PCC PERIPHERALS
PERTEC COMPUTER CORPORATION

Application Notes

Interfacing The PCC F6250 Group-Coded Recording/ Phase Encoded Formatter

FOREWORD

This Application Note provides basic information on interfacing a PCC PD F6250 Formatter into a data storage system in order to take advantage of Phase Encoded/Group-Coded Recording to enhance the reliability and increase the data transfer rate of the system.

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I. INTRODUCTION

The F6250 Formatter is a data system peripheral interfacing unit designed by Pertec Computer Corporation, Peripherals Division (PCC PD), Chatsworth, California.

The Formatter, shown in Figure 1-1, is a separate unit that manages up to four tape transports in accordance with commands from the host system controller.

When performing a write operation, the Formatter translates binary data from the controller into either Group-Coded Recording (GCR) or Phase Encoded (PE) format; generates and inserts the necessary preambles, postambles, etc.; commands the selected tape transport to write the data, checks for errors, provides status information, and notifies the controller of the success or failure of the data transfer.

When reading, the Formatter retrieves the data from the tape transport, translates it from GCR or PE into binary format, and offers the data to the controller.

In the PE mode, the Formatter enables the generation and reading of PE American National Standards Institute (ANSI Specification X3.39-1973) and IBM compatible tapes when used in conjunction with PCC PD T1940-96 tape transports. PE tapes are compatible between all families of PCC PD PE tape drives/PE formatters. Data encoding, decoding, deskewing, error detection, error correction, and tape motion control are provided by the formatter.

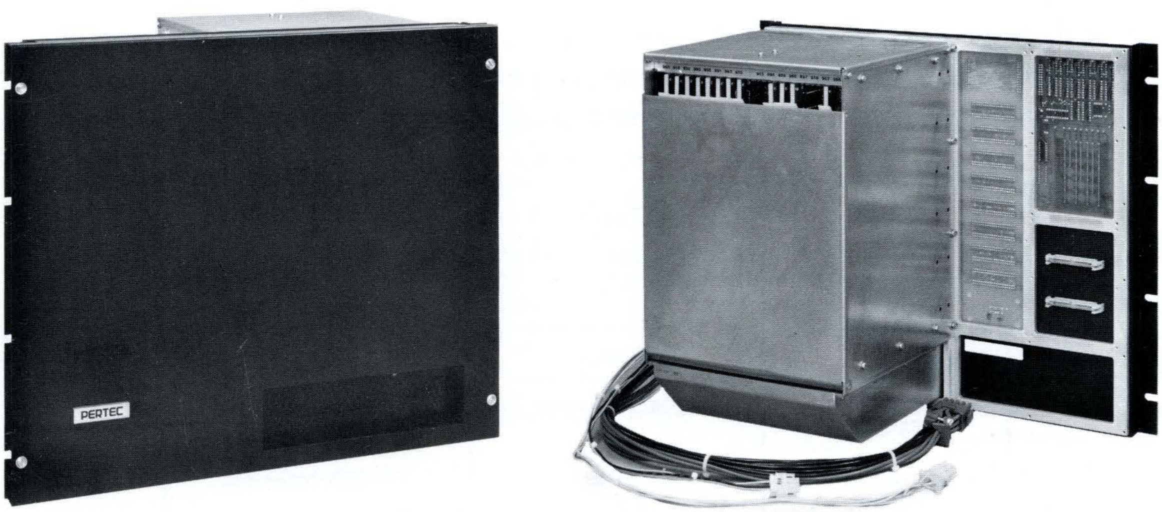


Figure 1-1. F6250 Formatter

In the GCR mode, the Formatter enables the generation and reading of GCR ANSI X3.54-1976 and IBM compatible magnetic tapes when used in conjunction with PCC PD T1940-96 tape transports. Data encoding, decoding, deskewing, error detection, error correction, and tape motion control are provided by the Formatter.

Individual selection and operation of up to four radially connected transports of the same speeds is provided. Table 1-1 compares data transfer rates for PE and GCR.

Details of the operations and interfacing requirements are given in this Application Note, and are summarized as follows:

- Section II defines the stringent requirements of magnetic recording tape formats as necessitated by fast transfer rates and high bit densities.
- Section III is a discussion of the overall function of the Formatter.
- Section IV provides hardware and software interfacing information.
- Section V describes the structure of the Formatter's common address space registers, which accommodate the traffic between the controller, formatter, and tape transports.
- Section VI details the various control/status/data modes of operation.
- Section VII provides information on various diagnostic provisions.

Additional information and source references are included as appendices.

Significant features of the F6250 Formatter are:

- Simplicity of interfacing requirements.
- Interrelationship of the Formatter with the Central Processing Units (CPU) of the minicomputers and microcomputers of the host system.
- The unburdening of the host system's controller of many management and formatting chores.
- Handshake transfer timing that permits the controller to deal with various peripherals at different transfer rates.
- Exceptional error monitoring and recovery capabilities.
- Keyboard entry provisions for testing and maintenance.
- Optimum operational and hardware reliability.

Table 1-1
GCR/PE Data Transfer Rate

Tape Speed	Transfer Rate	
	PE Format*	GCR Format**
1.905 m/s (75 ips)	120K bytes/sec	468.75K bytes/sec
3.175 m/s (125 ips)	200K bytes/sec	781.25K bytes/sec

*PE character density: 63 c/mm (1600 cpi)
**GCR character density: 246 c/mm (6250 cpi)

II. PE AND GCR RECORDING FORMATS

2.1 PE/GCR COMMON FORMATS

The following definitions of recording format elements apply to both the PE and GCR modes. The terms are illustrated in Figure 2-1.

(1) **Bit** — The smallest unit of binary information, either 0 or 1.

(2) **Byte**, or **Character** — Made up of several bits; e.g., a byte on tape consists of 9 parallel bits.

(3) **Block**, or **Record** — Consists of multiple bytes taken in series. The number of bytes within any given block is determined by the programmer.

(4) **File** — Made up of many blocks taken in series and separated by Inter-Block Gaps. The number of blocks within any given file is determined by the programmer.

(5) **Tape Mark**, or **File Mark** — A special control block which separates files.

(6) **Inter-Block Gap**, or **Inter-Record Gap** — A portion of tape containing no information, used to separate blocks.

(7) **Channel** — The path taken by serial bits read from (or that will be recorded on) a single track on the tape.

NOTE

In practice, channel and track are often used as synonymous terms; but the number assigned to a channel is a function of the order of bits in a parallel byte, while track numbers are assigned in numerical order from the reference edge of the tape.

(8) **Track** — The portion of the tape on which one channel of bits in series may be magnetically recorded.

(9) **Tape Format** — The entire set of parameters which uniquely define the characteristics of information as written on magnetic tape during a specified recording mode.

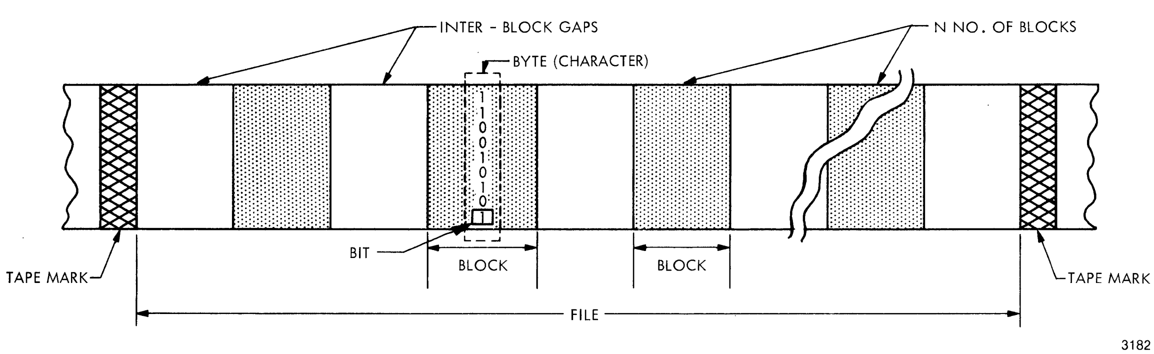


Figure 2-1. Common Data Format Elements

2.2 PHASE ENCODED (PE) MODE FORMATS

Recording formats for the Phase Encoded mode, operating at a character density of 63 c/mm (1600 cpi) are presented in the following illustrated text. ANSI interchange parameter limits and PCC PD values within these limits are discussed.

2.2.1 PE MODE OVERALL TAPE FORMAT

The overall tape format for PE Mode is illustrated in Figure 2-2. Portions of this format are detailed in Paragraphs 2.2.2 and 2.2.3.

2.2.2 PE MODE TAPE MARK FORMAT

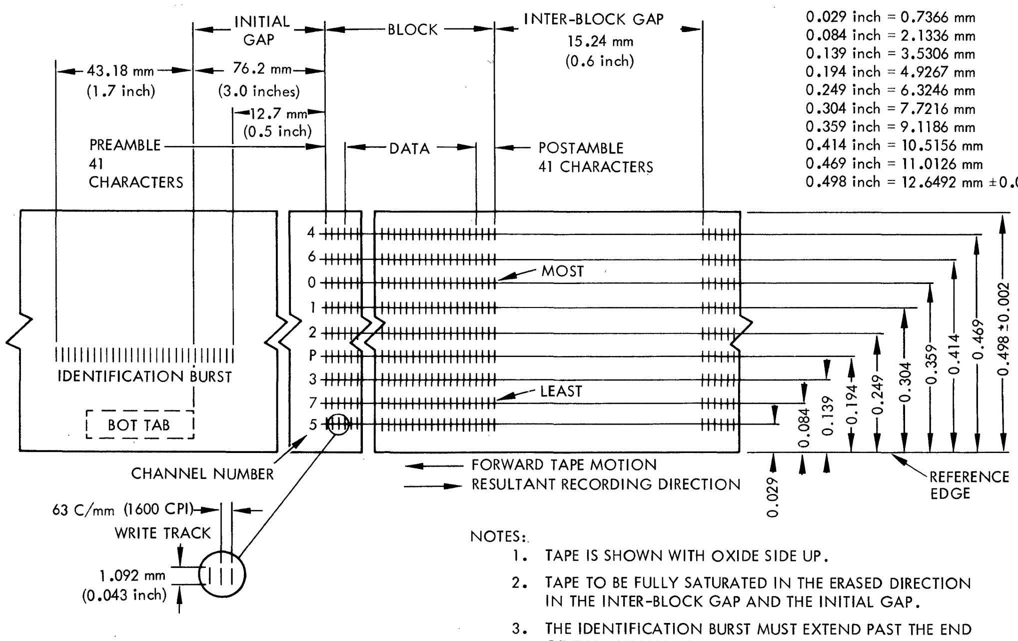
Figure 2-3 details the tape mark format used in PE mode. The tape mark is a special control block consisting of 64 to 256 flux reversals, at 126 flux reversals per millimeter (fr/mm) (3200 frpi), in channels 2, 6, and 7. Channels 1, 3, and 4 are dc-erased. Channels 5, P, and 0, in any combination, may be dc-erased or recorded in the manner stated for channels 2, 6, and 7. The PCC PD system uses 80 flux reversals in a tape mark.

2.2.3 PE MODE DATA BLOCK FORMAT

Figure 2-4 details the format for the data block. The Preamble consists of 40 characters of 0s followed by one character of 1s. A character is defined as nine bits in parallel, one bit per track (channel). The Postamble consists of one character of 1s, followed by 40 characters of 0s.

LEGEND:

0.029 inch = 0.7366 mm
0.084 inch = 2.1336 mm
0.139 inch = 3.5306 mm
0.194 inch = 4.9267 mm
0.249 inch = 6.3246 mm
0.304 inch = 7.7216 mm
0.359 inch = 9.1186 mm
0.414 inch = 10.5156 mm
0.469 inch = 11.0126 mm
0.498 inch = 12.6492 mm ±0.0508 mm



NOTES:

1. TAPE IS SHOWN WITH OXIDE SIDE UP.
2. TAPE TO BE FULLY SATURATED IN THE ERASED DIRECTION IN THE INTER-BLOCK GAP AND THE INITIAL GAP.
3. THE IDENTIFICATION BURST MUST EXTEND PAST THE END OF THE BOT MARKER.
4. THERE IS A TRACK PLACEMENT TOLERANCE OF ±0.0762 mm (±0.003 inch) FOR EACH TRACK.

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Figure 2-2. PE Overall Tape Format

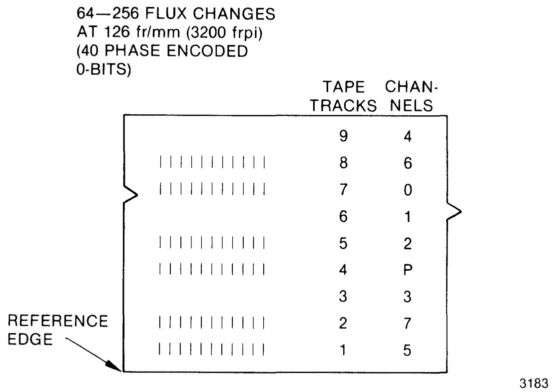


Figure 2-3. PE Tape Mark Format Detail

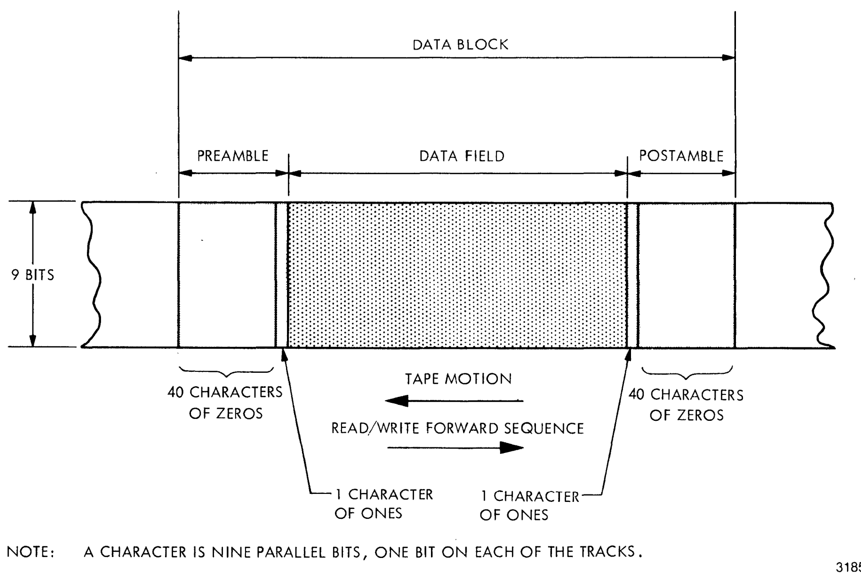


Figure 2-4. PE Data Block Format

2.3 GROUP-CODED RECORDING (GCR) MODE FORMATS

Recording formats for Group-Coded Recording mode, operating at a character density of 246 c/mm (6250 cpi) are presented in the following illustrated text. ANSI interchange parameter limits and PCC PD values within these limits are included.

2.3.1 GCR MODE OVERALL TAPE FORMAT

The overall tape format for GCR mode is illustrated in Figure 2-5. Portions of this format are detailed in Paragraphs 2.3.2 and 2.3.3.

