CONTROL DATA
CORPORATION

CONTROL DATA®
3518 & 3528
MAGNETIC TAPE CONTROLLER

REFERENCE MANUAL

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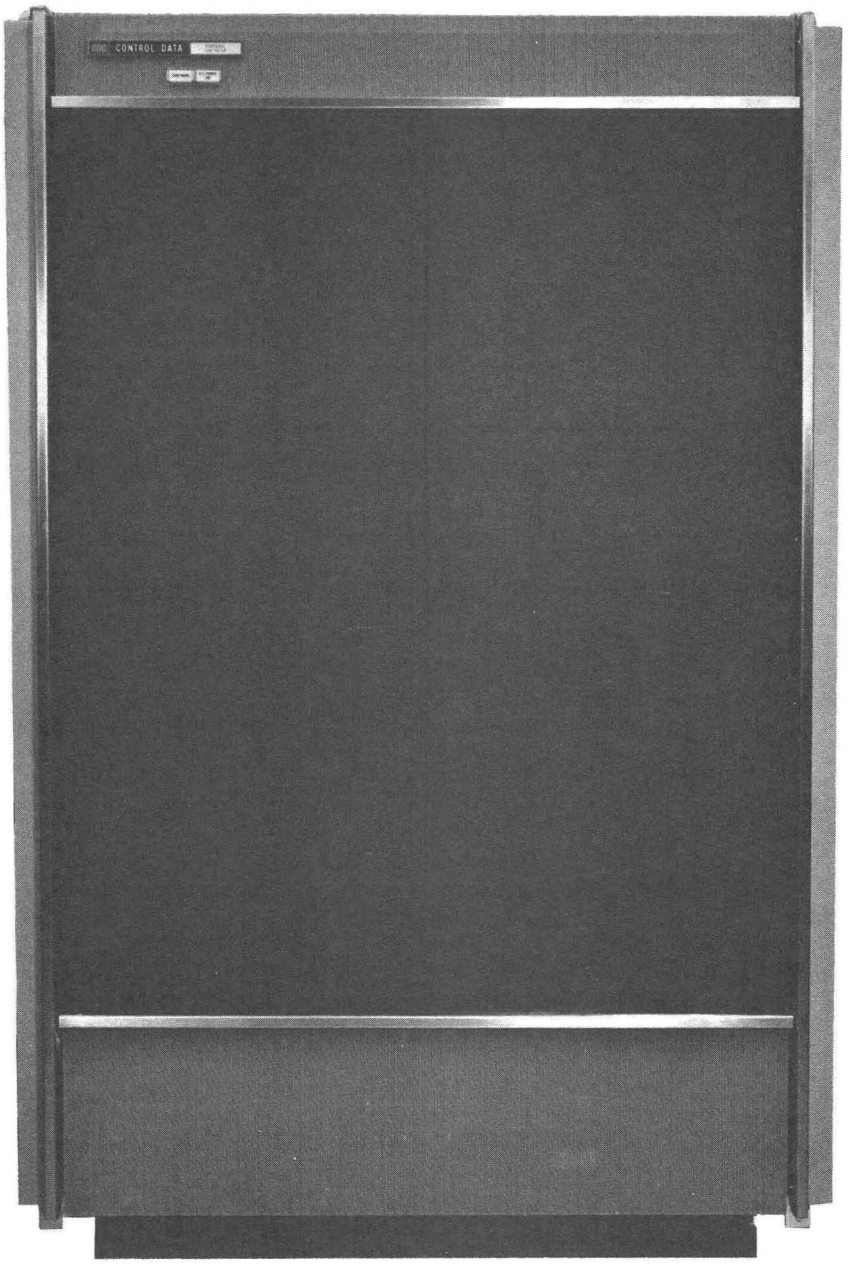

3518 & 3528 MAGNETIC TAPE CONTROLLER

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FUNCTIONAL DESCRIPTION 1

INTRODUCTION

The CONTROL DATA® 3518 and 3528 Magnetic Tape Controllers Interface Control Data 3000 Series Data Channels and Control Data 65X Magnetic Tape Transports (Units). The controllers synchronize data transfer and control the programmed selection of operating modes and conditions between the channels and tape units. Constructed of CDC® Intebrid circuits, the equipments handle an intermix of tape speeds and densities. The 3518 Controller is a single channel equipment, the 3528 Controller is a dual channel equipment. Each controller is available in three models which are all compatible with standard 3000 Series Data Channels and the Control Data 6681 Data Channel Converter.

3518 MAGNETIC TAPE CONTROLLER (1×8)

The 3518 Controller interfaces one data channel and up to eight tape units connected in series as shown in Figure 1-1. It is available in three models, 3518-1, 3518-2, and 3518-3, which operate the tape units listed in Table 1-1. In this configuration, a data channel can access but one tape unit at a time. Only one read, write, or other operation can be performed per channel.

3528 MAGNETIC TAPE CONTROLLER (2×8)

The 3528 Controller interfaces two data channels and up to eight tape units connected in parallel as shown in Figure 1-2. A data channel can access any one of eight tape units if they are not reserved by the other channel. This allows dual channel operations such as simultaneous reads, writes, or a read and write. This controller is also available in three models, 3528-1, 3528-2, and 3528-3, and differs from the 3518 Controller in that each model can control two tape units simultaneously, one per data channel. Each model also contains a switching matrix which provides for the parallel connection of tape units.

TABLE 1-1. CAPABILITIES OF VARIOUS CONTROLLER MODELS

CONTROLLER MODEL NO*	CONTROLS TAPE UNIT NO.	TRACKS	DENSITIES (CPI)	RECORDING METHOD	DESCRIPTION
3518-1 and 3528-1	657-X	7	200, 556, 800	NRZI	Seven track recording in binary or BCD without error correction or code conversion.
3518-2 and 3528-2	657-X	7	200, 556, 800	NRZI	Seven track recording in binary or BCD without error correction, but with 6 bit to 6 bit code conversion.
	659-X	9	800	NRZI	Nine track recording with automatic correction of single track errors on a re-read, and code conversion.
3518-3 and 3528-3	657-X	7	200, 556, 800	NRZI	Seven track recording in binary or BCD without error correction, but with 6 bit to 6 bit code conversion.
	659-X	9	800	NRZI	Nine track recording with automatic correction of single track errors on a re-read, and code conversion.
	659-X	9	1600	Phase-encoded	Nine track phase-encoded recording with automatic On-the-Fly error correction of single track errors due to dropped bits and code conversion.

*Within the capabilities of the tape units and limitations listed for the controller in Table 1-1, the -2 and -3 controller models can automatically handle any combination of tape speeds, densities, NRZI or phase-encoded recording available on the tape units listed. The 3518 Controller is a single-channel equipment performing one Read/Write operation at a time. The 3528 Controller is a dual-channel equipment that can perform two simultaneous Read/Write operations.

