.g. file unsafe, off-line, etc.) do not halt command execution.

**UNIT CHECK,** causing command rejection, is presented if:

Two Channel Switch feature is not installed in storage control.
Command is not first CCW in the chain.

**CHANNEL END/DEVICE END** presented after sense byte transfer if all other logical device addresses on the drive can be implicitly reserved.

**CHANNEL END** presented after sense byte transfer if operations initiated by the other interface are in process. (New operations initiated by the other interface will receive busy in the CSW.)

**DEVICE END** presented when all outstanding operations on the other interface have been completed.

Note: All addresses for the drive must be available before device can be reserved. See Unit Selection and Device Addressing.

# READ DIAGNOSTIC STATUS 1

| 0 Command Code 7 | 8 Data Address 31 | 32 Flags 36 | 37 000 39 | 40 47 | 48 Count 63 |
|---|---|---|---|---|---|
| Binary **0100 0100** Hex **44** | Specifies main storage location where data accumulated during prior diagnostic load or diagnostic write is to be stored. | Used at discretion of programmer. | | | 16 or 512 |

Chaining and Special Requirements: None

**READ DIAGNOSTIC STATUS 1** may perform either of two functions:

**COMMAND FOLLOWS A DIAGNOSTIC WRITE COMMAND:**

**ERROR CODE MESSAGE** (16 bytes) transferred from storage control buffer to main storage.

**CCW COUNT FIELD** should specify 16 bytes. CCW count < 16 causes command reject.

**CHANNEL END/DEVICE END** presented after transfer.

**COMMAND FOLLOWS A DIAGNOSTIC LOAD COMMAND:**

**DIAGNOSTIC TEST** (512 bytes) transferred from storage control buffer to main storage.

**CCW COUNT FIELD** should specify 512 bytes. CCW count < 512 causes command reject.

**CHANNEL END/DEVICE END** presented after transfer.

**INITIAL STATUS** normally zero.

**DIAGNOSTIC LOAD/DIAGNOSTIC WRITE** must precede the read diagnostic status 1 command; otherwise sixteen bytes of data are transferred from storage control buffer area. In this case, the first byte is hex FF and the remaining bytes are undefined.

**CHANNEL END/DEVICE END** are presented after data transfer.

# WRITE HOME ADDRESS

| 0 Command Code 7 | 8 Data Address 31 | 32 Flags 36 | 37 39 | 40 47 | 48 Count 63 |
|---|---|---|---|---|---|
| Binary **0001 1001** Hex **19** | Used during alternate track sparing for transferring defective track information from system to control storage. | Used at discretion of programmer. | 000 | | Five |

Chaining and Special Requirements: Must be preceded by a set file mask permitting write home address commands.

**WRITE HOME ADDRESS** is used primarily for compatibility with other direct access storage devices.

**INITIAL STATUS** normally zero.

**COMMAND EXECUTION** causes no data to be written to the disk.

**STORAGE CONTROL** requests five bytes and orients on index.

**CHANNEL END/DEVICE END** presented upon index detection.

# WRITE R0

| 0 Command Code 7 | 8 Data Address 31 | 32 Flags 36 | 37 000 39 | 40 47 | 48 Count 63 |
|---|---|---|---|---|---|
| Binary **0001 0101** Hex **15** | Specifies main storage location of R0 count, key and data bytes. | Used at discretion of programmer. | | | Specifies total number of bytes in R0 count, key and data areas. |

Chaining and Special Requirements: None

**WRITE R0** causes specified data in main storage to be written on selected drive.

**INITIAL STATUS** normally zero.

**COUNT AREA** is made up of the first eight bytes from main storage.

**NOTE:** The flag byte is generated by storage control; the remaining data is written in the key and data areas as specified by the KL and DL bytes in the count area.

**CORRECTION CODE BYTES** are written by storage control at the end of each record area.

**CCW COUNT FIELD** specifies the number of bytes (8 + KL + DL) to be transferred from main storage to the storage module.

**CCW COUNT < 8 + KL + DL:** storage control writes 0's in remainder of record.

**CHANNEL END/DEVICE END** is signaled after correction code bytes are written for the data area.

# ERASE

| 0 Command Code 7 | 8 Data Address 31 | 32 Flags 36 | 37 000 39 | 40 47 | 48 Count 63 |
|---|---|---|---|---|---|
| Binary **0001 0001** Hex **11** | Specifies main storage location where count, key, and data areas of the record are located. | Used at discretion of programmer. | | | Specifies number of bytes in count, key, and data areas of the record. |

Chaining and Special Requirements: Must be chained from either write R0, write CKD, *search ID equal or *search key equal.

**ERASES** record which overran track capacity.

**INITIAL STATUS** normally zero.

**CHAINING REQUIREMENTS** must be met; otherwise channel end, device end and unit check are presented in initial status.

**DATA TRANSFERRED FROM CHANNEL,** but not written on disk.

**TRACK** is erased to index.

*Search commands must compare equal on all bytes of the recorded field.

# WRITE COUNT, KEY, and DATA

| 0 Command Code 7 | 8 Data Address 31 | 32 Flags 36 | 37 000 39 | 40 47 | 48 Count 63 |
|---|---|---|---|---|---|
| Binary **0001 1101** Hex **1D** | Specifies main storage location where count, key and data bytes of record are located. | Used at discretion of programmer. | | | Specifies total number of bytes in count, key, and data areas. |

Chaining and Special Requirements: Must be chained from either write R0, write CKD, *search ID equal or *search key equal.

**WRITE COUNT, KEY, AND DATA** causes specified data in main storage to be written on selected drive.

**INITIAL STATUS** normally zero.

**COUNT AREA** is made up of the first eight bytes from main storage.

**FLAG BYTE** is generated by storage control; the remaining data is written in the key and data areas as specified by the KL and DL bytes in the count area.

**CORRECTION CODE BYTES** are written by storage control at the end of each record area.

**CCW COUNT FIELD** specifies number of bytes (8 + KL + DL) to be transferred from main storage to the drive.

**CCW COUNT < 8 + KL + DL:** storage control writes 0's in the remainder of the record.

**READ DATA/READ KEY AND DATA** may be inserted between search CCW and write CKD CCW.

**CHAINING REQUIREMENTS** must be met; otherwise channel end, device end and unit check are presented in initial status.

**CHANNEL END/DEVICE END** are signaled to the channel after data area correction code bytes are written for the data area.

*Search commands must compare equal on all bytes of the recorded field.

# WRITE SPECIAL COUNT, KEY, and DATA

| 0 Command Code 7 | 8 Data Address 31 | 32 Flags 36 | 37 39 000 | 40 47 | 48 Count 63 |
|---|---|---|---|---|---|
| Binary **0000 0001** Hex **01** | Specifies main storage location where count, key and data areas of the record are located. | Used at discretion of programmer. | | | Specifies number of bytes in the count, key, and data areas of the record segment. |

Chaining and Special Requirements: Must be chained from a write R0, write CKD, *search ID equal or *search key equal command.

**WRITE SPECIAL COUNT, KEY, AND DATA** formats a segment of an overflow record; last segment is written by a normal write CKD command.

**INITIAL STATUS** normally zero.

**COUNT AREA** is made up of the first eight bytes from main storage.

**FLAG BYTE** contains a 1 in bit position 1; generated and written by the storage control, this bit indicates that another part of the record is located on the next track.

**CORRECTION CODE BYTES** are written by storage control at the end of each record area.

**CCW COUNT FIELD** specifies number of bytes (8 + KL + DL) to be transferred from main storage to the drive.

**CCW COUNT 8 + KL + DL:** storage control writes 0's in the remainder of the record.

**READ DATA/READ KEY AND DATA** may be inserted between search CCW and write special CKD CCW.

**CHAINING REQUIREMENTS** must be met; otherwise channel end, device end and unit check are presented in initial status.

**CHANNEL END/DEVICE END** are signaled to the channel after data area correction code bytes are written for the data area.

*Search commands must compare equal on all bytes of the recorded field.

# WRITE DATA

| 0 Command Code 7 | 8 Data Address 31 | 32 Flags 36 | 37 000 39 | 40 47 | 48 Count 63 |
|---|---|---|---|---|---|
| Binary **0000 0101** Hex **05** | Specifies main storage location of data used to update record. | Used at discretion of programmer. | | | Specifies number of data bytes to be written. |

Chaining and Special Requirements: Must be chained from a *search ID equal or *search key equal command.

**WRITE DATA** performs normal record updating after track formatting.

**COMMAND EXECUTION** causes specified data in main storage to be written in data area of selected record.

**NUMBER OF BYTES WRITTEN:**

1. is specified in the count field of the write data CCW.
2. may be less than data length specified in formatted record.

**CCW COUNT < COUNT AREA DL:** storage control writes 0's in remaining data area, writes ECC bytes and presents channel end/device end to channel.

**CCW COUNT > COUNT AREA DL:** device end/unit check presented when DL byte count = zero.

**CHAINING REQUIREMENTS** must be met; otherwise channel end, device end, and unit check are presented in initial status.

*Search commands must compare equal on all bytes of the recorded field.

## WRITE KEY and DATA

| 0 7 Command Code | 8 31 Data Address | 32 36 Flags | 37 39 000 | 40 47 | 48 63 Count |
|---|---|---|---|---|---|
| Binary **0000 1101** Hex **0D** | Specifies main storage location of data to be used to update record. | Used at discretion of programmer. | | | Specifies number of key and data bytes to be written. |

Chaining and Special Requirements: Must be chained from a *search ID equal command.

**WRITE KEY AND DATA** is used for record updating after track formatting.

**INITIAL STATUS** normally zero.

**COMMAND EXECUTION** causes data from main storage to be written in key and data area of selected record.

**NUMBER OF BYTES WRITTEN:**

1. is specified in the count field of the write key and data CCW.
2. may be less than key and data length specified in formatted record.

**CCW COUNT < KL/DL BYTE COUNT:** storage control writes 0's in the remaining areas, writes ECC bytes, and presents channel end/device end to channel.

**CCW COUNT > KL/DL BYTE COUNT:** device end/unit check presented when KL/DL byte count = 0.

**CHAINING REQUIREMENTS** must be met; otherwise channel end, device end, and unit check are presented in initial status.

**CHANNEL END/DEVICE END** presented after ECC bytes have been written for the data area.

*Search commands must compare equal on all bytes of the recorded field.

The following channel programs are typical examples of how CCW's are arranged to format, read, and write records on the 2835/2305 facility. The examples do not include the CPU program which would be used to initiate the channel program.

Unless otherwise noted, all numbers used are hexadecimal.

Example 1: Format track 2A on head 4 with record zero and records R1, R2 and R3 for customer records. Assuming R0 has a key length of zero and a data length of eight bytes and R1, R2, and R3 have a key length of 6 bytes and a data length of 03E8 (1000 bytes).

The channel program used is:

Seek
Set File Mask
Set Sector
Write Record Zero
Write CKD
Write CKD
Write CKD

## SEEK

| 0 Command Code 7 | 8 Data Address 31 | 32 Flags 36 | 37 000 39 | 40 47 | 48 Count 63 |
|---|---|---|---|---|---|
| Binary<br>**0000 0111**<br>Hex<br>**07** | C C H H<br>03E8 = 00 00 00 2A 00 04 | 0100 | 000 | | 0006 |

Comments: The seek command is used to access the desired cylinder and to select the proper head. All seek commands transfer six bytes of data from main storage to the storage control. (Thus the byte count of six.) The first 3 bytes of the seek address are always 0's, the cylinder number (2A) is specified in the fourth byte, byte five is zero and byte six specifies the desired head (00 04 at 03EC and 03ED).