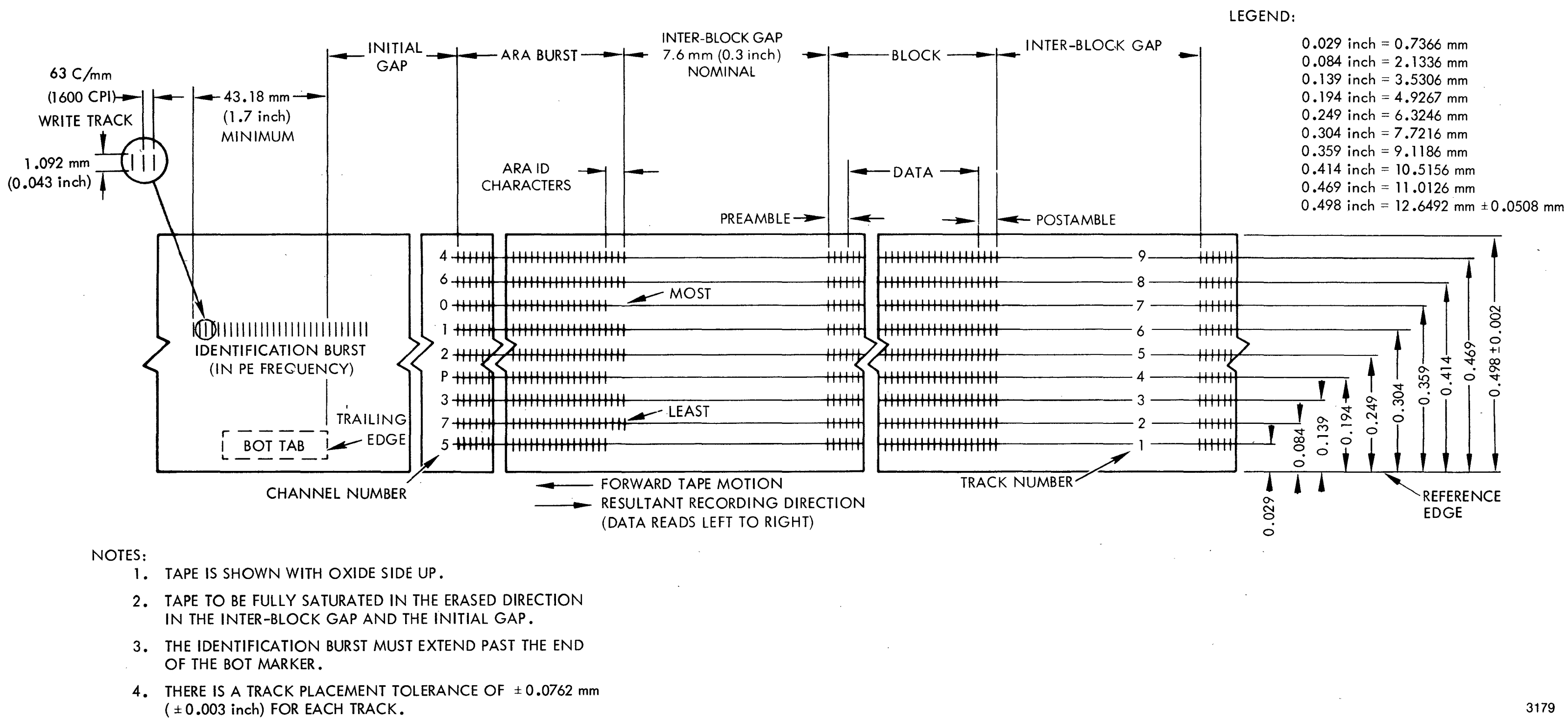


Figure 2-5. GCR Overall Tape Format

The Density Identification Area in the GCR recording format is identified by a burst of the recording at the BOT marker. This burst is in the PE frequency range on channel 1, with erasure on all other tracks. The ID burst begins 43.18 mm (1.7 inches) minimum before the trailing edge of the BOT marker and continues past the trailing edge of the BOT marker.

The Automatic Read Amplification (ARA) burst, immediately following the ID burst, consists of all 1s in all tracks, separated from the ID burst by an undefined gap. The burst of 1s is placed as follows: It begins no sooner than 38.1 mm (1.5 inches) and no later than 109.21 mm (4.3 inches), as measured from the leading edge of the BOT Marker. It ends no sooner than 241.3 mm (9.5 inches) and no later than 292.1 mm (11.5 inches), as measured from the leading edge of the BOT marker.

Appended to the end of the 1s burst is an ARA ID burst consisting of 1s in channels 7, 3, 2, 1, 6, and 4, and dc-erasure in channels 5, P, and 0. This ID Burst is approximately 50.8 mm (2 inches) long. (At least a contiguous 6.35 mm [0.25 inch] of this length must be error-free in all tracks at once.) There is a normal inter-block gap (IBG) between the ARA ID burst and the first data block.

2.3.2 GCR MODE TAPE MARK FORMAT

Figure 2-6 details the tape mark format used in GCR mode to mark the end of a file. The tape mark is a special block generated in response to the Write Tape Mark GCR command. One or more files may be written on a reel of tape.

The tape mark is specified as 250 to 400 flux reversals, all 1s, at 356 fr/mm (9042 frpi) in channels 7, 2, 6, 5, P, and 0, and dc-erasure in channels 3, 1, and 4.

NOTE

The flux reversal rate of 356 fr/mm (9042 frpi) is equal to the number of bit cells per inch. This accommodates data, encoding, error checking, and other overhead requirements. The payload (data) density is 246 c/mm (6250 cpi).

2.3.3 GCR MODE DATA BLOCK FORMAT

Figure 2-7 details the format for the data block. The various elements of the data block are further defined in the following paragraphs.

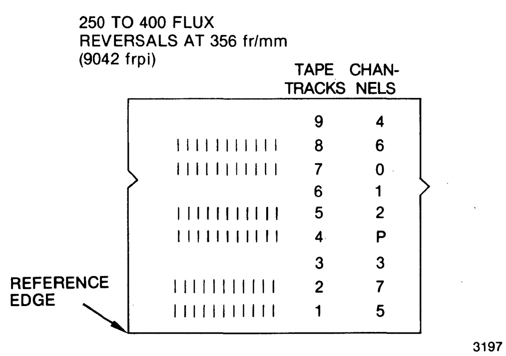
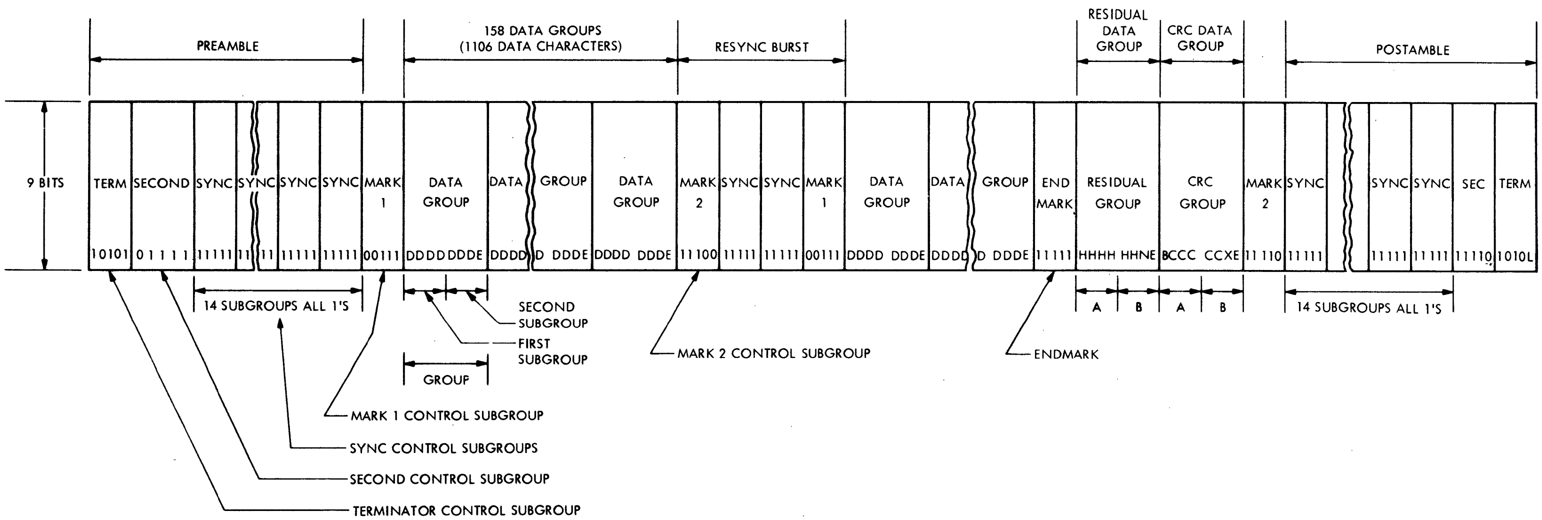


Figure 2-6. GCR Mode Tape Mark Format



NOTE: DATA, RESIDUAL AND GCR GROUPS ARE TRANSLATED FROM 8-BYTE TO 10-BYTE CODES BEFORE THEY ARE SENT TO THE TRANSPORT FOR RECORDING ON TAPE.

Figure 2-7. GCR Mode Data Block Format

2.3.3.1 Preamble

Each block of data is preceded by a preamble for synchronization purposes. The preamble, as recorded, consists of 80 characters, divided into five 16-character subgroups: one Terminator Control Subgroup, one Second Control Subgroup, and 14 Sync Control Subgroups.

(1) The Terminator Control Subgroup (TERM) is one set of nine parallel 5-bit serial values of 10101 in the respective tracks.located at the BOT end of each block and 1010L at the EOT end of each block, where L represents even longitudinal parity. The L bit of the last character restores the magnetic remanence to the erase state.

(2) The Second Control Subgroup is one set of nine parallel 5-bit serial values of 01111 in the respective tracks for the BOT end of the block and 11110 for the EOT end of the block interleaved between the respective Terminator Control Subgroups and the Sync Control Subgroups.

(3) The Sync Control Subgroup is one set of nine parallel 5-bit serial values, 11111 in the respective tracks. It is used to indicate recorded frequency and phase to allow synchronization of the Variable Frequency Clock (VFC).

2.3.3.2 Mark 1 Control Subgroup

This subgroup is one set of 5-bit serial values (00111) in each of the nine parallel tracks simultaneously. Mark 1 demarks the boundary between control subgroups and data. When the tape moves in the forward direction, Mark 1 indicates that data will follow.

2.3.3.3 Data Group

A Data Group is an essential element of Group-Coded Recording. Before encoding it develops as seven data characters plus an Error Correction Code (ECC) character, as shown in Figure 2-7 and Steps 1 through 5 of Table 2-1. Each of these data groups is divided into two data subgroups. Step 6 shows how each data subgroup is converted into a storage subgroup according to Table 2-2. Step 7 combines the storage subgroups into storage groups to be recorded on tape.

2.3.3.4 Resync Burst

After each 158 data groups (1106 data characters as calculated in data-group format), a resync burst, consisting of a Mark 2 Control Subgroup, two Sync Control Subgroups and one Mark 1 subgroup, is generated. The Sync Control Subgroups are formatted as described in Paragraph 2.3.3.1, Step 3. The Mark 2 Subgroup that ends the 158 data group series is the same as Mark 1 (refer to Paragraph 2.3.3.2), except that the 5-bit serial value is 11100. The Mark 1 Subgroup indicates the end of the sync burst, as described in Paragraph 2.3.3.2.

2.3.3.5 End Mark Control Subgroup

The End Mark is used to indicate the end of a series of complete data groups, and the beginning of the Residual Data Group. The End Mark is one set of nine parallel 5-bit serial numbers (11111) in each of the tracks.

2.3.3.6 Residual Data Group

The Residual Data Group positions are as follows:

(1) Group positions 1—6 contain residuum data characters or padding, i.e., the remainder of the number of characters divided by 7.

(2) Group position 7 contains an auxiliary CRC character (N).

Table 2-1
Controller-to-Tape Formatting Process

Step 1
Receives data from Controller at a rate of 6250X tape speed in ips.

Step 2
Forms 7-byte groups.

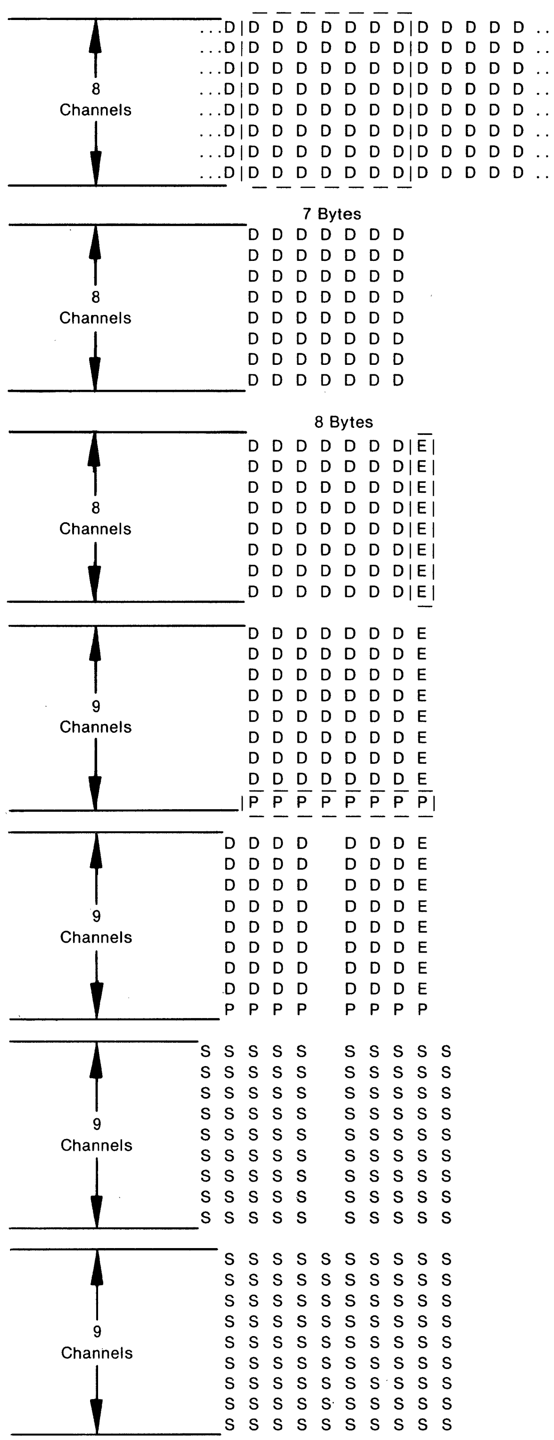
Step 3
Mathematically generates ECC character (E) to complete data group.

Step 4
Fills in vertical odd-parity channel to complete *(codeword)*.

Step 5
Divides *data group* into 2 data subgroups.

Step 6
Translates 4-byte data subgroups into 5-byte storage subgroups per Table 2-2.

Step 7
Recombines 2 storage subgroups into a GCR *storage group* for writing on tape.