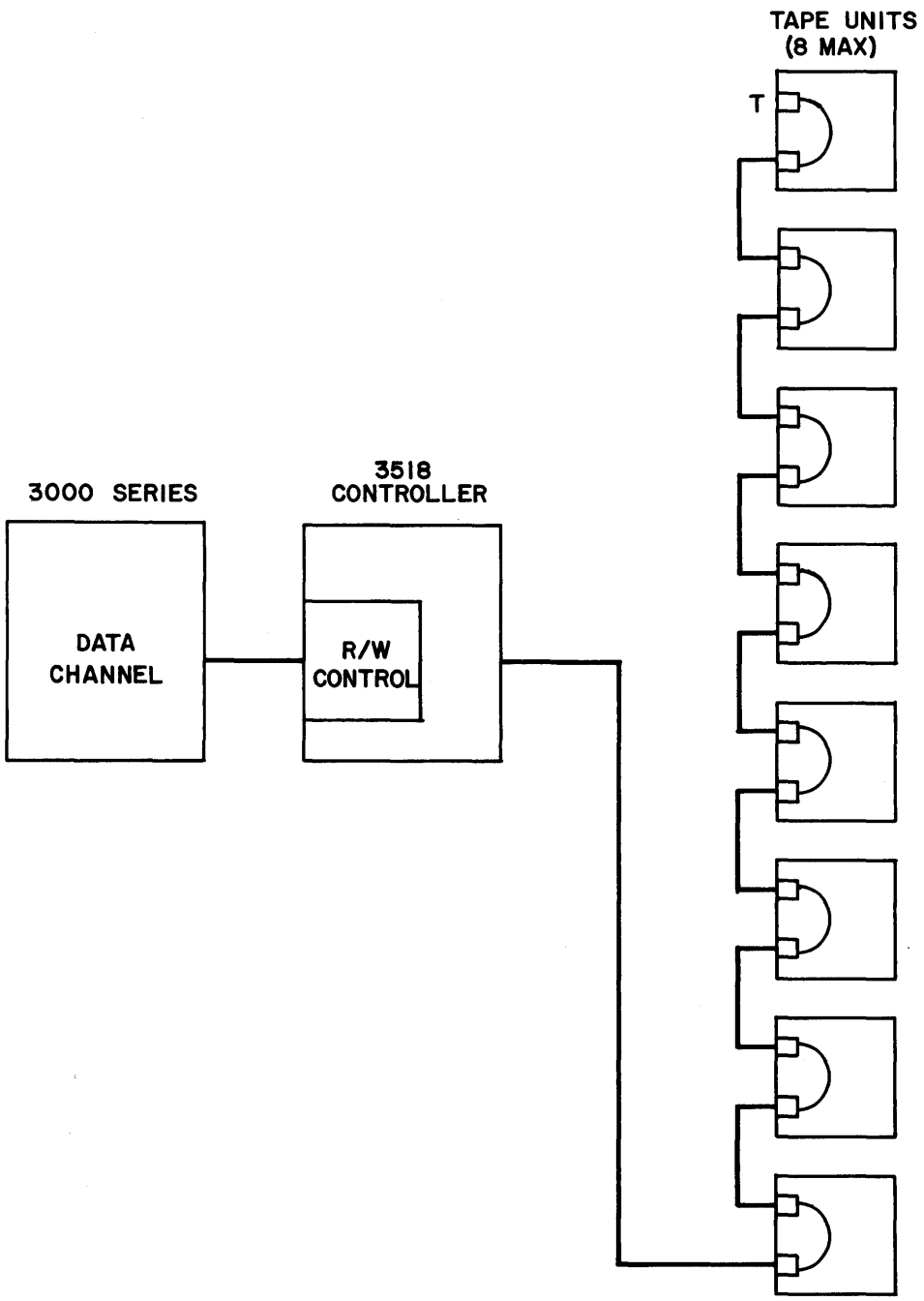


Figure 1-1. Typical Single Channel Configuration

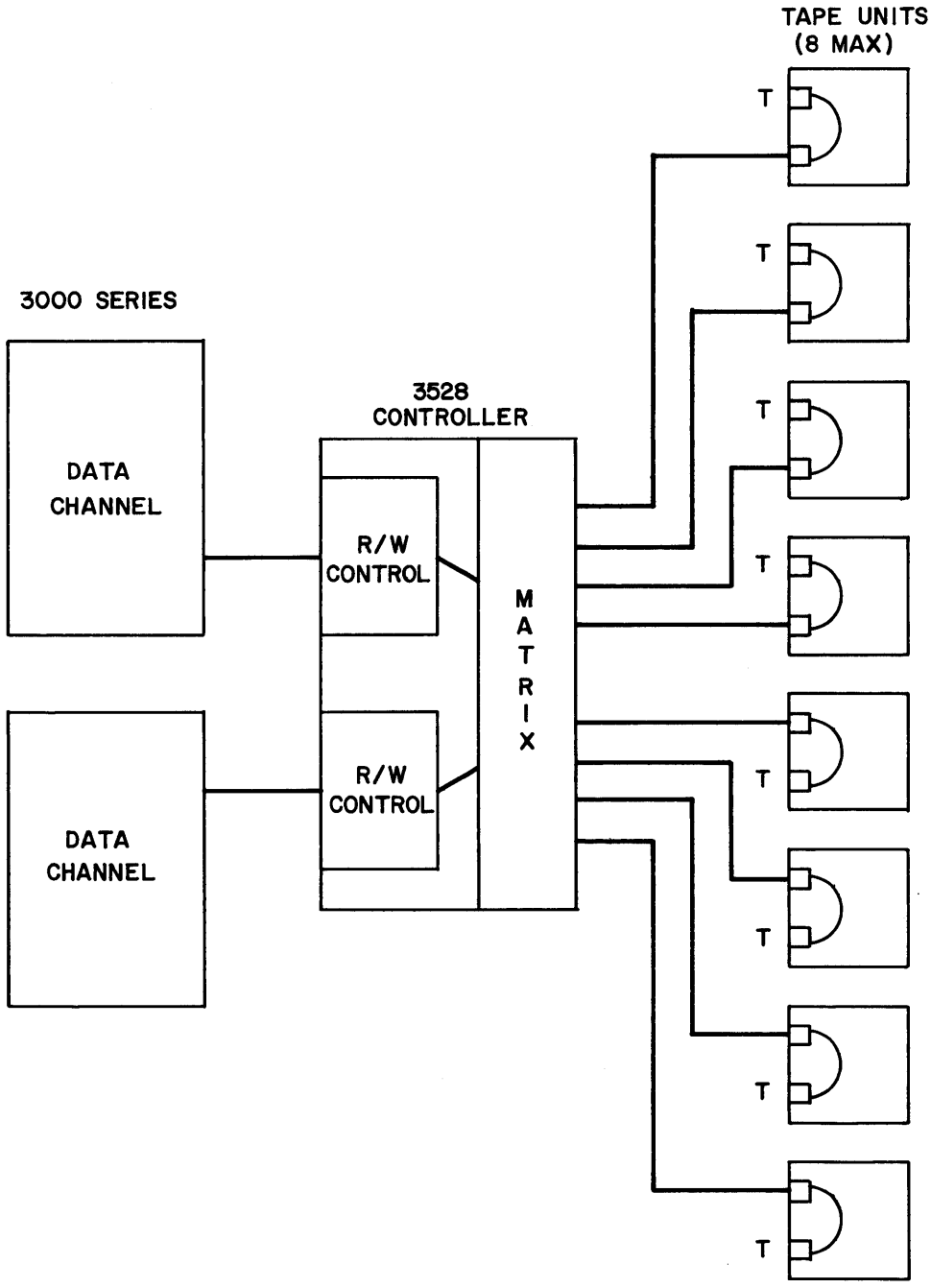


Figure 1-2. Typical Dual Channel Configuration

SUBSYSTEM CONFIGURATION

The controller is classed as an equipment in I/O programming with each read/write control assigned an equipment number. A separate data channel may be connected to each read/write control to communicate with any available tape unit. In the dual-channel configuration, a scanner allows only one data channel at a time to access the connect circuitry in the controller. Reserve logic permits a channel to reserve a tape unit from the other channel until released. Before any exchange of data can occur, the controller and tape unit must be selected by program control by sending a Connect code to the controller. The Connect code must match the switch settings on the controller and tape unit. When the controller is connected, Function codes are used to establish various operating modes and select or release conditions within the controller and tape unit. Status information on conditions within the equipment is available to the channel, whether or not the tape unit connect was successful, as long as the controller is connected.

Each 12-bit byte from the data channel is accompanied by a Connect, Function, or Data signal which defines the byte as a Connect or Function code, or data, respectively. Each byte is acknowledged by either a Reply or a Reject. Information sent from the controller to the channel consists of either 12-bit bytes of data or status information.

Connect codes provide for the automatic selection of tape units. Tape Motion codes control tape movement, such as rewinding, backspacing, or tape motion during a search operation. Some tape motion codes (Rewind, Backspace, Search FM/TM, etc.) are overlapping, i.e., as soon as the tape unit becomes Busy, the controller can perform an operation on another tape unit. Format and Mode selection codes select densities, set up code translation operations, and enable additional status sampling. Interrupt codes are used to halt operations when certain conditions develop.

The basic function of the subsystem is to store (write) and retrieve (read) information on tape. The data written on tape as the result of a single computer output instruction comprises a record. The length of a record may vary from one character to practically an unlimited number of characters. A file consists of one or more records, its length determined by the programmer. Data can be written in Non-Return to Zero Indiscrete (NRZI) or phase encoded format, with standard code conversion. Data is recorded on seven or nine track tape in one of four speeds depending upon the tape unit selected. The controller has the capability of automatically accommodating a large number of speed, density, and format combinations. Due to the combinations possible, the descriptions, codes, and programming considerations are described for a maximum configuration, and not in regard to specific models. The manual user must be cognizant of the model differences, and that all controllers do not have all capabilities described.

RECORDING METHODS

As the magnetic tape passes under the read/write heads, a change of state in the coils results in a corresponding flux reversal on tape. Ones and zeros are recorded in each track as a result of a flux change or no flux change, respectively, in NRZI; or flux changes to definite polarities for ones and zeros in phase recording. The flux reversals from seven read/write coils result in recording a seven-bit character (six data bits and one parity bit) on tape. An eight-bit character plus a parity bit are recorded on a nine track system. The two types of recording used, NRZI and phase encoded, are compared in Figure 1-3. Refer to Figures 1-4 and 1-5 for NRZI and phase encoded formats.

NRZI RECORDING

In this type of recording, "1" bits are recorded by changing the magnetic flux in either direction, whereas no flux reversals are used for recording "0's". Thus, NRZI indicates "Non Return On Zeros".

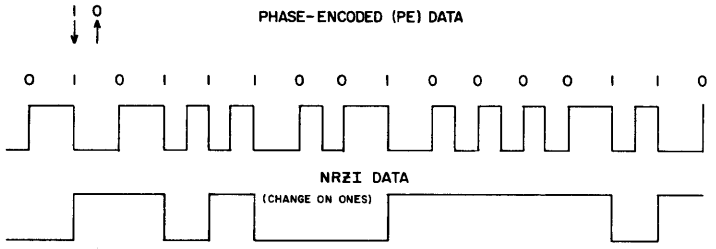


Figure 1-3. NRZI and Phase Bits

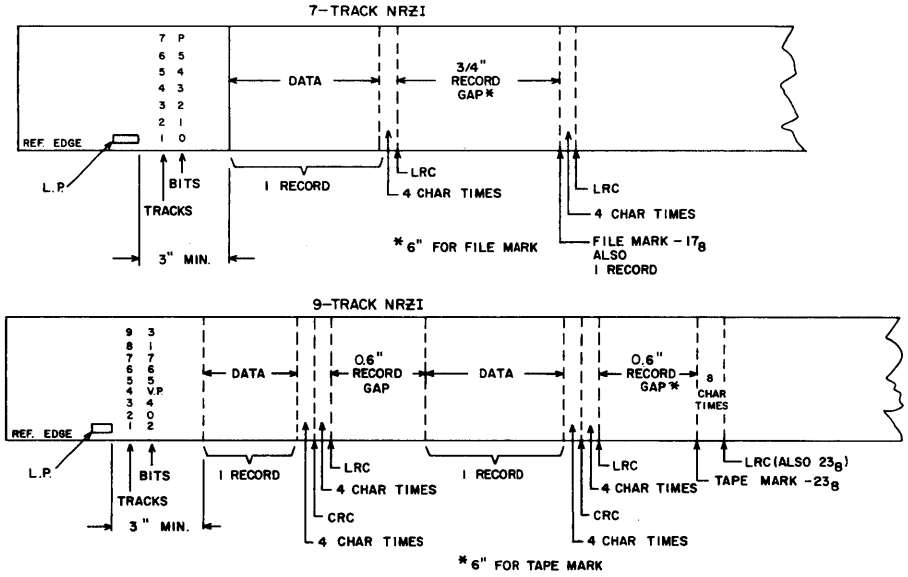


Figure 1-4. NRZI Formats

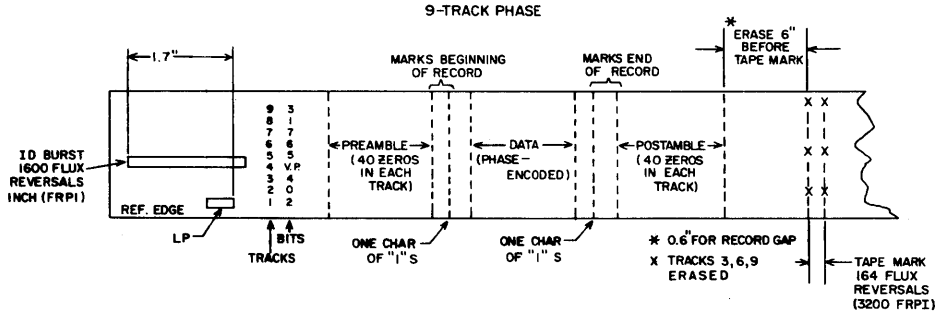


Figure 1-5. Phase Encoded Format

PHASE ENCODED

Phase encoded recording permits a higher concentration of bits and, as such, is used only for a density of 1600 CPI. Phase encoded recording requires the controller to insert phase bits (non-data bits) wherever consecutive one or zero patterns are written.