## SET FILE MASK

| 0 Command Code 7 | 8 Data Address 31 | 32 Flags 36 | 37 000 39 | 40 47 | 48 Count 63 |
|---|---|---|---|---|---|
| Binary **0001 1111** Hex **1F** | 03EE = C0 | 01000 | 000 | | 0001 |

Comments: The set file mask command is used to specify the types of operations that can be performed in this channel program. The mask byte in this case (1100 000 at address 03EE) permits all write and seek commands. The mask is reset to zero at the end of each chain of commands.

## SET SECTOR

| 0 Command Code 7 | 8 Data Address 31 | 32 Flags 36 | 37 000 39 | 40 47 | 48 Count 63 |
|---|---|---|---|---|---|
| Binary **0010 0011** Hex **23** | 1390 = 00 | 01000 | 000 | | 0001 |

Comments: Execution of a set sector command with an argument of zero orients the track to index. During the time that the 2835 is waiting for index, the channel is available to perform other operations on other device addresses.

## WRITE R0

| 0 Command Code 7 | 8 Data Address 31 | 32 Flags 36 | 37 000 39 | 40 47 | 48 Count 63 |
|---|---|---|---|---|---|
| Binary **0001 0101** Hex **15** | C C H H R KL DL DL<br>07D0 = 00 6A 00 08 00 00 00 08<br>07D8 = 00 00 00 00 00 00 00 00 | 01000 | 000 | | 0010 |

Comments: The write R0 command writes a count area, a key area (if the key length specified is not zero), and a data area whose length is dependent upon the value specified in the DL bytes of the count area. In this example, the data address is at 07D0 and a byte count of sixteen is specified.

Since the key length specified is zero, address 07D5 is coded 00 and no key area is written. The data length is eight bytes so addresses 07D6 and 07D7 are coded 00 08, and the data in the following eight main storage locations is written in the data area.

Note that the byte count in the write R0 command is sixteen and the 2835 requested sixteen bytes (eight for the count area and eight for the data area). Therefore, no incorrect length error is generated.

# WRITE CKD (3 CCW's Shown)

| 0 Command Code 7 | 8 Data Address 31 | 32 Flags 36 | 37 000 39 | 40 47 | 48 Count 63 |
|---|---|---|---|---|---|
| Binary<br>**0001 1101**<br>Hex<br>**1D** | R1 C C H H R KL DL DL<br>OBB8 = 00 2A 00 04 01 06 03 E8<br>R2<br>0FA0 = 00 2A 00 04 02 06 03 E8<br>R3<br>1388 = 00 2A 00 04 03 06 03 E8 | 01100<br><br>01100<br><br>00100 | 000<br><br>000<br><br>000 | | 0008<br><br>0008<br><br>0008 |

Chaining and Special Requirements:

Comments: Execution of the write CKD commands cause a count area, key area (if the key length specified is not zero), and a data area whose length is dependent upon the value specified in the DL bytes of the count area, to be written on the dsik.

The main storage locations specified in the data address are coded with the cylinder number, head number, record number, key length, and data length of each record. Since the key length specified is six, a key area six bytes long will be created. The data length specified is 03E8 (1000 bytes). Although the CCW byte count is only eight, and the channel byte count will go to zero after eight bytes have been written, the 2835 is committed to writing a key area six bytes long and a data area 1000 bytes long. Therefore, the 2835 inserts 0's in the applicable byte positions on the track until the 2835 byte count reaches zero.

The difference in the channel byte count and the 2835 byte count will cause an incorrect length indication; therefore the SLI flag (bit 34) is on in the CCW's.

In this example, six bytes of 0's will be recorded in the key area followed by 10 or 16 error correction code bytes, a gap, 1000 bytes of 0's and 10 or 16 more error correction code bytes. At a later time, data can be recorded in the key and data areas with the following CCW sequence.

Set Sector
Search ID Equal (R1)
TIC*-8
Write Key and Data
Search ID Equal (R2)
etc.

Example 2: Update Frank Smith's payroll record. Assumed:

1. The disk is organized by key areas.
2. Each key area contains an employee number.
3. Frank Smith's employee number 656151.
4. This employee number is located on track 0C head 04.
5. Key areas are 6 bytes long and data areas 64 ($100_{10}$) bytes long.

The channel program used is:

Seek
Search Key Equal
TIC*-8
Write Data

## SEEK

| 0 Command Code 7 | 8 Data Address 31 | 32 Flags 36 | 37 000 39 | 40 47 | 48 Count 63 |
|---|---|---|---|---|---|
| Binary **0000 0111** Hex **07** | C C H H<br>03E8 = 00 00 00 0C 00 04 | 01000 | 000 | | 0006 |
| Comments: As explained in example 1, the seek command transfers the track address to the storage control and selects the specified head. | | | | | |

## SEARCH KEY EQUAL

| 0 Command Code 7 | 8 Data Address 31 | 32 Flags 36 | 37 000 39 | 40 47 | 48 Count 63 |
|---|---|---|---|---|---|
| Binary **0010 1001** Hex **29** | (employee no.)<br>07D0 = F6 F5 F6 F1 F5 F1 | 01000 | 000 | | 0006 |
| Comments: After locating the proper cylinder and track, it is necessary to find Frank Smith's record. Since the disk is organized by keys, a search key equal command is executed. Execution of this command causes the 2835 to search the key field of the next record encountered on the track. If the key is not equal to Frank Smith's employee number, (main storage locations 07D0 to 07D5) the 2835 signals channel end and device end to the channel and the TIC command (back to search key equal) is executed. Subsequent key areas are searched until Frank Smith's record is found. The 2835 then signals channel end, device end, and status modifier to the channel. The status modifier bit in the ending status byte causes the channel to skip the next command (TIC) and execute the write data command. | | | | | |

## TRANSFER IN CHANNEL (TIC)

| 0 Command Code 7 | 8 Data Address 31 | 32 Flags 36 | 37 000 39 | 40 47 | 48 Count 63 |
|---|---|---|---|---|---|
| Binary **XXXX 1000** Hex **X8** | Address of search key equal CCW. | XXXXX | XXX | | XXXX |
| Comments: X = positions ignored. | | | | | |

## WRITE DATA

| 0 Command Code 7 | 8 Data Address 31 | 32 Flags 36 | 37 000 39 | 40 47 | 48 Count 63 |
|---|---|---|---|---|---|
| Binary **0000 0101** Hex **05** | (data to update record) 0BB8 = XX XX XX to 0C1C | 00000 | 000 | | 0064 |

Comments: The write data command transfers the data to update Frank Smith's payroll record from main storage locations 0BB8 to 0C1C to the disk.

Note: If Frank Smith's payroll record had not been on track 0C head 04, the program would loop between the search key equal and TIC until every key on the track had been searched. The 2835 would then signal unit check to the channel. A subsequent sense I/O command would indicate no record found.

The data just written could be verified by chaining the following CCW's to the write data command:

Read Sector (store sector address)
Set Sector (locate sector)
Search Key Equal (locate record)
TIC*-8
Read Data (verify data)

Example 3: Find and read Joe Brown's insurance policy number. Assume:

1. The disk is organized by ID – no keys.
2. Joe Brown's employee number is 12320.
3. The data length of each record is 00AA (170 bytes).
4. His policy number is in the data area.
5. The data set begins on cylinder 0A, track 00.

Using the record capacity chart in Appendix B, it is known that forty 170 byte records can be written on a 2305 track. Since the disk is organized by ID's (Joe Brown's = 12320) the track and record location can be determined by dividing the ID by the number of records per track. In this case:

$\frac{12320}{40} = 308$ Note: Add 1 to the remainder to establish the address of the specific record.

Thus, Joe Brown's ID is 308 tracks from the beginning of the data set. There is no remainder so the first record on the track will be Joe Brown's.

The CC HH R for the seek command is then determined by converting the 308 tracks to cylinders and adding the results to the beginning of the data set.

| | Cylinder | Head | Record | C | C | H | H | R |
|---|---|---|---|---|---|---|---|---|
| Starting Address: | 10 | 00 | 0 | 00 | 0A | 00 | 00 | 00 |
| Displacement:* | 37 | 04 | 1 | 00 | 25 | 00 | 03 | 28 |
| Result: | 47 | 04 | 1 | 00 | 2F | 00 | 03 | 28 |

*Determined by dividing 308 by 8.

The channel program used is:

Seek
Search ID Equal
TIC*-8
Read Data

## SEEK

| 0 Command Code 7 | 8 Data Address 31 | 32 Flags 36 | 37 000 39 | 40 47 | 48 Count 63 |
|---|---|---|---|---|---|
| Binary **0000 0111** Hex **07** | C C H H 03E8 = 00 00 00 2F 00 03 | 01000 | 000 | | 0006 |
| Comments: The seek command is executed to select cylinder 2F (decimal 44) and head 03. | | | | | |

## SEARCH ID EQUAL

| 0 Command Code 7 | 8 Data Address 31 | 32 Flags 36 | 37 000 39 | 40 47 | 48 Count 63 |
|---|---|---|---|---|---|
| Binary **0011 0001** Hex **31** | C C H H R<br>05DC = 00 2F 00 03 28 | 01000 | 000 | | 0005 |

Comments: The search ID equal command causes the first ID encountered on the track to be compared with Joe Brown's ID. All unequal comparisons of ID's cause the 2835 to signal channel end/device end to the channel, and the TIC command (back to the search ID equal) is executed. When an equal comparison is encountered (ID of record 40) the 2835 signals channel end, device end, and status modifier to the channel. Status modifier causes the next command (TIC) to be skipped and the read data command is executed.

If the search ID equal is not satisfied and index is passed twice, unit check is sent in the status byte. A subsequent sense I/O command would indicate no record found. The course of action would then be determined by the system error recovery procedures.

## TRANSFER IN CHANNEL (TIC)

| 0 Command Code 7 | 8 Data Address 31 | 32 Flags 36 | 37 000 39 | 40 47 | 48 Count 63 |
|---|---|---|---|---|---|
| Binary **XXXX 1000** Hex **X8** | Address of search ID equal CCW. | XXXXX | XXX | | XXXX |

Comments: X = positions ignored.

## READ DATA

| 0 Command Code 7 | 8 Data Address 31 | 32 Flags 36 | 37 000 39 | 40 47 | 48 Count 63 |
|---|---|---|---|---|---|
| Binary **0000 0110** Hex **06** | (insurance policy no.)<br>0BB8 = XX XX XX to 0C62 | 00000 | 000 | | 00AA |

Comments: Execution of the read data command causes the data area, containing Joe Brown's insurance policy number, to be read into main storage location 0BB8 to 0C62.

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## MULTIPLE TRACK (MT) OPERATION

On all search, and most read commands, the storage control can automatically select the next sequentially numbered head on the disk drive under control of bit 0 of the command code. If bit 0 is a 1 and data transfer of the command has not been initiated, the next sequentially numbered head is selected at index. This eliminates the need for seek head commands in a chain of read or search commands.

