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CDC[®] ADVANCED TAPE SUBSYSTEM
7021-31/32 MAGNETIC TAPE CONTROLLERS
7021-41/42 MAGNETIC TAPE CONTROLLERS
677-2/3/4 MAGNETIC TAPE TRANSPORTS
679-2/3/4/5/6/7 MAGNETIC TAPE TRANSPORTS

SUBSYSTEM REFERENCE MANUAL

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PREFACE

This manual contains general information and external programming information for the CONTROL DATA® Advanced Tape Subsystem (ATS).

The ATS includes 7021-31/32, 7021-41/42 Magnetic Tape Controllers, 677-2/3/4 Magnetic

Tape Transports, and 679-2/3/4/5/6/7 Magnetic Tape Transports. Additional information on the ATS is contained in the following manual.

NOTE

This manual does not include the FV620-A GCR option.

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WARNING

This equipment generates, uses and can radiate radio frequency energy and if not installed and used in accordance with the instructions manual, may cause interference to radio communications. As temporarily permitted by regulation, it has not been tested for compliance with the limits for Class A computing devices pursuant to Subpart J of Part 15 of the FCC Rules which are designed to provide reasonable protection against such interference. Operation of this equipment in a residential area is likely to cause interference in which case the user at his own expense will be required to take whatever measures may be required to correct the interference.

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INTRODUCTION

This manual describes the software capabilities provided by the Advanced Tape Subsystem (ATS).

ATS firmware resides in the read-only memory (ROM) located in the sequencer in the controller. The sequencer and associated firmware enable execution of physical tape operations required as a result of function codes issued from a CDC® CYBER 170, Model 172, 173, 174, or 175; CDC® CYBER Model 72, 73, or 74; or CDC® 6000 peripheral processing unit (PPU).

The ATS firmware serves as a programmable interface between the PPU and control hardware for the magnetic tape transports (tape units).

SUBSYSTEM CONFIGURATIONS

Figures 1-1 and 1-2 show the 1 x 8 and 2 x 8 ATS configurations. The controller in the 1 x 8 configuration connects one computer channel to as many as eight tape units. The controller in the 2 x 8 configuration connects two computer channels to as many as eight tape units. The 2 x 8 configuration consists of two controllers contained in separate cabinets.

The 2 x 8 configuration may connect to two channels from the same computer or to two channels from different computers. Data transfers to both channels from the 2 x 8 ATS may occur simultaneously. A connect to the same tape unit is on a one-at-a-time basis. The ATS provides the computer system with the recording capabilities listed in table 1-1. The ATS supports any intermix of tape units with the following restrictions.

- Any tape speed may be used for nonreturn to zero (NRZI) and phase encoding (PE) recording on any 6000, CDC CYBER 70, or CDC CYBER 170 system, provided no more than two other devices are daisy chained on the channel ahead of the ATS.
- A tape speed of 200 ips for group coded recording (GCR) is not allowed on 6000 or CDC CYBER systems, and the ATS must be the first device on the channel for CDC CYBER 170 systems. A 500-nanosecond transfer rate must be used on the CDC CYBER 170 channel.
- A tape speed of 150 ips for GCR recording requires that the ATS be the first or second device on the channel for 6000, CDC CYBER 70, or CDC CYBER 170 systems.
- A tape speed of 100 ips for GCR recording requires that the ATS be the first or second device on the channel for 6000 and CDC CYBER 70 systems and first, second, or third on the channel for CDC CYBER 170

systems. A 500-nanosecond transfer rate must be used when the ATS is the third device on the CDC CYBER 170 channel.

FUNCTIONAL DESCRIPTION

The channel interface receives a function code from the channel and sends it to the sequencer. The sequencer translates the function and selects a sequence of control words residing in its memory. Each control word provides a command code or a status select. There are 32 16-bit command codes which are used to provide control signals to other portions of the controller and to the tape units. Any one of 128 possible status conditions can be tested. These status conditions are used to define the next command code issued by the sequencer. The sequencer is capable of issuing one control word every 800 nanoseconds.

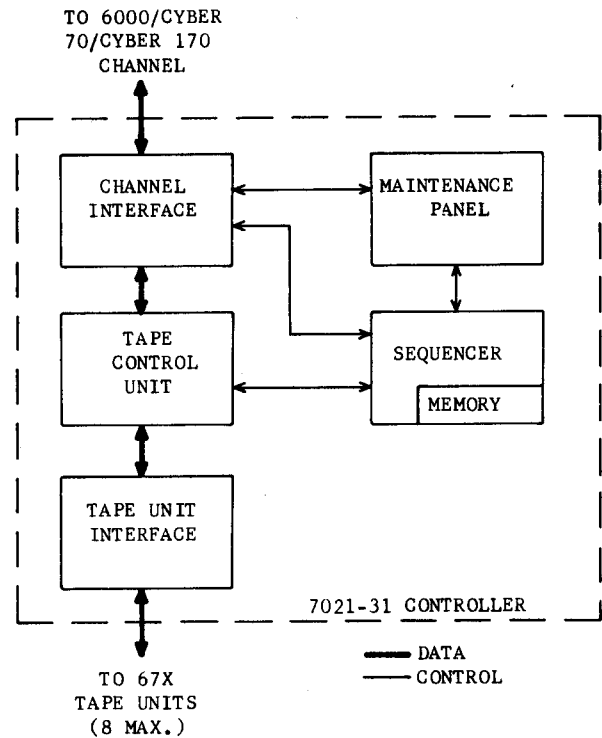
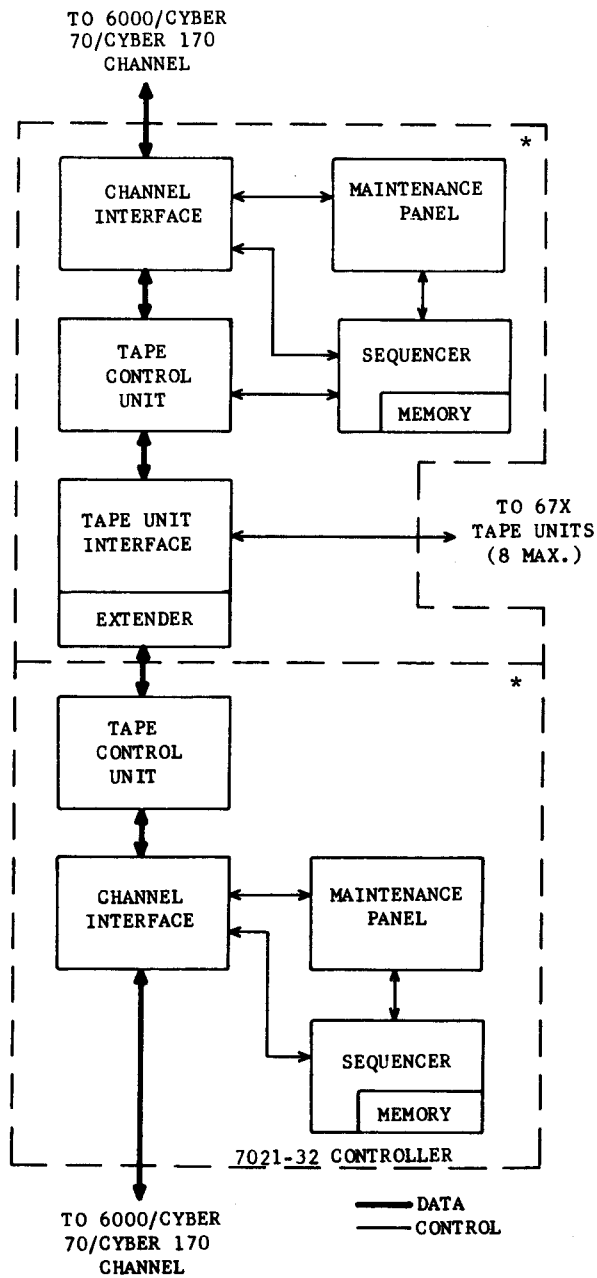


Figure 1-1. 1 x 8 ATS Configuration



* UPPER AND LOWER SECTIONS OF
DIAGRAM ARE CONTAINED IN
SEPARATE CABINETS

Figure 1-2. 2 x 8 ATS Configuration

TABLE 1-1. ATS RECORDING CAPABILITIES

Tape Unit	Tracks	Speed	Recording Method	Recording Density		
				PE	GCR	NRZI
679- 5	9	100 ips	PE and GCR	1600 cpi	6250 cpi	-
679- 6	9	150 ips	PE and GCR	1600 cpi	6250 cpi	-
679- 7	9	200 ips	PE and GCR	1600 cpi	6250 cpi	-
679- 2	9	100 ips	PE and NRZI	1600 cpi	-	800 cpi
679- 3	9	150 ips	PE and NRZI	1600 cpi	-	800 cpi
679- 4	9	200 ips	PE and NRZI	1600 cpi	-	800 cpi
677- 2	7†	100 ips	NRZI	-	-	556 and 800 cpi
677- 3	7†	150 ips	NRZI	-	-	556 and 800 cpi
677- 4	7†	200 ips	NRZI	-	-	556 and 800 cpi

†ATS also has read capability for 7-track, 200 cpi.

Abbreviations:

PE Phase encoding
GCR Group coded recording
NRZI Nonreturn to zero
ips Inches per second
cpi Characters per inch

INTRODUCTION

The function codes recognized by the controller are listed in table 2-1. Each function code is an octal code. The upper three bits (E digit) of each function code contain the equipment number of the controller. The equipment number in the function code must match the equipment number that is hard-wired in the controller. The equipment number is zero but may be modified by changing controller backpanel wiring.

Function codes and subfunction codes (bits 2⁶ through 2⁸) not listed in table 2-1 are illegal. An illegal function is either rejected by the controller or interpreted as a legal function listed in table 2-1.

One or more function codes must be sent by the PPU to the controller before transfer of data may occur between the computer channel and tape unit (TU). These initial function codes select the TU, specify recording mode and controller formats, and start tape motion. The sequencer translates each function code into command codes that are then sent to the tape control unit (TCU) or TU.

The PPU must request status with a function code after each function code is sent to determine if the function was performed. If the alert bit in returned status word 1 is a 0, the function was successfully executed. If the alert bit is a 1, succeeding status words must be examined to determine the error condition. The error code in status word 3 indicates a specific error that caused the function to fail. No error code in status word 3 and an alert bit in status word 1 indicate that the operation (including correct positioning of the tape) was performed, but a data error or a warning condition may exist.

If any function is issued (except E011 and E012) while the unit is busy, the function is rejected and a hang condition may occur. In this case, deactivate the channel and retry the function.

Status is reported only on the final block for those functions, such as search tapemark, that involve more than one block. The format unit and connect function codes clear any status conditions that may have remained from previous operations.

At the completion of each function, the sequencer returns to its idle loop and waits for the next function code. A function reply is returned to the PPU within 20 microseconds after the sequencer enters the idle loop regardless of any error, except channel parity error on the function code or a warmstart read error. At this time, the PPU avoids a longer delay by sending a status function code to determine end of operation of the previous function. Although no end of operation status bit exists, the sequencer indicates end of operation by returning the first word of requested status within 10 microseconds after receiving the status request. If more than 10 microseconds elapse, the PPU must de-

TABLE 2-1. FUNCTION CODES

Code	Name
E000	Clear tape unit
E001	Release connected unit
E004	Format unit
E005 †	Opposite parity (7-track only)
E105 †	Opposite density (7-track only)
E006 †	Normal read clip
E106 †	High read clip
E206 †	Low read clip
E306 †	Hyper read clip
E010 ††	Rewind
E110 ††	Rewind unload
E011	Stop motion
E012	General status (words 1 through 16)
E112	Detailed status (words 3 through 16)
E212	Unit status (words 11 through 16)
E013	Forespace (forward space)
E113	Backspace (backward space)
E114	Controlled backspace (equivalent number of words to move tape)
E015	Search tapemark forward
E115	Search tapemark backward
E02U	Connect to unit 0U (tape unit 0, 1, 2, 3, 4, 5, 6, or 7)
E03U	Connect to unit 1U (tape unit 10, 11, 12, 13, 14, 15, 16, or 17)
E12U	Warmstart read unit 0U (high density)
E13U	Warmstart read unit 1U (high density)
E32U	Warmstart read unit 0U (low density)
E33U	Warmstart read unit 1U (low density)
E040	Read forward
E140	Read backward
E047	Copy code translation read RAM
E247	Copy code translation write RAM
E050	Write
E250	Short write
E051	Write tapemark
E052	Erase
E252 ††	Data security erase (DSE)
E057	Load code translation read RAM
E257	Load code translation write RAM
E060	Rewind if EOT detected
E061	Wait for motion to stop
E071	Test velocity detectors

TABLE 2-1. FUNCTION CODES (Contd)

Code	Name
E072	Measure gap size forward
E172	Measure gap size backward
E073	Measure start time forward
E173	Measure start time backward
E074†	Set transfer check characters
E075†	Set loop write-to-read through TCU
E175†	Set loop write-to-read I through tape unit
E375†	Set loop write-to-read II through tape unit
E076†	Set even write path parity
E176†	Set even channel parity
E077†	Force data errors
E414	Master Clear

† One-shot function, condition is cleared at end of operation following next action function.
 †† Function overlaps with other function in progress on other tape unit.

activate the channel and repeat the status request. The worst-case time for the controller to reply with an inactive pulse to a status or stop motion function code is 70 milliseconds. The controller contains a 5-second deadman timer circuit to prevent the PPU from getting hung-up in a block transfer operation. The timer begins counting when the channel goes active and is reset by an empty or deactivate pulse from the PPU or ATS. If the timer expires, a deactivate pulse is returned to the PPU. A master clear is not generated, and the error is not reported in status. The deadman timer is not active during function operation.

FUNCTION CODES

The following paragraphs describe the octal function codes listed in table 2-1.

E000 — CLEAR TAPE UNIT

This code allows the PPU to clear temporary error conditions in the tape unit. Tape unit modes such as ready, write, and forward are not affected by this function.

A clear pulse is sent to the connected tape unit, and an inactive signal is returned to the PPU. During this time, the tape unit remains connected. If a tape unit is not connected, the function results in a no operation.

E001 — RELEASE CONNECTED UNIT

This code releases the currently connected tape unit to allow it to be available for connection to another controller. If a tape unit is not connected, the function results in a no operation.