In phase recording:

1. A "1" bit is recorded by switching the write head flux in the same direction as the erase head reference flux.
2. A "0" bit is recorded by switching the write head flux in the opposite direction as the erase head flux.

As opposed to NRZI recording, phase recording depends on a polarity shift for recording both ones and zeros. The polarity shift is required for successive bits of equal value, for example, such as two or more one bits recorded consecutively on any track. It is necessary therefore, to force a flux transition at the start of a character time so that the desired polarity switch for the data can be accomplished. These forced flux transitions, called phase bits, are synchronized and inserted into the recording stream by the controller. When the data is read, discriminator circuits in the controller are used to separate data bits and phase bits.

Special bit patterns, called preamble and postamble, precede and follow a record of phase encoded data. The preamble and postamble consist of 40 zeros in each track, separated from the data by a character of ones. The tape mark written for phase is also different than that for nine track NRZI, consisting of a special character with certain tracks set to zero and others erased. Phase encoded data is identified by an ID burst consisting of 1600 flux reversals per inch (FRPI) at Load Point, preceding the first record only. This ID burst is recorded in track 4 (parity) only. All other tracks are DC erased.

TRANSFER RATES

Character and byte transfer rates between the controller and tape units are listed in Tables 1-2, 1-3, and 1-4. The transfer rates are specified in KHZ for the various speeds and densities.

TABLE 1-2. CHARACTER TRANSFER RATES BETWEEN THE CONTROLLER AND TAPE UNITS

Tape Speed	200 CPI	556 CPI	800 CPI	1600 CPI
37.5 IPS	7.5	20.85	30	60
75.0 IPS	15.0	41.70	60	120
112.5 IPS	22.5	62.5	90	180
150.0 IPS	30.0	83.4	120	240

TABLE 1-3. BYTE TRANSFER RATES BETWEEN THE DATA CHANNEL AND SEVEN TRACK CONTROLLER

Tape Speed	Two 6-Bit Char per 12-Bit Byte 7 Track Assembly Mode And/Or 7 Track Conversion Mode			One 6-Bit Char per 12-Bit Byte 7 Track Suppress Assembly/Disassembly		
	200 CPI	556 CPI	800 CPI	200 CPI	556 CPI	800 CPI
37.5 IPS	3.75	10.425	15.0	7.5	20.85	30.0
75.0 IPS	7.5	20.85	30.0	15.0	41.70	60.0
112.5 IPS	11.25	31.25	45.0	22.5	62.5	90.0
150.0 IPS	15.0	41.7	60.0	30.0	83.4	120.0

TABLE 1-4. MAXIMUM BYTE TRANSFER RATES BETWEEN DATA CHANNEL AND NINE TRACK CONTROLLER

Tape Speed	Three 8-Bit Char per Two 12-Bit Bytes (See Note) Nine Track Packed Mode		Two 8 Bit Char per Two 6-Bit Char per 12-Bit Byte Nine Track Conversion Mode	
	800 CPI NRZI	1600 CPI PHASE	800 CPI NRZI	1600 CPI PHASE
37.5 IPS	30.0	60.0	15.0	30.0
75.0 IPS	60.0	120.0	30.0	60.0
112.5 IPS	90.0	180.0	45.0	90.0
150.0 IPS	120.0	240.0	60.0	120.0

NOTE

The rates shown for the nine track packed mode represent the shortest time between two successive bytes. The average rate is 2/3 of that shown. The computer must be capable of the rate shown but actual transfer is based on the 2/3 figure. This is because two 12-bit bytes must be transferred before two 8-bit characters can be written on tape. No more 12-bit bytes are transferred until the third 8-bit character is written on tape. A similar situation can occur during a read.

DATA TRANSFER OPERATIONS

Data transferred between the channel and tape unit may be in either binary coded decimal (BCD) or binary format. Whereas seven track recording may be either, nine track is always binary. Binary mode which uses odd parity is always used following a clearing operation or by function selection of binary mode. BCD (even parity) is selected only by function and is used only in seven track operations. External BCD is written on tape as the controller automatically converts it from internal BCD, the code used internally by 3000 computer systems. As external BCD is read, it is converted to internal BCD. A negation of this conversion is possible.

WRITE OPERATION

A Write operation is initiated by executing a computer output instruction.

In most seven track recording applications, 12-to 6-bit disassembly is used. The controller accepts 12-bit bytes from the data channel, and disassembles the data into 6-bit characters for recording on tape, upper 6 bits first. If the output instruction executed is character oriented, the disassembly is suppressed, and only the lower 6 bits from the channel are sampled, with the upper 1/2 of each byte ignored, except for transmission parity checking.

Data handling during nine track recording is done in either of the following two ways, as selected by function.

Packed Transfers

Unless code conversion (Set Conversion Mode, 0045) is selected, the controller assembles two 12-bit bytes from the channel, then disassembles the 24-bit word into three 8-bit characters and transmits them individually to the tape unit, upper 8 bits first.

Conversion Mode

When code conversion is selected, the controller disassembles 12-bit bytes received from the channel into two 6-bit characters. An internal controller memory is referenced for each character to obtain an equivalent 8-bit code, which is then transmitted to the tape unit. On reading, the process is essentially reversed, with 8-bit character codes used to address 6-bit equivalent codes in memory.

Internal memory parity is checked during all code conversion references, with odd parity used. Parity errors are recorded by setting bit 1 of the Status 2 conditions. In addition, all 6-bit codes stored in memory have a flag bit assigned (bit 6). If, while referencing 6-bit characters during Read operations, this bit is not set, it is assumed that an illegal memory address was referenced and a Flag Bit Error is set (bit 2 of Status 2). For example, such an error would occur if an illegal 8-bit code were read from tape or read error occurred. Memory parity errors and flag bit errors both cause Alert status bit (bit 10) to come up in Status 1 and 2.

A steady Write signal along with a Forward signal from the data channel starts tape motion. An independent Data signal comes up shortly after the Write signal, indicating information is available on the data lines.

When the data is accepted, a Reply signal is returned to the channel. The Reply signal drops the Data signal. When the Data signal goes down, the Reply signal drops.

If the Write signal is still present and the Data signal reappears, the Write operation continues until the range of data specified in the output instruction has been transmitted (operation complete). At this time the End of Record is marked by a special character or pattern, before the heads are stopped in the interrecord gap:

Seven track -- Longitudinal Redundancy Check character (LRC)
Nine track (NRZI) -- Cyclical Redundancy Check (CRC) followed by LRC
Nine track (Phase) -- Postamble (one frame of "1's", followed by forty frames of zeros)

An automatic Read after Write is performed for parity checking purposes. Non-stop Write operations are possible. The Write signal may come up again immediately or any time after the tape unit End of Record signal. A Write signal without a Data signal will cause a Lost Data condition and tape motion will stop. The Lost Data conditon must be cleared by a function other than a 5X function, or by a Master Clear before another Read or Write operation can be performed.

Seven Track Write Disassembly

During a seven track Write, each 12-bit byte received from the data channel is disassembled into two 6-bit characters to be written on tape. The upper 6 bits of the 12-bit byte are transferred before the lower 6 bits.

As each 6 bits is transferred to tape, a parity bit is added as required to generate odd parity on tape if the transfer is made in binary mode. If BCD is transferred, even parity is generated. In BCD, the parity bit is generated after the BCD conversion. Only an even number of characters can be written on tape in this mode of operation.

Seven Track Write-Suppress Disassembly

A Suppress Assembly/Disassembly line from the data channel, if activated, will cancel the disassembly during a Write. The lower 6 bits of the 12-bit byte from the data channel will be transferred to tape with correct parity during a Write. The upper 6 bits will be discarded. It is possible to write an odd number of data bits on tape in this manner.

Nine Track Write-Assembly/Disassembly (Packed)

Two 12-bit bytes from the data channel are assembled into a 24-bit register in the controller. Three 8-bit characters are disassembled from the 24-bit register and written on tape. If the output block consists of characters in multiples of three, an even number of bytes are transferred. The first 12-bit byte from the data channel goes into the upper 12 bits of the 24-bit register with the second byte going into the lower 12 bits. The first character to be written on tape is the upper 8 bits of the 24, the second is the middle 8 bits and the third the lower 8 bits. Since nine track recording is always odd parity, a parity bit is added to each 8-bit character as required to make the character parity odd. In the event that the output is a block of data consisting of an odd number of 12-bit bytes, the last data character to go on tape will be the upper 8 bits of the last 12-bit byte. The remaining lower 4 bits of the 12-bit byte will be discarded. See Figure 2-2 for special status conditions. In nine-track mode, there is no character mode. The above packed mode is used except for code conversion or 3N + 2 mode. (If 3N + 2 mode is selected, two characters are written in addition to any multiple of three characters. For further information see Format/Mode Selection Codes.)