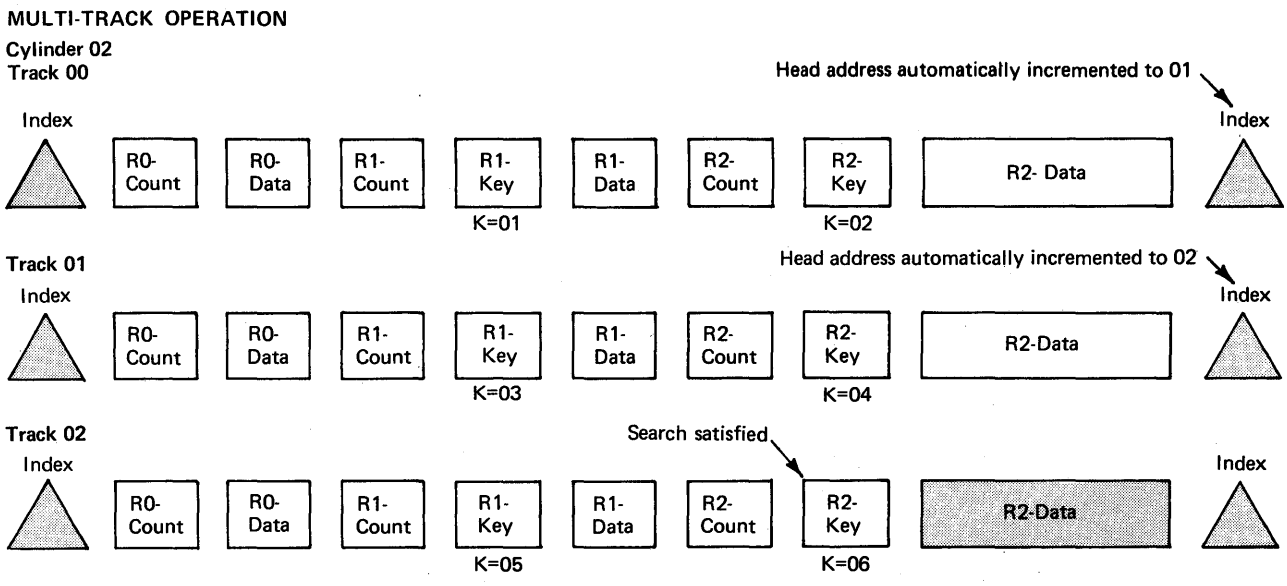
> Note: Channel end, device end, and unit check is signaled to the channel if the head switching operation crosses a file protected boundary, or exceeds the limits of the pseudo-cylinder.

Discretion must be used when using the MT bit. For example, if during a multi-track search operation the desired record is on the first track searched, but the search commences after that record is passed, the head number is advanced to the next track without comparing on the desired record. To avoid this condition a single track read home address or read R0 should be placed before the search to ensure that the search commences at R0 or R1 of the track. (See Figure 8.)

Multi-track operations are not used on Read IPL, Read Sector, or Read Diagnostic Status 1 commands.

## RECORD OVERFLOW

The record overflow function provides a means of processing logical records that exceed the capacity of a track. When using overflow records, the limiting factor to the size of the record is the cylinder boundary.




Channel program using multiple track search.

**Object:** Update John Doe's payroll record.
**Assume:** The disk is organized by keys, and the physical address of the record is unknown.
Set File Mask (allow write and seek commands).
Seek (cylinder 02, head 00).
Read Home Address (make sure all records are read).
Search Key Equal (MT bit on, argument = 06).
TIC * -8
Write Data (updates shaded area).

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Figure 8. Multiple Track Operation

## Formatting Overflow Records

The portion of an overflow record that is written on (or read from) one track is called a record segment. Each segment contains a count field, key field (optional), and a data field. The key and data lengths specified in the KL and DL bytes of the count field pertain to that segment, not the entire overflow record. Since only the key field of the first segment has significance, overflow records are usually formatted without key fields (KL=0).

Write special count, key, and data commands are used to format all segments of an overflow record except the last segment. As shown in Figure 9, the last segment is formatted with a normal write count, key, and data command.

Write special CKD commands cause a 1 to be written in bit position one of the flag byte of the record segment being written. This bit identifies the record as an overflow segment and indicates to subsequent commands processing the record, that the logical record continues on the following track.

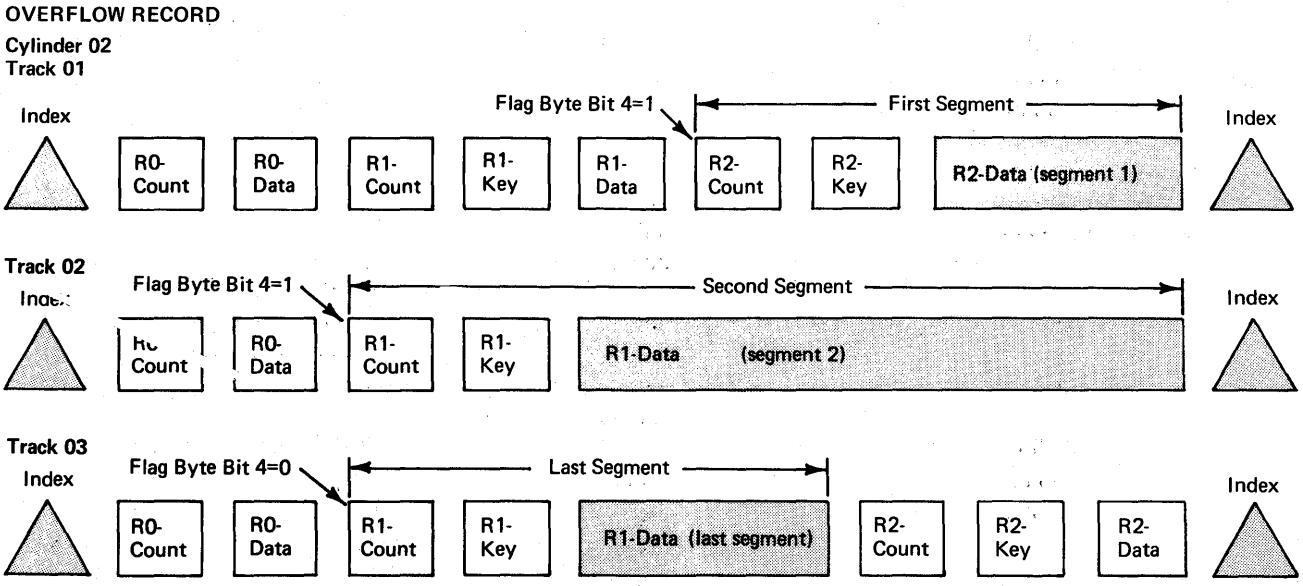
No internally generated head switching is associated with formatting overflow records. All head seeking must be done by the formatting program. (Figure 9) During read and write update operations, head switching will not occur in violation of the file mask or past the end of the cylinder.

All segments of an overflow record except the first must be written immediately following R0, and all segments except the last must be the last physical record on their respective tracks.

## Processing Overflow Records

The following commands may be used to read or update previously formatted overflow records.

- Read count, key, and data.
- Read key and data.
- Read data.
- Write key and data.
- Write data.




Typical channel programs for formatting, updating, and reading overflow records.

**Formatting:**
Set sector
Search ID R1 (track 1)
TIC* -8
Write special CKD (segment 1)
Seek head (next track)
Search ID R0 (track 2)
TIC* -8
Write special CKD (segment 2)
Seek head (next track)
Search ID R0 (Track 3)
TIC* -8
Write CKD (last segment)

**Updating:**
Set sector
Search ID R2 (segment 1)
TIC* -8
Write data (updates shaded areas)

**Reading:**
Set sector
Search ID R2 (segment 1)
TIC* -8
Read data (reads shaded areas)

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Figure 9. Record Overflow

When any of the above commands are used to process an overflow record, the operation does not terminate at the end of a record segment if the segment is flagged with bit 1 (on) in the flag byte. Instead, the head address is incremented by 1 at index, and the operation continues in the data field of record one on the next track. If this record segment is also flagged with bit 1 (on) in the flag byte, the operation continues on the next track. When a segment is found that is not flagged, the operation terminates at the end of the data field. The net effect of this procedure is that the data fields of all the record segments appear as a single logical data field.

If a data check or bus out parity error occurs, unit check is signaled at the end of the associated area.

> Note: If a write operation was in progress when the data check or bus out parity error occurred, unit check is signaled at the end of the record segment.

If the CCW count is less than number of bytes in the logical record, the operation continues to the end of the logical record before presenting ending status.

Spacing over overflow records does not occur automatically. The channel program must be written so that the entire logical record is spaced over, not just the first segment. For example, in the sequence:

```
Search ID (first segment)
TIC * -8
Read CKD (multi-track)
```

the read CKD does not read the next logical record on the cylinder. It reads starting at the count field of the second segment of the overflow record.

The sequence:

```
Search ID (first segment)
TIC * -8
Read Key and data (skip and SLI flags on)
Read CKD (multi-track)
```

reads the count, key, and data of the next logical record.

Multiple track operations should not be confused with overflow record operations. When processing overflow records, head switching occurs regardless of whether the MT bit is on or off.

## END-OF-FILE

An end-of-file record is used to define the end of a logical group of records. An end-of-file record is written by executing a write count, key, and data command with the DL bytes in the count area set to zero. Execution of a write CKD with a data length of zero causes the storage control to write a data area consisting of one byte of 0's (2 bytes on Mod 1) followed by the error correction code bytes. (Figure 10)

The KL portion of the count area can be either zero or non-zero. If KL equals zero, the end-of-file record contains the contents of the count area and data area only. If the key length is not zero, the key area is written as specified by the KL byte.

Detection of a data length of zero causes unit exception status to be generated. No data from the data area is transferred to the channel. A read R0, read CKD, or read KD will transfer the key area (if any) to the channel.

The unit exception is generated during execution of read IPL, read R0, read CKD, read KD, read data, write KD, and write data commands.

### *Rotational Position Sensing*

Rotational position sensing enables the channel to issue a seek to an angular track position. It permits channel disconnection during most of the rotational delay period and thus contributes to increased channel utilization.

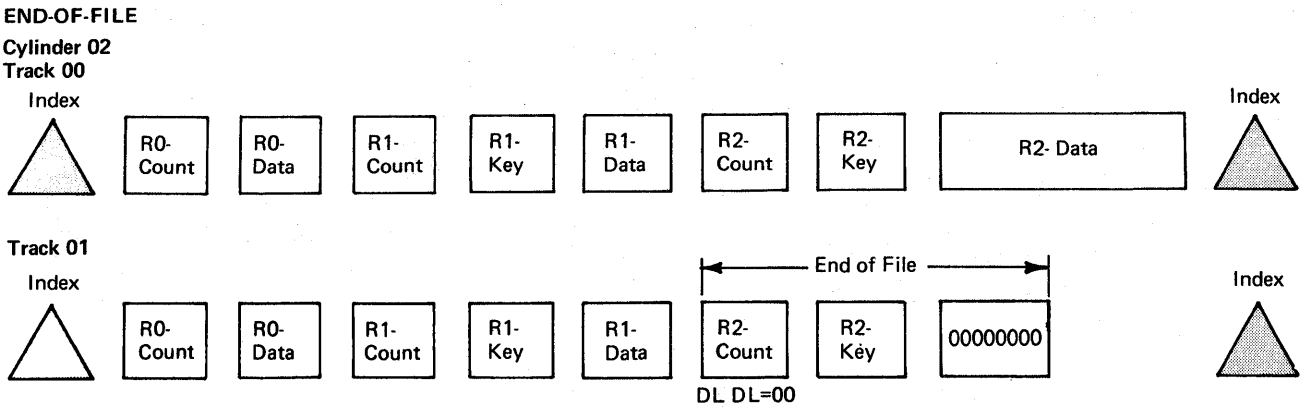
The control unit implements rotational position sensing by dividing each track into equal angular segments. There are 90 segments per track in the 2305 model 1 and 180 segments per track in the 2305 model 2.

The channel obtains the angular position of the given record by chaining a read sector command to a read, write, or search command that has operated on the record. The channel locates to a particular angular position by executing the set sector command.

An example of rotational position sensing is shown in Figure 11.