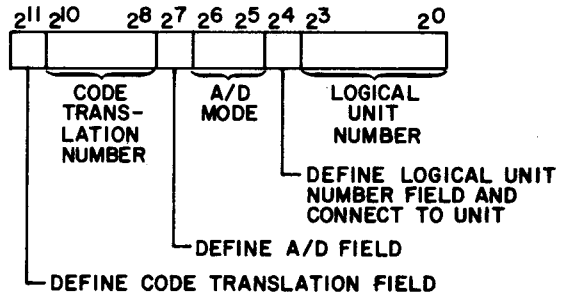
E004 — FORMAT UNIT

This code connects the controller to a tape unit and specifies the recording mode for the tape unit. It may also be used to modify one or more recording mode parameters without requiring all fields to be defined. The controller must be reformatted each time a new unit is selected.

After replying to the function, the sequencer waits for the PPU to activate the channel and send the first parameter word. Parameters in that word are processed before an empty signal is returned. If a connect is requested and cannot be completed, the channel is deactivated without accepting parameter word 2 or 3. If the connect field is defined, the specified tape unit is connected. Each of the other defined fields is stored, replacing the previous value. Undefined fields result in the previously defined values being retained. Parameter word 1 must always be sent. Parameter words 2 and 3 do not have to be sent if their fields are unchanged. If parameter word 3 is sent, it must be preceded by words 1 and 2.

Parameter (Word 1)

This word has the following format.



Bit 2¹¹ indicates that bits 2⁸ through 2¹⁰ contain the code translation number.

Bits 2⁸ through 2¹⁰ are coded as follows:

Bit	2 ¹⁰	2 ⁹	2 ⁸	
	0	0	0	No translation
	0	0	1	
	0	1	0	
	0	1	1	
	1	0	0	
	1	1	1	Translate with code table 1 through 4 (table must be loaded with desired code set before correct translation will occur).
	1	1	0	
	1	1	1	

Bit 2⁷ defines bits 2⁵ and 2⁶ as an assembly/dis-assembly code.

Bits 2⁵ and 2⁶ are coded as follows:

Bit	2^6	2^5	
0	0	0	6-bit mode (1 byte equals 2 frames). Refer to figure 2-1.
0	1	1	Packed mode (2 bytes equal 3 frames). Refer to figure 2-2.
1	0	0	Undefined
1	1	1	Undefined

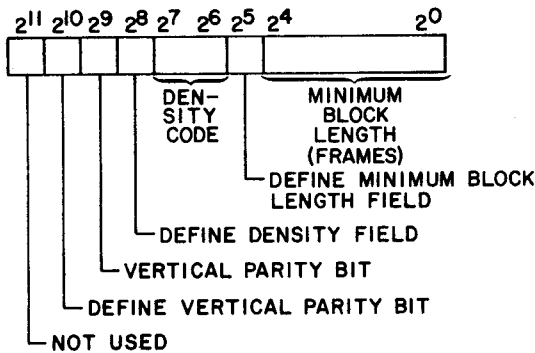
Bit 2^4 defines bits 2^0 through 2^3 as the code for the tape unit number and connection to that tape unit.

Bits 2^0 through 2^3 are coded for tape units 0 through 17. Only tape unit numbers 0 through 7 are allowed in a 1 x 8 or 2 x 8 configuration.

Code 0000 connects tape unit 0, and code 1111 connects tape unit 17.

Parameter Word 2

This word has the following format.



Bit 2^{11} is not used.

Bit 2^{10} defines bit 2^9 as the vertical parity bit.

Bit 2^9 indicates even vertical parity when it is a 1 and odd vertical parity when it is a 0.

Bit 2^8 defines bits 2^6 and 2^7 as the density code.

Bits 2^6 and 2^7 are coded as follows:

Bit	2^7	2^6	
0	0	0	800 cpi for 7-track unit 1600 cpi for 9-track unit
0	1	1	556 cpi for 7-track unit 800 cpi for 9-track low density unit 6250 cpi for 9-track high density unit
1	0	0	200 cpi 7-track unit (read-only) 1600 cpi 9-track unit
1	1	1	200 cpi 7-track unit (read-only) 800 cpi 9-track low density unit 6250 cpi 9-track high density unit

For 7-track units, density is selected whenever the density field is defined and a tape unit is connected.

For 9-track units, the density field is effective only when writing from loadpoint.

Bit 2^5 defines bits 2^0 through 2^4 as the minimum block length field in frames. These are data frames only and do not include preamble, postamble, or any other format frames.

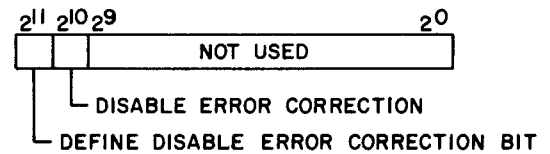
Bits 2^0 through 2^4 are coded as follows:

Bit	2^4	2^3	2^2	2^1	2^0		
	0	0	0	0	0	No noise recovery is performed	
	0	0	0	0	1	Blocks less than this selected value (data frames only and not tapemarks) are bypassed during read operations. The maximum decimal values that may be used are 31 for NRZI, 29 for PE, and 20 for GCR.	
							through
	1	1	1	1	1		

Minimum block length is used for read forward/backward and forespace/backspace operations.

Parameter Word 3

This word has the following format.



Bit 2^{11} defines bit 2^{10} as the disable error correction bit.

Bit 2^{10} indicates that error correction is disabled in all recording modes (GCR, PE, and NRZI) when a 1. When a 0, this bit indicates that error correction is enabled in all recording modes.

Bit 2^9 defines 2^8 as the single frame skew bit.

Bit 2^8 indicates that single frame skew check is selected. Usage of this bit is for diagnostics only.

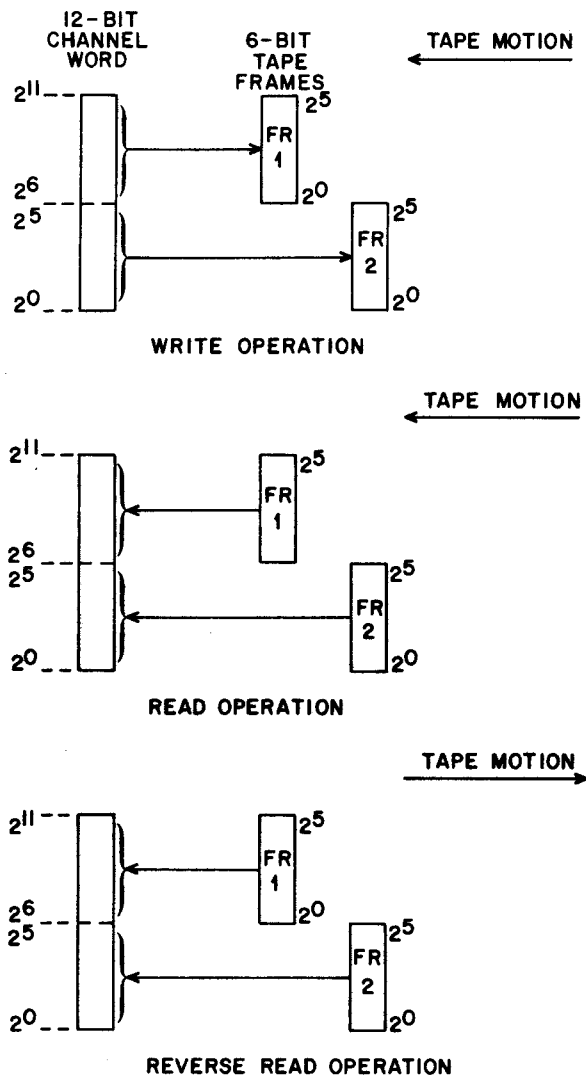


Figure 2-1. 6-Bit Mode (Assembly/Disassembly Mode 0)

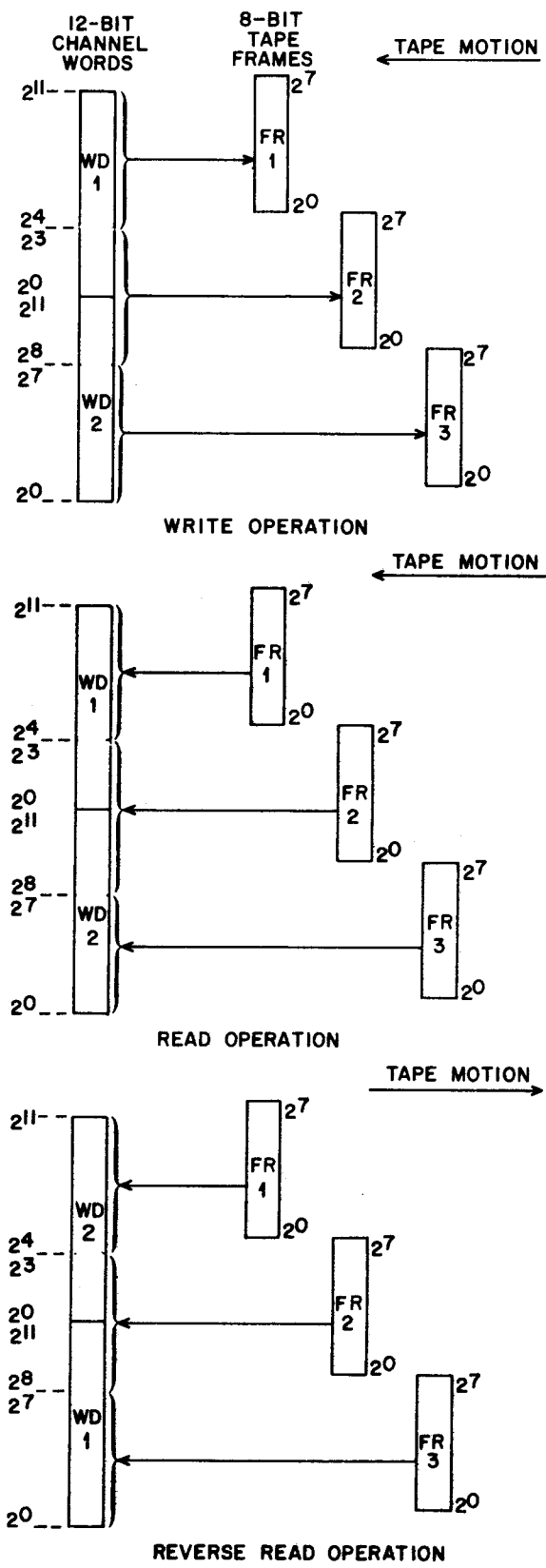


Figure 2-2. Packed Mode (Assembly/Disassembly Mode 1)

Following a master clear function, master clear signal, deadstart, or manual master clear, the default values for parameter word fields are:

Code translation = 0 (none)
A/D mode = 0 (6-bit)
Connected unit = none
Vertical parity = 0 (odd)
Recording mode = PE
Minimum block length = 0 (no noise recovery)
Error correction enabled

NOTE

A connect code does not change or reset previous values. In particular, density for 9-track recording remains the same as last selected in the tape unit. This allows a tape unit to be connected from either controller of a 2 x 8 configuration without disturbing its density. The controller reverts to PE recording mode when a tape unit is not connected. Density for 7-track recording is stored in the controller and remains the same as that last selected by a format unit function.

E005 — OPPOSITE PARITY

This function specifies that the next read-type function will use a vertical parity opposite to that specified in the last format unit function. It simplifies 7-track read error recovery by allowing the PPU to vary vertical parity without knowing if even or odd vertical parity is in use. It is effective for 7-track loop write to read operation and is a no operation for 9-track units. The parity change is reflected in bit 1 of status word 2. The following are considered read-type functions.

- Forespace/backspace
- Search tapemark forward/backward
- Measure gap size forward/backward
- Read forward/backward
- Read with check characters (forward/backward)

Parity specified in the last format unit function is restored at the end of operation of any action function. The following are considered action functions.

- Format/connect unit
- Rewind/rewind unload
- Forespace/backspace
- Controlled backspace
- Search tapemark forward/backward
- Warmstart read
- Read forward/backward
- Copy code translation read/write RAM
- Write/short write
- Write tapemark
- Erase/data security erase

- Load code translation read/write RAM
- Measure gap size forward/backward
- Measure start time forward/backward
- Set loop write-to-read through tape control unit
- Master clear

E105 — OPPOSITE DENSITY

This function specifies that the next write, loop write-to-read, or read-type function (refer to E005 description) will use a density opposite to that specified in the last format unit function. It simplifies 7-track read error recovery by allowing the PPU to vary density without knowing if 556-cpi or 800-cpi density is in use. It is a no operation for 9-track tape units and 7-track tape units using 200-cpi density. The original specified density is restored at the end of operation of any action function (refer to E005 description). The current density status is reflected in bit 2⁸ of status word 11.

E006 — NORMAL READ CLIP

This function simplifies PPU coding in read error recovery by allowing the clip level function to be issued even when a nominal clipping level is desired. The controller returns an inactive signal to the PPU. No other action occurs.

E106 — HIGH READ CLIP

This function specifies that the next read-type function (refer to E005 description) will be done at a higher than normal clipping level. It enables the PPU to raise the read clipping level during read error recovery to a level between normal and hyper. The clipping level is restored to normal at the end of operation of any action function (refer to E005 description).

E206 — LOW READ CLIP

This function specifies that the next read-type function (refer to E005 description) will be done at a lower than normal clipping level. It enables the PPU to lower the read clipping level during read error recovery to the same level used during erase operations. The clipping level is restored to normal at the end of operation of any action function (refer to E005 description).

E306 — HYPER READ CLIP

This function specifies that the next read-type function (refer to E005 description) will be done at a much higher than normal clipping level. It enables the PPU to raise the read clipping level during read error recovery to the same level used during write operations. The clipping level is restored to normal at the end of operation of any action function (refer to E005 description).

E010 — REWIND

This function repositions the tape to loadpoint on a tape unit that is connected, ready, and not busy. If the write current in the tape unit is still on at the end of the previous operation, a write jog (1.0 inch of tape erased) is performed. A rewind command is then sent to the tape unit, and the sequencer returns to the function idle loop. This allows operations to be performed on other tape units while a rewind is in progress.