Nine Track Write-Code Conversion

The Set Conversion Mode must be selected by function code 0045. A 12-bit byte from the data channel is disassembled into two 6-bit characters.

The quantity 400_8 is added to each 6-bit character to provide an address in memory for the area in which the 8-bit codes are stored. Using this address, the contents of the memory location will be read, parity checked, and the 8-bit code recorded on tape, with odd parity. Set Conversion Mode must be cleared by a 0044 function code, before any other data handling functions are performed such as Write FM/TM. Code Conversion can be performed on a seven track unit if the equivalent codes are limited to six bits plus parity, and flag bits as required. In the event that BCD mode is set during code conversion, even parity will be written on tape but no BCD conversion will take place. An all-zeros character from memory will result in no character being written on tape.

Write Jog

Any time a Write operation is followed by a Reverse operation, Backspace, Search Reverse, Rewind or Rewind Unload, the tape will move forward approximately 1/2 inch during which time it is DC erased. Upon the tape unit going Not Busy, the Reverse function is executed. The controller stays Busy during the jog sequence until the Reverse function is actually sent to the tape unit. Once the Reverse function causes the tape unit to go Busy, a different tape unit can be connected and operations performed on it. In the case of a Reverse function, a connect attempt to another tape unit will be rejected only during a write jog, if it occurs.

READ OPERATION

A Read operation is initiated by executing a computer input instruction. A steady Read signal from the data channel initiates tape motion. A backward Read will occur if selected by function code; otherwise the tape unit will read forward. An independent Data signal comes up after the Read signal and indicates that the data channel is ready to accept information from the tape. When the data is ready for transfer, a Reply will be sent to the data channel.

When the data channel accepts the information, the Data signal drops which, in turn, drops the Reply. If more information is to be read, the Data signal is brought up again indicating the data channel is again ready to accept information when read by the tape unit. The Read operation continues until the Read signal drops or an End of Record check character is read. Tape motion continues until the End of Record check character is read, even though the information is not accepted by the data channel. When reading from 1600 CPI phase encoded tape, the end of data is determined by a frame of all ones followed by a frame of all zeros. Tape motion continues until the read head reaches the inter-block gap and a stop is initiated. Non-stop Read operations are possible, since the Read signal can come up again immediately or any time after the tape transport End of Operation signal. This allows the possibility of maximum computer time while still maintaining full tape speed. If tape speed has begun

decelerating and the next Read request is in the same direction, the only waiting time is for the unit to get up to tape speed and begin reading the next record.

Seven Track Read Assembly

A seven track forward Read will assemble two 6-bit characters from tape into one 12-bit word for transfer to the data channel. The first character received from tape will be transferred to the upper 6 bits of the 12-bit word. The second 6 bits will be transferred to the lower 6 bits of the 12-bit word. (See Figure 1-6.)

In the event that an odd number of data characters is received from tape, the last valid character will appear in the upper 6 bits of the 12-bit byte. The lower 6 bits will be zeros. Bit 5 of status 2 (Character Fill) will indicate that the lower 6 bits of the last 12-bit byte transferred is a fill character.

Seven Track Read Suppress Assembly

If the Suppress Assembly/Disassembly line is up, each 6-bit character received from tape will be transferred to the lower 6 bits of the 12-bit byte. The upper 6 bits remain zero and the 12-bit byte is transferred to the data channel. No Character Fill status will occur. If a file mark is read during a forward Read, an octal 17 will appear in the upper 6 bits of the 12-bit byte and zeros in the lower 6 bits, if in Assembly mode.

In Suppress Assembly mode, the 17_8 will appear in the lower 6 bits instead of the upper. In either case, a File Mark status will occur. If read in binary mode, a parity error will be detected. If read in BCD mode, no parity error occurs.

Seven Track Reverse Read

During a Reverse Read, the order of assembly will be reversed to put the characters in the same position from which they came, unless an odd number of characters was written on the tape. In that case, the 6-bit characters will be displaced by one character when assembled into a 12-bit byte.

A Reverse Assembly line from the controller to the data channel will indicate that the 12-bit bytes are being sent to the data channel in reverse order.

In the event of Reverse Read in Suppress Assembly mode, the 6 characters from tape will be transferred to the lower 6 bits of the 12-bit byte, the same as for a Forward Read Suppressed Assembly. Reverse Read over a file mark will result in an octal 17 being read into the lower 6 bits of the 12-bit byte whether in Assembly mode or Suppress Assembly mode. File Mark status will occur. Reverse Read is not allowed from load point.

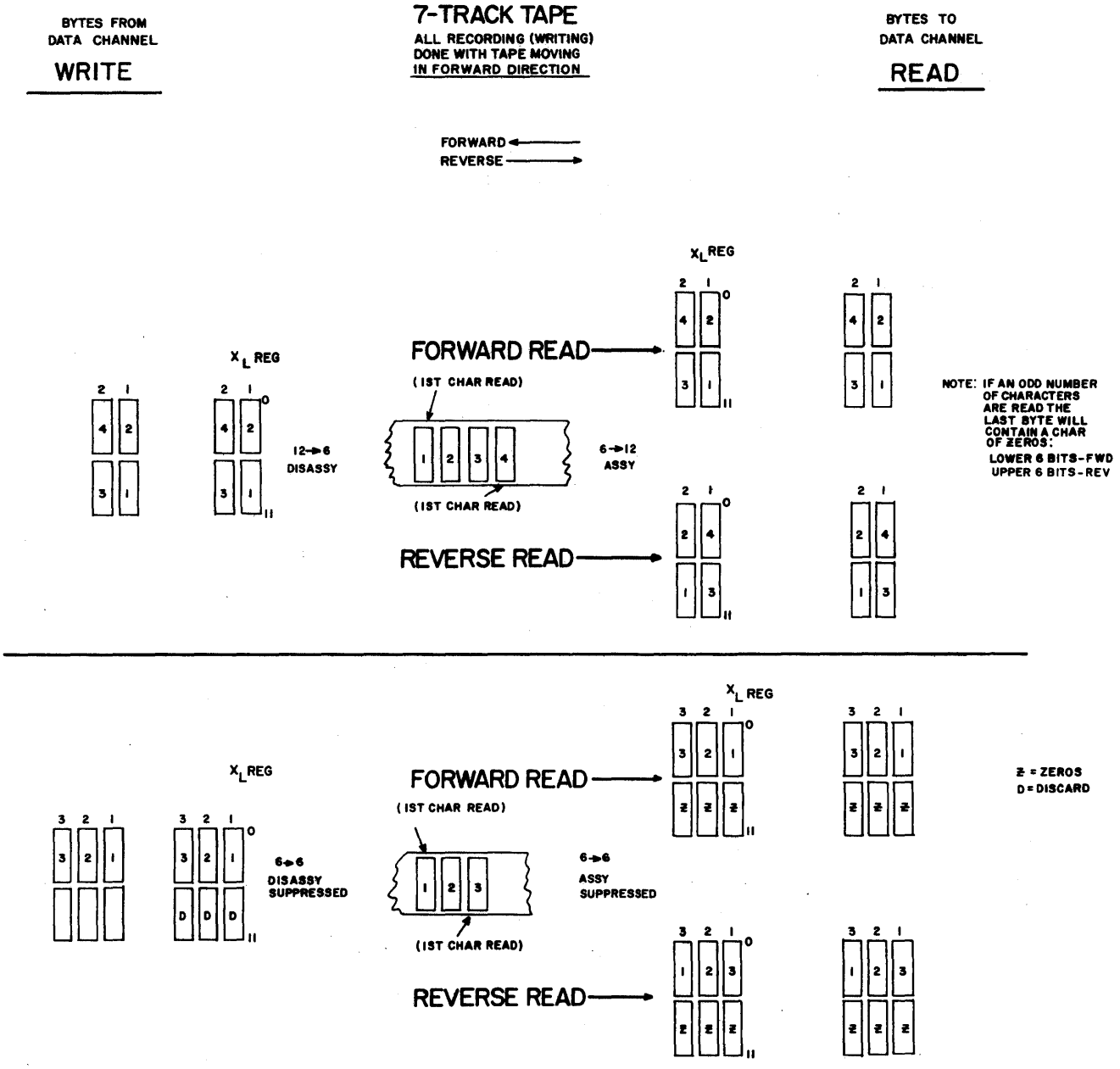


Figure 1-6. Seven Track Operations

Nine-Track Read Assy/Disassy (Packed)

During a Forward Read, the characters read from tape are assembled as follows:

Three 8-bit characters from tape are assembled into a 24-bit register and transferred to the data channel as two 12-bit bytes. (See Figure 1-7.)

The first 8-bit character from tape will go into the upper 8 bits of the 24-bit register. The second and third 8-bit characters will go into the middle and lower 8 bits of the 24-bit register, respectively. The upper 12 bits of the 24-bit register will be transferred to the data channel first and the lower 12 bits last. If the number of characters in the record is a multiple of three, an even number of 12-bit bytes will be transferred to the data channel.

If one additional character is received from tape, it will appear in the upper 8 bits of the last 12-bit byte transferred. The number of 12-bit bytes transferred will be odd and no Character Fill status will occur. The lower 4 bits of the last 12-bit byte will be meaningless data. The programmer can determine this condition by keeping count of the odd/even number of 12-bit bytes.

In the event that two extra 8-bit characters are received from tape over and above a multiple of three, they will be placed in the upper 16 bits of the 24-bit register and the lower 8 bits will be meaningless. Two extra 12-bit bytes will be transferred to the data channel. Since this is an even number of 12-bit bytes, the programmer cannot detect a character fill by the odd/even method, so Character Fill status (bit 5) occurs in Status 2. This indicates that the lower 8 bits of the last 12-bit byte transferred to the data channel are meaningless.