## COMMAND RETRY

Command retry is a channel/control unit procedure that causes an improperly executed command in a channel program to be automatically retried. The re-execution does not cause an interrupt and




Channel program with end-of-file record:

```
Set File Mask (allow seek and write)
Seek (cylinder 02, head 00)
Write Home Address
Write R0
Write CKD R1
Write CKD R2
Seek Head (cylinder 02, head 01)
Write Home Address
Write R9
Write R0
Write CKD R1
Write CKD R2 (data length = 00)
```

Figure 10. End Of File

programmed error recovery procedures are not required. Command retry is used:

1. To recover from correctable data errors (error burst of 11 bits or less) that occur during a read or search operation on a count or key area.

   During a read or search operation, the count or key area read from the disk is placed in a buffer in the control unit. When a correctable error occurs, the control unit corrects the data in the buffer and reissues the command that detected the error. During re-orientation to the record, the channel is free. When the failing command is re-executed, the corrected data from the buffer is used instead of the data actually on the track.
2. When an uncorrectable data error is detected, the failing command is reissued. If the error does not recur, the CCW chain continues. If the error recurs, the storage control retries the operation again.

   When a correctable error occurs in the data field of a record, correction information is sent to the channel in the sense data.
3. Command retry is also used to recover from command overrun and service overrun.

## MULTIPLE REQUESTING

The multiple requesting function provides the capability for record request queuing within the 2835/2305 facility. This queuing is accomplished by allowing multiple set sector commands to be issued to a single disk module.

The function is implemented by associating up to eight logical (system) device addresses with a single physical module. This permits the channel to issue a set sector command to one logical device, disconnect on channel end status, and then issue a set sector command to another logical device. The arguments transferred by the set sector command are stored in the control unit. Whenever the control unit is not executing a command and is not otherwise busy, it monitors the angular position counters in the attached disk modules. When a counter compares equal with one of the stored arguments for that module, the control unit raises request-in and, when polled, presents device end status for the appropriate logical device.

To properly complete a chain when the channel reconnects, the control unit must store the arguments of set file mask and seek commands issued previously in the same chain. If multiple requests are pending against a module, the proper head may no longer be selected when the channel reconnects to complete the chain. If this is the case, the control unit ensures that the proper head is reselected prior to raising request-in.

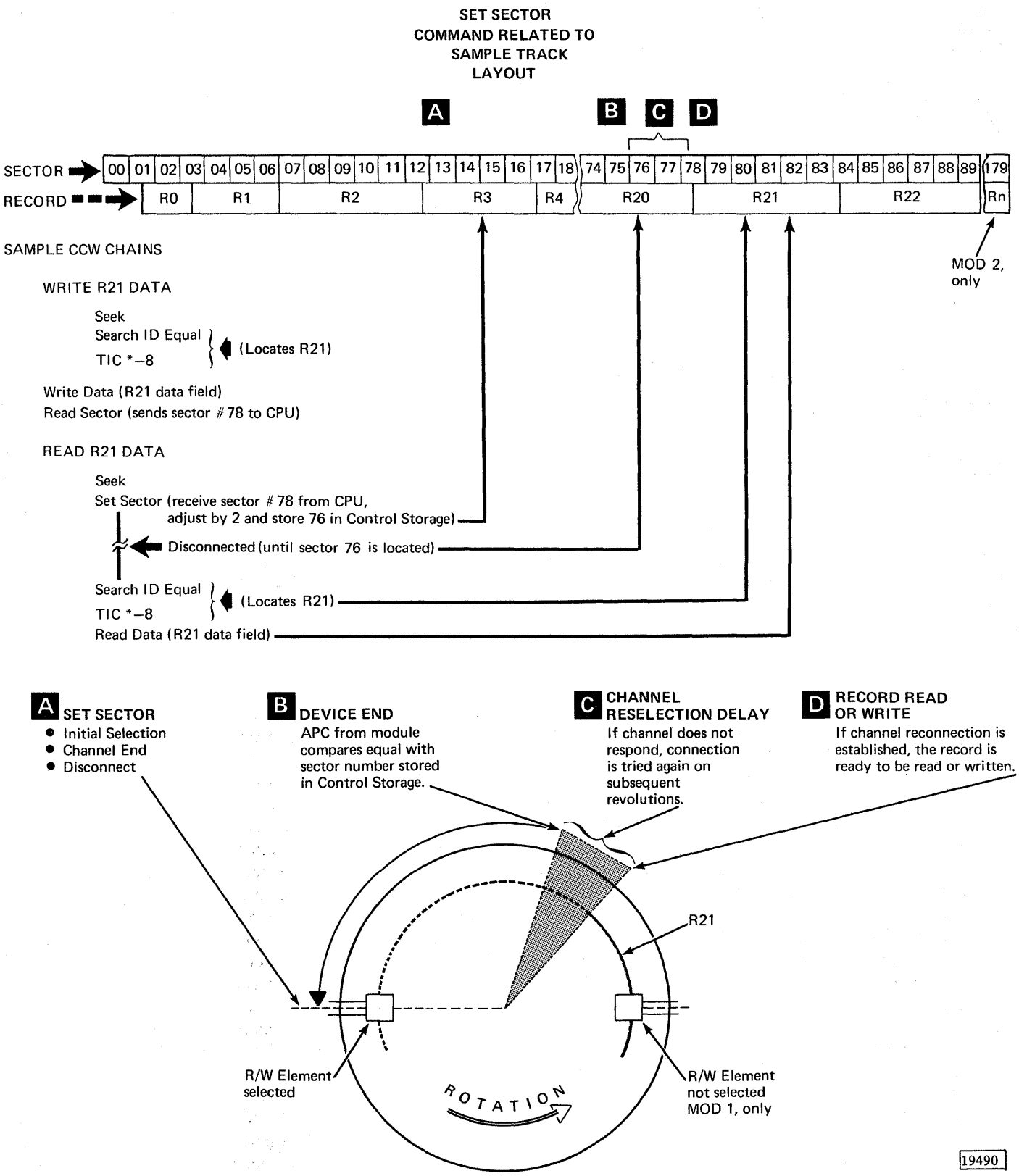



Figure 11. Rotational Position Sensing

# Storage Control Diagnostics

To provide maximum facility availability, the 2835 can execute diagnostic tests on a drive concurrent with normal system operations on the remaining drives. This mode of operation allows the customer engineer to diagnose and repair most drive failures while the facility continues to operate other attached drives. The 2835 provides a transient block of 512 bytes (128 words) of control storage to allow temporary residence for a specific diagnostic test.

The transient area is loaded by the system under control on the On-Line Test Executive Program (OLTEP). A special command (diagnostic write), loads a selected test into control storage and instructs the storage control to execute the test. This loading and execution can also be initiated from the CE panel.

After the test, error message information or test results are transferred from the 2835 to main storage by the diagnostic sense command. If the CE panel is used, the test results are displayed in the CE panel indicators.

### USAGE/OVERRUN/ERROR COUNTERS

The control unit maintains a set of counters for each drive. These counters accumulate total bytes read from the files, missing address marks, and all detected overruns. The counters are initialized with values that cause the byte counter to overflow if the predicted error rates are not exceeded. When a drive counter overflows, the contents of all counters for that drive are transferred to the buffered log, and the counters are reinitialized. The transfer is accomplished by the read buffered log command. Execution of this command causes the current contents of the counters to form the 15th and 16th entries in the log area.

### CONTROL UNIT BUFFERED LOG

The buffered log accumulates log entries of one or more of the following types:

1. Catastrophic control unit failures that result in a disconnect-in channel sequence.
2. Control unit control storage data errors.
3. Microprogram load file errors recovered by internal retry.
4. Usage/overrun/error counters that are logged when an overflow occurs.

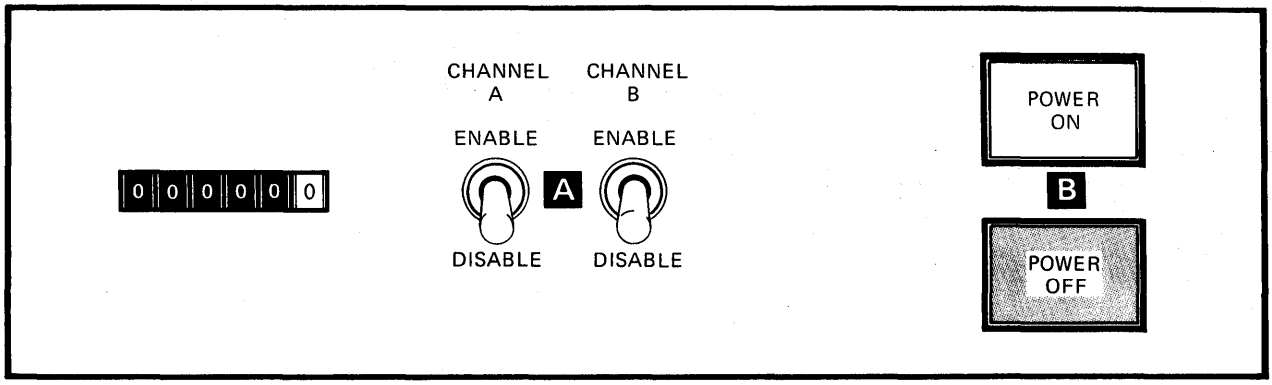
The buffered log is transferred to the channel when a read buffered log command is executed. (See Appendix C for log entry formats.)

### DISCONNECT IN

Disconnect in is activated by the control unit when a catastrophic error prevents normal microprogram termination of the sequence. It can be activated only when the control unit connected to the channel.

The channel responds to disconnect in by performing a selective reset and causing an I/O interruption. The interface control check bit is posted in the CSW.

2835 STORAGE CONTROL PANEL




**A** Toggle switch that must be in the enable position before the 2835 storage control is available to the channel. If two-channel switch feature is installed, a separate switch is provided for each channel.

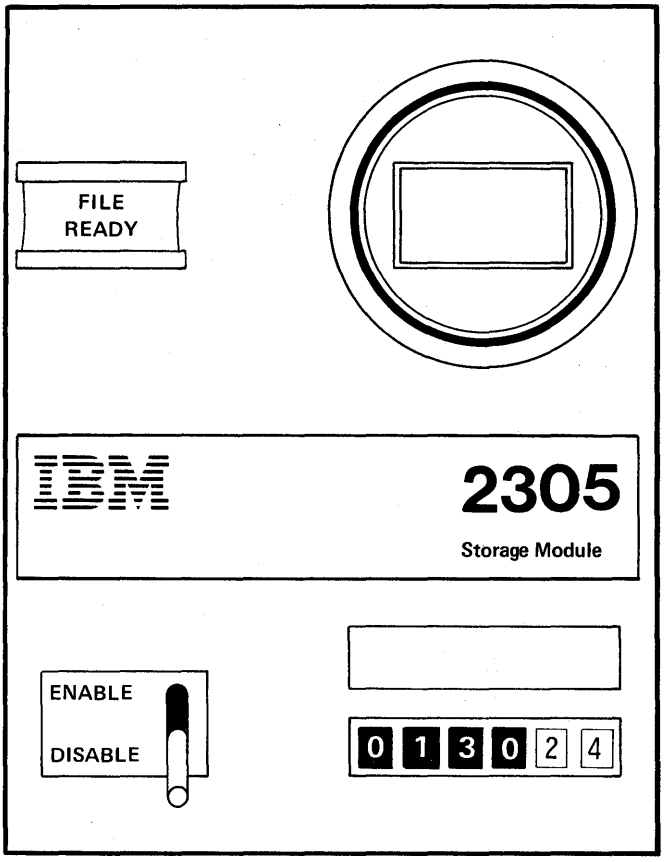
**B** Power Off: A momentary pushbutton that can be used to remove ac power from the 2305 facility.

If system power is on when the pushbutton is pressed, ac power is removed from the 2305 facility. If system power is later turned off, then on, ac power is reapplied to the 2305 facility; operation of the power on pushbutton is not required.