E110 — REWIND UNLOAD

This function repositions the tape to loadpoint and then unloads tape on a tape unit. If the write current in the tape unit is still on at the end of the previous operation, a write jog (1.0 inch of tape erased) is performed. A rewind unload command is then sent to the tape unit, and the sequencer returns to the function idle loop. This allows operations to be performed on other tape units while a rewind unload is in progress.

The tape unit must be connected, ready, and not busy in order for the rewind or rewind unload functions to execute.

E011 — STOP MOTION

This function is used to stop tape motion immediately [before an interblock gap (IBG) is reached] if a read forward/backward function, forespace/backspace function, or search tapemark forward/backward function is in progress.

If the sequencer is in its idle loop, this function is identical to the wait for motion to stop function (E061), except that the tape control unit status is not cleared.

The tape unit must be connected, ready, and not busy in order for the function to execute.

E012 — GENERAL STATUS

This function is used to request status from the controller and to determine when end of operation occurs.

If an end of operation has occurred, a function reply is returned to the PPU within 10 microseconds. After the PPU activates the channel, up to sixteen 12-bit status words (beginning with status word 1) are returned to the PPU. The status words are described in section 3. No error is reported if the PPU elects to deactivate the channel before accepting the full set of status words. The sequencer deactivates the channel after the last word of the set is accepted by the PPU.

If an end of operation has not occurred and a read-type function (refer to E005 description) is in progress, a function reply is sent to the PPU within 8 milliseconds, but no status words are returned. After receiving a function reply, the PPU activates

the channel and waits 10 microseconds for a full signal before deactivating the channel. The PPU may continue to check for end of operation by sending the status function at selected intervals.

If a function other than a read-type function is in progress, a function reply is not sent to the PPU until an end of operation occurs. A maximum delay of 50 milliseconds could occur while waiting for completion of a write tapemark or erase function.

E112 — DETAILED STATUS

This function is the same as the general status function, except up to fourteen 12-bit status words (beginning with status word 3) are returned to the PPU.

E212 — UNIT STATUS

This function is the same as the general status function, except up to six 12-bit status words (beginning with status word 11) are returned to the PPU.

E013 — FORESPACE

This function is used to position tape forward over the next physical data block without transferring data over the 6000/CDC CYBER channel. It may be used to test validity and generate block identification (ID) status of a data block since all error checks are performed on the block. The EOT is not monitored and tape may be pulled off the supply reel if this function is executed after the EOT is sensed.

Tape is moved forward until either 25 feet of blank tape is passed over or a physical record of at least minimum block size (as specified in the format unit function) is read. Data transfer is disabled, and the channel is not required to be active. Tape motion continues to the next IBG. The tape unit must be connected, ready, and not busy in order for the function to execute.

E113 — BACKSPACE

This function is used to position tape backward over the next physical data block on a tape unit without transferring data over the 6000/CDC CYBER channel. It may be used to test validity and generate block ID status of a data block since all error checks are performed on the block.

If the write current in the tape unit is still on at the end of the previous operation, a write jog (1.0 inch of tape erased) is performed. Tape is then moved backward until either 25 feet of blank tape is passed over, loadpoint is reached, or a physical record of at least minimum block size (as specified in the format unit function) is read. Data transfer is disabled, and the channel is not required to be active. Tape motion continues to the next IBG.

The tape unit must be connected, ready, and not busy in order for the function to execute.

E114 — CONTROLLED BACKSPACE

This function is used to move tape backward a distance determined solely by the number of words transmitted by the PPU. The function is used during write recovery to prevent premature stopping within an erroneous data block because of a false end of record.

After replying to the function, the sequencer waits for the PPU to activate the channel and start sending data. Backward tape motion is then started and continued until no more data is sent. At this time, the channel should be deactivated to prevent a lost data error. Nothing is erased or written on the tape during the backspace. A write jog is not performed before starting backward motion.

The first word of data is accepted when the read head is at the last frame of the previous block (gap control status). Data is accepted at the same rate as during a write operation. Density and the A/D mode currently selected affect the actual distance the tape is moved. At least one word of data must be sent by the PPU.

After moving the tape the distance determined by the amount of data sent, motion is continued through use of find gap until an IBG is reached. Find gap is a procedure used by the controller to ensure that tape is moved to the next IBG.

The status alert bit is set and an error code stored in status if the previous operation was not a write and if loadpoint is reached while data is still being sent or if no data was sent. The word count must be reduced by 5 to 8 percent to prevent the IBG from being missed because of a slightly fast tape speed.

The tape unit must be connected, ready, and not busy in order for the function to execute.

E015 — SEARCH TAPEMARK FORWARD

This function is used to move tape forward on a tape unit until a tapemark (filemark) is read. A series of forespace operations is performed until a tapemark is read or a catastrophic error occurs. An example of such an error is 25 feet of blank tape. No data is transmitted on the channel during the search for tapemark. If a tapemark is not found, tape will be pulled off the supply reel. Status applies only to the last block read, which is normally the tapemark. Errors in previous data blocks are not reported in status. The tape unit must be connected, ready, and not busy in order for the function to execute.

E115 — SEARCH TAPEMARK BACKWARD

This function is used to move tape backward on a tape unit until a tapemark (filemark) is read. A series of backspace operations are performed until a tapemark is read or a catastrophic error occurs. An example of such an error is load point encountered before finding tapemark. If the write current in the tape unit is on at the end of the previous operation, a write jog (1.0 inch of tape erased) is performed before backward motion starts. No data is transmitted on the channel during the search for tapemark. Status applies only to the last block read, which is normally the tapemark. Errors in previous

data blocks are not reported in status. The tape unit must be connected, ready, and not busy in order for the function to execute.

E02U — CONNECT TO UNIT 0U

Bits 2⁰ through 2² of this function are used to connect tape unit 0, 1, 2, 3, 4, 5, 6, or 7 without using the format unit function. This logically connects the selected tape unit to the channel and disconnects any currently connected tape unit. Motion-related hardware status such as parity error is cleared. If the specified unit is already connected, the unit select line is not disturbed, and only the mentioned status clearing occurs.

If the tape unit is inoperable, an error code is stored in status. The specified unit does not have to be ready, but the controller unit enable switch must be on, and the tape unit cannot be connected by another controller.

The tape unit parameters, including density, selected by the last format unit function are not changed or cleared by the connect to unit function. If the default values specified in the format unit function are desired, a master clear must be accomplished before the connect to unit function is initiated.

E03U — CONNECT TO UNIT 1U

This function is the same as connect to unit 0U function, except tape unit 10, 11, 12, 13, 14, 15, 16 or 17 is selected instead of 0, 1, 2, 3, 4, 5, 6, or 7. Only tape unit numbers 0 through 7 are allowed in a 1 x 8 or 2 x 8 configuration.

E12U — WARMSTART READ UNIT 0U, HIGH DENSITY

This function enables the system to deadstart from magnetic tape with only one function. Bits 2⁰ through 2² of this function connect tape unit 0, 1, 2, 3, 4, 5, 6, or 7. The specified unit must be ready, the controller unit enable switch must be on, and the tape unit cannot be connected by another controller.

A 6-bit assembly/disassembly mode is automatically selected for 7-track tape units while a packed assembly/disassembly mode is automatically selected for 9-track tape units.

This function selects an 800-cpi density for 7-track tape units. The proper density is automatically selected for 9-track tape units. The density for 7-track tape units is effective until the next format unit or master clear function.

Tape is rewound, and the first data block is read. Operation is identical to a read function, except the function reply is not returned to the PPU until the tape unit finishes rewinding. If the tape unit is not available or an error prevents the tape unit from reaching loadpoint, a function reply is not returned to the PPU.

This function must be preceded by a master clear operation to ensure that the default values (refer to E004 description) are selected.

E13U — WARMSTART READ UNIT 1U, HIGH DENSITY

This function is the same as function E12U, except tape unit 10, 11, 12, 13, 14, 15, 16, or 17 is selected. Only tape unit numbers 0 through 7 are allowed in a 1 x 8 or 2 x 8 configuration.

E32U — WARMSTART READ UNIT 0U, LOW DENSITY

This function is the same as function E12U, except 556-cpi density is selected for 7-track tape units.

E33U — WARMSTART READ UNIT 1U, LOW DENSITY

This function is the same as function E12U, except tape unit 10, 11, 12, 13, 14, 15, 16, or 17 is selected and 556 cpi density is selected for 7-track tape units. Only tape unit numbers 0 through 7 are allowed in a 1 x 8 or 2 x 8 configuration.

E040 — READ FORWARD

This function is used to transfer data from a tape unit to the PPU. After returning a function reply, the sequencer starts tape motion and waits for up to 25 feet of tape movement to reach the first data frame. At this time, the channel must go active. After a minimum block length of frames (specified in the format unit function) have been read into the channel interface buffer register, data transfer is enabled to the PPU. If end of operation occurs before the minimum block length is read, the data is discarded as noise, and the read is automatically repeated without PPU intervention.

When the IBG is reached, and the last word has been accepted by the PPU, an inactive pulse is returned by the controller. If the PPU elects to terminate data transfer before end of operation, it sends an inactive pulse to the controller before the channel buffer fills up without causing a lost data error. Tape motion continues until the IBG is reached. Only after the IBG is reached will the status function be accepted by the controller. Status is then reported for the entire data block regardless of when the PPU deactivates the channel. All redundancy checks are performed on the entire data block.

On-the-fly error correction occurs for both PE and GCR recording modes. Error correction occurs in 9-track, NRZI recording mode if the last read function detected a single-track error. Any function other than a read function (for example, a backspace function) may be performed between error detection and error correction for 9-track, NRZI recording.

During the read forward function, tape is moved away from loadpoint. If the end of tape (EOT) marker is reached or passed, the EOT status bit is set. However, a limit is not placed on how far tape may be moved past the EOT marker, and it is the PPU's responsibility to prevent tape from being pulled off the supply reel.

If the channel remains active after the end of data has been detected and the channel buffer is empty, the controller deactivates the channel within 20 micro-

seconds for GCR and PE recording modes and within four cell times for NRZI recording mode. The PPU must not deactivate the channel during an input operation unless the channel is full. (This requirement is not necessary if PPU bit 2⁵ is set in the deactivate channel instruction.)

The tape unit must be connected, ready, and not busy in order for the function to execute.

E140 — READ BACKWARD

This function is the same as the read forward function, except tape is moved toward loadpoint. If the write current in the tape unit is still on at the end of the previous operation, a write jog (1.0 inch of tape erased) is performed. If loadpoint is reached as tape moves backward, the beginning of tape (BOT) status bit sets and tape motion stops. An error is recorded to indicate abnormal termination. Data is assembled with the frames inverted to enable high to low order storage in memory.

E047 — COPY CODE TRANSLATION READ RAM

This function is used to copy the contents of the read RAM table residing in the tape control unit into PPU memory. The read RAM contains 256 8-bit entries. To receive the entire entry, packed assembly/disassembly mode is selected. Since the packed mode produces two 12-bit words for every three 8-bit entries, 171₁₀ 12-bit words must be read to copy the entire contents of read RAM. The lower four bits of word 171 contain the upper four bits of the first 8-bit entry. A deactivate pulse is not returned to the PPU regardless of the number of words read. The PPU must disconnect the channel after receiving the desired number of words. The read RAM table contains an internal code set. The entries are returned to the PPU in an external code set order. (Refer to load code translation read RAM function for format.) Before issuing this function, a format unit function must be issued specifying code table 1, 2, 3, or 4 and assembly/disassembly mode 1. Assembly/disassembly mode 0 for 7-track code sets may be used for 6-bit internal codes,

A tape unit must not be connected in order for the function to execute.

E247 — COPY CODE TRANSLATION WRITE RAM

This function is the same as the copy code translation read RAM function, except that it copies the contents of the write RAM table. The write RAM table contains the external code set. The entries are returned to the PPU in an internal code set order. (Refer to load code translation write RAM function for format.)

E050 — WRITE

This function is used to transfer a block of data from the PPU to the tape unit. At this time, write current is turned on or remains on and tape moves forward. After the end of the IBG is reached, the channel should be active and the PPU output registers full.

The IBG extends an additional 0.1 inch while waiting for channel data before a late data error is reported. If no data is sent within approximately 200 milliseconds, the write operation aborts and tape motion stops.

A write operation terminates when data is no longer available. As long as the 32-frame channel interface buffer register contains data, the channel may be deactivated and activated without an intervening function. This allows two PPUs to perform a chained write operation. The channel must be deactivated when the last frame is taken from the channel interface buffer register. With the buffer register full, the deactivate signal must be sent within 20 microseconds after the last empty signal has been returned to the PPU. If the PPU does not deactivate the channel, the controller deactivates it approximately 200 milliseconds after end of operation.

Error checks are performed on the written data detected by the read head. A discrepancy between the number of frames written and those read is reported as an error. An error is also reported if the tape velocity is not within certain limits.

The tape unit must be connected, ready, not busy, and have a write ring installed in order for the function to execute.

E250 — SHORT WRITE

This function is the same as the write function, except the final character that is transmitted is discarded. The number of characters written during 6-bit assembly/disassembly mode is $2N+1$, and the number is $3N+2$ during packed assembly/disassembly mode. The letter N is any integer.

E051 — WRITE TAPEMARK

This function is used to write an end of file terminating mark on the tape. First, approximately 2 inches of tape are erased, a tapemark is then written, and finally 2 more inches of tape are erased. A read after write check reports an error if poor erasure is detected or the tapemark is not properly detected.

The tape unit must be connected, ready, not busy, and have a write ring installed in order for the function to execute.

E052 — ERASE

This function is used to skip over a bad area of tape by including it in the IBG. Approximately 4 inches of tape, including stop distance, are erased. A read after write check at low clip level reports an error if poor erasure is detected. Any flux changes detected cause the erase error status bit to set.

The tape unit must be connected, ready, not busy, and have a write ring installed in order for the function to execute.