LEGEND:
D = 1 data bit
E = Error check bit
P = Parity bit
S = Storage bit
ECC = Error Correcting Code character

Table 2-2
Data Subgroup to Storage Subgroup Conversion

Data 1234/5678	Storage* 12345/678910
0 0 0 0	1 1 0 0 1
0 0 0 1	1 1 0 1 1
0 0 1 0	1 0 0 1 0
0 0 1 1	1 0 0 1 1
0 1 0 0	1 1 1 0 1
0 1 0 1	1 0 1 0 1
0 1 1 0	1 0 1 1 0
0 1 1 1	1 0 1 1 1
1 0 0 0	1 1 0 1 0
1 0 0 1	0 1 0 0 1
1 0 1 0	0 1 0 1 0
1 0 1 1	0 1 0 1 1
1 1 0 0	1 1 1 1 0
1 1 0 1	0 1 1 0 1
1 1 1 0	0 1 1 1 0
1 1 1 1	0 1 1 1 1

*Subgroup bit positions

(3) Group position 8 contains an ECC character (E). The residuum data characters occupy the lower-numbered positions, with the higher-numbered group positions containing padding characters of all 0s with odd parity. The group positions 1—6 may contain all padding or all data characters in accordance with the number of residuum characters modulo 7.

2.3.3.7 CRC Data Group

This specially formatted data group contains the CRC character and the residual character. The group positions are as follows:

(1) Group position 1 contains an all 0s character with odd parity or the CRC character (B).

(2) Group positions 2—6 each contain the CRC character (C).

(3) Group position 7 contains the residual character (X).

(4) Group position 8 contains the ECC character (E).

2.3.3.8 Postamble

The postamble follows the CRC group and a Mark 2 Subgroup, which is the same as Mark 1 (Paragraph 2.3.3.2), except that the 5-bit serial value is 11100. The postamble consists of 80 characters of which the first 14 subgroups are all 1s in all tracks followed by 11110 and 1010L in all tracks. (The L character is the last character, and is recorded to restore the residual magnetism of the tape to the IBG polarity.) The postamble is recorded for the purpose of electronic synchronization in reverse reading mode.

PCC

III. FUNCTIONAL DESCRIPTION

Working within a host system that employs compatible tape transports, such as Model T1940-96, the F6250 Formatter provides all control and data coding, decoding, formatting, and error detecting logic associated with writing/reading data in ANSI- and IBM-compatible PE or GCR formats.

3.1 PE MODE OF OPERATION

In the PE mode the formatter performs the following functions:

(1) Generates the PE preamble.

(2) Generates the PE postamble.

(3) Encodes data in the PE format, including the generation of the parity bit.

(4) Generates a PE Tape Mark upon command.

(5) Generates timing necessary to write an IBM/ANSI-compatible PE inter-block gap.

(6) Automatically records the PE Identification Burst prior to recording the first record on a tape.

(7) Completely recovers and decodes the PE read data.

(8) Detects and corrects errors.

(9) Automatically reads and detects PE Tape Marks.

(10) Automatically tests for and indicates the PE Identification Burst when reading the first record on a tape.

3.2 GCR MODE OF OPERATION

In the GCR mode the formatter performs the following functions:

(1) Generates the GCR preamble.

(2) Generates the GCR postamble.

(3) Encodes and writes data in the GCR format, including generation of the parity bit.

(4) Automatically inserts Resync Bursts interleaved in the block as required by the GCR format.

(5) Generates GCR Tape Marks upon command.

(6) Generates timing necessary to write an IBM/ANSI-compatible GCR inter-block gap.

(7) Automatically records the GCR Identification Burst prior to recording the first record on a tape.

(8) Records the Automatic Read Amplification (ARA) burst, including the ARA Identification Character.

(9) Completely recovers and decodes the GCR read data.

(10) Detects and corrects errors.

(11) Automatically reads and detects GCR Tape Marks.

(12) Automatically tests for and indicates the GCR Identification Burst when reading the first record on a tape.

(13) Tests for and indicates the GCR Automatic Read Amplification burst, including the ARA ID character.

3.3 GENERAL FUNCTIONAL THEORY

3.3.1 HOST SYSTEM COMMUNICATION THEORY

Communication with the Formatter is via a 16-bit Control/Status/Data (CSD) bi-directional bus to an array of 16-bit registers in the Common Address Space (CAS). Each of the 16-bit CAS registers can be addressed via the 5 CAS address lines (CAS0—CAS4).

NOTE

CAS0—CAS4 do not refer to register locations, but are parallel lines carrying bits which express the location number of a register in binary coded octal.

The host talks to the Formatter by addressing the appropriate CAS register, placing the message on the CSD bus and, through a write-handshake cycle, transferring (writing) the information from the 16-bit bus into the selected CAS 16-bit location, on a bit-to-bit relationship. This is the procedure used to provide the Formatter with all instructions from the host and all information about those instructions.

The host obtains information from the Formatter by addressing the CAS register it wants to read; then, through a read-handshake operation, the information in the selected CAS 16-bit location is presented to the host via the CSD bus. This is the procedure used to provide the host with status information, interrupt information, failure information, etc., from the Formatter.

The bi-directional bus is also used to transmit the write-tape or read-tape data to/from the Formatter in either 16-bit or 8-bit words, as selected by the host. A modified handshake operation is used for the write tape operation in which the Formatter strobes the bus for each word at an average data transfer rate proportional to tape speed. Similarly, in a read tape operation, the Formatter offers the strobe, at an average rate proportional to tape speed, along with each data word on the bus.

3.3.2 FORMATTER INTERNAL THEORY

The host system communications described in Paragraph 3.3.1 are processed by the Formatter as shown in Figure 3-1. The flow of information/data is supervised by a microprocessor and uses three paths, as follows:

(1) Control Input/Output (I/O) Path — The microprocessor bus is the control path for the Formatter. This path is used to move information from module to module. It also carries all internal instructions from the microprocessor to each module of the Formatter.

(2) Write Path — Incoming 16-bit or 8-bit host data words are formatted into 8-bit PE or GCR format tape bytes (plus parity bit) and are transferred to the selected transport via the transport interface module.

(3) Read Path — The 8-bit-plus-parity PE or GCR tape bytes from the transport interface module are routed to the read channels which synchronize and deskew the recovered data. The data is then routed to the error correction module which performs correction on the data as required. Finally, the read data is decoded and assembled into 16-bit or 8-bit (as selected by the host) words and transferred through the host interface module and across the bus to the host CPU.

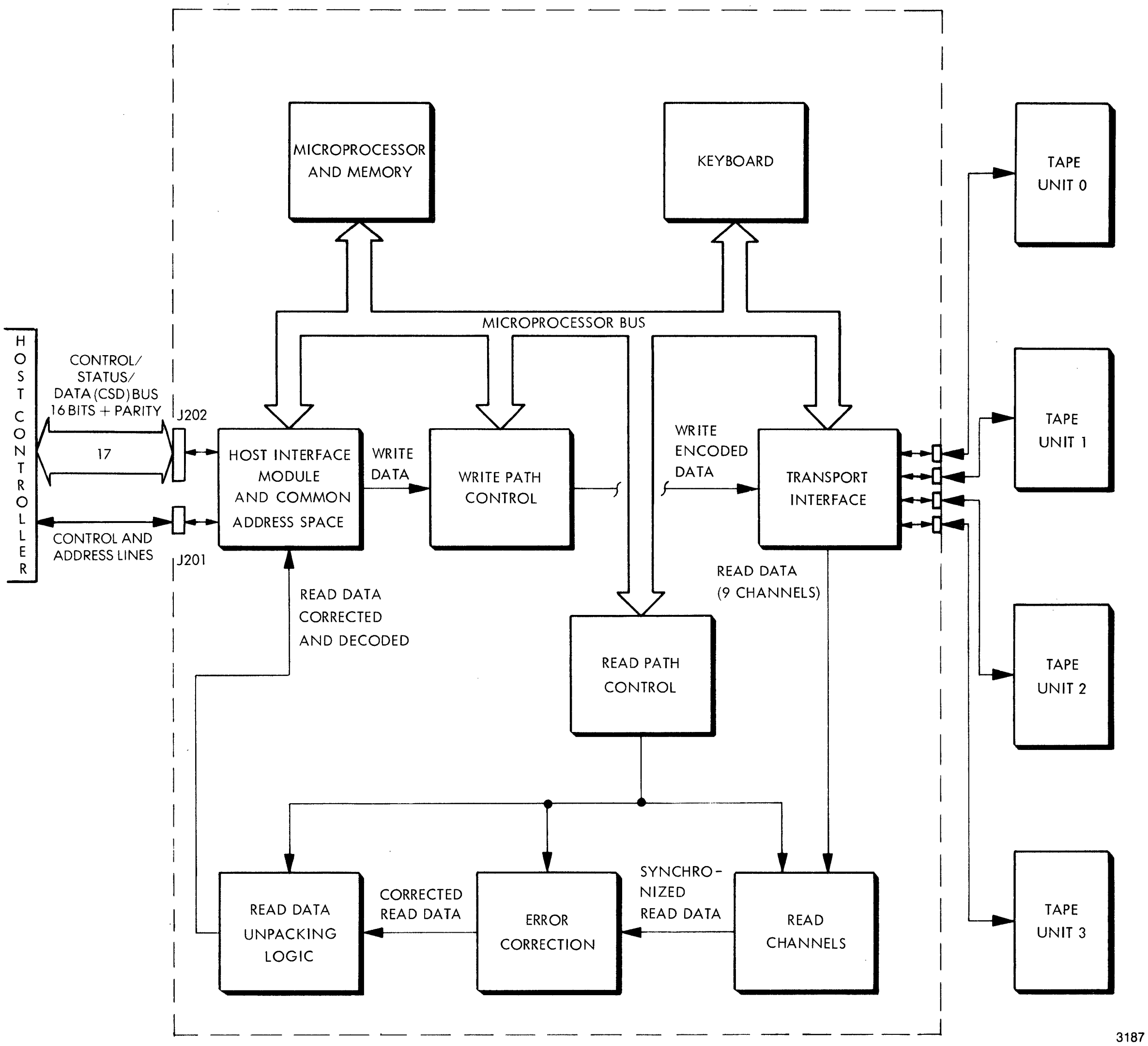


Figure 3-1. F6250 Formatter Block Diagram

IV. SYSTEM INTERFACING

4.1 CONTROLLER INTERFACE PROVISIONS

The F6250 Formatter interface is designed to communicate easily with the host Central Processing Unit (CPU) of minicomputers and microcomputers. The simplicity of interfacing to its I/O structure is one of the most important features of the Formatter.

Much of the tape-dependent functionality has been built into the Formatter, thus relieving the host CPU and controller of considerable design demands. For example, four PE/GCR tape units can be multiplexed on one Formatter. To the extent possible, this multiplexing is transparent to the host CPU.

Most minicomputer systems utilize a single highspeed bi-directional bus for communication between various components and peripherals. The PCC PD Formatter utilizes such a bus as a part of its interface. The host CPU acts as the bus master, communicating data and control information along the 16 lines of the bus. Full 16-bit words of information can be transferred between the host and the Formatter without assembly/disassembly of the 16-bit computer word. This 16-bit bi-directional bus interface, utilizing encoded fields as opposed to discrete bits, greatly reduces the hardware design requirements for the controller designer.

Each transfer of information across the bus is initiated by the host CPU and requires a response from the Formatter in order to complete the transfer. The asynchronous handshake operation precludes the need for synchronizing with a clocked system, thus preserving the CPU's ability to simultaneously interface with devices operating at other transfer rates.

Figure 4-1 illustrates the controller-to-Formatter and Formatter-to-transport interfaces. The complete Formatter interface with the controller consists of the following three groups of lines:

(1) A 16-bit-plus-parity bi-directional bus on which information can flow between the host CPU and the F6250 Formatter. This bus is aligned bit-to-bit with the 16 bits that make up the Common Address Space (CAS) registers in the Formatter described in Section V.

(2) Five CAS address select lines (BCD) allow the host to select any one of the CAS registers in the Formatter.

(3) Seven I/O control lines. Three of these control lines are utilized in a handshake operation. They are:

- Transfer Write (TWRT) (Controller to Formatter)

  If this control line is true, the information which is presented by the host on the bi-directional Control/Status/Data (CSD) bus is written into the selected Common Address Space (CAS) register in the Formatter at the time TREQ is true. If the TWRT control line is false, the information, which is in the selected CAS register of the Formatter, is presented on the CSD bus and is read by the host at the time TREQ is true.

- Transfer Request (TREQ) (Controller to Formatter)

  This control line initiates the handshake cycle to transfer information to or from the CAS register in the Formatter over the CSD bus.

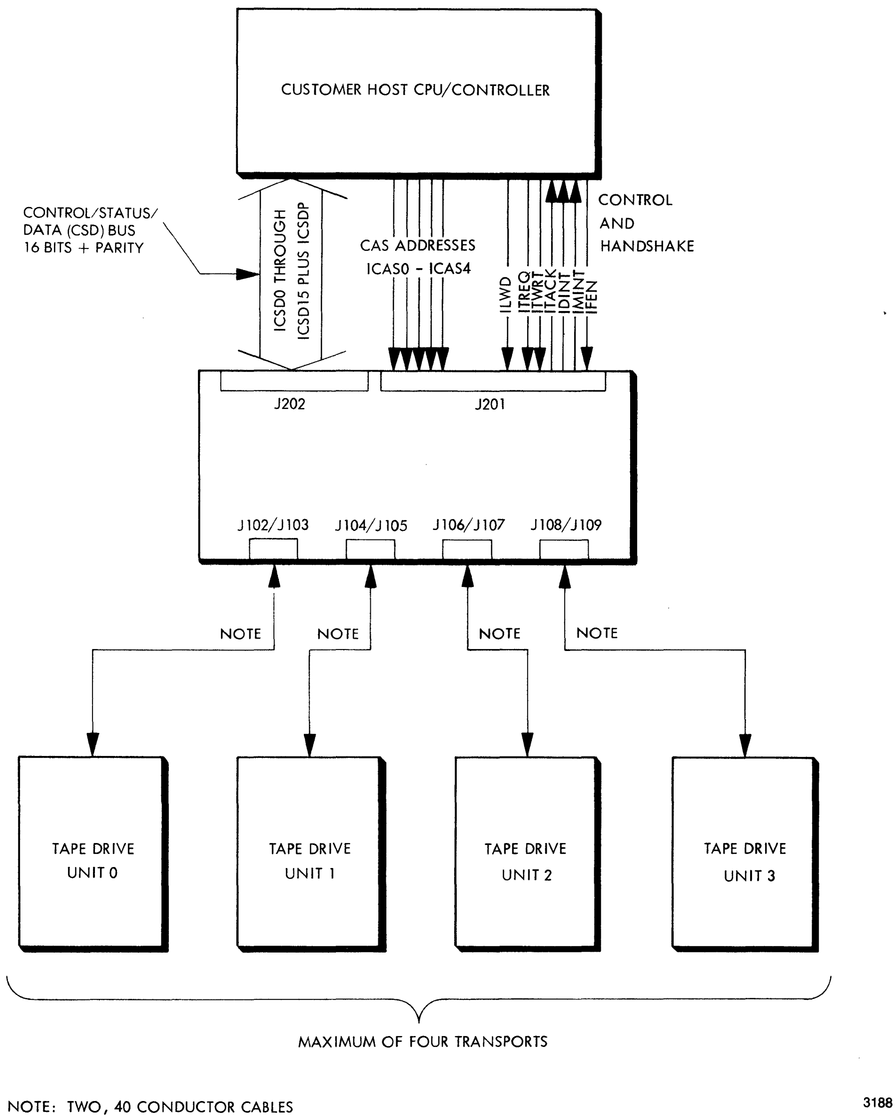


Figure 4-1. System Interconnection

- Transfer Acknowledge (TACK) (Formatter to Controller)

  This line is set by the Formatter in response to TREQ and, in turn, causes the TREQ to be reset. When TREQ is reset, the Formatter will reset TACK, thus completing the handshake cycle.