Nine-Track Reverse Read

During a Reverse Read, the first data character read from tape will be transferred to the lowest 8 bits of the 24-bit word. The first 12-bit byte transferred to the data channel will be the lower 12 bits of the 24-bit word. This will occur after the second 8-bit character is read from tape and placed in the middle 8 bits of the 24-bit word. If an odd number of 12-bit bytes are transferred to the data channel, no Character Fill status will occur. The upper 4 bits of the last 12-bit bytes transferred will be meaningless. If an even number of 12-bit bytes are transferred and a Character Fill status does occur, this indicates that two 8-bit characters in excess of a multiple of three were read and the upper 8 bits in the last 12-bit byte are meaningless.

A Reverse Assembly line from the data channel indicates that the 12-bit bytes being sent from the controller are in reverse order.

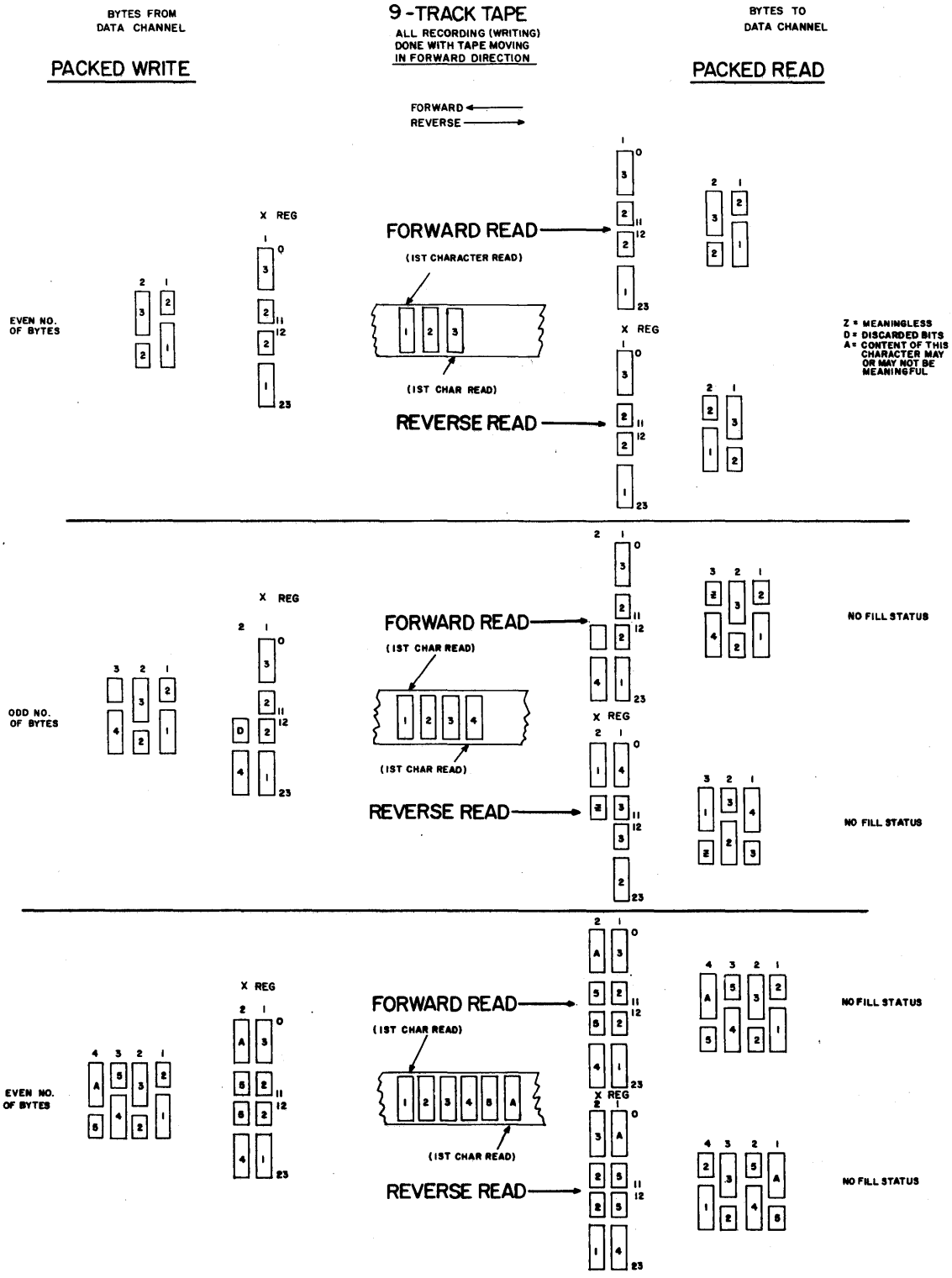


Figure 1-7. Nine Track Operations

Reverse Read over a tape mark in NRZI will cause an octal 23 to be read into the lower 8 bits of the single 12-bit byte transferred to the data channel. FM Detected status will occur in Status 1 and no Character Fill status will be indicated in Status 2. Reverse Read over a tape mark in phase encoding will result in a TM Detected status, but no information will be transferred to the data channel. Reverse Read is not allowed from load point.

Nine Track Read-Code Conversion

The Set Conversion Mode must be selected by function code (0045). Each 8-bit character read from tape is used as an address to the 500_8 character memory. Codes 000 through 377_8 will give access to the lower 256 (400_8) memory locations which hold previously stored 6-bit codes accompanied by a flag bit (bit 5), and a parity bit (bit 8) as required to give odd parity. Memory locations without a legal 6-bit code will have no flag bit but should have a parity bit as required for odd parity. If a memory location is addressed in which no legal 6-bit code has been stored, a Flag Bit Error is indicated by Alert status in Status 1 and Flag Bit Error in Status 2.

If a parity error exists on information read from memory, Alert status is indicated in Status 1 and Memory Parity Error status is indicated in Status 2.

The 6-bit codes read from memory at the address corresponding to the 8-bit characters from tape will be assembled into a 12-bit byte, according to the procedure used for a seven track Read in Assembly mode, forward or reverse as applicable. No Suppress Assembly Conversion mode operation is possible in nine track. Character Fill status will occur the same as for seven track Assembly mode read.

Flag Bit Error status and Memory Parity Error status will be cleared out by Master Clear, clearing of Set Conversion Mode, or reading or writing a new record.

Nine-Track Read Over Tape Mark

NRZI

During a nine track NRZI Read, if a record consisting of a tape mark is read, an octal 23 character from tape will be transferred to the upper 8 bits of the possible 24-bit word. Since no more characters arrive from tape, one 12-bit byte is transferred to the data channel. The TM Detected status will occur. Because nine track is always odd parity, no Parity Error status will occur.

Phase

If a phase tape mark is encountered during a nine track,phase encoded Read, no data will be transferred to the data channel. TM Detected status will occur.

SPECIAL OPERATIONS

Besides controlling data transfer operations, a number of special tape unit operations can be selected by issuing Function codes to the controller. Descriptions of these tape motion operations, which include searches, backspace and rewind, are found in the Operation and Programming section.

PARITY CHECKING

TRANSMISSION PARITY CHECKING

All information transmitted between a data channel and the controller is in odd parity; that is, the total number of "1" bits, including the parity bit, must be odd. If parity is even, a transmission parity error occurs and a parity error condition is recorded in the channel. The effects of transmission parity errors on the different types of data transmission are listed below.

Connect

If a parity error is detected during a connect, the equipment does not connect and neither a Reply, a Reject, or a Parity error signal is returned to the controller. However, the XMSN P.E. indicator on the controller will light. Lower 3000 series computers generate an internal Reject after 100 μsec. The error condition must be cleared before a connect can be accomplished.

Function

If a parity error is detected in a function, the function code is ignored, an External Parity Error signal is returned to the channel, and the XSMN P.E. indicator on the controller lights. The error condition must be cleared before a Function code will be accepted. Neither a Reply nor a Reject is returned to the channel. Lower 3000 series computers generate an internal Reject after 100 μsec. Although the controller may continue to operate, information received after the error occurs is unreliable and hence, the clearing should be done.

Write

If a transmission parity error is detected by the controller in a Write operation, both an External Parity Error signal and Reply signal are returned to the channel and the controller XMSN P. E. indicator lights. The output operation continues to normal completion despite parity errors. A parity error can be cleared by a reconnect or a Master Clear.

Read

If a transmission parity error is detected by the channel during a Read operation, the channel parity error indicator on the system console lights (3000 Computer Systems). The Read operation continues unless the program is arranged to sense the error and reread the data. A parity error can be cleared by a reconnect or a Master Clear.

EQUIPMENT PARITY CHECKING

During a Write operation, a parity-checking Read automatically follows every character written on tape. Each character written is read back from tape to the controller, where vertical parity is checked (see Figure 2-4). In NRZI the LRC character is also generated, and upon readback during the Write, the LRC character is used in a longitudinal parity check of the information written.

During normal Read operations, the controller makes similar checking operations to confirm that no information has been lost since the recording was made (see Figure 2-4). In the event that a file mark/tape mark (FM/TM) is read back, a FM/TM Detected status will occur.

VERTICAL PARITY CHECKING

During recording, vertical parity is established by adding a parity bit to every character which does not have the correct number of "1" bits. All binary characters (seven and nine track recording) are written with odd parity and BCD is written in even parity. If the wrong number of bits is detected on the Read after Write, or during a normal Read operation, a parity error results.

When a vertical parity error is detected, the controller VERT P. E. indicator lights and the condition is recorded in the controller. This causes an Alert status response in Status 1 (bit 10) and Vertical or Longitudinal P. E. status in Status 2 (bit 0). This condition can be programmed to cause an Abnormal End of Operation interrupt. A new Read, Write, or Master Clear is required to clear the error condition.