E252 — DATA SECURITY ERASE

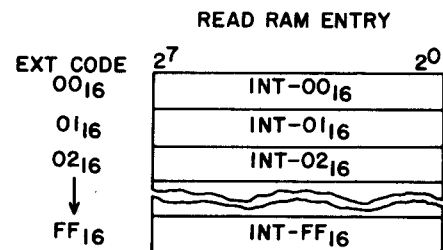
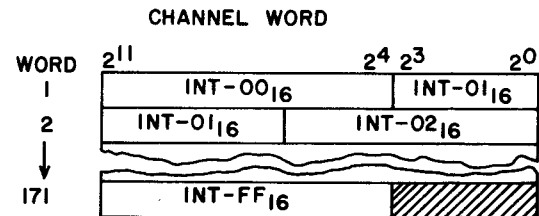
This function is used to ensure that all information following the last good block is erased to prevent unauthorized use of any data that may remain on

the tape. After replying to the function, the sequencer sends a data security erase (DSE) command to the tape unit and returns to its idle loop. This enables operations to be performed on other tape units while a DSE is in progress. The tape unit continues to erase tape until the EOT marker is reached. The only way to stop the tape unit early is to press its CLEAR switch.

The tape unit must be connected, ready, not busy, and have a write ring installed in order for the function to execute.

E057 — LOAD CODE TRANSLATION READ RAM

This function is used to store the code set in the currently selected read RAM table 1 through 4. Attempting to load table 0, 5, 6, or 7 results in data being accepted by the controller but not loaded. The read RAM holds 256 8-bit entries. The entire memory must be loaded. To load the entire entry, packed assembly/disassembly mode is selected. Since the packed mode requires two 12-bit words for every three 8-bit entries, 171_{10} 12-bit words must be written to load the entire read RAM. With packed mode selected, the lower four bits of word 171 are discarded. If more than 256 8-bit characters are written, the read RAM is wrapped, and previously stored entries are overlaid. The read RAM is loaded with the desired internal code set as follows:



Assembly/disassembly mode 0 may be used to load 6-bit codes. In this case, bits 2^6 and 2^7 are set to zero and 128_{10} channel words must be sent to the controller.

When data is read with code translation, each 8-bit external code character from the tape unit is used as an address to read its corresponding internal code character from the read RAM. This internal code character is then sent to the channel in place of the external code character.

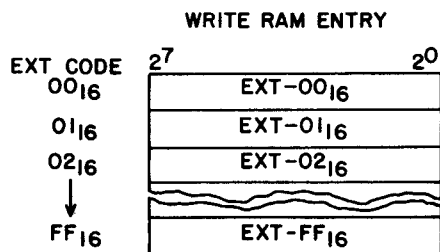
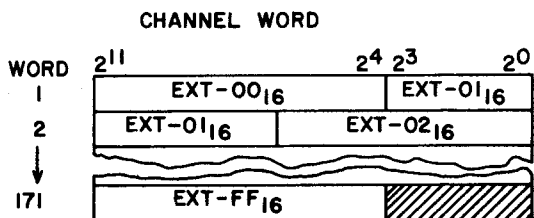
Before issuing this function, a format unit function must be issued specifying code table 1, 2, 3, or 4 and assembly/disassembly mode 1. It is acceptable to use assembly/disassembly mode 0 for 7-track code sets when using 6-bit internal codes. If 6-bit assembly/disassembly mode 0 is used, each channel word loads two RAM locations. Bits 2^6 and 2^7 of each location are set to 0. An output of 12810 channel words are used to load the entire RAM.

To allow detection of illegal 8-bit external code characters when translating to a 6-bit internal code, bit 2^6 may be set in all read RAM entries that correspond to the unacceptable external code. If bit 2^6 is then detected, the flag bit detected and alert status bits will set.

A tape unit must not be connected in order for the function to execute.

E257 — LOAD CODE TRANSLATION WRITE RAM

This function is the same as the load code translation read RAM function, except that it stores the code set in the write RAM table. The write RAM is loaded with the desired external code set as follows:



When data is written with code translation, each 8-bit internal code character from the channel is used as an address to read its corresponding external code character from the write RAM. This external code character is then sent to the tape unit in place of the internal code character.

E060 — REWIND IF EOT DETECTED

This function is used to prevent tape from being pulled from the supply reel while executing operations from the maintenance panel. If tape is at

or past the end of tape marker, a rewind operation and write jog, if needed, are executed. With tape at any other position, an operation does not occur.

The tape unit must be connected, ready, and not busy in order for the function to execute.

E061 — WAIT FOR STOP

This function is used to enable a start and stop mode of operation and to delay execution of the next function until a rewind is completed while executing operations from the maintenance panel.

After sending a function reply, the sequencer waits for not busy status (rewind not in progress) before testing the parked status bit. The parked status bit indicates that tape motion caused by an operation other than a rewind has stopped and the operation is complete.

The tape unit must be connected and ready in order for the function to execute.

E071 — TEST VELOCITY DETECTORS

This function is used to check operation of the tape velocity detectors in the tape control unit. The sequencer logically disconnects the tape unit and simulates tach pulses for slow, nominal, and fast tape speeds. Velocity status should be down for the slow and fast rates and up for the nominal rate. If not, the alert status bit is set and an error code is stored in status.

E072 — MEASURE GAP SIZE FORWARD

This function is used to check that the tape unit is able to provide the correct IBG length. It is also used to test the correspondence of velocity and distance over the IBG when its true length is known. The function moves tape two forespaces over consecutive data blocks. The IBG between the two blocks is measured for distance and time. The results are stored in status word 10. A read after write hyper clip level is used to minimize the chance of IBG noise affecting test results. Bits 2^6 through 2^{11} of status word 10 contain the number of tach pulses detected within the IBG. Each tach pulse equals 0.009425 inch. Bits 2^0 through 2^5 of status word 10 contain the time in 160-microsecond increments required to pass over the IBG. If more than 63 of these time increments elapse, the count remains at 63.

For all 7-track tape units with a 0.75-inch gap, there should be approximately 79.6 tach pulses. There should be approximately 46.9, 31.2, and 23.4 time increments for those tape units having 100-ips, 150-ips, and 200-ips speeds, respectively.

For all 9-track tape units with a 0.6-inch gap, there should be approximately 63.7 tach pulses. There should be approximately 37.5, 25.0, and 18.7 time increments for those tape units having 100-ips, 150-ips, and 200-ips speeds, respectively.

For all 9-track tape units with a 0.3-inch gap, there should be approximately 31.8 tach pulses. There should be approximately 18.7, 12.5, and 9.4 time increments for those tape units having 100-ips, 150-ips, and 200-ips speeds, respectively.

Before using this function, the two consecutive blocks must have been previously written on the tape and positioned forward of the read head.

The tape unit must be connected, ready, and not busy in order for the function to execute.

E172 — MEASURE GAP SIZE BACKWARD

This function is the same as the measure gap size forward function, except that it moves tape two backspaces over consecutive data blocks.

E073 — MEASURE START TIME FORWARD

This function is used to check that the tape unit reaches operation speed within an acceptable time and distance. The function moves tape one fore-space over a data block. The time and distance required for tape to reach 95 percent of operating speed is measured, and the results are stored in status word 10. Bits 2⁶ through 2¹¹ of status word 10 contain the number of tach pulses detected until the tape is up to speed. Each tach pulse equals 0.009425 inch.

Bits 2⁰ through 2⁵ of status word 10 contain the time in 40-microsecond increments until the tape is up to speed. If more than 63 of these time increments elapse, the count remains at 63.

The start distance should be 8 (+3, -1) tach pulses for 100-ips, 150-ips, and 200-ips 9-track PE/GCR tape units. The start distance should be 7 (+3, -1), 10 (+3, -1), and 12 (+3, -1) tach pulses for 100-ips, 150-ips, and 200-ips 9-track PE/NRZI or 7-track NRZI tape units, respectively.

The start time should be 31.0±3.1, 25.0±2.5 and 20.0±2.0 time increments for 100-ips, 150-ips, and 200-ips 9-track PE/GCR tape units, respectively. The start time should be 38.0±3.8, 35.0±3.5, and 33.0±3.3 time increments for 100-ips, 150-ips, and 200-ips 9-track PE/NRZI or 7-track NRZI tape units, respectively.

The tape unit must be connected, ready, and not busy in order for the function to execute.

E173 — MEASURE START TIME BACKWARD

This function is the same as the measure start time forward function, except that it moves tape one backspace over a data block.

The start distance should be 14 (+3, -1) tach pulses for 100-ips, 150-ips, and 200-ips 9-track PE/GCR tape units. The start distance should be 7 (+3, -1), 10 (+3, -1), and 12 (+3, -1) tach pulses for 100-ips, 150-ips, and 200-ips 9-track PE/NRZI or 7-track NRZI tape units, respectively.

The start time should be 45.0±4.5, 40.0±4.0, and 35.0±3.5 time increments for 100-ips, 150-ips, and 200-ips 9-track PE/GCR tape units, respectively. The start time should be 38.0±3.8, 35.0±3.5 and 33.0±3.3 time increments for 100-ips, 150-ips, and 200-ips 9-track PE/NRZI or 7-track NRZI tape units, respectively.

E074 — SET TRANSFER CHECK CHARACTERS

This function is used to check error correction code (ECC) characters during GCR recording. The ECC characters are treated as part of the data during the next read function. This function is cleared at the end of any action function (refer to E005 description). This function does not affect PE or NRZI recording modes. When used for GCR read operations, frame count, CRC, AUX CRC, and CRC 1-2 compare errors occur.

The tape unit must be connected, ready, and not busy in order for the function to execute.

E075 — SET LOOP WRITE-TO-READ THROUGH TAPE CONTROL UNIT

This function is used to check the write and read data paths in the tape control unit (TCU). The write data is passed directly into the TCU read path where full error checking is performed.

The sequencer sets the TCU in loop write-to-read (LWR) mode and waits for the channel to go active. The PPU must send one of the following parameter codes to format the controller.

Parameter Code (octal)	Speed (ips)	Recording Mode
0153	100	GCR
0152	150	GCR
0350	200	GCR
0557	100	PE
0556	150	PE
0754	200	PE
0553	100	9-track NRZI
0552	150	9-track NRZI
0750	200	9-track NRZI
0473	100	7-track NRZI
0472	150	7-track NRZI
0670	200	7-track NRZI

After receiving the parameter word, the sequencer returns an empty signal and the PPU must deactivate the channel. The next write, short write, or write tapemark function is executed in the TCU in the LWR mode. Any other function, except opposite density, opposite parity, even write path parity, even channel parity, and status functions following the set LWR mode in the TCU, is illegal.

Write and forward status are true as long as the controller is in LWR mode. The LWR mode is cleared at the end of any action function (refer to E005 description).

The 9-track NRZI mode always has an 800-cpi density. The density for the 7-track NRZI mode is the same as the last 7-track density set by the format unit function. The 7-track density is set to 800-cpi on any master clear.

The controller disconnects any connected tape unit when this function is executed.

E175 — SET LOOP WRITE-TO-READ I THROUGH TAPE UNIT

This function is used to check the write and read paths in the TCU, TCU to tape unit cable, and tape unit receivers and transmitters.

The sequencer sets the tape unit in LWR mode, replies to the function, and then returns to its idle loop. The next function must be a write, short write, write tapemark, opposite density, opposite parity, or status function. Data is transferred to the tape unit where it is gated directly from the receivers to the transmitters and sent back to the TCU for error checking. The data transfer occurs at the density and speed selected in the tape unit. Write current may be either on or off in the tape unit. Write and forward status is present to the PPU until the LWR mode is cleared. The LWR mode is cleared at the end of any action function (refer to E005 description).

The tape unit must be connected, ready, and not busy.

E375 — SET LOOP WRITE-TO-READ II THROUGH TAPE UNIT

This function is the same as the set loop write-to-read I through tape unit function, except data is transferred to the tape unit where it is gated to the read path (bypassing the write drivers and recording head) and sent back to the TCU for error checking; write current must be off in the tape unit; and the tape unit must be connected, ready, not busy, and not write.

E076 — SET EVEN WRITE PATH PARITY

This function is used to check parity error detection in the tape control unit data path. The next write function is performed with even parity intentionally generated in the write path. This function is cleared at the end of any action function (refer to E005 description).

E176 — SET EVEN CHANNEL PARITY

This function is used to check parity error detection in the PPU. The next read function supplies even channel parity on data sent to the PPU and the status functions supply even parity on status sent to PPU. This function is cleared at the end of any action function (refer to E005 description).

E077 — FORCE DATA ERRORS

This function is used to disable one or more tracks during the next write function in order to check

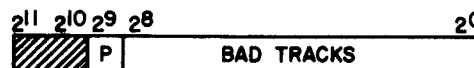
error correction during the succeeding read function or loop write to read function.

This function enables the next write function to produce a data block with bad tracks as specified in the accompanying parameter word.

The recording mode determines the method of disabling a track. For NRZI mode, all zeros are written in the track (dc erased). For PE mode, all data transitions are disabled. For GCR mode, illegal 4-bit to 5-bit code translations are performed.

The function is cleared at the end of any action function (refer to E005 description) or before writing the GCR residual and CRC groups.

The parameter word has the following format.



Bits 210 and 211 are not used.

Bit 29 is used for PE mode only. When it is a 1, bad tracks are written in the entire block including the preamble. When it is a 0, the preamble is written in a normal manner. This bit must be a 1 for NRZI and GCR recording.

Bits 20 through 28 specify which tracks will be disabled. Bit assignments are as follows:

Bit	Track
28	9
27	8
26	7
25	6
24	5
23	4
22	3
21	2
20	1

This function may be used with a write function, loop write-to-read through TCU function, or loop write-to-read through tape unit function. If used with either loop write-to-read function, this function must follow the loop function. The data pattern must be all 0's or all 1's if PE mode is used. For GCR mode, all 4-bit codes except 0000 cause an illegal 5-bit code to be generated.

E414 — MASTER CLEAR AND GO

This function is used to provide a programmed master clear. The controller responds to this function in the same manner as to a channel master clear signal. It is recognized by the channel interface rather than by the sequencer. A function reply is returned to the PPU within 5 microseconds after the controller receives the function. A master clear signal is sent to the TCU which disconnects any currently connected tape unit. The sequencer is returned to location zero and executes an internal diagnostic program before going to the idle loop.

INTRODUCTION

The controller returns status information to the PPU in response to general, detailed, and unit status functions. For general status, up to sixteen 12-bit status words are returned to the PPU. For detailed status, the first two words are skipped and words 3 through 16 are returned to the PPU. For unit status, the first 10 words are skipped and words 11 through 16 are returned to the PPU. Table 3-1 identifies each bit of the 16 status words.