The remaining four control lines include two interrupt lines from the Formatter. One interrupt line (Data Interrupt, DINT) is used to indicate that the last data word in a data transfer operation has been sent and that the Interrupt Code and/or Failure Code may be read from CAS by the host. The interface timing requirements for a tape unit data transfer operation are discussed in Section VI.

The other interrupt line (Motion Interrupt, MINT) is used in any motion command execution to indicate that the motion command has been completed by the Formatter and that the Interrupt Code and/or Failure Code may be read from CAS by the host. The interface timing requirements for a motion command operation are covered in Section VI. The MINT line is also used in the Tape Unit Sense (TUS) command to indicate that the sense information has been placed on the CSD bus by the Formatter and may be read by the host. The interface timing requirements for the TUS command are discussed in Section VI.

Another line is the optional Last Word (LWD). This signal is coincident with the last word of a data transfer. It is used as an alternative to byte count to terminate a data transfer.

The final control line is the Formatter Enable (FEN) line. This line, from the controller, enables the other interface lines to the controller, but unlike all other interface signals the IFEN signal is active high in order to permit offline testing when the interface is disconnected from the controller.

4.2 INTERFACE TIMING SEQUENCE

Figure 4-2 illustrates the handshake timing sequence for a transfer of information from the host (via the 16-bit bus) to the Formatter's CAS registers.

Figure 4-3 illustrates the handshake timing sequence for a transfer of information from the Formatter's CAS registers to the host via the 16-bit bus.

4.3 FORMATTER INPUT/OUTPUT CONNECTIONS

Table 4-1 provides the pin assignments for interface connectors J1 and J2. The interconnection cables must be PCC-approved flat ribbon cables (3M part No. 3365) or harness of individual twisted pairs with the following characteristics.

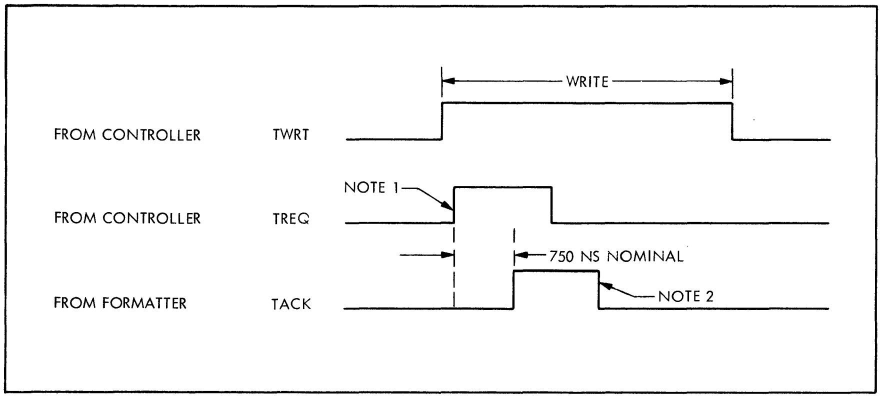
(1) Maximum length: 6 m (20 feet).

(2) Characteristic impedance: 110 to 150 ohms.

(3) 22 to 28 gauge conductors with a minimum insulation thickness of 0.25 mm (0.01 inch).

It is important that signal lines are capacitively shielded; i.e., that the lines in the cable are arranged ground-signal-ground. Termination requirements are shown in Figure 4-4.

Figure 4-5 shows how data are translated from tape data to word format. Binary weighting and ASCII relationship is also given.



NOTES:

1. CAS0 THROUGH CAS4, TWRT, CSD0 THROUGH CSDP MUST BE STABLE BY LEADING EDGE OF TREQ.
2. TACK IS RESET WHEN TREQ IS RESET.
3. AT THE INTERFACE, LOW=TRUE; THEREFORE, TWRT BECOMES ITWRT (LOW=TRUE FOR WRITE, AND HIGH FOR READ) ETC.

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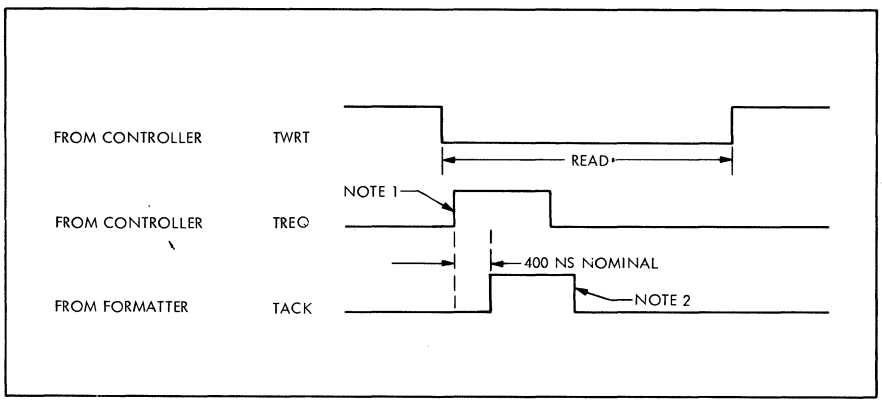
Figure 4-2. Controller to Formatter Handshake Timing for Writing in CAS



NOTES:

1. CAS0 THROUGH CAS4, TWRT, CSD0 THROUGH CSDP MUST BE STABLE BY LEADING EDGE OF TREQ.
2. TACK IS RESET WHEN TREQ IS RESET.
3. AT THE INTERFACE, LOW=TRUE; THEREFORE, TWRT BECOMES ITWRT (LOW=TRUE FOR WRITE, AND HIGH FOR READ), ETC.

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Figure 4-3. Controller to Formatter Handshake Timing for Reading CAS

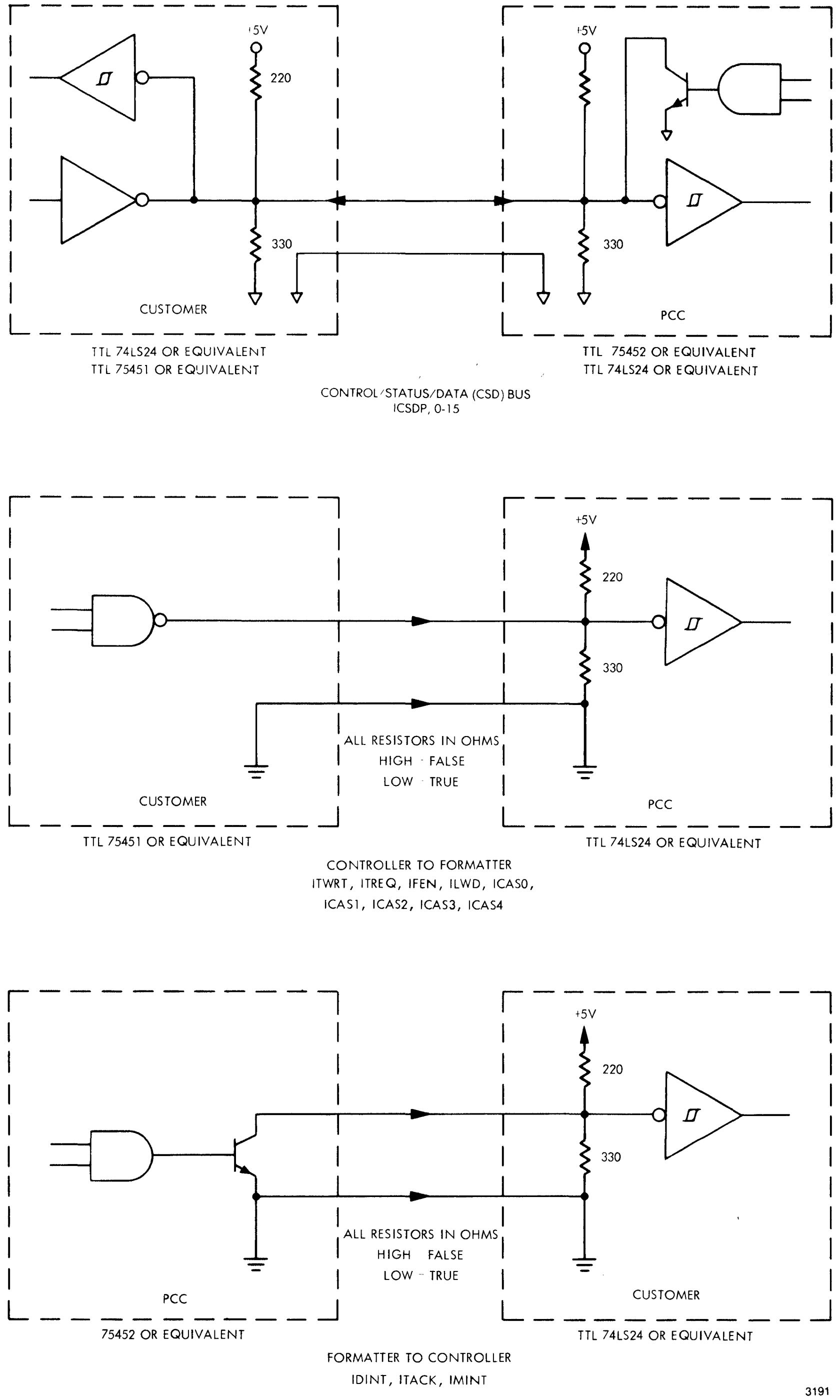

Figure 4-4. Interface Driver, Receiver and Terminator Requirements

Table 4-1
Formatter Interface Connector Pin Assignments

J1 Control

Live Pin	Gnd Pin	Signal	Name
1	18	TRANSFER REQUEST	TREQ
2	19	TRANSFER ACKNOWLEDGE	TACK
3	20	TRANSFER WRITE	TWRT
4	21	CAS SELECT	CAS0
5	22	↕	CAS1
6	23	↕	CAS2
7	24	↕	CAS3
8	25	CAS SELECT	CAS4
9	26	MOTION INTERRUPT	MINT
10	27	FORMATTER ENABLE	FEN
11	28	DATA TRANSFER INTERRUPT	DINT
12	29	LAST WORD (OPTIONAL)	LWD
13	30	SPARE	
14	31	↕	
15	32	↕	
16	33	↕	
17	34	SPARE	

J2 Data

Live Pin	Gnd Pin	Signal	Name
1	18	CONTROL/STATUS/DATA	CSD0
2	19	↕	CSD1
3	20	↕	CSD2
4	21	↕	CSD3
5	22	↕	CSD4
6	23	↕	CSD5
7	24	↕	CSD6
8	25	↕	CSD7
9	26	↕	CSD8
10	27	↕	CSD9
11	28	↕	CSD10
12	29	↕	CSD11
13	30	↕	CSD12
14	31	↕	CSD13
15	32	↕	CSD14
16	33	↕	CSD15
17	34	CONTROL/STATUS/DATA	CSDP

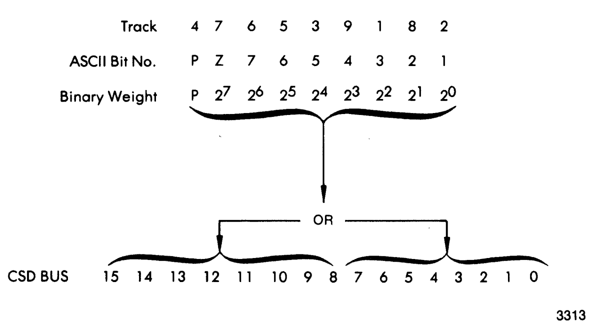

Figure 4-5. Bit Assignment

V. COMMON ADDRESS SPACE AND CODING REQUIREMENTS

5.1 COMMON ADDRESS SPACE STRUCTURE

The Common Address Space (CAS) is an array of 16-bit memory locations (registers) in the F6250 Formatter. The 16-bit width of the Common Address Space corresponds to the 16 bits of the Control/Status/Data (CSD) bus. All control or status transfers take place by writing into or reading from registers in the CAS using the CSD bus.

A 5-bit binary address selects a location in the CAS for a transfer. The reading or writing is determined by the handshake sequences illustrated in Figures 4-2 and 4-3.

Table 5-1 identifies each 16-bit memory location of the CAS with its corresponding bit content. In the table, each CAS location is identified in octal numbers and in binary coded octal. The name is given for reference purposes, and the normal mode of CAS access (reading and/or writing) is provided.

Four of the CAS locations are associated with any data transfer operation (read or write on tape). However, the CAS does not handle the data. The locations are 0, 1, 2 and 5. Paragraph 6.1 contains a detailed description of the contents of these registers.

Six of the CAS locations are associated with any motion command (non-data transfer) operation, such as REWIND. These locations are 4 and 13—17. Paragraph 6.2 contains a detailed description of the contents of these registers.

Two of the CAS locations (7 and 10) are used to provide Tape Unit Sense (TUS) information (status reports) to the controller upon request. Paragraph 6.3 contains a detailed description of the contents of these registers.

Two of the CAS locations (20 and 21) are used during diagnostic operations. Section VII contains a detailed description of the contents of these registers.

5.2 FUNCTION CODE ORGANIZATION

The Function Codes, shown in Table 5-2, are 6-bit binary codes containing instructions to the Formatter from the controller. If the function to be performed by the Formatter is a Data Transfer Function, the Function Code is written into CAS location 0 by the host CPU. The Function Codes associated with all Motion Commands or with the Tape Unit Sense (TUS) command are written into CAS locations 14—17, according to tape unitselection.

Referring to Table 5-2, all Function Codes have bit-0 as 1 because this is the GO bit. It is the GO bit that informs the Formatter that a new command has been loaded. The GO bit is not intended to be a status bit and is integrated into the Binary Coded Octal number as follows: The Function Code is an octal number, which is expressed in the first five digits of the Binary Coded Octal (BCO) column. The additional digit is the GO bit. When the complete BCO is read in straight octal, it becomes the Octal GO number. (E.g., the function code for REWIND is 03_8, which is 00 011 in BCO. When the GO bit is added, this becomes 000 111, which is 7 in octal as shown in the Octal GO column.)

Table 5-2 lists the functions and the corresponding Function Codes in both octal and in binary coded octal form and also provides a description of each function.