Power On: A momentary pushbutton that can be used to reverse the effect of the power off switch. If system power is on, and the power off switch is pressed to remove ac power from the 2305 facility, then pressing the power on switch will restore ac power to the 2305 facility.

Whenever system power is brought up, ac power is applied to the 2305 facility, regardless of what was previously done to the two pushbuttons.

11835A




**READY INDICATOR:** When illuminated, this light indicates that the module identified by the number on the indicator is ready. After power is applied, a warm-up period of about 5 minutes is required before the module is ready for processing.

**ENABLE/DISABLE:** Enables or disables communication between the associated device and control unit. The processor must be in the stop or wait state for the transfer of the switch from one position to the other to be effective.

**USAGE METER:** Records actual process time.

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## TWO CHANNEL SWITCH

The two channel switch special feature provides the ability for the 2835 Storage Control to be shared by two channels. The channels may be attached to the same or different central processing units. Individual storage modules attached to the storage control may be reserved for the exclusive use of either of the channels. Channel switching and device reservation are controlled by the channel program. Two special commands are associated with two channel switch operation device reserve and device release. (See "Channel Commands.")

### Channel Selection Switch

Channel selection is determined by the "setting" of a three position switch in the 2835. When the switch is in neutral, the 2835 can be selected by either channel. The channel A position indicates that the storage control has been selected by channel A, and the channel B position indicates that the storage control has been selected by channel B.

Once the 2835 has been selected by either channel, it is reserved to that channel until ending status is presented. The channel selection switch will then return to neutral unless:

1. Chaining is indicated and device end is included in the status.
2. A contingent connection is established. (See "Contingent Connection.")

When a channel connection is maintained as a result of a contingent connection, the storage control will not respond to polling by the channel, except to present stacked status or control unit end. When the contingent connection is terminated, the channel selection switch returns to neutral.

The length of time the storage control is connected to a channel determines how the selection switch responds to a channel initiated sequence from the other channel. The channel/storage control connection is classified as either instantaneous or long.

Note: In the following descriptions, the conditions of both channels are reversible.

INSTANTANEOUS CONNECTIONS: At the moment the channel selection switch connects to a channel, the connection is considered to be instantaneous; the state of a channel connection changes from instantaneous to long if:

1. The channel is processing a start I/O instruction.
2. The channel indicates chaining on device end during a polling sequence.

If a channel/storage control connection is caused by a condition other than 1 or 2, the state of the connection remains instantaneous until the operation is complete and the selection switch returns to neutral.

During an instantaneous connection on channel A, the selection switch does not respond to a channel initiated selection sequence on channel B until the instantaneous connection is terminated. At the termination of the instantaneous connection, the selection switch either remains connected to channel A (if the connection state changed from instantaneous to long), or returns to neutral. If the switch returns to neutral from channel A during a channel initiated selection sequence on channel B, the switch immediately connects to channel B. If the connection state changed from instantaneous to long on channel A, the response of the selection switch is as described in "Long Connection."

LONG CONNECTION: During a long connection on channel A, the storage control responds with a short control unit busy sequence (busy and status modifier) to a channel initiated selection sequence on channel B.

Whenever the short control unit busy sequence occurs, the storage control attempts to present control unit end status to channel B after the selection switch returns to neutral. The address byte associated with this status is the address of the lowest numerical device address which is not implicitly connected to either interface.

The pending control unit end status does not cause the storage control to appear busy to channel A as long as the selection switch is not actually connected to channel B.

## Device Status

Multi-tagged status is presented to all interfaces not partitioned from the storage control. A multi-tagged status condition causes status to be generated for each of the attached channels. The status must be accepted by a channel before it can use the device.

Tagged status is associated with a particular interface and is made available only to that interface. The status remains pending until accepted over the interface identified by the tag.

Whenever a device is busy for any reason, including reservation to channel A, a command from channel B addressed to that device will be rejected with busy status. This, in turn, will cause the storage to attempt to present to channel B a status byte containing device end after the busy condition has been terminated. The address byte associated with this status byte will be the same as that associated with the busy status byte.

Device end status resulting from any channel command will be presented to the channel that issued the command.

Device end status resulting from a not-ready to ready transition will be presented as multi-tagged status.

## Addressing

The base address (four high-order bits) of the storage control on one channel is independent of the base address on the other channel. However, the four low-order address bits for any attached device must be the same on both channels.

## Resets

A system reset can be initiated by either channel at any time. A system reset: (1) resets all reservations and status conditions stored in the storage control for the resetting channel, (2) terminates all block multiplex command chains in progress on the resetting channel A, (3) resets all device interrupts not associated with the other channel. Reservations, status, and device interrupts for, as well as block multiplex chains in progress on, the other channel are not affected. If a channel initiates a system reset while the selection switch is connected to the other channel, a machine reset is performed when the selection switch goes to neutral. A selective reset has no effect on device reservations or status.

*Error Condition Table*

The error condition table (Figure 12) identifies the primary sense bits (bytes 0-2) that are posted by the 2835, and maps each into a specific recovery action to be invoked by the system.

## ERROR CORRECTION FUNCTION

The 2835 Storage Control posts the data check and correctable sense bits if a correctable data error is detected in the data area during the processing of a basic command.

Correctable data errors in count and key areas are corrected internally by utilizing command retry. Such cases are not posted with the correctable and data check sense bits and do not cause a system interrupt.

If the correctable and data check sense bits are included in the sense information, sense bytes 18 through 22 provide the error pattern and displacement as shown in the following illustration:

| Sense byte | 18 | 19 | 20 | 21 | 22 |
|---|---|---|---|---|---|
| Contents | Displacement | | Error Pattern | | |

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The displacement is used to align the error pattern with the erroneous bytes in main storage. The displacement specifies the number of bytes the error pattern must be shifted relative to the last byte transferred.

The error pattern is used to correct the erroneous data in main storage. Error correction is performed by aligning the error pattern bytes with the bytes specified by the displacement and exclusively ORing the error pattern with the main storage data.

## SPECIAL CASES

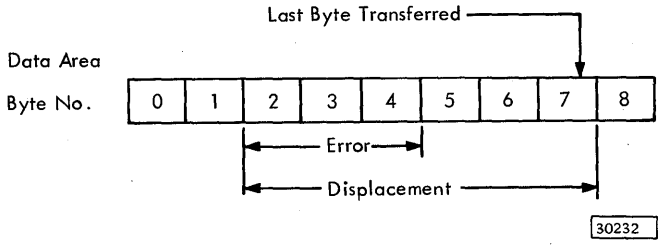
If the displacement is equal to 0, the error burst occurred in data bytes which were not transferred to main storage due to truncation. In this case, the control unit sets the three error pattern bytes to 0 before transferring the sense information. The error recovery procedure bypasses the exclusive OR operation and continues to the next step as specified in the recovery action table.

If the skip bit is on in the failing CCW, data was not transferred to main storage. In this case, the error correction function should be bypassed, the error recovery procedure should be continued as specified in the recovery action table.

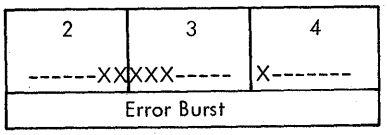
## ERROR CORRECTION EXAMPLE FOR MODEL 2

To clarify the correction procedure, the following example is given:

> Assume a data area is nine bytes in length, only eight bytes were transferred to main storage because of a short count in the CCW, and the error pattern has a displacement of 6.



Assume the error affected bytes 2, 3, and 4 as follows:




where: (-) corresponds to a correct bit

(X) corresponds to an incorrect bit

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The condition illustrated above generates sense bytes 18, 22 as follows:

Sense Bytes 18 and 19
00000000 00000110
Sense Bytes 20, 21, and 22
00000011 11100000 10000000

Error correction is accomplished by aligning the error pattern with main storage bytes 2, 3, and 4 and exclusively ORing the error pattern with the main storage bytes.

Note: For model 1, the data is correctable only if the error occurs on one path. Because every other byte of the preceding example is written on path 0 and path 1, respectively, the error burst affects bytes 2, 4, and 6 rather than 2, 3, and 4. The exclusive OR in main storage would be with bytes 2, 4, and 6.

## CONSTRUCTION OF RESTART CCW

If operation incomplete (byte 1, bit 7) of the sense information is set, a logical operation was in progress and data transfer had been initiated when an error or unusual condition occurred. The error recovery procedure corrects the unusual condition and continues the operation that was in progress from the point of interruption to the normal ending point. Sense byte 3 provides the restart command code.

The restart CCW is constructed with the following procedure:

1. The command code byte is provided in sense byte 3.
2. The data address is that of the interrupted CCW, plus the count of that CCW, minus the residual count in the CSW.
3. The flags (except for PCI) are those of the interrupted CCW.
4. The count is the residual count in the CSW. If the CSW residual count is 0, then there is some problem in creating the CCW, for a 0 count cannot be used. In this case, a count of 1 may be used, and the CCW address should point to a byte of 00 (hex) in main storage.

The programmer should be aware that a second operation incomplete might occur while executing the restart CCW. In this case, a new restart CCW may be generated from the old restart CCW, using the procedure described, but care must be used in not destroying the old restart CCW before generating the new one.

# Recovery Action Table

The recovery action table (Figure 13) specifies an error correction function (ECF) as a necessary step in the recovery procedure. The section entitled "Error Correction Function" provides the ECF algorithm and related instructions that are required.

| Error Correction Table | | | | |
|---|---|---|---|---|
| Status Bit | Sense Byte | Sense Bit | Condition | Action |
| 45 | | | Channel Control Check | 5 |
| 46 | | | Interface Control Check | 5 |
| 44 | | | Channel Data Check | 6 |
| 47 | | | Chaining Check | 6 |
| 38 | | | Unit Check | 12 |
| | 1 | 0 | Permanent Error | 1 |
| | 0 | 3 | Equipment Check | 6 |
| | 0 | 2 | Bus Out | 3 |
| | 0 | 1 | Intervention Required | 4 |
| | 0 | 0 | Command Reject | 2 |
| | 1 | 4 | No Record Found | 2 |
| | 0 | 5 | Overrun | 6 |
| | 1 | 1 | Invalid Track Format | 2 |
| | 0 | 4 | Data Check | 7 |
| | 1 | 2 | End of Cylinder | 8 |
| | 1 | 5 | File Protect | 9 |
| | 2 | 0 | Buffered Log Full | 11 |
| 42 | | | Program Check | 2 |
| 43 | | | Protection Check | 2 |
| 39 | | | Unit Exception | 2 |
| 41 | | | Incorrect Length | 2 |
| Notes: All of the indicators defined above must be checked in sequence until the one caused by the error condition is found. | | | | |