Bits 2^4 , 2^5 , and 2^{11} of word 1, bits 2^0 through 2^{11} of words 2 through 7, bits 2^0 through 2^6 and 2^9 through 2^{11} of word 8, and bits 2^5 through 2^{11} of word 9 originate in the TCU. These status bits are cleared by all functions from the PPU, except the status functions.

Bits 2^0 through 2^3 and 2^7 of word 1, bits 2^7 and 2^8 of word 8, and bits 2^0 through 2^7 of words 11 through 16 originate in the tape unit. These status bits are cleared when the tape unit is released.

STATUS WORD DEFINITIONS

WORD 1 — GENERAL STATUS

Bit 2^{11} — Alert

This bit indicates that an abnormal condition is reported in various status words.

The following status word bits cause the alert bit to set.

Status Word	Bit	Description
3	2^{11}	Lost data
3	2^{10}	Unit check
3	2^9	Tape parity error
3	2^8	Channel parity error
3	2^7	TCU parity error
3	2^6 through 2^0	Error code (excluding zero)
4	2^{11}	Pointer error
4	2^{10}	Dual-track correction
4	2^9	Single-track correction
5	2^{11} through 2^0	
6	2^{11} through 2^0	
9	2^{11}	False gap bypassed
9	2^{10}	Noise bypassed
9	2^8	Late data

Bit 2^{10} — Not Used

This bit is not used.

Bit 2^9 — Tape Unit Not Connected

When this bit is a 0, it indicates that a tape unit is connected.

Bit 2^8 — Not Used

This bit is not used.

Bit 2^7 — Write Ring

This bit indicates that the tape reel has a write ring and therefore is not file-protected.

Bit 2^6 — 9-Track

This bit indicates that a 9-track tape unit is logically connected.

Bit 2^5 — Character Fill

This bit indicates that the lower 6 or 8 bits of the final data word returned to the PPU contain fill bits. This gives the character an undefined value. If only the lower 4 bits of the final data word are fill bits, the character fill bit does not set.

Bit 2^4 — Filemark

This bit indicates that the last data block read or written was identified as a filemark or tapemark.

Bit 2^3 — End of Tape (EOT)

This bit indicates that tape is positioned at or beyond the EOT marker. Less than 10 useable feet of tape remain on the reel. The status bit is cleared when the EOT marker passes the sensor in the reverse direction.

Bit 2^2 — Beginning of Tape (BOT)

This bit indicates that tape is positioned at the BOT marker (loadpoint).

TABLE 3-1. STATUS BIT ASSIGNMENTS

	211	210	29	28	27	26	25	24	23	22	21	20
GENERAL STATUS ORIGIN → WD 1	ALERT	0	TU CONNECT	0	WRITE RING	9 TRACK	CHARACTER FILL	FILE MARK	EOT	BOT	UNIT BUSY	UNIT READY
WD 2	CRC BLOCK ID x ⁸ x ⁷ x ⁶ x ⁵ x ⁴ x ³ x ² x ¹ x ⁰									0	EVEN VERTICAL PARITY	0
DETAILED STATUS ORIGIN → WD 3	LOST DATA	UNIT CHECK	TAPE PARITY ERROR	CHANNEL PARITY ERROR	TCU PARITY ERROR	ERROR CODE						
WD 4	POINTER ERROR	DUAL-TRACK CORRECTION	SINGLE-TRACK CORRECTION	DEAD TRACK REGISTER								
				TRK 9	TRK 8	TRK 7	TRK 6	TRK 5	TRK 4	TRK 3	TRK 2	TRK 1
WD 5	VERTICAL PARITY ERROR	LONGITUDINAL PARITY ERROR	CRC-DETECTED ERROR	AUX. CRC-DETECTED ERROR	CRC1-CRC2 COMPARE ERROR	SINGLE-FRAME ERROR	FALSE EOP	VELOCITY ERROR	FRAME COUNT ERROR	FLAG BIT DETECTED	SLOW START ERROR (WRITE ONLY)	EXCESSIVE SKEW ERROR
WD 6	POINTER MERGE ERROR	WRITE PATH PE	WRITE REGISTER PE	READ CODE TRANSLATION PE	WRITE CODE TRANSLATION PE	READ BUS PE	GCR WRITE PATH PE	GCR WRITE BUS PE	NRZI WRITE PATH PE	NRZI READ PATH PE	BAD RESYNC BURST	POWER INTERRUPT
WD 7	UPPER ROM PE	LOWER ROM PE	SEQUENCE COMMAND ERROR	VALID TRACK POINTERS								
				TRK 9	TRK 8	TRK 7	TRK 6	TRK 5	TRK 4	TRK 3	TRK 2	TRK 1
WD 8	SINGLE FRAME SKEW	CODE TRANSLATION	A/D MODE	LAST DIRECTION REVERSE	LAST OPERATION WRITE	ERROR CORRECTION DISABLED	0	0	0	0	0	0
WD 9	FALSE GAP BYPASSED	NOISE BYPASSED	CRC-CORRECTABLE ERROR	LATE DATA (WRITE ONLY)	CAPSTAN SLIP (WRITE ONLY)	EARLY READ AFTER WRITE EOP	ERASE ERROR	UNDEFINED			CLIP LEVEL FLAG 2 ¹	CLIP LEVEL FLAG 2 ⁰
WD 10	COUNTER # 1						COUNTER # 2					
UNIT STATUS ORIGIN → WD 11	GCR CAPABILITY	NRZI CAPABILITY	0	7-TRACK DENSITY	7-TRACK UNIT	WRITE CURRENT FAILURE	DUAL DENSITY	DENSITY		SPEED		
WD 12	0	0	0	0	LAMP FAILURE	LEFT COLUMN FAULT	RIGHT COLUMN FAULT	RESET BUTTON	DSE	ERASE CURRENT FAILURE	AIR PRESSURE FAILURE	LOAD FAILURE
WD 13	0	0	0	0	WINDOW OPEN	DOOR OPEN	PARKED	AIR FLOW CHECK	THERMAL CHECK	CLEANER ACTIVE	CARTRIDGE PRESENT	CARTRIDGE OPEN
WD 14	0	0	0	0	LOAD BUTTON	AUTO HUB ACTIVATED	SET LOOPS	TAPE PRESENT	REELS LOADED	LOAD-REWIND	LOAD COMPLETE	LOAD CHECK
WD 15	0	0	0	0	AFC FAULT	0	0	0	0	0	0	0
WD 16	0	0	0	0	IBG COUNTER 10 ¹				IBG COUNTER 10 ⁰			

Bit 2¹ — Unit Busy

This bit indicates that the tape unit is performing a rewind or a data security erase function.

Forward or reverse tape motion for all other functions is reported by bit 2⁵ (parked) in status word 13.

Bit 2⁰ — Unit Ready

This bit indicates that tape is loaded and the START switch was the last switch pressed on the tape unit. This bit is a 1 during rewind and data security erase functions and a 0 during a rewind unload function.

WORD 2 — CRC BLOCK IDENTIFICATION

Bits 2¹¹ through 2³ — Block Identification Code

This is a 9-bit cyclic redundancy code that is generated from the last data block that was read or written. Its purpose is to help the PPU locate the last good data block during read or write recovery. The code is invalid if a parity error status bit is set.

For 9-track recording, the block identification code is generated from corrected data before code translation takes place. For 7-track recording, the block identification code is generated after code translation takes place provided BCD coding is selected by the format unit function (E004).

The block identification code is developed for all data transfer operations to and from the tape unit and also for loop write-to-read operations. The code developed when reading a block in reverse is different than the code developed when reading the same block in a forward direction.

Bit 2² — Not Used

This bit is not used.

Bit 2¹ — Even Vertical Parity

This bit indicates that the current vertical parity selected in the TCU is even.

Bit 2⁰ — Not Used

This bit is not used.

WORD 3 — DETAILED STATUS

Bit 2¹¹ — Lost Data

This bit indicates that the PPU failed to deactivate the channel soon enough after stopping the transfer of data or failed to keep up to the tape unit transfer rate.

Bit 2¹⁰ — Unit Check

This bit indicates that an abnormal condition is reported in status words 11 through 13.

The following status word bits cause the unit check bit to set. The unit check bit, in turn, sets the alert bit.

Status Word	Bit
11	2 ⁶ Write current failure
12	2 ⁷ Lamp failure
12	2 ⁶ Left column fault
12	2 ⁵ Right column fault
12	2 ⁴ Reset button
12	2 ² Erase current failure
12	2 ¹ Air pressure failure
12	2 ⁰ Load failure
13	2 ⁷ Window open
13	2 ⁴ Air flow check
13	2 ³ Thermal check

Bit 2⁹ — Tape Parity Error

This bit indicates that an error was detected and reported in status word 4, 5, 6, or 9 in the last data block. This condition requires error recovery by the PPU.

The following status word bits cause the tape parity error bit to set. The tape parity error bit, in turn, sets the alert bit.

Status Word	Bit
4	2 ¹¹ Pointer error
5	2 ¹¹ Vertical parity error
5	2 ¹⁰ Longitudinal parity error
5	2 ⁹ CRC detected error
5	2 ⁸ Auxiliary CRC detected error
5	2 ⁷ CRC1-CRC2 compare error (write mode)
5	2 ⁶ Single frame error
5	2 ⁵ False EOP
5	2 ⁴ Velocity error (write mode)
5	2 ³ Frame count error
5	2 ⁰ Excessive skew error
6	2 ¹ Bad resync burst
9	2 ⁹ CRC correctable error
9	2 ⁷ Capstan slip
9	2 ⁶ Early read after write EOP
9	2 ⁵ Erase error

Bit 2⁸ — Channel Parity Error

This bit indicates that incorrect parity was detected in the data just written. Incorrect channel parity in a function code is indicated by no response from any equipment on the channel and an error code if the next function is a status request.

Bit 2⁷ — TCU Parity Error

This bit indicates that a discrepancy is reported in status words 5, 6, and 7 during an internal data redundancy check in the TCU.

The following status word bits cause the TCU parity error bit to set. The TCU parity error bit, in turn, sets the alert bit.

Status Word	Bit	
5	2 ⁷	CRC1-CRC2 compare error (write mode)
6	2 ¹¹	Pointer merge error
6	2 ¹⁰	Write path parity error
6	2 ⁹	Write register parity error
6	2 ⁸	Read code translation parity error
6	2 ⁷	Write code translation parity error
6	2 ⁶	Read bus parity error
6	2 ⁵	GCR write path parity error
6	2 ⁴	GCR write bus parity error
6	2 ³	NRZI write path parity error
6	2 ²	NRZI read path parity error
7	2 ¹¹	Upper ROM parity error
7	2 ¹⁰	Lower ROM parity error
7	2 ⁹	Sequence command error

Bits 2⁶ through 2⁰ — Error Code

If this code has a value other than zero, it indicates that the requested operation was not performed. All possible coded errors are listed in table 3-2.

WORD 4 — DEAD TRACK REGISTER (FOR 9-TRACK RECORDING ONLY)

Bit 2¹¹ — Pointer Error

During a read operation, this bit indicates that the error is so extensive that correction is impossible. For NRZI recording mode, no correction is attempted in the next read forward function (E040) or read backward function (E140). For PE recording mode, two or more tracks simultaneously contain an error. For GCR recording mode, this status bit is always a 0.

During a write operation in NRZI or PE mode, this bit indicates that one or more tracks contain an error. For GCR mode, more than one track contains an error, or another serious error, such as a dead track, was detected.

Bit 2¹⁰ — Dual-Track Correction (For GCR Mode Only)

This bit indicates that two tracks were simultaneously corrected.

TABLE 3-2. STATUS WORD 3 ERROR CODES

Error Code (Octal)	Description
01	Tape unit off-line or not powered
02	Tape unit connected to another controller
03	Tape unit number manually excluded
04	Tape unit not ready
05	Miscellaneous tape unit check or interrupt
06	Missing write ring
07	Unit not capable of tape's density
10	Over 25 feet of blank tape
12	Bad ID burst written
13	Unit unable to set gains on GCR tape
16	Tape unit AGC not set in all tracks
20	TCU failed velocity test
21	Second block not read by measure gap function
22	Gap size over 20 inches on measure gap function or tape unit failed to reach operating speed for measure start function
30	Loadpoint unexpectedly encountered
31	Tape unit 10 through 17 requested by TCU only supports 0 through 7
32	Tape unit busy rewinding or doing a data security erase
33	Write current on for tape unit loop write-to-read II function
34	Write must precede controlled back-space function
35	TCU not capable of required density
36	Write attempted at 200-cpi density
40	Tape unit gap control status failed
140	Tape unit failed to execute a data security erase
41	Tape unit failed to reach operating speed
42	Tape unit failed to move tape
43	Erase head current failed to turn on
143	Tape unit write status stuck
44	Tape unit failed to stop
45	Tape unit reverse status stuck
145	Tape unit forward status stuck
46	Missing read-after-write end of operation
47	Tape unit failed to select density
50	Illegal function
51	No tape unit connected

TABLE 3-2. STATUS WORD 3 ERROR CODES (Contd)

Error Code (Octal)	Description
52	No function parameters sent
55	Channel parity error on last non-status function
61	Channel not full at beginning of write
62	Channel not active in time for read
63	Channel unexpectedly became active
64	Channel hung active and empty
65	Channel hung active and full
70	Internal diagnostic failure

Bit 2⁹ — Single Track Correction

During NRZI mode, this bit indicates that correction was applied to the track determined to be in error by the last block read during a forward read function (E040) or backward read function (E140). Correction results only if a vertical parity error occurs within the block.

During PE or GCR mode, this bit indicates that correction was limited to one track. Both single- and double-track correction may occur on the same GCR record.

Bits 2⁸ through 2⁰ — Dead Track Register

During NRZI mode, these bits indicate which tracks within the last data block had error correction applied.

During PE or GCR mode, these bits indicate the tracks that are being dead-tracked at the end of operation.

Bits 2⁰ through 2⁸ correspond to tracks 1 through 9 as follows:

Status Bit	2 ⁸	2 ⁷	2 ⁶	2 ⁵	2 ⁴	2 ³	2 ²	2 ¹	2 ⁰
Tape unit track	9	8	7	6	5	4	3	2	1
Tape unit data bit	2 ³	2 ¹	2 ⁷	2 ⁶	2 ⁵	p	2 ⁴	2 ⁰	2 ²
Tape unit bus	4	6	0	1	2	p	3	7	5

WORD 5 — ERROR INDICATORS

Bit 2¹¹ — Vertical Parity Error

This bit indicates that one or more corrected data frames contain incorrect vertical parity.