Table 5-1
Common Address Space Bit Assignment

CAS Location						CAS Register Name	Read/ Write	Common Address Space (CAS) Bit Assignment (Transferred over the CSD0 through CSD15 bus)																COMMENTS
Octal	Binary Coded Octal																							
	CS4	CS3	CS2	CS1	CS0			15_{10}	14_{10}	13_{10}	12_{10}	11_{10}	10_{10}	9_{10}	8_{10}	7_{10}	6_{10}	5_{10}	4_{10}	3_{10}	2_{10}	1_{10}	0_{10}	
0_8	0	0	0	0	0	Data Transfer Control	R/W				UBL	← N/A →						DATA TRANSFER FUNCTION CODE (See Table 5-2)					GO X	Used in data transfer operations. Shared by all four tape units. CAS locations 2 and 5 must be loaded prior to Function Code. (SER suppresses retry on error.)
1_8	0	0	0	0	1	Data Transfer Interrupt	R	DATA TRANSFER FAILURE CODE (Table 5-4)						← N/A →				DATA TRANSFER INTERRUPT CPDE (See Table 5-3)						
2_8	0	0	0	1	0	Byte Control	R/W	SER	DATA FORMAT (of the CSD bus)			SKIP COUNT (No. of all-0 bytes)				← RECORD COUNT (No. of records, in binary) →						COMMAND ADDRESS (Tape Unit No.)		
3_8	0	0	0	1	1	Not Used	—	← N/A →																
4_8	0	0	1	0	0	Motion Interrupt	R/W	← N/A →															MO	Bit 0 is the Motion Interrupt bit. Bit 0 is reset by writing in a 1.
5_8	0	0	1	0	1	Byte Count	R/W	← BYTE COUNT (16 bits max., or 177777_8 max.) to be read from or written on tape →																Used in data transfer operations. Shared by all four tape units.
6_8	0	0	1	1	0	Not Used	—	← N/A →																
7_8	0	0	1	1	1	Extended Status	R	RDY	PRES-ENT	ONL	REW	PE	BOT	EOT	FPT	AVAIL	0	MAINT	← N/A →					Tape unit sense command (TUS). Used to read these locations during the time the Motion Interrupt bit is set (location 4).
10_8	0	1	0	0	0	Serial Number (SN)	R	BCD SN, UNIT 3				BCD SN, UNIT 2				BCD SN, UNIT 1				BCD SN, UNIT 0				
11_8	0	1	0	0	1	Not Used	—	← N/A →																
12_8	0	1	0	1	0	Not Used	—	← N/A →																
13_8	0	1	0	1	1	Motion Command Interrupt	R	MOTION COMMAND FAILURE CODE (MINT causes *read this*) (Table 5-4)						MINT ADDR (Binary)		N/A		MOTION COMMAND INTERRUPT CODE or F6250 INITIATED INTERRUPT (Table 5-3)						F6250 Initiated Interrupt Codes are read while the Motion Interrupt bit is set (location 4). Motion command operations
14_8	0	1	1	0	0	Motion Command Control, Unit 0	R/W	← COMMAND COUNT, UNIT 0 (No. of times the command is executed) →								N/A		MOTION COMMAND FUNCTION CODE, UNIT 0 (Table 5-2)					GO 0	
15_8	0	1	1	0	1	Motion Command Control, Unit 1	R/W	← COMMAND COUNT, UNIT 1 →								N/A		MOTION COMMAND FUNCTION CODE, UNIT 1 (Table 5-2)					GO 1	
16_8	0	1	1	1	0	Motion Command Control, Unit 2	R/W	← COMMAND COUNT, UNIT 2 →								N/A		MOTION COMMAND FUNCTION CODE, UNIT 2 (Table 5-2)					GO 2	
17_8	0	1	1	1	1	Motion Command Control, Unit 3	R/W	← COMMAND COUNT, UNIT 3 →								N/A		MOTION COMMAND FUNCTION CODE; UNIT 3 (Table 5-2)					GO 3	
20_8	1	0	0	0	0	Diagnostic 1		← INTERNAL ADDRESS →																Diagnostic operations. (See Tables 6-3 and 6-5.)
21_8	1	0	0	0	1	Diagnostic 2		FM RDY	FM CLR	MC PE	INVR	CPE	EV PAR	HLDA	HOLD	← INTERNAL DATA →								

Table 5-2
Function Code Organization

Type	Function Code (First 5 Bits)	Octal Go (6 Bits)	Binary Coded Octal	Function Name	Counts	Description/Comments	Possible Interrupt Codes (See Tables 5-3 and 5-4)
DATA TRANSFER[1]	00	01	000 001	EXTENDED SENSE		Provides 30 sense bytes.	DONE
NO OP[2]	01	03	000 011	NO OP		Generate a unique NO OP interrupt code.	NO OP
MOTION COMMANDS[1]	02	05	000 101	UNLOAD		Unload tape and interrupt immediately.	DONE, ERROR, TDP[3]
	03	07	000 111	REWIND		Rewind tape and interrupt when done.	DONE, ERROR, TDP[3]
SENSE COMMAND[2]	04	11	001 001	TAPE UNIT SENSE (TUS)		Put status information into CAS 7 and 10 (valid for ATTN bit set)	DONE, HOLD, TDP[3]
MOTION COMMANDS[2]	05	13	001 011	DATA SECURITY ERASE (DSE)		Erase the remainder of tape and rewind (<10 feet beyond EOT).	DONE, ERROR, TDP[3]
	06	15	001 101	WRITE TM PE	Command Count	Write the specified number of characters in a PE tape mark.	DONE, ERROR, EOT, FPT, TDP[3]
	07	17	001 111	WRITE TM GCR	Command Count	Write the specified number of characters in a GCR tape mark.	DONE, ERROR, EOT, FPT, TDP[3]
	10	21	010 001	SPACE FWD REC	Command Count	Space forward the specified number of records; stop if TM.	DONE, ERROR, TM, TDP[3]
	11	23	010 011	SPACE REV REC	Command Count	Space reverse the specified number of records; stop if TM or BOT.	DONE, ERROR, TM, BOT, TDP[3]
	12	25	010 101	SPACE FWD FILE	Command Count	Space forward the specified number of tape marks.	DONE, ERROR, TDP[3]
	13	27	010 111	SPACE REV FILE	Command Count	Space reverse the specified number of tape marks; stop if BOT.	DONE, ERROR, BOT, TDP[3]
	14	31	011 001	SPACE FWD EITHER	Command Count	Space forward the specified number of records and/or tape marks.	DONE, ERROR, TDP[3]
	15	33	011 011	SPACE REV EITHER	Command Count	Space reverse the specified number of records and/or tape marks; stop if BOT.	DONE, ERROR, BOT, TDP[3]
	16	35	011 101	ERASE GAP PE	Command Count	Erase 3 inches of tape in PE Mode.	DONE, ERROR, FPT, EOT, TDP[3]
	17	37	011 111	ERASE GAP GCR	Command Count	Erase 3 inches of tape in GCR mode.	DONE, ERROR, EOT, FPT, TDP[3]
	20	41	100 001	CLOSE FILE PE		Write 2 TMs. Space reverse 1.	DONE, EOT, ERROR, FPT, TDP[3]
	21	43	100 011	CLOSE FILE GCR		Write 2 TMs. Space reverse 1.	DONE, EOT, ERROR, FPT, TDP[3]
	22	45	100 101	SPACE TO LEOT		Space forward until 2 TMs. Space reverse 1.	DONE, ERROR, NEX
	23	47	100 111	SPACE FWD FILE/LEOT		Space forward to TM. Stop if 2 successive TMs.	DONE, ERROR, NEX, LEOT, TDP[3]
DATA TRANSFER FUNCTIONS[1]	30	61	110 001	WRITE PE	Record Count, Byte Count	Write the specified number of PE records	DONE, ERROR[5], EOT, RETRY[4], FPT, TDP[3], BAD TAPE
	31	63	110 011	WRITE GCR	Record Count, Byte Count	Write the specified number of GCR records.	DONE, ERROR[5], EOT, RETRY[4], FPT, TDP[3], BAD TAPE
	34	71	111 001	READ FWD	Record, Byte, and Skip Counts	Read the specified number of records in forward.	DONE, ERROR, TM, RETRY[4], LONG RECORD, SHORT RECORD, RETRY OPPOSITE[4], TDP[3], UNREADABLE, BAD TAPE
	37	77	111 111	READ REV	Record, Byte, and Skip Counts	Read the specified number of records in reverse.	DONE, ERROR, TM, RETRY[4], BOT, LONG RECORD, SHORT RECORD, RETRY OPPOSITE[4], TDP[3], UNREADABLE, BAD TAPE

NOTES:
1. Binary representation of the octal Function Code is in CAS location 0, bits 0—5.
2. Binary representation of the octal Function Code is in CAS location 14, 15, 16, or 17, bits 0—5.
3. TDP (Tape Drive Problem) covers the following Interrupt Codes: NOT READY, NOT AVAILABLE, OFF LINE, NEX, TAPE UNIT FAULT A.
4. For SER = 0 only.
5. For SER = 1 only.

Several of the Motion Commands have Command Count quantities associated with them. The Command Count specifies the number of times the command is to be performed. The Command Count is written into the CAS by the host at the time the Function Code is written into CAS. Either 0 or 1 may be used to specify a single operation. If an operation is terminated prematurely, the Command Count may be read by the host CPU to determine the number of operations which were not performed.

Data Transfer Functions have Record Counts, specifying the number of records to read or write; Byte Counts, specifying the length of the record or records to be read or written; and Skip Counts, specifying the number of bytes to be transferred as all 0s before the actual data transfer. The counts associated with a data transfer function must be loaded into the respective CAS locations prior to writing the Function Code and GO bit. See Paragraph 6.1 for detailed descriptions of these counts.

5.3 INTERRUPT CODES

The Interrupt Codes are 6-bit binary-coded octal (BCO) signals used to interrupt the host CPU. There are three types of Interrupt Codes:

- Data Transfer
- Motion
- Formatter-initiated.

Interrupt Codes associated with a data transfer function, such as READ FWD, are located in CAS location 1, bits 0—5. The host CPU reads the data transfer Interrupt Code when it receives Data Interrupt (DINT).

Interrupt Codes associated with motion commands (such as REWIND) or Formatter-Initiated Interrupts are located in CAS location 13, bits 0—5. The Motion Interrupt Bit (CAS Location 4, bit 0) and the Motion Interrupt (MINT) line will be set when a motion command is completed or a hardware fault is detected. Since the host CPU may have up to four motion commands active at any time, the host reads the motion address (MINT ADR, location 13, bits 8 and 9) to determine which tape unit has finished, and the Interrupt Code to determine which interrupt level action to take. If the Interrupt Code indicates a hardware fault condition, the Failure Code will contain additional information for the system error log. The host must write a 1 into the Motion Interrupt Bit, after it has read the codes, to allow any further interrupts.

The host CPU must monitor the state of the DINT and MINT interface lines at all times in order to be able to respond to interrupts.

Table 5-3 lists the interrupts and the corresponding Interrupt Codes in octal and BCO forms for data transfer functions. Table 5-4 lists the interrupts and the corresponding Interrupt Codes for motion commands. Table 5-5 lists the interrupts and the corresponding Interrupt Codes for Formatter-Initiated Interrupts. Note that several of the Interrupt Codes are common to data transfer operations and motion commands.

The following Interrupt Codes are undefined: octal 16, and 35—37. In addition, Interrupt Code 00 is not a legal Interrupt Code.

Table 5-3
Data Transfer Interrupt Codes

Interrupt Code			Definition	Tape Position	Byte Count	Record Count	Possible Data Transfer Commands	Host Response
Octal	Binary Coded Octal	Name						
01	000 001	DONE	The read or write completed successfully.	As expected	No change	0	All	Return *operation complete.*
02	000 010	TM	Unexpected Tape Mark encountered during a read operation.	After the Tape Mark	No change	Number of records not read	Read FWD, Read REV	Stop any look-ahead buffering. Return *end of file reached.*
03	000 011	BOT	Unexpected BOT encountered during a read reverse operation.	At BOT	No change	Number of records not read	Read REV	Stop any look-ahead buffering. Return *end of file reached.* Set *beginning of tape* status.
04	000 100	EOT	A successful write operation has completed beyond the EOT marker.	As expected	No change	0	Write PE, Write GCR	Return *end of tape error.* (Never rely on the physical relationship between EOT and record location, since this can change between units.)
10	001 000	FPT	A write was attempted on a file-protected tape.	No change	No change	No change	Write PE, Write GCR	Return *illegal write.*
11	001 001	NOT RDY	Tape unit is on-line and available but not ready.	N/A	No change	No change	All	Retry the operation after a delay.
12	001 010	NOT AVAIL	Tape unit is on-line, but not available or is in maintenance mode.	No change	No change	No change	All	Return *device error.*
13	001 011	OFF LINE	The tape unit is not switched on-line.	No change	No change	No change	All	Inform operator of the condition. Retry the operation after a delay.
14	001 100	NEX	Tape unit does not exist or power is off.	No change	No change	No change	All	Return *device error.*
15	001 101	NOT CAPABLE	During read, no record or tape mark detected in 6.25 m (25 ft) or unrecognizable ID at BOT.	At BOT or after 6.25 m (25 ft) of tape	No change	No change	Read FWD, Read REV	Return device error. Invoke tape labelling procedure for blank tape.
20	010 000	LONG REC	The last record read was longer than the Byte Count value, but was otherwise read correctly.	After the long record	Actual record length	Number of records not read, including current record	Read FWD, Read REV	Set *incorrect record length* status. Obtain actual size from Byte Count location. Return *record is longer than user requested.*
21	010 001	SHORT REC	The last record read was shorter than the Byte Count value, but was otherwise read correctly.	After the short record	Actual record length	Number of records not read, including current record	Read FWD, Read REV	Set *incorrect record length* status. Obtain actual size from Byte Count location.
22	010 010	RETRY	Error, the last operation should be repeated.	No change	No change	Number of records not read or written	All, with SER =0	Repeat the previous operation, starting at the record in error.
23	010 011	RETRY OPP	Read error, the last read should be performed in the opposite direction.	After the bad record	No change	Number of records not read	Read FWD, Read REV with SER = 0	Read opposite (see Note).
24	010 100	UNREADABLE	Read retries have failed to read the record.	After the bad record	No. of bytes transferred	Number of records not read	Read FWD, Read REV with SER = 0	Return *data error.*
25	010 101	ERROR	An error has occurred which requires a retry, but SER is set.	After the bad record	No. of bytes transferred	Number of records not written	All, with SER = 0	The user performs an error recovery algorithm, if any.
26	010 110	EOT ERROR	A write error has occurred beyond the EOT marker, and SER is set.	After the bad record	No change	Number of records not read	Write PE, Write GCR with SER = 1	The user performs an error recovery algorithm, if any.
27	010 111	BAD TAPE	Tape position has been lost, or write retries have failed to write the record.	Unknown	No. of bytes transferred	Number of records not read or written	All, with SER = 0	Return *data error.* Return *device error.*
30	011 000	FMTR FAULT A	The hardware has failed, or a software bug has been detected. The failure code contains more specific information.	Unknown	Unknown	Unknown	All	Enter the Failure Code in the system's error log. Return *device error.*
31	011 001	TU FAULT A	The tape unit has failed. The Failure Code contains more specific information.	Unknown	Unknown	Unknown	All	Enter the Failure Code in the system's error log. Return *device error.*

NOTE: Following is the procedure for host response to a Retry Opposite (RETRY OPP) interrupt:

1. Use Record Count to de-queue any records which were correctly transferred. Load Record Count with 0.
2. Byte Count now contains the Formatter's best guess of the actual record length. Use this value to recompute the memory buffer address and Skip Count. It is not necessary to reload the Byte Count. If the record will not fit in the buffer, compute the number of words for the data channel to skip, or return *data error.*
3. Issue the READ FWD or READ REV command (opposite to the initial direction before any errors occurred).
4. Follow the appropriate response to any resulting Interrupt Code. The Formatter will return a DONE or possibly a SHORT REC Interrupt Code when the record is correctly read and positioned in memory.