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Figure 12. Error Correction Table

| Recovery Action Table | |
|---|---|
| Action Number | Action |
| 1 | Provide an operator message and exit to permanent error. |
| 2 | Exit with a permanent error. |
| 3 | (A) Retry the chain of commands from the last restart point once.<br>(B) On the second occurrence of the error condition do Action 1. |
| 4 | (A) Retry the chain of commands from the last restart point once.<br>(B) On the second occurrence of the error condition, provide an Operator message. Set the UCB Not Ready and retry the chain of commands when the device becomes ready. |
| 5 | (A) If CCH (Channel Check Handler) is incorporated in the system, and if the No Retry bit in the ERPIB is not on, do Action 6.<br>(B) Otherwise, do Action 1. |
| 6 | (A) Retry the chain of commands from the last restart point ten times.<br>(B) If the error condition persists after ten retries, do Action 1. |
| 7 | (A) If the correctable bit (Byte 2, bit 1) is not on, do Action 6.<br>(B) If the correctable bit is on, perform ECF.<br>(C) If Operation Incomplete is on, do Action 10.<br>(D) If the failing CCW was the last CCW in the chain, exit with no error.<br>(E) If the failing CCW was not the last CCW in the chain, execute the following CCW chain:<br>Seek (CCHH provided in sense bytes 4-7)<br>Set File Mask (Same as original)<br>Set Sector ('S' provided in sense byte 9)<br>Search ID equal (CCHHR provided in sense bytes 4-8)<br>TIC *-8<br>NOP (Space over error record)<br>TIC (CSW) |
| 8 | (A) Update the users seek argument to the next cylinder and head 0.<br>(B) If Operation Incomplete is on, do Action 10(B).<br>(C) Execute the following CCW chain:<br>Seek (Argument from Step A)<br>Set File Mask (Same as original)<br>Set Sector 0<br>TIC(CSW-8) |
| 9 | (A) If the interrupted CCW is a seek command, execute the following CCW chain:<br>Seek (Users argument)<br>Set File Mask (Same as original)<br>TIC (CSW)<br>(B) If the interrupt was caused by a multi-track operation, increment the users seek argument by 1.<br>(C) If Operation Incomplete is on, do Action 10(B).<br>(D) Continue the operation by executing the following CCW chain:<br>Seek (Argument from Step B)<br>Set File Mask (Same as original)<br>TIC (CSW-8) |
| 10 | (A) Increment the seek argument (CCHH as provided in Sense bytes 4-7) by 1.<br>(B) Construct the restart CCW. Sense Byte 3 provides the restart command code.<br>(C) Complete the interrupted operation and continue the user's chain (if appropriate) by executing the following CCW chain:<br>Seek (Argument from Step A)<br>Set File Mask (Same as original)<br>Search ID Equal (Record 1)<br>Restart CCW<br>TIC (CSW) |
| 11 | Transfer contents of Buffered Log to main storage. |
| 12 | Perform a sense command and continue with the checks as indicated in the Error Condition Table. |

Figure 13. Recovery Action Table

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# Appendix A: Record Track Capacities

| 2305 MODEL 1 CAPACITY | | | | | | | |
|---|---|---|---|---|---|---|---|
| WITHOUT KEYS | | | | | | | |
| BYTES PER RECORD | | RECORDS PER | | | | BYTE CAPACITY PER MODULE | |
| MINIMUM | MAXIMUM | TRACK | CYLINDER | MODULE | FACILITY | MINIMUM | MAXIMUM |
| 23 | 36 | 31 | 248 | 11904 | 23808 | 273792 | 428544 |
| 37 | 52 | 30 | 240 | 11520 | 23040 | 426240 | 599040 |
| 53 | 70 | 29 | 232 | 11136 | 22272 | 590208 | 779520 |
| 71 | 88 | 28 | 224 | 10752 | 21504 | 763392 | 946176 |
| 89 | 106 | 27 | 216 | 10368 | 20736 | 922752 | 1099008 |
| 107 | 128 | 26 | 208 | 9984 | 19968 | 1068288 | 1277952 |
| 129 | 150 | 25 | 200 | 9600 | 19200 | 1238400 | 1440000 |
| 151 | 174 | 24 | 192 | 9216 | 18432 | 1391616 | 1603584 |
| 175 | 200 | 23 | 184 | 8832 | 17664 | 1545600 | 1766400 |
| 201 | 230 | 22 | 176 | 8448 | 16896 | 1698048 | 1943040 |
| 231 | 260 | 21 | 168 | 8064 | 16128 | 1862784 | 2096640 |
| 261 | 296 | 20 | 160 | 7680 | 15360 | 2004480 | 2273280 |
| 297 | 334 | 19 | 152 | 7296 | 14592 | 2166912 | 2436864 |
| 335 | 376 | 18 | 144 | 6912 | 13824 | 2315520 | 2598912 |
| 377 | 424 | 17 | 136 | 6528 | 13056 | 2461056 | 2767872 |
| 425 | 478 | 16 | 128 | 6144 | 12288 | 2611200 | 2936832 |
| 479 | 538 | 15 | 120 | 5760 | 11520 | 2759040 | 3098880 |
| 539 | 608 | 14 | 112 | 5376 | 10752 | 2897664 | 3268608 |
| 609 | 688 | 13 | 104 | 4992 | 9984 | 3040128 | 3434496 |
| 689 | 782 | 12 | 96 | 4608 | 9216 | 3174912 | 3603456 |
| 783 | 892 | 11 | 88 | 4224 | 8448 | 3307392 | 3767808 |
| 893 | 1024 | 10 | 80 | 3840 | 7680 | 3429120 | 3932160 |
| 1025 | 1186 | 9 | 72 | 3456 | 6912 | 3542400 | 4098816 |
| 1187 | 1388 | 8 | 64 | 3072 | 6144 | 3646464 | 4263936 |
| 1389 | 1648 | 7 | 56 | 2688 | 5376 | 3733632 | 4429824 |
| 1649 | 1996 | 6 | 48 | 2304 | 4608 | 3799296 | 4598784 |
| 1997 | 2480 | 5 | 40 | 1920 | 3840 | 3834240 | 4761600 |
| 2481 | 3210 | 4 | 32 | 1536 | 3072 | 3810816 | 4930560 |
| 3211 | 4424 | 3 | 24 | 1152 | 2304 | 3699072 | 5096448 |
| 4425 | 6852 | 2 | 16 | 768 | 1536 | 3398400 | 5262336 |
| 6853 | 14136 | 1 | 8 | 384 | 768 | 2631552 | 5428224 |

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| 2305 MODEL 1 CAPACITY | | | | | | | |
|---|---|---|---|---|---|---|---|
| WITH KEYS | | | | | | | |
| BYTES PER RECORD ($K_L+D_L$) | | RECORDS PER | | | | BYTE CAPACITY PER MODULE | |
| MINIMUM | MAXIMUM | TRACK | CYLINDER | MODULE | FACILITY | MINIMUM | MAXIMUM |
| 29 | 58 | 21 | 168 | 8064 | 16128 | 233856 | 467712 |
| 59 | 94 | 20 | 160 | 7680 | 15360 | 453120 | 721920 |
| 95 | 132 | 19 | 152 | 7296 | 14592 | 693120 | 963072 |
| 133 | 174 | 18 | 144 | 6912 | 13824 | 919296 | 1202688 |
| 175 | 222 | 17 | 136 | 6528 | 13056 | 1142400 | 1449216 |
| 223 | 276 | 16 | 128 | 6144 | 12288 | 1370112 | 1695744 |
| 277 | 336 | 15 | 120 | 5760 | 11520 | 1595520 | 1935360 |
| 337 | 406 | 14 | 112 | 5376 | 10752 | 1811712 | 2182656 |
| 407 | 486 | 13 | 104 | 4992 | 9984 | 2031744 | 2426112 |
| 487 | 580 | 12 | 96 | 4608 | 9216 | 2244096 | 2672640 |
| 581 | 690 | 11 | 88 | 4224 | 8448 | 2454144 | 2914560 |
| 691 | 822 | 10 | 80 | 3840 | 7680 | 2653440 | 3156480 |
| 823 | 984 | 9 | 72 | 3456 | 6912 | 2844288 | 3400704 |
| 985 | 1186 | 8 | 64 | 3072 | 6144 | 3025920 | 3643392 |
| 1187 | 1446 | 7 | 56 | 2688 | 5376 | 3190656 | 3886848 |
| 1447 | 1794 | 6 | 48 | 2304 | 4608 | 3333888 | 4133376 |
| 1795 | 2278 | 5 | 40 | 1920 | 3840 | 3446400 | 4373760 |
| 2279 | 3008 | 4 | 32 | 1536 | 3072 | 3500544 | 4620288 |
| 3009 | 4222 | 3 | 24 | 1152 | 2304 | 3466368 | 4863744 |
| 4223 | 6650 | 2 | 16 | 768 | 1536 | 3243264 | 5107200 |
| 6651 | 13934 | 1 | 8 | 384 | 768 | 2553984 | 5350656 |

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| 2305 MODEL 2 CAPACITY | | | | | | | |
|---|---|---|---|---|---|---|---|
| WITH KEYS | | | | | | | |
| BYTES PER RECORD ($K_L$+$D_L$) | | RECORDS PER | | | | BYTE CAPACITY PER MODULE | |
| MINIMUM | MAXIMUM | TRACK | CYLINDER | MODULE | FACILITY | MINIMUM | MAXIMUM |
| 21 | 27 | 47 | 376 | 36096 | 72192 | 758016 | 974592 |
| 28 | 34 | 46 | 368 | 35328 | 70656 | 989184 | 1201152 |
| 35 | 41 | 45 | 360 | 34560 | 69120 | 1209600 | 1416960 |
| 42 | 48 | 44 | 352 | 33792 | 67584 | 1419264 | 1622016 |
| 49 | 56 | 43 | 344 | 33024 | 66048 | 1618176 | 1849344 |
| 57 | 64 | 42 | 336 | 32256 | 64512 | 1838592 | 2064384 |
| 65 | 73 | 41 | 328 | 31488 | 62976 | 2046720 | 2298624 |
| 74 | 82 | 40 | 320 | 39720 | 61440 | 2273280 | 2519040 |
| 83 | 91 | 39 | 312 | 29952 | 59904 | 2486016 | 2725632 |
| 92 | 102 | 38 | 304 | 29184 | 58368 | 2684928 | 2976768 |
| 103 | 112 | 37 | 296 | 28416 | 56832 | 2926848 | 3182592 |
| 113 | 123 | 36 | 288 | 27648 | 55296 | 3124224 | 3400704 |
| 124 | 135 | 35 | 280 | 26880 | 53760 | 3333120 | 3628800 |
| 136 | 148 | 34 | 272 | 26112 | 52224 | 3551232 | 3864576 |
| 149 | 161 | 33 | 264 | 25344 | 50688 | 3776256 | 4080384 |
| 162 | 175 | 32 | 256 | 24576 | 49152 | 3981312 | 4300800 |
| 176 | 190 | 31 | 248 | 23808 | 47616 | 4190208 | 4523520 |
| 191 | 206 | 30 | 240 | 23040 | 46080 | 4400640 | 4746240 |
| 207 | 223 | 29 | 232 | 22272 | 44544 | 4610304 | 4966656 |
| 224 | 241 | 28 | 224 | 21504 | 43008 | 4816896 | 5182464 |
| 242 | 261 | 27 | 216 | 20736 | 41472 | 5018112 | 5412096 |
| 262 | 282 | 26 | 208 | 19968 | 39936 | 5231616 | 5630976 |
| 283 | 305 | 25 | 200 | 19200 | 38400 | 5433600 | 5856000 |
| 306 | 330 | 24 | 192 | 18432 | 36864 | 5640192 | 6082560 |
| 331 | 357 | 23 | 184 | 17664 | 35328 | 5846784 | 6306048 |
| 358 | 386 | 22 | 176 | 16896 | 33792 | 6048768 | 6521856 |
| 387 | 418 | 21 | 168 | 16128 | 32256 | 6241536 | 6741504 |
| 419 | 453 | 20 | 160 | 15360 | 30720 | 6435840 | 6958080 |
| 454 | 493 | 19 | 152 | 14592 | 29184 | 6624768 | 7193856 |
| 494 | 536 | 18 | 144 | 13824 | 27648 | 6829056 | 7409664 |
| 537 | 585 | 17 | 136 | 13056 | 26112 | 7011072 | 7637760 |
| 586 | 639 | 16 | 128 | 12288 | 24576 | 7200768 | 7852032 |
| 640 | 701 | 15 | 120 | 11520 | 23040 | 7372800 | 8075520 |
| 702 | 772 | 14 | 112 | 10752 | 21504 | 7547904 | 8300544 |
| 773 | 853 | 13 | 104 | 9984 | 19968 | 7717632 | 8516352 |
| 854 | 949 | 12 | 96 | 9216 | 18432 | 7870464 | 8745984 |
| 950 | 1061 | 11 | 88 | 8448 | 16896 | 8025600 | 8963328 |
| 1062 | 1196 | 10 | 80 | 7680 | 15360 | 8156160 | 9185280 |
| 1197 | 1361 | 9 | 72 | 6912 | 13824 | 8273664 | 9407232 |
| 1362 | 1568 | 8 | 64 | 6144 | 12288 | 8368128 | 9633792 |
| 1569 | 1833 | 7 | 56 | 5376 | 10752 | 8434944 | 9854208 |
| 1834 | 2187 | 6 | 48 | 4608 | 9216 | 8451072 | 10077696 |
| 2188 | 2682 | 5 | 40 | 3840 | 7680 | 8401920 | 10298880 |
| 2683 | 3425 | 4 | 32 | 3072 | 6144 | 8242176 | 10521600 |
| 3426 | 4663 | 3 | 24 | 2304 | 4608 | 7893504 | 10743552 |
| 4664 | 7140 | 2 | 16 | 1536 | 3072 | 7163904 | 10967040 |
| 7141 | 14569 | 1 | 8 | 768 | 1536 | 5484288 | 11188992 |