Bit 2¹⁰ — Longitudinal Parity Error (For NRZI Mode Only)

This bit indicates that one or more tracks contain incorrect longitudinal parity.

Bit 2⁹ — CRC Detected Error (For 7- or 9-Track NRZI and GCR Only)

This bit indicates that the cyclic redundancy check detected an error.

Bit 2⁸ — Auxiliary CRC Detected Error (For GCR Only)

This bit indicates that the auxiliary cyclic redundancy check detected an error.

Bit 2⁷ — CRC1/CRC2 Compare Error

This bit indicates that the CRC generated on data written does not match the CRC generated on data read.

If the error occurs during a read operation, it indicates that an error occurred in the channel buffer.

Bit 2⁶ — Single Frame Error (For NRZI Only)

This bit indicates that more than 1.5 cell times of blank tape occurred in a data block. The amount of blank tape is not enough to cause an end of operation.

Bit 2⁵ — False EOP

This bit indicates that an end of operation occurred before the end of the data block was reached. For 7-track NRZI, blank tape occurred for at least 2.5 cell times, and more than one frame had blank tape within 6.5 cell times.

For 9-track NRZI, blank tape occurred for at least 2.5 cell times, and more than two frames had blank tape or continued blank tape within the next 8 cell times.

For PE, the number of all 0's characters in the postamble during a read operation was not in a range of 8 to 44. For a read after write operation, the postamble all 0's character range is 32 to 42. The bit also sets if a nonzero character occurs within the minimum number of postamble characters.

For a GCR read operation, the number of consecutive all 1's characters in the postamble was not in a range of 30 to 90. For a read after write operation, the postamble all 1's character range is 65 to 90.

Bit 2⁴ — Velocity Error

This bit indicates that the tape reached operating speed but deviated by more than ±5 percent before the end of operation.

Bit 2³ — Frame Count Error

This bit indicates that the number of frames detected in the read after write operation did not equal the number of frames written during any recording mode.

This bit may also indicate that the number of frames detected did not agree with the residual character read in a GCR write or read operation.

Bit 2² — Flag Bit Detected

This bit indicates that bit 2⁶ of the RAM memory entries was detected in the set state. This must occur when reading with code translation and the assembly/disassembly mode equal to zero (6-bit mode).

Bit 2¹ — Slow Start Error

During a write operation, this bit indicates that the IBG was lengthened by over 0.02 inch because the tape unit was slow in reaching operating speed.

Bit 2⁰ — Excessive Skew Error

This bit indicates that one or more tracks had more than the permitted amount of skew.

For a PE read operation, the maximum skew allowed is 7 cell times. For a PE read-after-write operation, the maximum skew allowed is 2 cell times. For a GCR read operation, the maximum skew allowed is 39 cell times.

For GCR read-after-write operation, the maximum skew allowed is 14 cell times. This error may also occur if the preamble is not properly decoded in all tracks.

For a GCR read-after-write operation, the maximum skew allowed is 14 cell times.

WORD 6 — TCU INTERNAL ERRORS**Bit 2¹¹ — Pointer Merge Error**

This bit indicates that a logical error occurred in the error correction circuits.

Bit 2¹⁰ — Write Path Parity Error

This bit indicates that a parity error was detected in the write path circuits.

Bit 2⁹ — Write Register Parity Error

This bit indicates that a parity error was detected in the write register.

Bit 2⁸ — Read Code Translation Parity Error

This bit indicates that a parity error occurred in the code translation read RAM memory.

Bit 2⁷ — Write Code Translation Parity Error

This bit indicates that a parity error occurred in the code translation write RAM memory.

Bit 2⁶ — Read Bus Parity Error

This bit indicates that a parity error was detected on the read bus.

Bit 2⁵ — GCR Write Path Parity Error

This bit indicates that a parity error was detected in the GCR write path.

Bit 2⁴ — GCR Write Bus Parity Error

This bit indicates that a parity error was detected on the GCR write bus.

Bit 2³ — NRZI Write Path Parity Error

This bit indicates that a parity error was detected in the NRZI write path.

Bit 2² — NRZI Read Path Parity Error

This bit indicates that a parity error was detected in the NRZI read accumulation circuit during a loop write-to-read function (E075 or E175).

Bit 2¹ — Bad Resync Burst

This bit indicates that a bad resync burst was detected in one or more tracks during a GCR read after write check.

This bit may also indicate that mark two at the start of the postamble is not recognized in the read after write check.

Bit 2⁰ — Power Interrupt

This bit is reserved for future use and is a constant 0.

WORD 7 — VALID POINTERS**Bit 2¹¹ — Upper ROM Parity Error**

This bit indicates that a sequencer memory parity error occurred in the upper half of ROM memory (bits 2¹² through 2²³).

Bit 2¹⁰ — Lower ROM Parity Error

This bit indicates that a sequencer memory parity error occurred in the lower half of ROM memory (bits 2⁰ through 2¹¹).

Bit 2⁹ — Sequence Command Error

This bit indicates that an error was detected internal to the sequencer.

Bits 2⁸ through 2⁰ — Valid Track Pointers

These bits indicate which tracks caused a valid error pointer in the last data block during GCR or PE recording. Bits 2⁰ through 2⁸ correspond to tracks 1 through 9 as follows:

Status Bit	2 ⁸	2 ⁷	2 ⁶	2 ⁵	2 ⁴	2 ³	2 ²	2 ¹	2 ⁰
Tape unit track	9	8	7	6	5	4	3	2	1
Tape unit data bit	2 ³	2 ¹	2 ⁷	2 ⁶	2 ⁵	p	2 ⁴	2 ⁰	2 ²
Tape unit bus	4	6	0	1	2	p	3	7	5

WORD 8 — SUBSYSTEM MODE**Bit 2¹¹ SINGLE FRAME SKEW**

This bit indicates that a single frame skew condition has occurred.

Bit 2¹⁰ — Code Translation

This bit indicates that code translation has been specified in the format unit function (E004).

Bit 2⁹ — Assembly/Disassembly Mode

When a 1, this bit indicates that the packed assembly/disassembly mode has been specified in the format unit function. When a 0, it indicates that the 6-bit assembly/disassembly mode is specified in the format unit function (E004).

Bit 2⁸ — Last Direction Reverse

This bit indicates that the last direction command issued to the tape unit requested that it move backward toward loadpoint. This status bit is always a 0 when either an E075 or E175 loop write to read function is in progress.

Bit 2⁷ — Last Operation Write

This bit indicates that the last tape unit operation was a write, write filemark, or erase because current is present in the write and erase heads. This status bit is also a 1 when either an E075 or E175 loop write to read function is in progress.

Bit 2⁶ — Error Correction Disabled

This bit indicates that no error correction will be performed by the controller. This applies to all modes of recording.

Bits 2⁵ through 2⁰ — Not Used

These bits are not used.

WORD 9 — FLAG BIT REGISTER**Bit 2¹¹ — False Gap Bypassed**

This bit indicates that one or more false IBGs were skipped over before finding a gap of at least 300 microseconds (0.03 to 0.06 inch).

Bit 2¹⁰ — Noise Bypassed

This bit indicates that one or more noise-length blocks were skipped over before reading a legitimate block or filemark. The minimum block length is defined in the format unit function.

Bit 2⁹ — CRC Correctable Error (For 9-Track NRZI Only)

This bit indicates that the last block read with a read forward or read backward function contains a one-track error. Error correction for this track is performed on the next read forward or read backward function.

Bit 2⁸ — Late Data

This bit indicates that the IBG was lengthened by over 0.1 inch because the PPU delayed sending the first write data word.

Bit 2⁷ — Capstan Slip

This bit indicates that too much time was required for the first write data frame to reach the read head even though the capstan was moving at rated speed.

Bit 2⁶ — Early Read-After-Write End of Operation

This bit indicates that end of operation occurred before all data was read.

Bit 2⁵ — Erase Error

This bit indicates that unerased flux changes were detected at a low read clip level while forming the IBG or during an erase function.

Bits 2⁴ through 2² — Undefined

These bits are used by the sequencer as general-purpose logic flags.

Bits 2¹ and 2⁰ — Read Clip Level

These bits provide a code that indicates one of the following clip levels at which the next read operation will be performed.

Bits 2 ¹	Bit 2 ⁰	Clip Level
0	0	Normal
0	0	High
1	0	Low
1	1	Hyper

WORD 10 — COUNTERS

Bits 2¹¹ through 2⁶ — Counter Number 1

These bits give the current count of a modulo 64 counter (no end-around carry). The counter contains the number of tach pulses detected during measure gap size forward and backward functions (E072 and E172) or measure start time forward and backward functions (E073 and E173).

Bits 2⁵ through 2⁰ — Counter Number 2

These bits give the current count of a noncycling 6-bit counter (values greater than 62 are represented by all 1's). The counter contains the number of 160-microsecond increments detected during measure gap size forward and backward functions (E072 and E172) or measure start time forward and backward functions (E073 and E173).

WORD 11 — HARDWARE CAPABILITY AND TAPE UNIT STATUS

Bit 2¹¹ — GCR Capability

This bit indicates that the TCU contains the group coded recording option.

Bit 2¹⁰ — Not NRZI Capability

When this bit is a 0, it indicates that the TCU contains the NRZI option to enable controller operation with all densities of both 7-track and 9-track NRZI tape units.

Bit 2⁹ — Not Used

This bit is not used.

Bit 2⁸ — 7-Track Density

When a 1, this bit indicates that the currently connected tape unit is 7-track with a density of 556 cpi. When a 0, this bit indicates any other density or mode of recording.

NOTE

Status bits 2⁷ through 2⁰ pass through the controller from the tape unit to the PPU without being manipulated by the controller.

Bit 2⁷ — 7-Track Tape Unit

This bit indicates that the connected tape unit is 7-track.

Bit 2⁶ — Write Current Failure

This bit indicates that one or more write head windings are open or the write head current is on while reading.

Bit 2⁵ — Dual Density

This bit indicates that the connected tape unit is 9-track and is capable of switching densities (always true for 9-track CDC units).

Bits 2⁴ and 2³ — Density (For 9-Track Tape Units Only)

These bits provide a code that indicates one of the following densities.

Bit 2 ⁴	Bit 2 ³	Density
0	0	1600 cpi, PE
0	1	1600 cpi, PE
1	0	800 cpi, NRZI
1	1	6250 cpi, GCR

Bits 2² through 2⁰ — Speed Capability of Tape Unit

These bits form a code that indicates one of the following tape speeds.

Bits 2 ²	Bit 2 ¹	Bit 2 ⁰	Tape Speed
0	0	0	No tape unit connected
0	0	1	Illegal
0	1	0	100 ips
0	1	1	Illegal
1	0	0	Illegal
1	0	1	200 ips
1	1	0	150 ips
1	1	1	Illegal

WORD 12 — SENSE BYTE 2 OF TAPE UNIT

Bits 2¹¹ through 2⁸ — Not Used

These bits are not used.

NOTE

Status bits 2⁷ through 2⁰ pass through the controller from the tape unit to the PPU without being manipulated by the controller.

Bit 2⁷ — Lamp Failure

This bit indicates that the fiber optics lamp circuit is open.

Bit 2⁶ — Left Column Fault

This bit indicates that a loop fault occurred on the take-up reel side of the loop box.

Bit 2⁵ — Right Column Fault

This bit indicates that a loop fault occurred on the supply reel side of the loop box or tape loop was pulled out of the left column.

Bit 2⁴ — Reset Button

This bit indicates that the CLEAR switch on the tape unit has been pressed. It clears upon receipt of a clear tape unit function, power up master clear, or column loaded pulse.

Bit 2³ — Data Security Erase

This bit indicates that the tape unit is performing a data security erase.

Bit 2² — Erase Current Failure

This bit indicates that the erase head winding is open or the erase head current is on while reading.

Bit 2¹ — Air Pressure Failure

This bit indicates low or absent air pressure in the tape unit.

Bit 2⁰ — Load Failure

This bit indicates that the tape failed to load in the tape unit. It is cleared only by a clear tape unit function (E000).

WORD 13 — SENSE BYTE 5 OF TAPE UNIT

Bits 2¹¹ through 2⁸ — Not Used

These bits are not used.

NOTE

Status bits 2⁷ through 2⁰ pass through the controller from the tape unit to the PPU without being manipulated by the controller.

Bit 2⁷ — Window Open

This bit indicates that the window is open.

Bit 2⁶ — Door Open

This bit indicates that the front door of tape unit is open.

Bit 2⁵ — Parked

This bit indicates that tape has stopped moving in the tape unit.

Bit 2⁴ — Air Flow Check

This bit indicates that loss of cooling air has been detected.

Bit 2³ — Thermal Check

This bit indicates that tape deck temperature has exceeded maximum allowable value.

Bit 2² — Cleaner Active

This bit indicates that the tape cleaner is not in the home (inactive) state.

Bit 2¹ — Cartridge Present

This bit indicates that a tape cartridge is present.

Bit 2⁰ — Cartridge Open

This bit indicates that a tape cartridge is open.

WORD 14 — SENSE BYTE 7 OF TAPE UNIT

Bits 2¹¹ through 2⁸ — Not Used

These bits are not used.

NOTE

Status bits 2⁷ through 2⁰ pass through the controller from the tape unit to the PPU without being manipulated by the controller.

Bit 2⁷ — LOAD Button

This bit indicates that the LOAD button on the tape unit was pressed.

Bit 2⁶ — Auto Hub Activated

This bit indicates that the pressure system is active and has activated the auto hub.

Bit 2⁵ — Set Loops

This bit indicates that tape is threaded between the supply and takeup reels but is not necessarily in the loop columns.

Bit 2⁴ — Tape Present

This bit indicates that tape is positioned over the EOT/BOT sensor.

Bit 2³ — Reels Loaded

This bit indicates that tape is attached to the take-up reel but is not in the loop columns.

Bit 2² — Load-Rewind

This bit indicates that the load-rewind mode is selected in the tape unit.

Bit 2¹ — Load Complete

This bit indicates that tape is located in both loop columns, but tape is not necessarily at loadpoint.

Bit 2⁰ — Load Check

This bit indicates that the load operation has been aborted. It lights the LOAD FAULT indicator on the tape unit and is cleared only by pressing the CLEAR switch on the tape unit.