LONGITUDINAL PARITY CHECKING(NRZI ONLY)

Longitudinal parity (even parity) is established by writing a LRC character at the end of each record. This character contains a "1" bit in every track which does not otherwise have an even number of one bits. In nine track NRZI, the character is written following the CRC character. If an odd number of bits is detected during a Read after Write, or during a normal Read operation parity check, a longitudinal parity error results.

When such an error is detected, the controller LONG P. E. indicator lights and the condition is recorded (causing an Alert status in Status 1, bit 10, and a Longitudinal P. E. status in Status 2, bit 0). The condition can be programmed to cause an Abnormal End of Operation interrupt. A new Read, Write, Channel Clear, or Master Clear is required to clear the error condition.

ERROR DETECTION AND CORRECTION

The controller provides error detection and error correction facilities for nine track recording, with a different method used for 800 CPI NRZI than for 1600 CPI phase recording. The error detection automatically occurs during Read operations. If a single-track error is detected in NRZI mode, error correction is performed by the controller by complementing the bit in error, provided the program re-reads the data record. In phase, no reread is required, since the bit in error is complemented On-the-Fly. In phase, Status 2, bit 7 is set when an error correction has been performed.

Multi-track error corrections are not possible, but status on this condition is available with bit 4 of Status 2.

For maintenance purposes or diagnostic checkout, phase On-the-Fly error detection and correction can be disabled by the NEG EC/EC PHASE switch on the maintenance panel.

NRZI ERROR DETECTION/CORRECTION

The controller generates a CRC character for each record written on tape. On each character pattern written, the controller performs a sequence of Exclusive OR's, right shifts, and conditional complements, with the results from each sequence propagated into the sequence for the next character written.

While writing the last character in a record, a rotating pattern of 727_8 is exclusively OR'ed with the cumulative results to form the CRC character, which in turn is written on tape.

When any record of 800 CPI data is read, the controller generates another CRC character as each character (including the CRC from tape) is read. Simultaneously, each character is checked for vertical parity, and similar to CRC generation, any parity error indications are Exclusively OR'ed, shifted, and complemented in an Error Pattern Register (EPR) for each character read. If, upon completion of the Read, the CRC just generated does not equal the rotating pattern 727_8, a CRC error has occured. The condition is recorded by setting bit 3 of Status 2.

The controller will identify the bit in error by comparing the quantity in the CRC register with the contents of the EPR. The EPR contains a value representing the vertical parity errors detected during reading of the record. If the two registers do not compare, the CRC register is shifted again and another compare of the contents of both registers is made.

The number of comparisons required before the registers are found to be equal corresponds to the number of the bit in error. A counter is incremented on each comparison. If, for example, the registers are equal on the first comparison, the counter will stop at 0. This indicates that a bit in the track corresponding to bit zero is in error. When this track is known, the program can reverse tape motion and the record can be reread. As the vertical parity is checked on the reread, the character containing the parity error will be identified. Since the position of the erroneous bit within the character is known, this bit can be corrected, i. e., complemented, and sent to the data channel. If the record is not reread, the controller drops the error correction mode as another record is started. If more than one record is backspaced over, or a Connect function is attempted, the error correction mode is also dropped. During a reread in Correct mode, a CRC check is made on the corrected data, but a new track search does not occur. If a CRC error occurs again and another reread is performed, the same track will be corrected. To reread the record without Correct mode (so as to perform the track search again), more than one record must be backspaced. If the registers are still not equal after nine comparisons, the error is uncorrectable due to multiple track errors or a zero CRC register condition.

In a Reverse Read, if an error occurs in the CRC character itself, error correction will be impossible.

PHASE ERROR DETECTION/CORRECTION

During a Read of a phase encoded tape, if a bit is dropped in any one track, the controller will generate the correct bit for that track for each character remaining in that record based on odd parity, looking at the remaining tracks.

When single track error correction is performed, alert status will not occur, but a Phase Error Correction Status bit becomes present in Status 2, bit 7. This bit indicates that an error correction has been performed.

In the event that a bit drops in more than one track, an Alert status occurs and a Multi-Track Phase Error status occurs in Status 2 (bit 4). Proper correction does not occur with multi-track errors. The On-the-Fly error correction may be made inoperative by turning the NEG EC/EC PHASE switch to the NEG EC position.

INT TO EXT BCD

When BCD mode has been selected by function (0002) and a Write is initiated on a seven track tape unit, the controller automatically performs internal to external BCD conversion, unless negated. The data recorded will be in even parity. To provide bits for generating sprockets during a Read, any attempt to write an all zero character on tape will result in the converting of it to an octal 12 which will be written on tape. Any time bit 4 of the outputted character is a one, the controller automatically complements bit 5, resulting in converting:

$2X_8$ to $6X_8$
$3X_8$ to $7X_8$

During a seven track Read operation in BCD mode, the data is checked for even parity. External to internal BCD conversion takes place, resulting in changing:

12_8 to 00
$6X_8$ to $2X_8$
$7X_8$ to $3X_8$

A Negate BCD Conversion line from the channel, if enabled, will disable the BCD conversion, but it will not switch the format selected from BCD to binary, on either a Read or Write. Parity checked and generated will be even parity. Nothing will be written on tape for an all zeros character if BCD conversion is negated.

CODES 2

INTRODUCTION

Table 2-1 lists the codes used in programming the controller/tape unit subsystem. All codes are transmitted over the standard channel interface to the controller. In 3000 Series systems, the codes are issued by program execution of the appropriate Connect, Select/Function, and Sense or Copy status instructions. Systems that interface the controller via channel converters generate identical codes through similar instruction execution. The sections following the table describe each code. Bit 0 is the rightmost bit.

TABLE 2-1. CONNECT, FUNCTION, AND STATUS CODES

CONNECT	
Connect Controller and Tape Unit Code	N00U
N - Equipment Number or Read/Write Control U - Tape Unit Number	
FUNCTION	
Tape Motion Codes	
Rewind	0010
Rewind Unload	0011
Backspace	0012
Search File Mark Forward/Search Tape Mark Forward	0013
Search File Mark Reverse/Search Tape Mark Reverse	0014
Write End of File Mark/Tape Mark	0015
Skip Bad Spot	0016
Format and Mode Selection Codes	
Release	0000
Binary	0001
Coded	0002
556 CPI Density	0003
200 CPI Density	0004
Clear	0005
800 CPI Density	0006
1600 CPI Density	0007
Clear Reverse Read	0040

TABLE 2-1. CONNECT, FUNCTION, AND STATUS CODES (Cont'd)

Set Reverse Read	0041
Clear Memory Mode	0042
Set Memory Mode	0043
Clear Conversion Mode	0044
Set Conversion Mode	0045
Clear Controlled Backspace	0046
Set Controlled Backspace	0047
Programmable Clip Level	0050
Clear Opposite Channel (Used in 2 X 8 only)	0051
Clear 3N + 2 Mode	0052
Set 3N + 2 Mode	0053
Clear Status 2, Return to Status 1	0056
Set Status 2	0057
Interrupt Codes	
Interrupt on Ready and Not Busy	0020
Release Interrupt on Ready and Not Busy	0021
Interrupt on End of Operation	0022
Release Interrupt on End of Operation	0023
Interrupt on Abnormal End of Operation	0024
Release Interrupt on Abnormal End of Operation	0025

STATUS

STATUS 1	STATUS 2	
Ready	Transverse and/or Longitudinal P. E.	XXX1
R/W Control and/or Tape Unit and/or Channel Busy	Memory Parity Error	XXX2
Write Enable	Memory Flag Bit Error	XXX4
File Mark/Tape Mark Detected	CRC Error	XX1X
Load Point	Multi-Track Phase Error or Uncorrectable CRC Error (NRZI)	XX2X
End of Tape	Character Fill	XX4X
Density	Character Crowding or Dropout and False End of Operation	X1XX
Density	Phase Error Correction	X2XX
Lost Data	False Postamble Detected	X4XX
End of Operation	End of Operation	1XXX
Alert	Alert	2XXX
Tape Unit Reserved (2x8 only)	Cold Start	4XXX

CONNECT CODE

The computer must send a Connect code accompanied by a Connect signal to select the 1 X 8 controller and tape unit before any Function codes can be sent or an I/O operation can be started. The Connect code consists of the lower 12 bits of the Connect instruction as shown in Figure 2-1. The N portion of the code must match the setting of the EQUIP. NO. switch on the maintenance panel. The U portion of the code determines the selection of tape units 0 through 7. Bits 3 through 8 are not used.

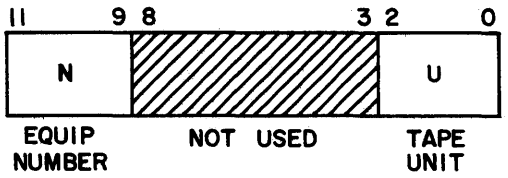


Figure 2-1. Connect Code

A Reply is returned to the channel indicating the connect was successful, providing the following conditons are met:

1. The requested tape unit or read/write control is Not Busy or reserved by another channel.
2. The N portion of the Connect code matches the equipment number of the read/write control.
3. The U portion of the Connect Code matches the unit number switch on a tape unit.

NOTE

Due to the series cabling scheme shown in Figure 1-1, a Reply is returned in 1 x 8 configurations even though the selected unit is physically not in the system. Status 1 must be checked for bit 0 (Ready) to determine if the connect was successful. Do not loop on Ready status without a connect for each status attempt.

4. A transmission parity error is not detected.

When a connect cannot be completed, a Reject may or may not be returned to the channel, depending upon the following conditions:

A Reject will be returned to the channel if:

1. A connect is attempted on a read/write control already connected and active (or Busy). When the Connect signal is dropped, the Reject condition is cleared, and operation continues on the read/write control already connected.
2. A connect is attempted, the read/write control is Not Busy, but the tape unit is reserved by another channel. The tape unit previously connected remains reserved to its channel until released, cleared, or assigned a new unit number. When reserved, no other channel has access to it. Since it is possible for one channel to reserve all tape units, care must be taken to release units not essential to the current program.