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| 2305 MODEL 2 CAPACITY | | | | | | | |
|---|---|---|---|---|---|---|---|
| WITHOUT KEYS | | | | | | | |
| BYTES PER RECORD | | RECORDS PER | | | | BYTE CAPACITY PER MODULE | |
| MINIMUM | MAXIMUM | TRACK | CYLINDER | MODULE | FACILITY | MINIMUM | MAXIMUM |
| 21 | 23 | 67 | 536 | 51456 | 102912 | 1080576 | 1183488 |
| 24 | 27 | 66 | 528 | 50688 | 101376 | 1216512 | 1368576 |
| 28 | 30 | 65 | 520 | 49920 | 99840 | 1397760 | 1497600 |
| 31 | 34 | 64 | 512 | 49152 | 98304 | 1523712 | 1671168 |
| 35 | 37 | 63 | 504 | 48384 | 96768 | 1693440 | 1790208 |
| 38 | 41 | 62 | 496 | 47616 | 95232 | 1809408 | 1952256 |
| 42 | 45 | 61 | 488 | 46848 | 93696 | 1967616 | 2108160 |
| 46 | 49 | 60 | 480 | 46080 | 92160 | 2119680 | 2257920 |
| 50 | 53 | 59 | 472 | 45312 | 90624 | 2265600 | 2401536 |
| 54 | 58 | 58 | 464 | 44544 | 89088 | 2405376 | 2583552 |
| 59 | 62 | 57 | 456 | 43776 | 87552 | 2582784 | 2714112 |
| 63 | 67 | 56 | 448 | 43008 | 86016 | 2709504 | 2881536 |
| 68 | 72 | 55 | 440 | 42240 | 84480 | 2872320 | 3041280 |
| 73 | 77 | 54 | 432 | 41472 | 82944 | 3027456 | 3193344 |
| 78 | 82 | 53 | 424 | 40704 | 81408 | 3174912 | 3337728 |
| 83 | 87 | 52 | 416 | 39936 | 79872 | 3314688 | 3474432 |
| 88 | 93 | 51 | 408 | 39168 | 78336 | 3446784 | 3642624 |
| 94 | 99 | 50 | 400 | 38400 | 76800 | 3609600 | 3801600 |
| 100 | 105 | 49 | 392 | 37632 | 75264 | 3763200 | 3951360 |
| 106 | 111 | 48 | 384 | 36864 | 73728 | 3907584 | 4091904 |
| 112 | 118 | 47 | 376 | 36096 | 72192 | 4042752 | 4259328 |
| 119 | 125 | 46 | 368 | 35328 | 70656 | 4204032 | 4416000 |
| 126 | 132 | 45 | 360 | 34560 | 69120 | 4354560 | 4561920 |
| 133 | 139 | 44 | 352 | 33792 | 67584 | 4494336 | 4697088 |
| 140 | 147 | 43 | 344 | 33024 | 66048 | 4623360 | 4854528 |
| 148 | 155 | 42 | 336 | 32256 | 64512 | 4773888 | 4999680 |
| 156 | 164 | 41 | 328 | 31488 | 62976 | 4912128 | 5164032 |
| 165 | 173 | 40 | 320 | 30720 | 61440 | 5068800 | 5314560 |
| 174 | 182 | 39 | 312 | 29952 | 59904 | 5211648 | 5451264 |
| 183 | 193 | 38 | 304 | 29184 | 58368 | 5340672 | 5632512 |
| 194 | 203 | 37 | 296 | 28416 | 56832 | 5512704 | 5768448 |
| 204 | 214 | 36 | 288 | 27648 | 55296 | 5640192 | 5916672 |
| 215 | 226 | 35 | 280 | 26880 | 53760 | 5779200 | 6074880 |
| 227 | 239 | 34 | 272 | 26112 | 52224 | 5927424 | 6240768 |
| 240 | 252 | 33 | 264 | 25344 | 50688 | 6082560 | 6386688 |
| 253 | 266 | 32 | 256 | 24576 | 49152 | 6217728 | 6537216 |
| 267 | 281 | 31 | 248 | 23808 | 47616 | 6356736 | 6690048 |
| 282 | 297 | 30 | 240 | 23040 | 46080 | 6497280 | 6842880 |
| 298 | 314 | 29 | 232 | 22272 | 44544 | 6637056 | 6993408 |
| 315 | 332 | 28 | 224 | 21504 | 43008 | 6773760 | 7139328 |
| 333 | 352 | 27 | 216 | 20736 | 41472 | 6905088 | 7299072 |
| 353 | 373 | 26 | 208 | 19968 | 39936 | 7048704 | 7448064 |
| 374 | 396 | 25 | 200 | 19200 | 38400 | 7180800 | 7603200 |
| 397 | 421 | 24 | 192 | 18432 | 36864 | 7317504 | 7759872 |
| 422 | 448 | 23 | 184 | 17664 | 35328 | 7454208 | 7913472 |
| 449 | 477 | 22 | 176 | 16896 | 33792 | 7586304 | 8059392 |
| 478 | 509 | 21 | 168 | 16128 | 32256 | 7709184 | 8209152 |
| 510 | 544 | 20 | 160 | 15360 | 30720 | 7833600 | 8355840 |
| 545 | 584 | 19 | 152 | 14592 | 29184 | 7952640 | 8521728 |
| 585 | 627 | 18 | 144 | 13824 | 27648 | 8087040 | 8667648 |
| 628 | 676 | 17 | 136 | 13056 | 26112 | 8199168 | 8825856 |
| 677 | 730 | 16 | 128 | 12288 | 24576 | 8318976 | 8970240 |
| 731 | 792 | 15 | 120 | 11520 | 23040 | 8421120 | 9123840 |
| 793 | 863 | 14 | 112 | 10752 | 21504 | 8526336 | 9278976 |
| 864 | 944 | 13 | 104 | 9984 | 19968 | 8626176 | 9424896 |
| 945 | 1040 | 12 | 96 | 9216 | 18432 | 8709120 | 9584640 |
| 1041 | 1152 | 11 | 88 | 8448 | 16896 | 8794368 | 9732096 |
| 1153 | 1287 | 10 | 80 | 7680 | 15360 | 8855040 | 9884160 |
| 1288 | 1452 | 9 | 72 | 6912 | 13824 | 8902656 | 10036224 |
| 1453 | 1659 | 8 | 64 | 6144 | 12288 | 8927232 | 10192896 |
| 1660 | 1924 | 7 | 56 | 5376 | 10752 | 8924160 | 10343424 |
| 1925 | 2278 | 6 | 48 | 4608 | 9216 | 8870400 | 10497024 |
| 2279 | 2773 | 5 | 40 | 3840 | 7680 | 8751360 | 10648320 |
| 2774 | 3516 | 4 | 32 | 3072 | 6144 | 8521728 | 10801152 |
| 3517 | 4754 | 3 | 24 | 2304 | 4608 | 8103168 | 10953216 |
| 4755 | 7231 | 2 | 16 | 1536 | 3072 | 7303680 | 11106816 |
| 7232 | 14660 | 1 | 8 | 768 | 1536 | 5554176 | 11258880 |

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# Appendix B: Sense Bytes

| SENSE BYTE 0 | |
|---|---|
| Bit 0<br>Command Reject | 1. Invalid command code.<br>2. Invalid command sequence.<br>3. Invalid or incomplete argument transferred by a control command.<br>4. Write portion of file mask violated. |
| Bit 1<br>Intervention Required | 1. Addressed device not physically attached to system.<br>2. Addressed device not ready. |
| Bit 2<br>Bus Out Parity | 1. The 2835 has detected bad parity in data transferred from the channel. |
| Bit 3<br>Equipment Check | 1. An unusual hardware condition detected in the channel, storage control, or drive. (Condition further defined in sense bytes 16 thru 23.) |
| Bit 4<br>Data Check<br>See Note 1 | 1. A data error detected in information received from a disk drive. Byte 2 - bit 1, indicates if error is permanent or correctable.<br>2. Sychromization of read electronics to drive data was unsuccessful. |
| Bit 5<br>Overrun<br>See Note 2 | 1. The storage control received a byte from a drive before the last byte read was accepted by the channel.<br>2. A data byte was received too late from the channel during a write operation.<br>3. A command was received too late to be executed. |
| Bit 6 | 1. Not used - set to 0. |
| Bit 7 | 1. Not used - set to 0. |

Note 1: Byte 2 - bit 1 on indicates correctable error; bytes 18 thru 22 contain error correction information as shown in Format 2. Byte 7 indicates specific nature of the condition.

Note 2: Detection of an overrun immediately stops data transmission. When writing, the remaining portion of the record area is padded out with the last byte received.

If the overrun condition exists after retry is exhausted, byte 1 - bit 0 (permanent error) is posted with overrun. Without byte 1 - bit 0, it indicates that command retry was inhibited.

Sense byte 7 distinguishes between data overrun and command overrun.