WORD 15 — SENSE BYTE 4 OF TAPE UNIT

Bits 2¹¹ through 2⁸ — Not Used

These bits are not used.

NOTE

Status bit 2⁷ passes through the controller from the tape unit to the PPU without being manipulated by the controller.

Bit 2⁷ — AGC Fault

This bit is used in GCR mode only to indicate that one or more tracks have maximum gain setting. It clears when the BOT is detected. It does not set unit check (status word 3, bit 2¹⁰). Error code 16 in status word 3 is reported the first time this bit is set.

Bits 2⁶ through 2⁰ — Not Used

These bits are not used.

WORD 16 — SENSE BYTE 3 OF TAPE UNIT

Bits 2¹¹ through 2⁸ — Not Used

These bits are not used.

NOTE

Status bits 2⁷ through 2⁰ pass through the controller from the tape unit to the PPU without being manipulated by the controller.

Bits 2⁷ through 2⁴ — IBG Counter 10¹

These bits indicate the current value of the ten's digit of the IBG counter in the tape unit. The counter is BCD-coded.

Bits 2³ through 2⁰ — IBG Counter 10⁰

These bits indicate the current value of the unit's digit of the IBG counter in the tape unit.

ALERT SITUATIONS

The status resulting from a given operation determines when and if error recovery should be performed by the PPU. The alert bit (status word 1, bit 2¹¹) signifies a condition to be logged by the PPU. This situation may or may not require error recovery. Table 4-1 lists the six different situations that cause the alert bit to set. A description of each situation follows.

ERROR CODE

Bits 2⁰ through 2⁶ of status word 3 define a situation that normally requires operator intervention. This

situation could be a programming error, hardware fault, or incorrect use of hardware such as mounting a tape of the wrong density.

TAPE PARITY ERROR

This situation occurs in detailed status and requires error recovery to be performed. The most likely cause for this situation is in the tape media, although it could possibly occur in the tape unit hardware.

TABLE 4-1. SET ALERT BIT SITUATIONS

Error Code	Tape Parity Error	Unit Check (Faults)	TCU Error	Lost Data/Channel PE	Miscellaneous Errors
Refer to appendix A for a description of the error codes. This situation requires operator/manual intervention or a condition to be logged.	Pointer error Vertical parity error Longitudinal parity error CRC detected error ACRC detected error CRC 1-2 compare error Single frame error False EOP Velocity error Frame count error Excessive skew error Bad resync burst Erase error Capstan slip CRC correctable error Early read-after-write EOP This situation is a read/write error probably due to tape media unless in LWR mode.	Right column Left column Write current failure Erase current failure Reset button Fiber optics Air pressure failure Load failure Window open Air flow check Thermal check This situation is a tape drive problem.	Pointer merge error Write path PE Write register PE Read code translation PE Write code translation PE Read bus PE GCR write path PE GCR write bus PE NRZI write path PE NRZI read path PE Upper ROM PE Lower ROM PE Sequence command error CRC1-2 compare error This situation is a controller problem.	This situation is a controller or channel software problem.	Single-track correction Dual-track correction Slow start error Late data Noise bypassed False gap bypassed Flag bit detected This situation is a condition to be logged for trend analysis.

UNIT CHECK

This situation occurs in the connected tape unit and causes it to be inoperable. An example of this situation is a load fault or loop fault. The ready condition in the tape unit drops when unit check occurs. An attempt should be made to restore the tape unit to normal operation by pressing the CLEAR switch on the tape unit and reloading tape, if necessary. If unit check persists, the tape unit should be downed.

TCU ERROR

This situation indicates an internal error was detected in the controller. The controller should be cleared with the master clear function (E414) and the operation repeated. If the situation persists or recurs intermittently, the channel should be downed.

LOST DATA AND CHANNEL PARITY ERROR

Error recovery is mandatory for this situation. Tape parity error may or may not accompany this situation.

MISCELLANEOUS ERRORS

This situation includes such errors as error correction, slow start, and late data. The errors should be logged, but error recovery is not necessary. Status bits for these errors are intended to point to potential hardware failure. Excessive error correction could indicate marginal tape unit hardware. Slow start errors could indicate a bad capstan motor.

CHANNEL/TAPE UNIT/TAPE MEDIA ERRORS

Most tape media errors are caused by oxide defects, media contamination, or head contamination. Normal error recovery procedures should overcome these errors. Media defects usually cause tape parity error and one or more error bits in status word 5. A defective area near BOT may make it impossible to write the density identification burst properly. Error code 12 is reported in status word 3, and use of the tape should be discontinued.

Major failures within the tape unit cause unit check and loss of ready condition. The cause for loss of the ready condition is reported in unit status. The ready status should be one of the first things checked when an alert is detected. Data errors in the tape unit hardware that do not cause a loss of the ready condition can be diagnosed with the set loop write-to-read I and II through tape unit functions (E175 and E375) or with statistics comparing tape unit errors and tape media errors.

The loop write-to-read functions cycle data through the tape unit but not through the recording head. A loop write-to-read transfer should be done as soon as

the tape unit goes ready after tape is loaded. Successful completion of the set loop write-to-read II through tape unit function (E375) indicates that controller and tape unit hardware are functional up to the recording head. No errors or error correction should occur. The block ID should be simultaneously checked using a predefined data pattern with a known block ID. The data pattern used is not critical. This operation also checks for input and output channel parity problems.

Many possible controller failures are self-diagnosed and reported as a TCU parity error. This error bit should be interrogated immediately after alert occurs. Other error bits should be ignored if a TCU error occurs since a defective controller may cause a tape parity error situation. A master clear function (E414) should be used to clear the controller and to force execution of a short diagnostic program within the controller. A diagnostic failure is denoted by the controller not responding to any other function. The sequencer address displayed on the maintenance panel indicates the probable failure.

Set loop write-to-read through TCU function (E075) may also be used to isolate a controller problem. The output data following this function is circulated through the controller write and read paths without going to the tape unit. An alert condition should not occur if the controller is operating properly.

ERROR CORRECTION ON READ-AFTER-WRITE DATA

Error correction is not performed in PE and NRZI write modes. Any data error sets tape parity error.

Error correction is performed in GCR write mode because increased density places severe demands on user tape quality, and GCR error correction capabilities are greatly improved over PE and NRZI.

Certain conditions of single track error correction during a GCR write operation cause alert, single track correction, and valid pointer to occur. These conditions indicate that a specific track was corrected. Single track correction under these conditions should be logged, but error recovery should not be performed. If two or more tracks are in error, or if format characters (preamble, postamble, resync burst, and so on) are bad in all tracks, tape parity error sets, and error recovery should be performed.

VELOCITY ERRORS

Velocity errors in write mode cause tape parity error to set, and error recovery should be performed. Velocity errors may occur during read mode but do not directly cause alert or tape parity error. For this reason, error recovery should not be performed on read velocity errors unless another error is present.

A potential lost data condition exists using a 200-ips GCR tape unit on a CDC CYBER 170 channel running at a 1-microsecond transfer rate. In this case, read lost data may occur if the tape speed is out of

tolerance. If lost data and velocity error occur under this circumstance, the block should be backspaced and reread. The same conditions causing this error should not exist for the second read.

POSITIONING

All ATS controllers contain block identification (BID) hardware. BID positioning should be used instead of the controlled backspace method whenever possible, because BID is insensitive to tape unit speed variations.

If the controlled backspace method is used, the frame count must be reduced by 5 to 8 percent to avoid missing the IBG due to tape unit speed variations. The controller uses the find gap procedure after the word count expires. At least one data word must be sent by the PPU.

LOAD FAULTS

Load faults are defined by two bits in detailed status. Load failure bit (status word 12, bit 2⁰) should be logged by the PPU and then cleared to prevent multiple entries in the software engineering file. Load check bit (status word 14, bit 2⁰) lights the LOAD FAULT indicator on the tape unit and cannot be cleared by the PPU. It is cleared by the CLEAR switch on the tape unit.

AGC FAULTS

Improper setting of automatic gain control in the tape unit while reading in GCR mode results in error code 16 in status word 3 being sent to the PPU. AGC fault bit (status word 15, bit 7) remains set until tape is positioned back to BOT. Normally,

the tape can be read under these conditions. This bit does not set alert. The AGC fault bit should be logged when error correction or error recovery occurs. This condition can be used as an early warning that the tape is no longer reliable until cleaned and recertified.

NOISE PROCESSING (READ MODE)

Minimum block length (MBL) as defined in the format unit function (E004) description in section 2 should be used to reject noise on NRZI tapes. It should be set to 18₁₀ frames (ANSII minimum limit) or some value shorter than any expected data block. MBL usage is not necessary for PE and GCR tapes since noise is eliminated in these formats. However, MBL may be used to reject system noise records on existing PE tapes.

NOISE PROCESSING (WRITE MODE)

Erase error and false EOP status bits may indicate the presence of unwanted flux transitions in the IBG. Normal write error recovery should be used. This includes backspace, erase, and rewrite. If the tape cannot be cleanly erased, it should be replaced.

CLIP LEVEL USAGE

Clip levels should be used during read recovery to adjust to amplitude variation caused by the tape media. Several read attempts should be made at each level, starting with low level and proceeding to high and hyper levels. Use of high and hyper levels is more effective for NRZI than PE or GCR recording.

ERROR CODES

A

The error codes detected are returned to the error code field of detailed status to indicate specific error conditions. All error codes are shown in octal.

These error codes are categorized as follows:

<u>Range</u>	<u>Description</u>
01-07	Error codes in this range indicate that the unit requires operator attention.
10-17	Error codes in this range indicate that the tape is unusable for this operation.
20-27	Error codes in this range indicate that an error was detected during execution of a diagnostic function.
30-37	Error codes in this range indicate that an illegal procedure was performed due to an error in the user's routine.
40-47	Error codes in this range indicate that the tape unit is inoperable and the customer engineer should be notified.
50-67	Error codes in this range indicate that an illegal procedure was performed by PPU software or that an illegal channel condition was detected by the controller.
70-77	Error codes in this range indicate that a failure internal to the controller was detected.

<u>Error Code</u>	<u>Description</u>	<u>Action</u>
01	A connect was rejected because the unit was either off-line, powered off, or not cabled to the controller.	Report error condition.
02	A connect was rejected because the unit was already connected to the other controller in a 2 x 8 configuration.	Report error condition.
03	A connect was rejected because the unit access switch was in the OFF position for this controller.	Report error condition.
04	The function was rejected because the unit was not ready.	Report tape position uncertain and log error.
05	Unit was declared not ready during last operation because of a unit check or interrupt.	Report tape position uncertain and log error.
06	A write was not executed due to a missing write ring.	Report a request to supply a write ring.
07	The unit is not capable of reading the tape's density (9-track units only).	Request to mount tape on a 9-track unit of the opposite type. The two types are: 679-2, 3, 4 (PE/NRZI-capable) and 679-5, 6, 7, (PE/GCR-capable).
10†	More than 25 feet (7.6 metres) of blank tape was encountered.	Report error.
12	Unable to write from loadpoint due to bad tape (could not detect ID burst immediately after writing it).	Request a different reel and log this event.
13	The tape unit AGC could not be set properly on this tape.	Abandon further efforts to read tape and log this event.
16	The tape unit AGC is not properly set in all tracks. The tape should be readable.	Log condition and discontinue use of reel.

† To prevent mispositioning if data is present immediately after the length of blank tape detected has exceeded the limit, a 1-inch (25 millimetre) controlled backspace (forespace if backward operation) is performed before this error code is reported.

<u>Error Code</u>	<u>Description</u>	<u>Action</u>
20	A failure was detected in the controller velocity detect hardware (occurs only during execution of test velocity detector function).	Replace velocity detect module in controller.
21†	The second block was not read by the measure gap size function.	Run diagnostic on unit to isolate failure.
22†	If from measure gap function, indicates that IBG over 20 inches was measured. If from measure start time function, indicates that the unit did not attain operating speed within 200 milliseconds (does not occur on any other functions).	Run diagnostic on unit to isolate failure.
30†	Backward motion was attempted at the loadpoint marker.	Report condition to operating system/user.
31†	Tape unit 10 through 17 was requested and subsystem only supports unit numbers 0 through 7.	Log condition and report to operating system.
32†	Motion was attempted on a unit while rewinding or performing a data security erase.	Wait until unit is not busy.
33	Write current on for tape unit loop write-to-read II function.	Logically remove unit from system and log error.
34†	A controlled backspace function was attempted when the previous operation was not a write.	Suspect system error.
35†	The controller is not capable of the requested density.	Suspect system error.
36	A write was attempted at a recording density of 200 cpi.	Suspect system error.
40	Gap control status failed to occur within 270 milliseconds.	Logically remove unit from system and log error.
140	Tape unit failed to execute a data security erase.	Logically remove unit from system and log error.
41	Velocity failed to reach 95 percent of rated speed within 270 milliseconds.	Logically remove unit from system and log error.
42	The unit failed to move the tape when tape movement was requested.	Logically remove unit from system and log error.
43	The erase or write current failed to occur when a write was requested.	Logically remove unit from system and log error.
143	The write current failed to turn off for a read operation.	Logically remove unit from system and log error.
44	The tape unit was still busy or not parked 270 milliseconds after the stop command was sent to the unit.	Logically remove unit from system and log error.
45	Reverse status was still indicated after a forward signal was sent to the unit.	Logically remove unit from system and log error.
145	Forward status was still indicated after a reverse signal was sent to the unit.	Logically remove unit from system and log error.
46	A block was written, but no data was detected in the read-after-write.	Logically remove unit from system and log error.
47	The tape unit would not select density on command.	Logically remove unit from system and log error.
50	Unrecognizable function code.	If error persists, suspect system error. Reissue function one more time.
51†	The function was rejected because the unit was not connected.	Suspect system error.
52†	The function required one or more words of parameters that were not issued within 270 milliseconds of the function.	Reissue function and required parameters one more time. If error persists, suspect system error.
55	Channel parity error during function transmission.	Refer to appendix D.
61†	Data was not received in time for write or load code table operation. For write, 4 inches (102 millimetres) of tape motion are allowed. For load code table, 270 milliseconds are allowed.	Perform lost data recovery procedure.

† This error code can be caused by a PPU programming error. Refer to the proper function definition in section 2 to ensure correct usage.