Upon a Reject, the computer reads the next instruction at the Reject address (P+1). If the connect was completed as far as the controller, equipment status is available to determine the cause of the Reject, even though it may have been caused by the tape unit reserve.

Neither a Reject nor Reply will be returned to the channel if:

1. The N portion of the Connect code does not match the equipment number of the read/write control. Equipment status is not available.
2. A transmission parity error is detected in the Connect code. The XMSN P.E. indicator lights for the read/write control in which the parity error was detected. Parity errors can be cleared by a new connect attempt or a Master Clear.

In the 2 X 8 controller, a scanner allows only one data channel at a time to access the connect circuitry. If a connection is made, a Reply is returned to the data channel. A Reject will be sent only if the read/write control with which the connect is being attempted is busy or if the opposite channel already has access to the read/write control. In the event that the tape unit being sought is reserved by the other channel, a Reject will be returned if the connect to the controller was successful. A "1" in bit 11 (4XXX) of Status 1 indicates that the tape unit is reserved by the other channel.

FUNCTION CODES

Function codes establish I/O operating modes and select or release conditions within the tape subsystem. The controller and tape unit must be connected to recognize Function codes; unconnected controller and units are not affected. In 3000 Series systems, the codes are specified by the lower 12 bits of a Select/Function instruction and are transmitted to the controller over the normal data interface. Table 2-1 lists all applicable function codes.

The controller examines each Function code for parity errors and if an error is detected, the requested function is not performed. Since neither a Reply nor Reject are returned to the data channel, the computer generates an internal reject after 100 μsecs. An External Parity Error signal is returned to the data channel and the XMSN P. E. indicator on the controller lights.

Although parity errors may be cleared by a Master Clear, a reconnect is necessary to enable equipment recognition of new Function codes. The Master Clear is not necessary since another connect attempt automatically clears the error condition.

If no parity error is detected by the controller and the requested function can be performed, a Reply is immediately returned to the channel.

The controller replies to all 002X and 005X function codes. If any 003X, 006X, or 007X function codes are sent, they will be rejected. The 000X, 001X, and 004X function codes are rejected any time the read/write control is active. The 001X functions will also be rejected by tape unit Busy.

There are three classes of function codes - Tape Motion, Format and Mode Selection, and Interrupt.

TAPE MOTION CODES

Tape motion codes are accepted only when the tape unit is Ready and Not Busy. As soon as the code is accepted and initiated, a Reply is returned to the data channel.

Rewind (0010)

This code rewinds tape at high speed to load point. The code has no effect when the tape is at load point. The time required to rewind a 2400 foot reel of tape is as follows.

Seconds (maximum)	At Tape Speed (IPS)
210	37.5
130	75.0
85	112.5
85	150.0

Rewind Unload (0011)

This code rewinds tape at high speed to load point. All further operations with this tape unit are locked out until the tape is manually reloaded. The tape unit goes Not Ready at the beginning of the Rewind Unload function.

Backspace (0012)

This code backspaces the tape one record or until load point is detected. If the tape is initially at load point and if fewer than two characters precede the load point, it unloads the tape. If the Reverse Read operation is initiated, a Backspace code results in forward tape motion.

A Backspace function with Reverse Read set will result in forward tape motion over one recorded block of tape. This is referred to as a Forespace. If a Forespace is initiated from load point on a nine-track tape unit with NRZI recording, the tape unit will move the first record past the read heads and stop in the inter-record gap between the first and second records. If the tape is phase-encoded, the tape unit will stop with the read head in the gap between the ID burst and the first record. The first record will not have passed under the read head.

Search File Mark Forward/Search Tape Mark Forward (0013)

This code initiates a Forward Search in the tape unit until the tape unit logic detects a file mark or tape mark (FM/TM). No information will be transferred to the data channel other than a FM/TM Detected status and/or an interrupt on Abnormal End of Operation, if selected. If no FM/TM is detected, it will result in running off the end of tape. Since all the search logic is in the tape unit, other operations can be performed on other tape units once the Search is initiated by the function and verified by the tape unit status indicating Busy. No interrupt is possible unless the tape unit performing the search remains connected or until it is reconnected. No parity errors will occur due to a Search operation.

Search File Mark Reverse/Search Tape Mark Reverse (0014)

This code backspaces tape until the tape unit logic detects a FM/TM or a load point is detected. If no FM/TM or load point is detected, it will result in running off the end of tape. Otherwise, the description for code 0013 applies.

Write End of File Mark/Tape Mark (0015)

When connected to a seven-track tape unit, this function will cause the tape to move approximately 6 inches during which the tape is DC erased. An octal character 17 is written followed four character times later by an LRC character which will also be an octal 17. A vertical parity error will occur due to a properly written file mark when in binary mode, seven track. In nine track, 6 inches of tape are erased and a tape mark written which is an octal character 23 followed eight character times later by an octal LRC character of 23. There is no CRC character recorded in a nine track NRZI tape mark. When End of Operation status occurs after properly writing a file mark or tape mark on either a seven or nine track tape unit in NRZI, FM/TM Detected status will occur.

When connected to a tape unit capable of writing in phase mode and with 1600 CPI phase encoding selected, a tape mark may be written by executing this function. Six inches of tape will be DC erased. Then a tape mark record will be written at 164 flux reversals (at a 3200 FRPI rate) in tracks 1, 2, 4, 5, 7, and 8, with tracks 3, 6, and 9 being DC erased.

Skip Bad Spot (0016)

When this function is initiated, tape motion occurs and approximately 6 inches of tape is DC erased. No characters are recorded. The read threshold is automatically decreased making the read back more sensitive, and the pickup of any bit in any track will result in an Alert (bit 10) and Parity Error (bit 0) status in Status 2.

FORMAT/MODE SELECTION CODES

These codes are used to set up recording formats and select operating modes prior to initiating a Read or Write operation. The codes cannot be accepted during a Read or Write operation (Reject is returned), but are recognizable as soon as:

1. End of Record is marked on a Write operation.
2. End of Record is received on a Read operation.

Release (0000)

This code clears both the existing tape unit connection and the channel reserve on that unit, but does not clear the reserve logic in any other tape units reserved by that data channel.

Binary (0001)

This code causes all data to be written/read in binary (odd parity) notation. The same effect is obtained by a clearing operation.

Coded (0002)

This code causes all data to be written/read in BCD (even parity) notation. The controller automatically converts data received from the channel to external BCD, and data transmitted to the channel to internal BCD. This conversion can be prevented if the Negate BCD Conversion line is up. If connected to a nine track tape unit, the BCD mode cannot be selected. If the controller is already in BCD mode when a connect is made to a nine track tape unit, all operations on the nine track unit will be in binary mode. However, if a seven track tape unit is reselected (during the nine track operation) all operations on the seven track unit will be in BCD.

556 CPI (0003)

This code causes all data to be written and read at 556 characters per inch density if connected to a seven track tape unit. If the code is sent when connected to a nine track tape unit, it will be rejected.

200 CPI (0004)

This code causes all data to be written/read at 200 characters per inch density if connected to a seven track tape unit. If the code is sent when connected to a nine track tape unit, it will be rejected.

Clear (0005)

This code clears all tape unit reservations made by the data channel as well as the existing unit connection. It permits other channels to gain access to these units.

800 CPI (0006)

This code causes all information to be written and read at 800 characters per inch density if connected to a seven track tape unit. If sent to a nine track unit, it will write in 800 CPI but read in either 800 or 1600 CPI depending on which density is on tape. Density switching is automatic.

1600 CPI (0007)

This code causes all information to be written at 1600 characters per inch density (for nine track units only). A Read operation will adjust automatically to the density on tape.

Clear Reverse Read (0040)

This code clears the condition set by the Set Reverse Read code, 0041.

Set Reverse Read (0041)

This code selects a Reverse Read operation. Refer to the Reverse Read description in Section 4.

Clear Memory Mode (0042)

This code clears the condition set by the Set Memory Mode code, 0043.

NOTE

This code must be used prior to executing the Clear Conversion Mode function (0044) or Conversion mode will not clear out.

Set Memory Mode (0043)

This code is used to load the controller memory for a subsequent 6-bit/8-bit code conversion operation. The codes must be arranged and stored in central storage prior to the conversion operation. Then code 0043 is executed and a block of exactly 320 (500_8) 12-bit bytes is outputted. If less than 500_8 bytes are sent, parity errors will occur when the memory is read (during code conversion), unless the same number of characters were read as were outputted. If more than 500_8 bytes are written, the channel will hang up. No End of Operation will occur and the controller will remain Busy. The maximum character trans-

fer rate is 500 KHZ (approximately 2 μsec memory cycle time). Refer to the Loading Memory description in Section 4.

This code can also be used to read back stored codes in the event that a check of the memory contents is desired. To read memory, execute code 0043 and input exactly 500_8 bytes. Only the lower nine bits will contain information. The flag bit is not checked since unused locations would cause flag bit errors. Vertical parity is checked and an error would be indicated by Alert and Memory Parity Error status in Status 2. The character transfer rate during a read will depend on the computer capability (up to 500 KHZ). If less than 500_8 characters are attempted, no problem will occur. If more than 500_8 characters are requested, the channel will hang up, no End of Operation will occur, and the controller will remain Busy.

NOTE

Executing the Set Memory Mode function also places the controller in Code Conversion mode. However, selecting Clear Memory Mode will not clear out Conversion Mode. Thus, upon executing a Clear Memory Mode, a code conversion read or write can immediately be performed without initiating the Set Conversion Mode (0045).

Clear Conversion Mode (0044)

This code clears the condition selected by Set Conversion Mode function code 0045.

NOTE

Prior to using this code, Clear Memory Mode, 0042, must be selected or Set Conversion Mode will reset.

Set Conversion Mode (0045)

This code selects 6 to 8 bit code conversion in the controller and is applicable to seven or nine track recording (if the controller is a nine track model). Subsequent Write or Read operations reference the controller memory to obtain equivalent codes for the conversion. The codes must be preloaded into the controller memory.