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| SENSE BYTE 1 | |
|---|---|
| Bit 0<br>Permanent Error | 1. Storage control retry has been attempted and was unsuccessful. |
| Bit 1<br>Invalid Track Format | 1. An attempt has been made to write data exceeding track capacity.<br>2. An attempt to read data that has been written past index. |
| Bit 2<br>End of Cylinder | 1. A multi-track read or search operation has attempted to continue beyond the addressable limit of the pseudo-cylinder boundary.<br>2. An overflow operation has attempted to continue beyond the addressable limit of the pseudo-cylinder boundary. (Byte 1 - bit 7, operation incomplete also set.) |
| Bit 3 | 1. Not used - set to 0. |
| Bit 4<br>No Record Found | 1. Two index points sensed in the same command chain without an intervening read operation in a data area.<br>2. Two index points sensed in the same command chain without an intervening write, sense, or control command. |
| Bit 5<br>File Protected | 1. A seek command has violated the file mask.<br>2. A multi-track read or search operation has violated the file mask.<br>3. An overflow operation has violated the seek portion of the file mask. (Byte 1 - bit 7, operation incomplete also set.) |
| Bit 6 | 1. Not used - set to 0. |
| Bit 7<br>Operation Incomplete | 1. One of the following conditions occurred during the processing of an overflow record:<br>a. Overflow to a file protected boundary. (Byte 1 - bit 5, file protected also set.)<br>b. Overflow past the pseudo-cylinder boundary. (Byte 1 - bit 2, end of cylinder also set.)<br>c. A data error was detected. |

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| SENSE BYTE 2 | |
|---|---|
| Bit 0<br>Buffered Log Full | 1. The buffered log is 75% full and a read buffered log command should be issued to obtain the outstanding log information. |
| Bit 1<br>Correctable<br>See Note 3 | 1. Indicates that the data check posted in sense byte 0 - bit 4, is correctable. Sense bytes 18 thru 22 identify the error pattern and error pattern displacement. |
| Bit 2 thru 7 | 1. Not used - set to 0. |
| **SENSE BYTE 3** | |
| Bits 0 thru 7<br>Restart Command | 1. When byte 1 - bit 7 (operation incomplete) is set, this byte identifies the operation in progress when the interrupt occurred.<br>0000 0110 = A read operation was in progress.<br>0000 0101 = A write operation was in progress.<br>When byte 1 - bit 7 is zero, sense byte three is zero. |
| **SENSE BYTE 4** | |
| Bits 0 thru 7 | 1. Not used - set to 0. |
| **SENSE BYTE 5** | |
| Bits 0 thru 7<br>Cylinder Address | 1. Identifies the cylinder address of the most recent seek argument from the channel. |
| **SENSE BYTE 6** | |
| Bits 0 thru 7<br>Head Address | 1. Identifies head address of last seek. Head address is updated during multi-track and overflow operations. |
| Note 3: With byte 0 - bit 4 (data check) bytes 18 thru 22 contain error correction information as shown in Format 2. | |

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| SENSE BYTE 7 - MESSAGE CODE | |
|---|---|
| Bits 0 thru 7 (Hex) | |
| 04 | • File mask violation - multitrack |
| 05 | • File mask violation - Seek |
| 07 | • File mask violation - overflow |
| 08 | • No record found - Search |
| 09 | • Index before Address Mark - Space Count |
| 0C | • No record found - Read |
| 10 | • PCI Fetch Interrupt |
| 20 | • End of Cylinder - MT |
| 21 | • End of Cylinder - O'flow Rec. |
| 30 | • Data Check - count area |
| 31 | • Data Check - key area |
| 34 | • Data Check - data area (Model 2) |
| 35 | • Data Check - data area (Model 1) |
| 3B | • Data Check - No R0 Found |
| 3D | • Data Check - Sync Byte Missing |
| 3E | • Data Check - All Missing on Retry |
| 3F | • Data Check - Overskew (Model 1) |
| 40 | • Index detected during Space Count |
| 42 | • Read/Write past index |
| 80 | • Invalid command |
| 82 | • Invalid prerequisite |
| 83 | • Invalid data length |
| 84 | • Invalid argument transferred |
| 85 | • Second alternate track spare attempted |
| 8A | • Write Mask Violation |
| 8B | • Diagnostic Write - Mask Violation |
| 90 | • Invalid retry command |
| 91 Note 1 | • Equipment Check - CU or Drive |
| 92 | • Retry Aborted |
| 94 | • Index missing |
| 95 | • APC Failure |
| 9F | • Invalid Error Branch |
| A0 | • Bus out parity |
| C0 | • File inoperative |
| C1 | • Inline contention |
| D0 | • Command overrun |
| D1 | • Data overrun |
| E1 | • MPL File Read Check |
| E2 | • MPL File Seek Check |
| E4 | • MPL File Not Ready |
| F0 | • Buffered log full |
| Note 1: With byte 0, bit 3 (equipment check), bytes 16 thru 23 contain storage control and module check indicators as shown in Format 1. | |

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| SENSE BYTE 8 - CYLINDER (1) | |
|---|---|
| Bits 0 thru 7 | • High order cylinder byte from ID area of last record processed. |

| SENSE BYTE 9 - CYLINDER (2) | |
|---|---|
| Bits 0 thru 7 | • Low order cylinder byte from ID area of last record processed. |

| SENSE BYTE 10 - HEAD (1) | |
|---|---|
| Bits 0 thru 7 | • High order head byte from ID area of last record processed. |

| SENSE BYTE 11 - HEAD (2) | |
|---|---|
| Bits 0 thru 7 | • Low order head byte from ID area of last record processed. |

| SENSE BYTE 12 - RECORD | |
|---|---|
| Bit 0 thru 7 | • Record number from ID area of last record processed. |

| SENSE BYTE 13 - SECTOR | |
|---|---|
| Bits 0 thru 7 | • Sector number of last record processed. |

| SENSE BYTE 14 | | |
|---|---|---|
| | MODEL 1 | MODEL 2 |
| Bit 0 | • Switched to channel B. | • Switched to channel B. |
| Bit 1 | • Diag mode. | • Drive in diagnostic mode. |
| Bit 2 | • Spare sel - path 0. | • Spare head selected. |
| Bit 3 | • Spare sel - path 1. | • Not used - set to 0. |
| Bit 4 | • Side B selected. | • Not used - set to 0. |
| Bit 5 | • Not used - set to 0. | • Not used - set to 0. |
| Bit 6 | • Path 0. | • Not used - set to 0. |
| Bit 7 | • Path 1. | • Not used - set to 0. |

| SENSE BYTE 15 | |
|---|---|
| Bits 0 thru 7 | • Not used - set to 0. |

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| SENSE BYTES 16 - 19 | | | | |
|---|---|---|---|---|
| SENSE BYTE | BIT | FORMAT 1 - EQUIPMENT CHECK MODEL 1 | FORMAT 1 - EQUIPMENT CHECK MODEL 2 | FORMAT 2 CORRECTABLE DATA CHECK ** MODEL 1 and 2 |
| 16 | 0 | Overskew * | SERDES Parity | Not used |
| | 1 | Data Overrun | Overrun | |
| | 2 | Mark Out Check | IR Reg Parity | |
| | 3 | Fetch Counter Chk | CBO Reg Parity | |
| | 4 | ECC Check 1 | ECC Check 1 | |
| | 5 | ECC Check 2 | ECC Check 2 | |
| | 6 | ECC Input Check | Not used | |
| | 7 | Byte Counter Check | Byte Counter Check | |
| 17 | 0 | Ser/Des Parity 0 | IW Reg Parity | Not used |
| | 1 | Ser/Des Parity 1 | Drive/Bit Ring Check | |
| | 2 | IW Register Parity 0 | CUEND * | |
| | 3 | IW Register Parity 1 | PLO Pulse Missing | |
| | 4 | IR Register Parity 0 | VFO Phase Error | |
| | 5 | IR Register Parity 1 | Channel Check | |
| | 6 | SKBO Check 0 | Data Error * | |
| | 7 | SKBO Check 1 | CUDI Check | |
| 18 | 0 | Ser/Des Ring 0 | Drive Select Check | Displacement 1 |
| | 1 | Ser/Des Ring 1 | CUDI Invalid Tag | |
| | 2 | VFO Phase Error | Device Check | |
| | 3 | Missing PLO Pulses | TA Reg Check | |
| | 4 | ECC Decoder Check | CUDI Reg Check | |
| | 5 | Channel Check | TD Reg Check | |
| | 6 | Data Error * | Search Compare Chk | |
| | 7 | CU/DI Check | ECC Check | |
| 19 | 0 | Drive Selection Chk | Not used - set to 0 | Displacement 2 |
| | 1 | CU/DI Invalid Tag | Not used - set to 0 | |
| | 2 | Device Check | Not used - set to 0 | |
| | 3 | TA Register Check | Not used - set to 0 | |
| | 4 | CU/DI Register Chk | Not used - set to 0 | |
| | 5 | TD Register Check | Not used - set to 0 | |
| | 6 | Search Compare Chk | Not used - set to 0 | |
| | 7 | Not used - set to 0 | Not used - set to 0 | |

* Does not cause equipment check.

** Refer to error correction functions.

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| SENSE BYTES 20 - 23 | | | | |
|---|---|---|---|---|
| SENSE BYTE | BIT | FORMAT 1 - EQUIPMENT CHECK MODEL 1 | FORMAT 1 - EQUIPMENT CHECK MODEL 2 | FORMAT 2 CORRECTABLE DATA CHECK MODEL 1 and 2 |
| 20 | 0 | Inoperative | Inoperative | Pattern 1 |
| | 1 | Disk Speed | Disk Speed | |
| | 2 | APC Failure | APC Failure | |
| | 3 | APC Sync | APC Sync | |
| | 4 | 378 Jump | 378 Jump | |
| | 5 | 378 Sequence | 378 Sequence | |
| | 6 | 378 Illegal | 378 Illegal | |
| | 7 | PLO Sync | PLO Sync | |
| 21 | 0 | Bus Out Check | Bus Out Check | Pattern 2 |
| | 1 | Not used - set to 0 | Not used - set to 0 | |
| | 2 | Not used - set to 0 | Not used - set to 0 | |
| | 3 | Bus In Check | Bus In Check | |
| | 4 | Multipath Check | Not used - set to 0 | |
| | 5 | Not used - set to 0 | Not used - set to 0 | |
| | 6 | Not used - set to 0 | Not used - set to 0 | |
| | 7 | Path 1 Check | Not used - set to 0 | |
| 22 | 0 | Clip Check | Clip Check | Pattern 3 |
| | 1 | Address Reg Check | Address Reg Check | |
| | 2 | Write Past Index | Not used - set to 0 | |
| | 3 | Read Seq Check | Read Seq Check | |
| | 4 | Not used - set to 0 | Not used - set to 0 | |
| | 5 | Write Seq Check | Write Seq Check | |
| | 6 | Simultaneous Rd/Wr | Simultaneous Rd/Wr | |
| | 7 | Current Sink On | Current Sink On | |
| 23 | 0 | Write Transition Chk | Write Transition Chk | Not used |
| | 1 | Not used - set to 0 | Not used - set to 0 | |
| | 2 | Write Driver Check | Write Driver Check | |
| | 3 | Current Source Chk | Current Source Chk | |
| | 4 | High Current Source | High Current Source | |
| | 5 | Slider Select | Slider Select | |
| | 6 | Read Bias | Read Bias | |
| | 7 | Not used - set to 0 | Not used - set to 0 | |

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# Appendix C: Log Entry Format

**LOG ENTRY**

| Entry Type | Byte 0 (0 1 2 3 7) | Byte 1 | Byte 2 | Byte 3 | Byte 4 | Byte 5 | Byte 6 | Byte 7 |
|---|---|---|---|---|---|---|---|---|
| **Control Unit Selective Reset** | 0 0 1 | Storage Error Register | TC Register | TG Register | Failing Address: High | Failing Address: Low | Error Latches: 0 - 7 | Error Latches: 8 - 15 |
| **MPL File Check** | 0 1 1 | 0 3: Data Check Count; 4 7: Seek Check Count | | 0 | | | | |
| **Usage/Overrun Counters** | 1 0 0 — 4: Drv 1; 6: OFlow | Overrun Counters: Chan A | Overrun Counters: Chan B | OFlow; A.M. Check Count | 0: OFlow; Usage Counter: 0-7 | Usage Counter: 8 - 15 | Usage Counter: 16 - 23 | Usage Counter: 24 - 31 |
| **Correctable Data Check** | 1 1 0 | Retry Count | Command Byte | Device Address | 0: Chan B; 1: Diag MD; 2: Spare 0; 3*: Spare 1; 4*: Side B; 6*: Path 0; 7*: Path 1 | Cylinder Address | Head Address | Record Number |
| **Uncorrectable Data Check** | 1 1 1 | Retry Count | Command Byte | Device Address | 0: Chan B; 1: Diag MD; 2: Spare; 4: Side B; 7: Path 1 | Cylinder Address | Head Address | Record Number |

* Model 1 only

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