<u>Error Code</u>	<u>Description</u>	<u>Action</u>
62 †	PPU was not ready to receive data for a read function.	Perform lost data recovery procedure.
63 †	The data channel was found unexpectedly active. This condition is detected when the channel remains active for 270 milliseconds while the sequencer is in the idle loop. The channel is deactivated.	Suspect system error or channel hardware error.
64 †	The channel was hung active and empty following a load or copy code table operation.	Suspect system error or channel hardware error.
65 †	The channel was hung active and full for 270 milliseconds during a status function.	Suspect system error or channel hardware error.
70	The controller detected an internal failure while executing the internal diagnostics following a master clear.	Run controller diagnostics to isolate failure.

† This error code can be caused by a PPU programming error. Refer to the proper function definition in section 2 to ensure correct usage.

Code translation can be performed on the fly using one of four available memories (RAMs). Each code table consists of a 256-entry write table and a 256-entry read table. Each memory location (entry) contains eight bits. The PPU must load RAMs prior to usage. (Refer to load code translation RAM function definition in section 2.)

Accomplish translation by using a 6- or 8-bit byte as an address to the selected memory. The contents of each location is the desired code. The controller hardware adds a parity bit to each location as the tables are loaded. The read or write code translation parity error bit is set whenever the referenced location contains even parity.

Use the flag bit test to detect illegal 6-bit codes while reading 9-track tape. This error bit (status word 5, bit 2²) will set any time an accessed read

table location has bit 2⁶ set when reading with code translation in A/D mode 0.

Seven-track external BCD conversion is done by hardware separate from the code translation RAMs. Internal to external BCD conversion consists of changing 00g character to 12g and complementing bit 2⁵ if 2⁴ is a logical one. External to internal conversion done in the read hardware is the logical inverse of this procedure. BCD conversion is enabled whenever the mode is 7-track, even parity, and code table 1, 2, 3, 4, or 7 is selected. This allows external to internal BCD conversion to be combined with another code translation if table 1, 2, 3, or 4 is selected or done without any other code translation if table 7 is selected.

Figures B-1 and B-2 show the location of the code translation memories within the controller data path.

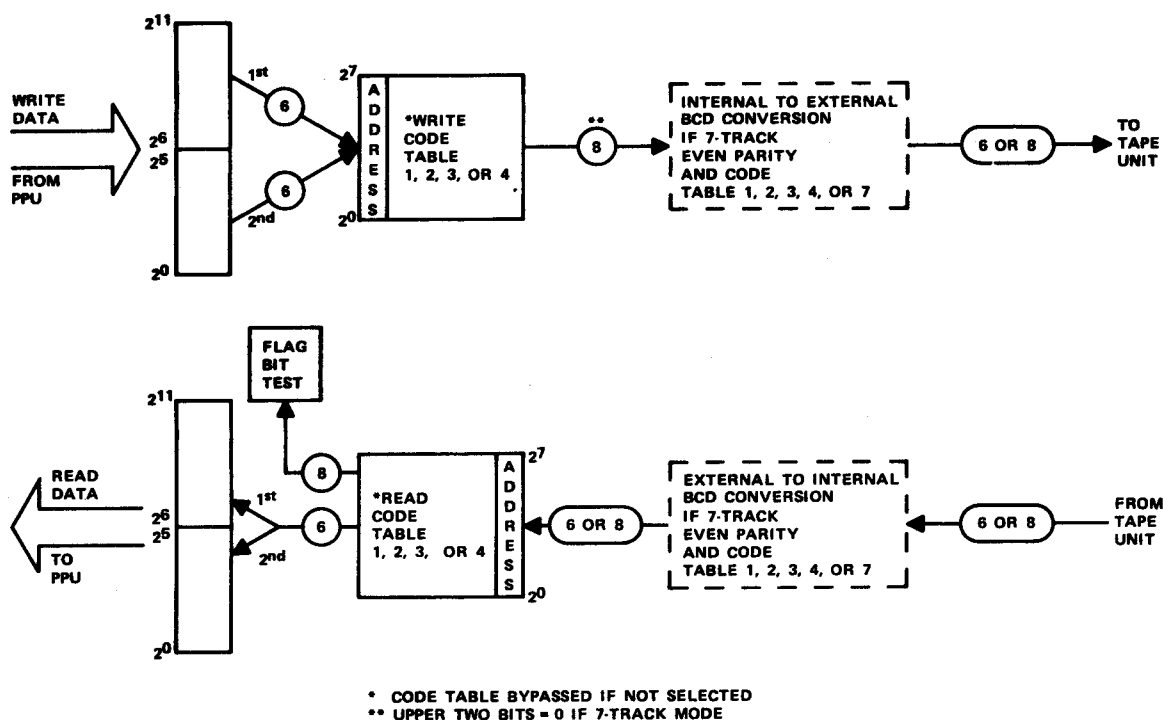


Figure B-1. Code Translation in A/D Mode 0

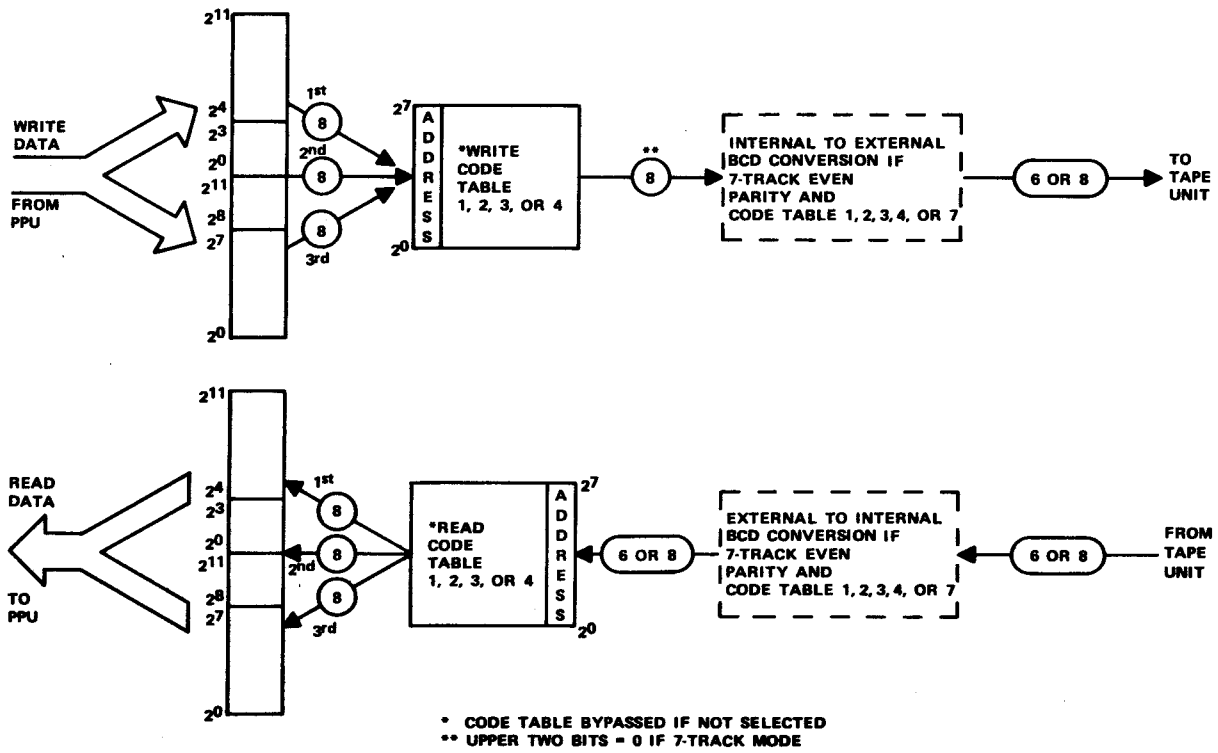


Figure B-2. Code Translation in A/D Mode 1

Data correction is available on all 9-track tapes. Data correction is initiated in three ways, depending on whether 800 cpi (NRZI), 1600 cpi (PE), or 6250 cpi (GCR) recording mode is being used. NRZI error correction is limited to single track errors. Both PE and GCR correction may include two or more tracks per data block. Error correction activity in all modes may be disabled by a parameter in the format unit function.

800-CPI (NRZI) DENSITY

At the completion of a read operation, the cyclic redundancy check register and the error pattern register are checked by the controller to determine if an error was limited to one track and which track was affected. The track in error number is saved in the controller for automatic correction the next time a read forward or read reverse is executed on this tape unit. The PPU should issue a backspace and a read forward or a forespace and a read reverse to allow the controller to correct the error. If a 2 x 8 configuration is being used, corrective reread must be performed on the side of the configuration last using the unit.

If a vertical parity error is detected during the corrective reread, the single track correction bit and one of the bits in the dead track register in detailed status are set (refer to section 3).

Data for the track in error is generated by the values required for correct vertical parity. If no vertical parity error is detected, corrective recovery is not necessary and the dead track register is zero.

Corrected data is subjected to CRC, vertical parity, and longitudinal parity testing. If any of these errors occur, tape parity error is set and the correction was unsuccessful.

Successful error correction is denoted by alert, single track correction, and the dead track register indicating the corrected track.

1600-CPI (PE) DENSITY

Corrective recovery for 1600-cpi 9-track tape is performed as data is being transferred. Any of the nine tracks which loses synchronization, where a full cycle of flux reversals does not occur within 1.5 cell times, is corrected.

The tape parity error bit in detailed status is zero when the correction is successful, indicating that no further recovery is required.

If more than one track loses synchronization at one time, the pointer error bit in detailed status is set, requiring that the parity error recovery procedures listed in section 4 be executed.

Successful error correction is denoted by alert, single track correction, and the tracks corrected defined in the valid pointers and/or the dead track register.

6250-CPI (GCR) DENSITY

Corrective recovery for 6250-cpi tape is performed as data is being transferred. A technique using an error correction character, odd vertical parity, and track pointers is used. The hardware can simultaneously correct any two tracks in error. More than two tracks per block can be corrected depending on the physical position of the errors. Corrected data is verified by vertical parity, CRC, auxiliary CRC, frame count, and false end of operation tests.

The tape parity error bit is zero for successful correction in read mode. Tape parity error will normally be accompanied by one of the error bits in status word 5. Dual track correction will cause tape parity error in read-after-write-mode (refer to section 4).

Successful correction is denoted by alert, single and/or dual track correction, and the corrected tracks defined in the valid pointers and/or dead track register.

This appendix describes the four types of channel parity error recovery procedures for the CDC CYBER 170 series.

It is the operating system programmer's responsibility to code these procedures as required by the system requirements.

FUNCTION ERROR FROM PPU TO ATS

The controller performs the following procedure when a channel parity error is detected on a function code from the PPU.

1. Sets the general status alert bit.
2. Sets the detailed status error code 55g.
3. Does not transmit an inactive (acceptance) reply to the PPU.
4. Takes no other action.

The PPU should perform as follows:

1. Time out the functions to avoid hanging the channel.
2. Disconnect the channel.
3. Request general and/or detailed status.
4. Resend the function once before abandoning the operation.

Error code 55g will be reported until a nonstatus function is received without a parity error.

PPU PARAMETER TRANSFER TO ATS

The following procedure is performed when a channel parity error occurs on PPU parameter transfer to the controller.

The PPU should perform as follows:

1. Complete the parameter transfer.
2. Send a general status function (E012).

The controller performs as follows:

1. Sets the general status alert bit.
2. Sets the channel parity error bit in status word 3.

The PPU should perform as follows:

Resend the function and parameters once before abandoning the operation.

NOTE

The parameters are processed by the controller regardless of channel parity error.

PPU OUTPUT DATA TRANSFER TO ATS

The following procedure is performed when a channel parity error occurs on PPU output data transfer to the tape unit.

The PPU should perform as follows:

1. Complete the output data transfer.
2. Request a general status function (E012).

The controller performs as follows:

1. Sets the general status alert bit.
2. Sets the channel parity error bit in status word 3.

To recover the data, use the write parity error recovery procedures described in section 4.

INPUT STATUS OR DATA TRANSFER TO PPU

The following procedure is performed when a channel parity error occurs on input status or data transfer to the PPU.

The PPU should perform as follows:

1. Test the appropriate bit in the status and control registers prior to sending the next function.
2. Perform one of the following to attempt recovery.
 - a. Status - Resend the function and input the status words several times before downing the channel.
 - b. Data (ATS read forward or backward) - Use normal read recovery.

MEDIA REQUIREMENTS FOR MAGNETIC TAPE OPERATION

E

Magnetic tapes used on CDC subsystems must meet the following ANSI standards.

X3.40-1976	Unrecorded Tape for Information Interchange (9-track 200 and 800 CPI, NRZI and 1600 CPI, PE)
X3.54-1976	Recorded Magnetic Tape for Information Interchange (6250 CPI, Group Coded Recording)
X3.39-1973	Recorded Magnetic Tape for Information Interchange (1600 CPI, NRZI)
X3.22-1973	Recorded Magnetic Tape for Information Interchange (800 CPI, NRZI)
X3.14-1973	Recorded Magnetic Tape for Information Interchange (200 CPI, NRZI)

Failure to meet these standards may result in unsatisfactory performance and interchange. Note that 1.0-mil tape is not allowed by ANSI X3.40-1976.

Most tapes properly certified for 1600-cpi operation will operate satisfactorily at 6250 cpi.

Control Data ALPHA PHI and OMEGA PHI will meet ANSI standards and are recommended for use on CDC equipment.

Examples

Inhibitor characteristics include poor edge conditions, excessive tape wear products, interlayer slippage, tendency for oxide coating to transfer to the back of the reels next layer, and tendency for tape constituents to separate and cause deposits leading to tape stick or to inhibiting proper performance of other tapes. Tapes which exhibit these characteristics may not give satisfactory performance and may result in excessive errors.

INHIBITOR TAPES

Definition Inhibitor tapes are tapes that degrade performance of the tape transport such that unsatisfactory operation is experienced with the tape in question, or with an otherwise satisfactory tape mounted on a transport in subsequent passes.

Requirement The tape shall not be an inhibitor tape.

CDC employees may order ANSI standards from the CDC System Standards Department located at HQW11H. All others may order them directly from:

American National Standards Institute, Inc.
1430 Broadway
New York, New York 10018

COMMENT SHEET

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Subsystem Reference Manual

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