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Table 5-4
Motion Command Interrupt Codes

Interrupt Code			Definition	Possible Motion Command Functions	Host Response
Octal	Binary Coded Octal	Name			
01	000 001	DONE	Operation completed as expected.	All except NO OP	Return *operation complete.*
02	000 010	TM	Unexpected tape mark.	SPACE FWD REC, SPACE REV REC	Stop any look-ahead buffering. Return *end of file reached.*
03	000 011	BOT	Unexpected beginning of tape marker.	SPACE REV REC, SPACE REV FILE, SPACE REV EITHER	Stop any look-ahead buffering. Return *end of file reached.* Set *beginning of tape* status.
04	000 100	EOT	Tape is positioned beyond the end of tape marker (write).	WTM PE, WTM GCR, ERG PE, ERG GCR, Close File PE, Close File GCR	Return *end of tape* error. (Note: Do not rely on the physical relationship between EOT and record location since this can change between units.)
05	000 101	LEOT	Unexpected logical end-of-tape (EOT) mark (2 tape marks).	SPACE FWD File/ LEOT	Return *logical end of tape*, or other appropriate action.
06	000 110	NO OP	NO OP completed.	NO OP	Return *operation complete.*
07	000 111	REWINDING	Tape unit has started rewind operation.	REWIND, UNLOAD	Mark TU as bus 4. Expect future interrupt.
10	001 000	FPT	A write was attempted on a file protected tape.	WTM PE, WTM GCR, ERG PE, ERG GCR, Close File PE, Close File GCR	Return *illegal write.*
11	001 001	NOT RDY	TU is on-line and available but not ready.	All except NO OP and TUS	Retry the operation after a delay.
12	001 010	NOT AVAIL	TU is on-line but not available.	All except NO OP and TUS	Return *device error.*
13	001 011	OFF LINE	TU is not switched on line.	All except NO OP and TU	Inform operator of condition. Retry operation after delay.
14	001 100	NEX	TU does not exist or power is off.	All except NO OP and TUS	Return *device error.*
15	001 101	NOT CAPABLE	During SPACE operation, no record or tape mark detected in 6.35 m (25 ft) or unrecognizable ID at BOT.	SPACE (All)	Return *device error.* Invoke tape labeling procedure for blank tape.
27	010 111	BAD TAPE	Tape position is lost.	All except NO OP, TUS, DSE, REWIND, UNLOAD	Return *device error.* Return *data error.*
30	011 000	FMTR FAULT A	Hardware failure — see Failure Code for details.	All	Enter Failure Code in system's error log. Return *device error.*
31	011 001	TU FAULT A	Tape unit hardware failure. Failure Code contains more specific information.	All	Enter Failure Code in system's error log. Return *device error.*

Table 5-5
Formatter Initiated Interrupt Codes

Interrupt Code			Definition	Host Response
Octal	Binary Coded Octal	Name		
17	001 111	ON LINE	A tape unit is on-line with tape loaded*	Continue any processes that were waiting for the selected tape transport.
32	011 101	FMTR FAULT B	Formatter or interface failure. Refer to Failure Code for more information about the failure.	Enter the Failure Code in the system's error log. Issue FMTR CLEAR unless retry count limit is reached. Reissue all commands for which interrupts have not been received. Update retry count.
33	011 011	TU FAULT B	Tape unit failure. See Failure Code for more information about the failure.	Enter the Failure Code in the system's error log. Issue FMTR CLEAR unless retry count limit is reached. Reissue all commands for which interrupts have not been received. Update retry count.
34	011 100	CAS FAULT	Host has accessed an invalid CAS location (INVR). Host CPU write into CAS has caused even parity.	Enter the Failure Code in the system's error log. Issue FMTR CLEAR unless retry count limit is reached. Reissue all commands for which interrupts have not been received. Update retry count.

*TUS information (Paragraph 6.3) is valid during this interrupt.

5.4 FAILURE CODES

The Failure Code is a 6-bit binary code which contains information for the system error log. The Failure Code for a data transfer operation can be read by the host CPU at CAS location 1 (bits 10—15) when DINT is true. The Failure Code for a Motion Command can be read by the host CPU at CAS location 13 (bits 10—15) when MINT is true. In some cases, the Failure Code can be used to indicate the source of an error; however, its primary function is to categorize the type of failure, providing supplemental information to the Interrupt Code.

The Failure Codes associated with each Interrupt Code are defined in Table 5-6.

Table 5-6
Failure Code for Interrupts

Interrupt Code		Failure Code	
01	(Done) Operation completed as expected.	00 01	Extended sense data not updated. Internal status contains something of interest and extended sense data has been updated (for diagnostic purposes).
02	(TM) Unexpected tape mark has been sensed.	00	(Always zero.)
03	(BOT) Unexpected beginning-of-tape mark has been sensed.	01 02 03	Command was issued while BOT is at sensor. BOT was sensed after tape motion started. Automatic Read Amplification (ARA) ID has been detected.
04	(EOT) Tape is positioned at or beyond the end-of-tape marker. This code is issued only by write type commands.		Failure codes same as for 01 (Done).
05	(LEOT) Logical end of tape found before command completed. This code is issued only by the SP FWD File/LEOT command.	00	(Always zero.)
06	(NO OP) A no operation (NO OP) command has completed.	00	(Always zero.)
07	(REWINDING) The tape is rewinding and will interrupt again when done. Issued only by the rewind command when completion of the rewind may not happen until some time later.	00	(Always zero.)
10	(FPT) Tape files are write protected. Issued only by write type commands.	00	(Always zero.)
11	(NOT READY) Subsystem not ready to perform command.	01 02 03	Tape unit is on-line but not ready. Possible when drive is manually rewound from front panel or is loading. A fatal error has occurred and this command cannot be performed until that error status has been presented and a FMTR clear received. Access to tape drive is allowed but drive is either rewinding or doing a data security erase from a keypad command.
12	(NOT AVAIL) Tape unit is not switched to selected port.	00	(Always zero.)
13	(OFF-LINE) Tape unit is switched off-line.	00	(Always zero.)
14	(NON EX) Tape unit is non-existent.	00	(Always zero.)
15	(NOT CAPABLE) Subsystem not capable of performing read command.	01 02 03 04	No record was found within 25 feet of tape (blank tape). ID marker was not PE or GCR code. ARA ID cound not be found. No gap was found after ID burst (PE) or ARA ID Burst (GCR).
17	(ON-LINE) Tape unit just transitioned from not ready to ready. This code also presents sense data for tape unit.	00	(Always zero.)
20	(LONG REC) Record was read without error but the size was larger than the specified byte count value.		Failure codes same as for 01 (Done).

Table 5-6
Failure Code for Interrupts (Continued)

Interrupt Code		Failure Code	
21	(SHORT REC) Record was read without error but the size was shorter than the specified byte count value.		Failure codes same as for 01 (Done).
22	(RETRY) Error, the initial operation should be retried.	01	At least one bit other than single track error set in ECCSTA register.
		02	CRC error, ACRC error or UNCORRECTABLE set in ECCSTA register.
		03	UNCORRECTABLE error set in ECCSTA register.
		04	AMTIE, PNTR mismatch, UNCORRECTABLE, 2 TRK error or single TRK error set in ECCSTA register.
		05	At least one bit set in ECCSTA register.
		06	At least one write fail bit set in RPFAIL and RPATH registers.
		07	More than one write fail bit set in RPFAIL and RPATH registers.
		10	RSTAT contains bad code.
		11	CRC characters from WMC and RMC do not match.
		12	CSD data bus parity error.
23	(RETRY OPP) Error, the initial read should be performed in the opposite direction.		Failure codes same as for 22 (RETRY).
24	(UNREADABLE) Read retries have failed to read the record.		Failure codes same as for 22 (RETRY).
25	(ERROR) An error has occurred which requires a retry, but retries are suppressed.		Failure codes same as for 22 (RETRY).
26	(EOT ERROR) A write error has occurred beyond the EOT marker but retries are suppressed.		Failure codes same as for 22 (RETRY).
27	(BAD TAPE) Write retries have failed to write the record or position has been lost.		Failure codes same as for 22 (RETRY).
30	(TM FAULT A) The hardware has failed, or the CAS was loaded with incorrect command data.	01	Illegal command code.
		02	Data transfer command issued while a non-data transfer command in progress on the same tape unit.
		03	Illegal format or skip count codes.
		04	RUN was not received from DBUSSTA register.
		05	Command read from RMC register RCMLP did not match the command loaded into RCMD register. This code generated in selected function routine.
		06	ECC ROM parity error.
		07	XMC ROM parity error.
		10	Command read from RMC register RCMLP did not match the command loaded into RCMD register. This code generated when verify ID burst command loaded during write of BOT area.
		11	Command read from RMC register RCMLP did not match the command loaded into RCMD register. This code generated when verify ARA burst command loaded during write of BOT area.
		12	Command read from RMC register RCMLP did not match the command loaded into RCMD register. This code generated when verify ARA ID command loaded during write of BOT area.
		13	Command read from RMC register RCMLP did not match the command loaded into RCMD register. This code generated when verify gap command loaded during write BOT area.
		14	Command read from RMC register RCMLP did not match the command loaded into RCMD register. This code generated when read ID burst command loaded during read of BOT area.
		15	Command read from RMC register RCMLP did not match the command loaded into RCMD register. This code generated when verify ARA ID command loaded during read of BOT area.
		16	Command read from RMC register RCMLP did not match the command loaded into RCMD register. This code generated when verify gap command loaded during read of BOT area.
		17	Command read from RMC register RCMLP did not match the command loaded into RCMD register. This code generated when find gap command loaded during erase gap routine.
		20	WMC LEFT failed to set in extended sense routine.
		21	"XDC PE" set in INTSTA register.
		22	XMC done did not set.
		23	WMC ROM PE or RD PE set in WMCERR register.

Table 5-6
Failure Code for Interrupts (Continued)

Interrupt Code		Failure Code	
31	(TU FAULT A) The tape unit has failed.	01	TU status parity error.
		02	TU command parity error.
		03	Rewinding tape went off-line.
		04	Tape went not ready during DSE.
		05	TU CMD status changed during DSE.
		06	TU velocity never came up to speed.
		07	TU velocity changed after up to speed.
		10	TU CMD did not load correctly to start tape motion in selected function routine.
		11	TU CMD did not load correctly to set drive density.
		12	TU CMD did not load correctly to start tape motion to write BOT ID burst.
		13	TU CMD did not load correctly to backup tape to BOT after failing to write BOT ID.
		14	Failed to write density ID burst correctly.
		15	Failed to write ARA burst correctly.
		16	Failed to write ARA ID correctly.
		17	ARA ERROR bit set in MIA status B register.
		20	Late AGC bit set in TU diagnostic register.
		21	Could not find a gap after the ID, code was written correctly.
		22	TU CMD did not load correctly to start tape motion to read ID burst.
		23	Time-out looking for BOT after detecting ARA ID burst.
		24	Failed to write tape mark correctly.
		25	Velocity error while trying to reposition for retry of writing tape mark.
		26	TU CMD did not load correctly to start tape motion in erase gap routine.
		27	Could not detect a gap in erase gap routine.
		30	Could not detect a gap after writing record.
		31	Read path terminated before entire record was written.
		32	Could not find a gap after writing record and read path terminated early.
		33	TU CMD did not load correctly to backup for retry of write tape mark.
		34	TU velocity changed after up to speed while trying to reposition for retry of writing tape mark.
		35	TU CMD did not load correctly to backup to retry a read of BOT ID.
32	(TM FAULT B) F6250 detected an error condition not associated with any command.	00	RSTO interrupt occurred with FMTR RDY still set.
		01	Power failed interrupt.
		02	Interrupt for unknown reason on Channel 5.5.
		03	Interrupt for unknown reason on Channel 6.5.
		04	Interrupt for unknown reason on Channel 7.
		05	Interrupt for unknown reason on Channel 7.5.
		06	CAS contention retry count expired.
		07	CAS contention error not retryable.
		10	Queue error, could not find queue entry.
		11	Queue entry already full.
		12	8085 ROM parity error.
34	(CSD FAULT) CSD control bus fault.	01	Control bus parity error.
		02	Illegal register referenced.

VI. BASIC MODES OF OPERATION

All operations of the Formatter and an associated tape unit can be categorized as; a data transfer operation, in which the Formatter/tape unit handle data in conjunction with the host; as a motion operation, in which the Formatter/tape unit functions in a non-data mode; as a tape unit sense operation, in which the host is inquiring of the Formatter regarding the status of a tape unit; or as an extended sense operation, in which the host is inquiring of the Formatter regarding the contents of various error and sense registers.

These four types of operations are detailed individually in Paragraphs 6.1, 6.2, 6.3, and 6.4. They have, however, a number of common characteristics which are summarized below.

(1) The host CPU issues a command on the CSD bus to the tape subsystem.

(2) The host CPU issues the 5-bit address of a particular CAS register location associated with that command.

(3) Through a handshake operation using the control lines, the Formatter writes the command into the selected CAS register.

(4) The Formatter causes the tape transport to execute the command.

(5) The Formatter issues an Interrupt Code (and Failure Code) to the CPU on the CSD bus and sets the appropriate interrupt line.

(6) The CPU addresses the CAS location containing the Interrupt and/or Failure Code.

(7) Through a handshake operation, the host reads the Interrupt and/or Failure Code.

6.1 PERFORMING A DATA TRANSFER OPERATION

There are four data transfer operations, they are:

(1) Write PE

(2) Write GCR

(3) Read Forward

(4) Read Reverse

The data transfer interface is shared by all four tape units, so only one transfer may be active at a time. There are three CAS registers used to specify a data transfer command. When loading the three locations which define a command, CAS location 0 must be loaded last.

(1) CAS location 0, DATA TRANSFER CONTROL — contains the data transfer Function Code in bits 1—5 and the GO bit in bit 0. Bit 12 is the Unrestricted Block Length (UBL) bit, written when using the Last Word option whenever an infinite or unrestricted block length is required. See Paragraph 5.1 and Table 5-2 for a complete description of Function Codes.

(2) CAS location 5, BYTE COUNT — contains the length of the record to be read or written. If the actual length of a record read differs from the Byte Count, the actual length is returned to the host in Byte Count, accompanied by a LENGTH ERROR INTERRUPT CODE.

NOTE

When using the Last Word option of the F6250, it is not necessary to load a Byte Count into CAS.

(3) CAS location 2, BYTE CONTROL — contains the following:

- CMD ADDR in bits 0 and 1 specifies in BCD the tape unit being used.
- RECORD COUNT in bits 2—7 specifies the number of records to read or write. When non-0, it is decremented after each correctly transferred record. It is not decremented after an unsuccessful error retry operation, but indicates to the host CPU the number of records remaining to be transferred. The Record Count will be 0 upon a normal termination.
- DATA FORMAT in bits 12—14 defines the manner in which 8-bit tape bytes are assembled/disassembled to/from the host CPUs 16-bit or 8-bit words. Refer to Table 6-1.
- SKIP COUNT in bits 8—11. When the F6250 is operating in the 16-bit data transfer mode, the exact number of tape bytes to be written on tape is explicitly defined by the Byte Count placed beforehand in the CAS memory. There can be an even or odd number of tape bytes. All data transfers begin with a full 16-bit word, and end with a full or half-word as the case may be. The Skip Count is used when reading the tape backwards, to begin the backward data transfer with a full or half-word, thus allowing the host CPU to locate a record in the location from which it was written in its memory. Table 6-2 gives the location most or least significant byte position of the 16-bit interface word) of the first tape byte read versus Skip Count.

  When the F6250 is operating with the Last Word option, a Skip Count of 0001 causes the last 16-bit word to be written as a half-word (one tape byte) and according to the Data Format Code. A Skip Count of 0000 would, of course, write both bytes.

  When the F6250 is operating in the 8-bit data transfer mode, Skip Count has no significance.
- Suppress Error Repositioning (SER) in bit 15, if set, will suppress the repositioning of the tape for a retry following an error. If SER is not set, the Formatter's error recovery algorithms will inform the CPU of the next operation to perform via the Interrupt Code.

In addition to the three CAS registers which specify a data transfer command, CAS location 1 contains the Interrupt Code (bits 0—5) and the Failure Code (bits 10—15). Refer to Section V for a detailed description of the Interrupt and Failure Codes.

The interface sequences for the four data transfer operations are identical. Refer to Figure 6-1. A data transfer period commences with the leading edge of the GO bit (determined by the host CPU). During this period, the host CPU switches the CSD bus from a Control/Status Mode to a Data Mode and ignores the MINT (Motion Interrupt) line from the Formatter. Since the CSD bus is in a Data Mode, no subsequent command to read or write in the CAS is allowed during the data transfer period. The actual data transfers are strobed by the TACK line. TACK is used to provide transfer strobes to the controller. When reading tape, data is valid on the trailing edge of TACK. When writing tape, data is taken on the trailing edge of TACK. Each TACK pulse transfers 16 data bits (2 tape bytes) or 8 data bits (1 tape byte) over the CSD bus according to the Data Format Code selected by the host.

At the termination of a data transfer function (trailing edge of Data Interrupt (DINT)), the host CPU may return the CSD bus to a Control/Status mode and read CAS location 1 to check for the data transfer Interrupt Code and/or Failure Code. Furthermore, if the Motion Interrupt (MINT) line is found to be set, the host may read CAS location 13 to determine a motion command Interrupt and/or Failure Code from any other tape unit.

Table 6-1
Data Byte Format

Data Format Code	CPU 16-Bit Word 15 14 13 12 11 10 9 8 (Most Significant Byte)	CPU 16-Bit Word 7 6 5 4 3 2 1 0 (Least Significant Byte)
0 0 0	◄—— Second Byte ——►	◄—— First Byte ——►
0 0 1	◄—— First Byte ——►	◄—— Second Byte ——►
1 0 1	◄—— Not Used ——►	◄—— Tape Byte ——►

Table 6-2
Skip Count/Data Format Relationship

Skip Count	Data Format = 000 (Byte Significance)		Data Format = 001 (Byte Significance)	
	READ FWD	READ REV	READ FWD	READ REV
0 0 0 0	Least	Most	Least	Most
0 0 0 1	Most	Least	Most	Least

NOTE: There are only two defined states to the Skip Count format. Undefined Skip Counts will result in a FAULT INTERRUPT from the Formatter to the controller.

6.2 PERFORMING A MOTION COMMAND

The motion commands are described in Table 5-2. The interface sequences for all motion commands are identical and are as illustrated in Figure 6-2. Since there is a separate CAS register used to specify motion commands for each of the four tape units, all four may be active at any time. The Formatter will service motion commands sequentially. The four CAS motion command registers are:

CAS location 14 — Tape Unit 0
CAS location 15 — Tape Unit 1
CAS location 16 — Tape Unit 2
CAS location 17 — Tape Unit 3

The structures of these four CAS registers are identical and are as follows:

(1) The Function Code is contained in bits 1—5 and the GO bit in bit 0. Refer to Paragraph 5.1 and Table 5-2 for a complete description of the Function Codes.

(2) The Command Count in bits 8—15 specifies the number of times the command is to be performed. A Command Count of either 0 or 1 may be used to specify a single operation. If an operation is terminated prematurely, the Command Count field may be read by the host CPU to determine the number of operations which were not performed. Note also from Table 5-2 that only 10 of the motion commands have Command Counts associated with them, i.e., the Command Counts for the other 7 motion commands are set to 0 or 1 by the controller.

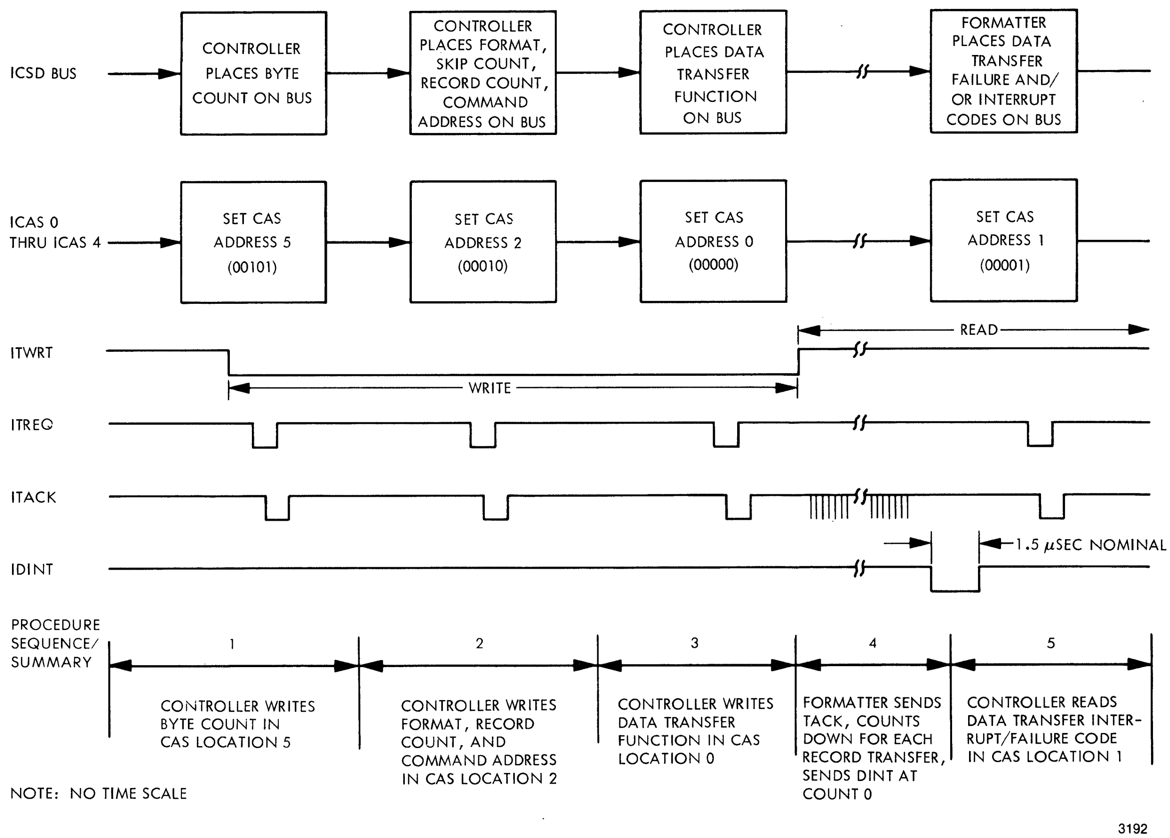

Figure 6-1. Interface Sequence for a Data Transfer Function and Extended Status

In addition to the four CAS registers used to specify motion commands, CAS location 13 is used to inform the host CPU of the command status. When a motion command is completed, the Motion (MO) Interrupt bit in CAS location 4 and the MINT line will be set. At this time, the host reads the MINT ADR in bits 8 and 9 of CAS location 13 to determine which interrupt-level action to take. If the Interrupt Code indicates a hardware fault condition, then the host reads the Failure Code in bits 10—15 for additional information for the system error log. The information contained in CAS location 13 is valid only during the time MINT is true. Finally, the host writes a 1 into CAS location 4 bit 0 resetting the Motion (MO) Interrupt bit and the MINT line. This allows further interrupts.

6.3 PERFORMING A TAPE UNIT SENSE COMMAND

The Tape Unit Sense (TUS) command may be used by the host to obtain information about a specific tape drive. This sense information is provided primarily for system initialization or error logging. When the command is given via one of the four motion command control CAS locations, the following information about the specified tape drive is available during the time the Motion Interrupt bit is set and may be read by the Controller by addressing CAS locations 7 or 10. TUS Information is also valid during the ON LINE Formatter-Initiated Interrupt (refer to Paragraph 5.3, and Table 6-3). The interface sequence for a TUS command is illustrated in Figure 6-3.

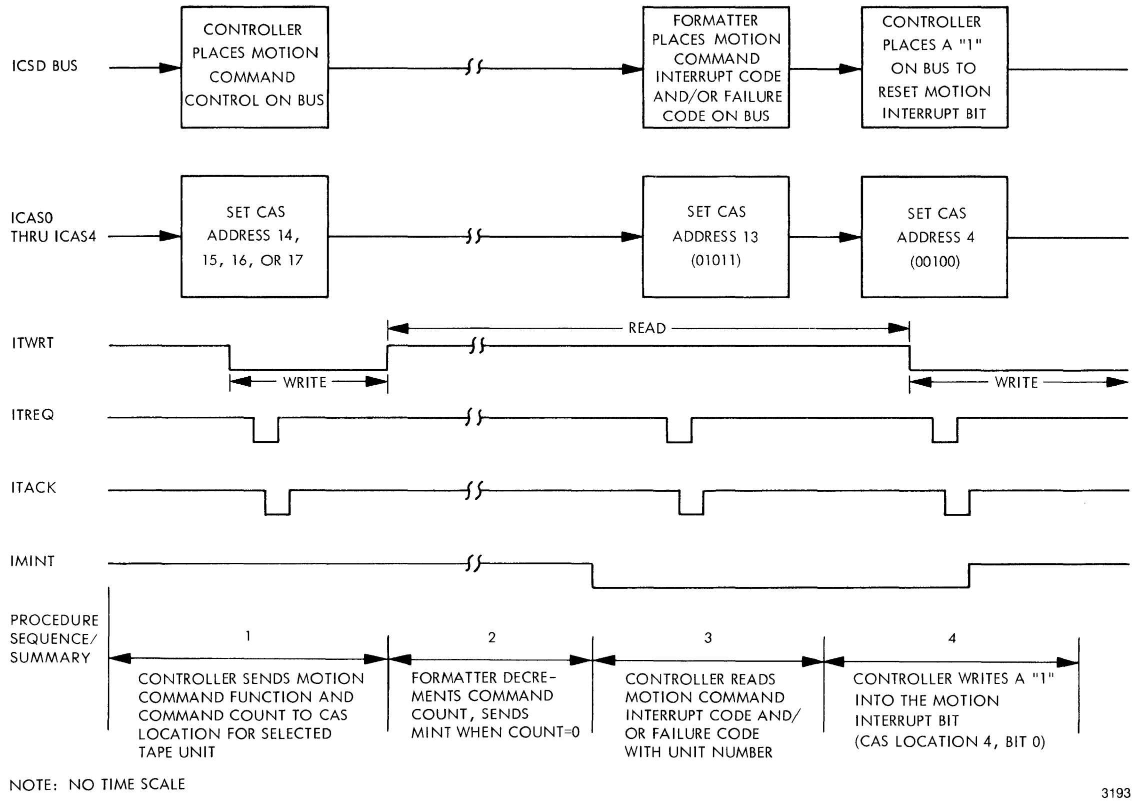

Figure 6-2. Interface Sequence for a Motion Command

6.4 PERFORMING AN EXTENDED SENSE COMMAND

In addition to the four data transfer operations described above, an Extended Sense command (Function Code 00) can be issued to the F6250 CAS location 0. This command will cause the F6250 to present 30, 16-bit sense words (or 60, 8-bit sense words) to the host on the CSD bus. The execution of the Extended Status command is the same as for a READ operation. This command typically is issued to the F6250 following an error interrupt message from the F6250. The formatter will display at the interface, the contents of approximately 50 of its internal error and sense registers in addition to other status information, thus allowing the host to log detail error information.

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Table 6-3
Tape Unit Sense Status Information

CAS Location	Bit	Name	Definition
7	15	RDY	Tape unit has a tape mounted.
	14	PRES	Tape unit has power applied.
	13	ONL	Tape unit is on-line.
	12	REW	Tape unit is rewinding.
	11	PE	Tape unit is set for PE recording format.
	10	BOT	Tape is positioned at load point.
	9	EOT	Tape is positioned beyond the end-of-tape marker.
	8	FPT	Tape is file-protected and may not be written on.
	7	AVAIL	Tape unit is available to host CPU.
	5	MAINT	Tape unit is in maintenance mode and may not be used.
	4	DSE	Tape unit is performing in the erase phase of the Data Security Erase (DSE) function.
	0—3	—	Not applicable.
10	0—3	BCD SN Tape Unit 0	Binary-coded-decimal serial number of tape unit 0.
	4—7	BCD SN Tape Unit 1	Binary-coded-decimal serial number of tape unit 1.
	8—11	BCD SN Tape Unit 2	Binary-coded-decimal serial number of tape unit 2.
	12—15	BCD SN Tape Unit 3	Binary-coded-decimal serial number of tape unit 3.

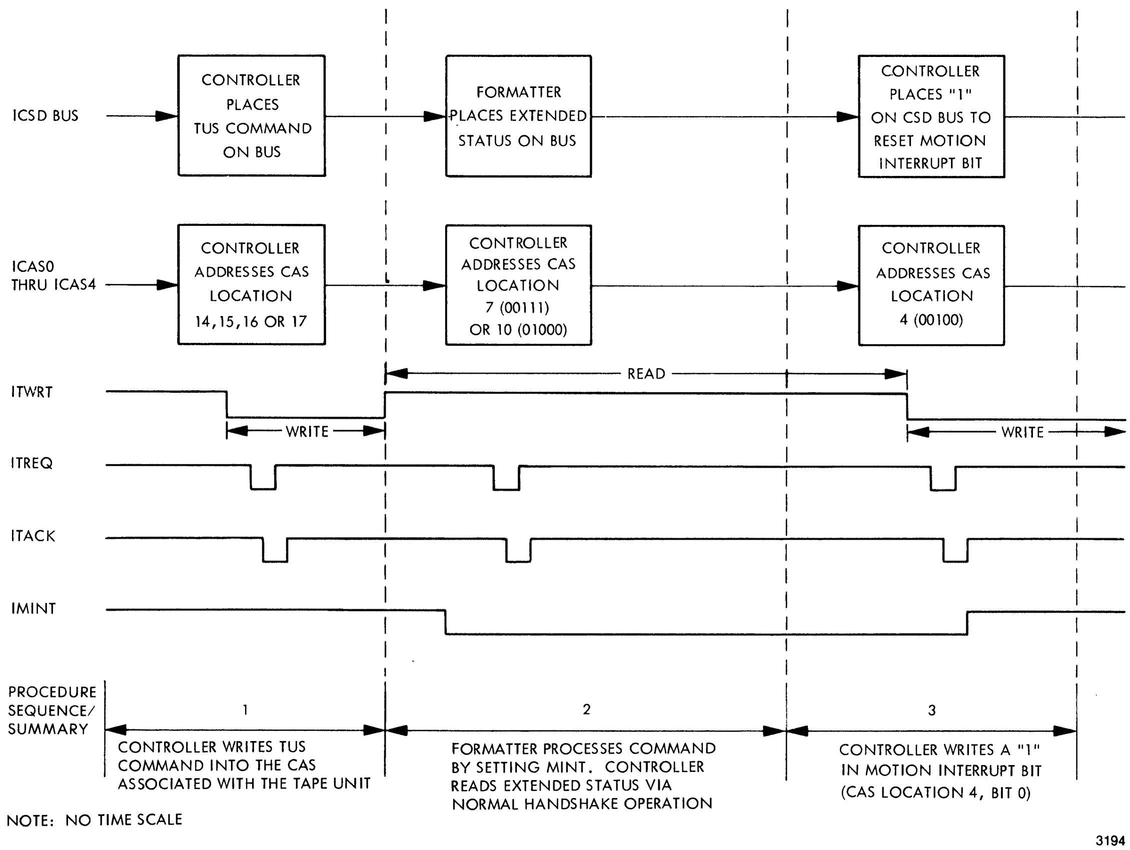

Figure 6-3. Interface Sequence for a Tape Unit Sense (TUS) Command

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VII. FORMATTER DIAGNOSTICS

The Formatter is capable of performing self-diagnosis in essentially three levels of operation as described in Paragraph 7.1—7.3.

7.1 ON-LINE DIAGNOSTIC LEVEL

The first level of diagnostic operation is resident to the Formatter and functions whenever the Formatter is on-line. This mode utilizes the normal operational interface; i.e., the Interrupt Codes and Failure Codes (Paragraphs 5.2 and 5.3) in conjunction with the MINT and DINT interface lines whenever the Formatter is performing any function. The purpose of this mode of operation is to provide the CPU with a continuous report of performance and to alert the CPU in the event a fault occurs.

A subset, of the first level diagnostics, also occurs when the Formatter is not performing a function. Whenever in the *idle* mode, the Formatter's microprocessor calls up self-test routines (which are stored in the Formatter memory) for each microsequencer of the Formatter and causes these routines to be executed. As the microprocessor polls individual microsequencers, various status bits are checked, and the communication process to the microsequencers is verified. This *self-policing* mode reports any faults to the host CPU by use of the Formatter-Initiated Interrupts (Paragraph 5.2) and the MINT interface line.

Thus, this first level of diagnostics provides the host CPU with continuous fault monitoring of the Formatter during both active operations and idle periods.

7.2 OFF-LINE/KEYBOARD DIAGNOSTIC LEVEL

The second level of diagnostics is an off-line mode, utilizing a built-in keyboard. This mode allows the service technician to call up self-test routines to verify individual module integrity. In addition, a loop write-to-read command can be executed within the Formatter at read time data rates, including ± 20 percent margin testing of the data frequency. This test fully verifies the read path and the write path within the Formatter (refer to Figure 3-1 and Paragraph 3.3.2). An additional routine can be called up which has the ability to extend the write-to-read loop test to include the transport interface module, the transport interface cables, and the interface PCBAs in the transports, thus verifying the integrity of the radial interface to the tape units.

In addition, the service technician can call-up the following tape transport routines using the keyboard:

- Rewind
- Write Tape Mark PE
- Write Tape Mark GCR
- Erase Gap PE
- Erase Gap GCR
- Forward Space Either
- Reverse Space Either
- Write PE (including load point formatting)
- Write GCR (including load point formatting)
- Read FWD (data integrity check)
- Read REV (data integrity check)

The keyboard allows the service technician to execute the routines in single step mode, repeat mode, or they can be strung together with separate command counts for each command; the execution can be halted on error; error logging can be used to perform data-reliability test on the subsystem, and the extended sense can be made available to the service technician when using the keyboard.

These tape transport tests, when taken in conjunction with the Formatter module tests, can quickly isolate a fault to a serviceable sublevel or function.

7.3 HOST CPU DIAGNOSTICS

The host CPU level of diagnostics uses the host CPU to control the diagnostic evaluation of the F6250 subsystem. While the subsystem is off-line to users, the diagnostic program operates as a normal task in the computing *mix*. The purpose of this program is significantly different from the test routines discussed previously. The normal operational on-line diagnostic level tests general system integrity and the off-line keyboard level tests the modular components — both will detect solid failures which will show up with a thorough, though nonrepetitive series of tests. The host CPU level is looking for transients — intermittent failures which occur very seldom but more often than the 10^{12} bit failure rate allows. These failures are very difficult to isolate and have given rise to maintenance comment that "two percent of the errors take ninety-eight percent of a maintenance technician's time".

The program may be used in either of two test modes. In the first mode, files of indirect (canned) commands are executed by the operator. Results are displayed on a pass/fail basis. Although flexibility is limited, operators with limited knowledge can run the subsystem tests. The second mode is interactive from a display console. In this mode, the technician enters commands to the program. Under his direction routines are executed, contents of internal memory locations are displayed or modified, and results are tested against predefined criteria. The technician must have a high level of knowledge of the subsystem operation to use this mode successfully.

The program can test either the complete subsystem (formatter plus drive) or the formatter only. At the subsystem level, the technician creates a simple program consisting of tape commands (e.g., write forward, close GCR file) and macro commands (e.g., loop, compare buffers) and directs the program to execute it. He also has the capability to specify which errors are to be recognized, counted, and compared against test limits. At the end of the run, an additional command will display the results of the data compare between the actual and expected responses.

The formatter level of this program operates closer to a diagnostic type of testing. A series of module test routines are run in whatever sequence is requested for the number of execution loops specified. The technician can inspect or modify formatter registers or memory, set breakpoints, and display or modify the CAS. As in the subsystem mode, the operator directs the program through a terminal or through running indirect files.

The module test routines consist of interface tests between the host CPU and the formatter, and twenty-four microdiagnostic test packages for internal formatter testing. Each is designed to test the various modules, submodules, or individual circuits of the formatter.

The codes are loaded by the host CPU across the interface. While the microdiagnostics are running, the formatter acts as the master and the host acts as the slave. Each package typically consists of 25 separate tests which check a portion of the formatter and return error messages isolating the faults to the individual circuit boards or to the circuits.

The host program is written primarily in FORTRAN. A few portions, such as the formatter interface drivers must be written in assembly language. The individual microdiagnostic tests are written in 8085 assembly language.

In addition to the registers in the CAS previously discussed, two more registers (20, 21) can be addressed for diagnostic purposes. They are described in Table 7-1 in order that hardware provisions can be made in the host CPU. These registers should only be accessed for diagnostic purposes. Table 7-1 identifies the bits used in CAS addresses 20 and 21. Table 7-2 defines each optional diagnostic name.

Table 7-1
Bit Identities for Registers 20 and 21

CAS Address	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
20	INTERNAL ADDRESS															
21	FM* RDY	FM CLR	MC PE*	INVR *	CPE *	EV PAR	HLDA *	HOLD	INTERNAL DATA							
*Read-only bits																

Table 7-2
Optional Diagnostics

Name	Meaning
MC PE	A microcomputer ROM parity error has occurred.
INVR*	A reference has been made to a non-existent register address.
CPE*	The Formatter has detected a parity error as a result of a write to some register address.
EV PAR	A diagnostic bit which causes even parity to be generated and checked for the I/O bus.
FM CLR	Will cause the Formatter microprocessor to restart at initial program conditions.
HOLD	Will cause the Formatter microprocessor to stop.
*INVR and CPE will also cause a FAULT interrupt to be generated to the host CPU.	

APPENDIX A
GCR ERROR DETECTION AND CORRECTION

Because of the high bit density of GCR, errors are usually caused by track dropouts (identified by the loss of read amplifier signals) or excessive phase shifts in the digital decoding circuits. The coding scheme for GCR is designed to correct these types of errors as well as many random errors which may be spread over many tracks in a record.

CODEWORD

The basis for the GCR error detection and correction lies in the grouping of the data into rectangular codewords with two orthogonal sides for checkbits. See Figure A-1 below and Table 2-1. One of the checkbits is the familiar vertical parity. The other checkbit is the error correcting Code (ECC) character, the eight bits of which are computed from a data polynomial using a generator polynomial.

NOTE

The vertical parity bit of the ECC character is part of the parity checkbit.

ERROR CORRECTION

The error bits along any two tracks form a cluster-error that can be corrected as a unit in each rectangular codeword. Error correction is performed, on the fly, for each rectangular codeword independent of preceding codeword errors. Any error pattern in any single track within a codeword is detectable and correctable. In addition, any two tracks in error within a codeword are correctable, provided the error tracks are identified by some external pointers. However, only those two tracks may be corrected until such time as a resync burst (refer to Paragraph 2.3.3.4) resets the error correction logic.

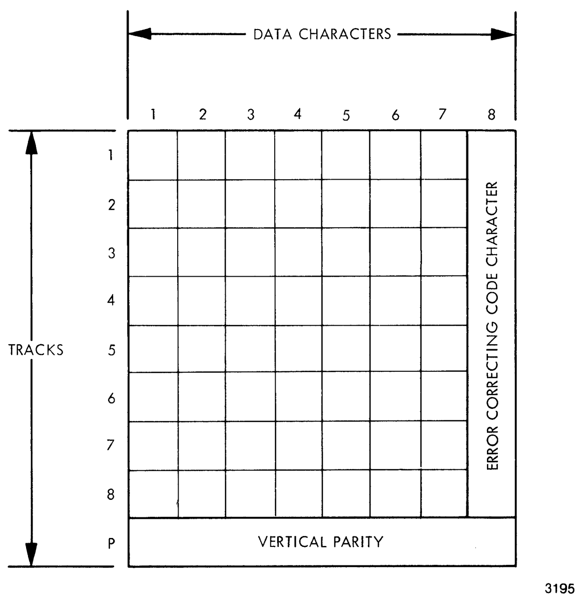


Figure A-1. GCR Rectangular Codeword

ERROR DETECTION

In addition to the ECC character used for error correction, two other check characters are used in the GCR format for error detection. They are the Cyclic Redundancy Check (CRC) character and the Auxiliary Cyclic Redundancy Check (AUX CRC) character. These two check characters do not identify where an error exists, only that one does, thus providing a final check of the data after it has been read. Once a data error condition is indicated, the computer can invoke its retry procedures. It is necessary to use both of these check characters since each code covers most of the holes of the other, thus reducing the probability of undetected errors.

APPENDIX B
BLOCK (RECORD) SIZE VS. DATA CAPACITY

Table B-1 gives the relationship between BLOCK (or RECORD) size and data capacity for PE and GCR modes on a 732-meter (2400-foot) reel of tape.

Table B-1
Data Capacity/Block Size

Block Size Bytes	Data Capacity, Mbytes	
	PE	GCR
256	9.7	21.6
512	16.0	38.6
1K	23.5	62.6
2K	31.1	92.9
3K	34.8	110.8
4K	37.1	122.6
5K	38.6	130.9
6K	39.7	137.1
8K	41.1	145.8
10K	42.0	151.6
12K	42.6	155.7
14K	43.0	158.7
16K	43.4	161.1
18K	43.7	163.0
20K	43.9	164.6
40K	44.9	171.9
80K	45.5	175.9

APPENDIX C
APPLICABLE DOCUMENTS

1. American National Standard ANSI X3.40-1976; Unrecorded Magnetic Tape for Information Interchange (9-Track 200 and 800 cpi, NRZI, and 1600 cpi, PE).

2. American National Standard ANSI X3.39-1973; Recorded Magnetic Tape for Information Interchange (1600 cpi, PE).

3. American National Standard ANSI X3.54-1976; Recorded Magnetic Tape for Information Interchange (6250 cpi, Group-Coded-Recording).

4. PCC PD Engineering Specification for F6250 Formatter, PCC PD Drawing 107311.

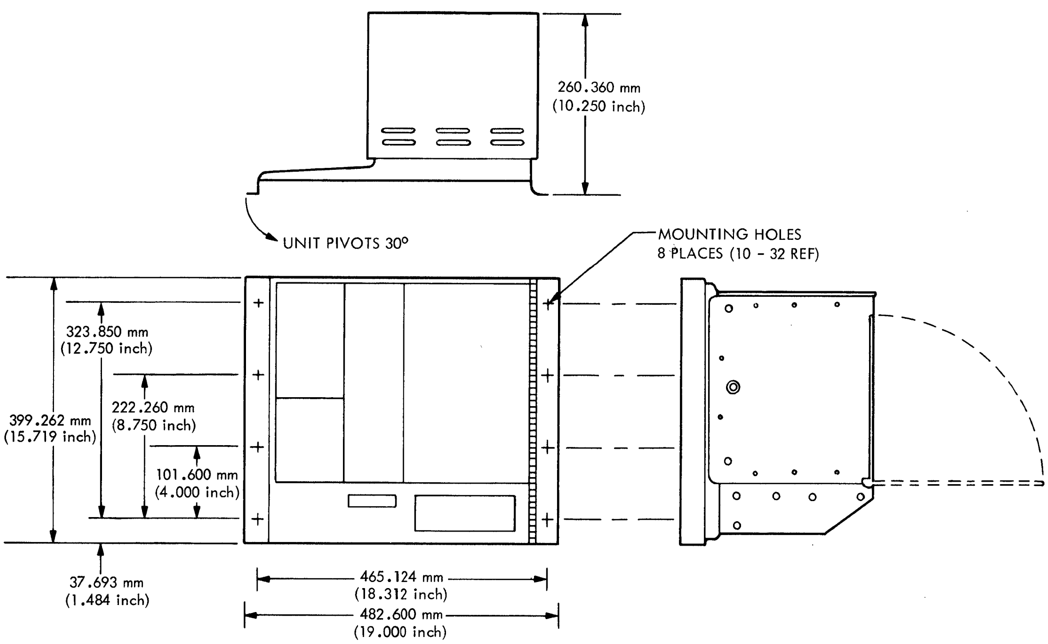
5. PCC PD T1940-96 Tape Transport Specification (Standard Interface and Multiplexed Interface), PCC PD Drawing 107931.

6. PCC PD Engineering Specification for F6250 Formatter Power Supply, PCC PD Drawing 108400.

APPENDIX D
MECHANICAL INTERFACES OF THE FORMATTER AND POWER SUPPLY

When integrating a PCC PD F6250 Formatter into a system, it should be noted that forced convection cooling is the sole means of heat dissipation and that the unit is designed for vertical mounting. The operating temperature range of the unit is consistent with normal environments; however, care must be taken when enclosing the unit to provide adequate air flow so that operating temperature limits will not be exceeded.

Electrical connection between the Formatter and the controller is made through two 34-pin PC mount connectors, J201 and J202, 3M Part Number 3431. Electrical connections between the Formatter and tape units are made through one 50-pin PC mount connector, J102, J103, J104, or J105, 3M Part Number 3433. Electrical connections between the Formatter and its external power supply are made through three connector/cables which mate with power supply connectors.



NOTES:
1. CONFORMS TO EIA STD RS-310 (RACKS, PANEL AND ASSOCIATED EQUIPMENT).
2. DIMENSIONS SHOWN ARE FOR REFERENCE ONLY.
3. FRONT DUST COVER NOT SHOWN. COVER NORMALLY SECURED WITH FOUR SCREWS (ONE AT EACH CORNER), WITH OR WITHOUT STANDOFFS.

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Figure D-1. F6250 Formatter Outline

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PCC

PCC PERIPHERALS

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PCC reserves the right to change specifications at any time. It is PCC policy to improve products as new techniques and components become available.

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