Clear Controlled Backspace (0046)

This code clears the controlled backspace function set by function code 0047.

Set Controlled Backspace (0047)

This code allows the controller to assume control of tape motion during a backspace instead of the tape unit. It allows the controller to backspace over a bad record and stop at the interrecord gap (IRG). This is done by performing an output (Write) from the data channel after selection of the controlled backspace function. The data output is required to move tape, and it must be the same length as the record which is to be backspaced over.

After a bad record is backspaced over and the IRG is reached, a reverse read should be performed from this point until it can be determined that a good record has been encountered. A forward read should then be initiated to position past (forward) the last good record to the IRG. A Skip Bad Spot function should then be performed to erase over the bad record. If parity is good during the skip bad spot, the record can be rewritten immediately following it. In NRZI, noise records can be written on both sides of a bad spot to identify it.

After a controlled backspace over a bad record, only a reverse read or reverse skip bad spot should be performed. It is illegal to output data or perform a write file mark or forward read. If this is done, record gaps will be short and repeated operations of this type may result in destroying the previous good record. Controlled backspace is not permissible over a noise record nor if Lost Data status occurs during a Write. In addition to the 0046 function, controlled backspace is cleared at completion of its associated channel output.

Programmable Clip Level (0X50)

This allows the capability of selecting by program, the additional clipping levels in the tape unit at which a tape record can be read to enable the recovery of marginally recorded tapes. The clip level can be selected by function code 0X50. The value of X will determine the clip level during the next read for both the Inter-Record Gap (IRG) and the record as shown below. The function must be selected prior to the initiation of each read of a tape record if a clip level is to be applied to that record.

FUNCTION	BITS 8	7	6	DESCRIPTION OF CLIP
0050	0	0	0	IRG and Normal Read
0150	0	0	1	IRG and Low Level Read
0250	0	1	0	IRG and Write Level
0350	0	1	1	IRG and High Level Read
0450	1	0	0	$\overline{\text{IRG}}$ and Normal Read
0550	1	0	1	$\overline{\text{IRG}}$ and Low Level Read
0650	1	1	0	$\overline{\text{IRG}}$ and Write Level
0750	1	1	1	$\overline{\text{IRG}}$ and High Level Read

Clear Opposite Channel (0051)

This is a special purpose function for use in the 2x8 controller only. It has the same effect as a Master Clear on the channel opposite that which is initiated. This function must never be used except in the event that one subsystem is down and cannot clear and release its reserved tape units. In this case, the opposite subsystem (channel) can use this function to assume control of the tape units.

Clear 3N + 2 Mode (0052)

This code clears the 3N + 2 mode set by function code 0053.

Set 3N + 2 Mode (0053)

If an even number of 12-bit bytes are transferred in nine-track mode, this code allows writing two extra 8-bit characters on tape in addition to any multiple of three characters. The third character (lowest order 8 bits in the last 12-bit byte) will not be written. An even number of 12-bit bytes will be read in this case, but the lowest order eight bits of the last byte will be meaningless. Therefore, Character Fill status will be required to determine that an even number of bytes were transferred.

If an odd number of 12-bit bytes are transferred, selection of 3N + 2 mode will not have any effect on the results. Transfer will be the same as that shown in Figure 1-7.

The 3N + 2 mnemonic is defined as follows:

3 - Three 8-bit characters. In nine track assy/disassy, this packs into two 12-bit characters.

N - Any integer. When multiplied by three, it results in a multiple of three characters. If the number of characters in a record is a multiple of three, an even number of 12-bit bytes are transferred to the data channel.

+2 - The number of characters transferred in addition to any multiple of three.

This code must be selected when in nine-track mode only. It cannot be used with any other mode. With 3N + 2 mode selected, records of length 3N + 2 and 3N + 1 may be written. Without 3N + 2 mode selected, records of 3N and 3N + 1 may be written. (If a record of 3N + 2 length is attempted without 3N + 2 mode selected, the results will be uncertain.)

Clear Status 2 (0056)

This code clears the condition selected by Set Status 2, 0057. A reconnect will have the same effect.

Set Status 2 (0057)

Two levels of status are available to the programmer. This function code causes the Status 2 condition to be enabled to the status lines. Status 1 is restored by the 0056 function code, by a new operation that moves the tape, by a Master Clear, or a connect attempt. See Table 2-1 for the status bit assignments.

INTERRUPT CODES

The interrupts that can be selected or released enable the programmer to determine when the subsystem is ready for an operation or has completed an operation. If any one of the conditions selected for an interrupt occur, the controller returns an Interrupt signal to the data channel on a line corresponding to the connected or reserved equipment.

If the interrupt system in the computer has been set to recognize the interrupt, it can be used to automatically enter an interrupt processing routine or, alternately, the program can copy or sense external interrupt status to determine what equipment has interrupted.

The Interrupt signal remains up until cleared by reselecting the interrupt, releasing the interrupt by function, or Master Clearing the system. Any XX2X function will clear the interrupt. Interrupt codes (XX2X) are never rejected.

Interrupt on Ready and Not Busy (0020)

This code causes the controller to send an Interrupt signal to the data channel when the tape unit is in a Ready and Not Busy condition (i.e., power is applied, the tape unit is under computer control, and all tape motion is ceased). The Interrupt signal remains up until cleared by selecting the Release code (0021), reselecting the interrupt, or by clearing the control, or executing any XX2X function.

Release Interrupt on Ready and Not Busy (0021)

This code clears an Interrupt on Ready and Not Busy selection and the Interrupt signal to the data channel.

Interrupt on End of Operation (0022)

This code causes the controller to send an Interrupt signal to the data channel when the channel terminates a Read or Write operation, when a tape unit senses the End of Record during a Read operation, or upon completion of a function that moves tape. The Interrupt signal remains up until cleared by reselecting the interrupt (0022), selecting release (0023), or clearing the control, or executing any XX2X function.

Release Interrupt on End of Operation (0023)

This code clears the Interrupt on End of Operation selection and the Interrupt signal to the data channel.

Interrupt on Abnormal End of Operation (0024)

This code causes the controller to send an interrupt signal to the data channel after an abnormal condition occurs. These abnormal conditions are end of tape, file mark, load point, vertical parity error, longitudinal parity error, lost data, parity error during a Skip Bad Spot operation, and connected tape unit beoming Not Ready, or any of the conditions causing an Alert status (2XXX).

In all but the Not Ready, an interrupt occurs when one or more of these conditions are encountered and an end of record mark is written or read by the tape unit. In the case of an interrupt on a connected tape unit becoming Not Ready, the interrupt occurs immediately when the connected tape unit goes from a Ready to a Not Ready condition (e.g., if the power is turned off on the tape unit). However, it does not occur during a Connect operation or when a Release code (0000) is executed.

NOTE

Load point is an abnormal condition only for Interrupt on EOP and Interrupt on Abnormal EOP.

A new Read or Write operation cannot start until the Interrupt signal is cleared. The Interrupt signal can be cleared by reselecting the Interrupt (0024), selecting Release (0025), or a Master Clear, or executing any XX2X function.

Release Interrupt on Abnormal End of Operation (0025)

This code clears an Interrupt on Abnormal End of Operation selection and the Interrupt signal to the data channel.

STATUS CODES

Status codes permit the monitoring of several controller and tape unit operating conditions. The codes are made available to the data channel over 12 status lines following any successful Connect operation, or following any rejected connect as long as the controller portion of the connect attempt was successful. The codes are sampled by the computer upon execution of Sense or Copy External status instructions.

Two types of status are available, Status 1 and Status 2. Status 2 is selected by function code (0057), whereas Status 1 is obtained by clearing Status 2 (0056), by Master Clear, by a new operation that moves tape, or by a connect. Table 2-1 lists the status bit assignments.

Status 1 will automatically be available at the End of Operation time immediately following an operation involving tape motion, or following a Master Clear or a connect. Except for Lost Data, Status 1 and 2 indicate true (current) status for the tape unit to which the controller is connected. Lost Data status will remain until a function (other than Status 1 and 2 functions) or a Master Clear is performed. A connect attempt will not clear Lost Data

status. Three status replies are common to both Status 1 and 2, End of Operation, Alert, and Tape Unit Reserved.

STATUS 1 CODES

Ready (XXX1)

Bit 0 is set when the tape unit is in a Ready condition (i.e., power is applied and the Ready switch/indicator is lit). The tape unit is operational.

Read/Write Control and/or Tape Unit Busy (XXX2)

If the tape unit is Ready, bit 1 is set when a read/write control (equipment) is Busy and/or, if the unit is Ready and tape motion is initiated by an operating Function code. In these two cases, it remains set until 3 milliseconds after tape motion stops. Bit 1 is cleared approximately 3 milliseconds after an End of Operation from the tape unit. Bit 1 cannot be set if bit 0 is clear.

Write Enable (XXX4)

Bit 2 is set when the file protection (write lockout) ring is on the tape reel. When this ring is present, it is possible to read from and write on the tape. When the ring is absent, it is possible to read from but not write on the tape.

File Mark/Tape Mark Detected (XX1X)

Bit 3 is set whenever FM/TM mark is read. It remains set until a new tape motion function, a Read or Write operation, or a clearing operation is initiated or until a new unit is connected. If still at FM/TM and the same unit is reconnected, FM/TM Detected status will be present.

NOTE

If a file mark is detected during a Search Backward to File Mark and this is followed by a forward Read operation, the file mark is the first record read.

Load Point (XX2X)

Bit 4 is set when the tape is at load point. It is cleared when the tape moves off the load point.

End of Tape (XX4X)

Bit 5 is set when the end of tape marker is detected. It is cleared when the end of tape marker is sensed during a Reverse operation.

Density (X1XX) (X2XX)

Density status is controlled by the tape unit to which the channel is connected. If not connected to any tape unit, bits 6 and 7 are both zero and are indistinguishable from 200 CPI status unless a determination is made that the controller channel is connected to a tape unit. Bit 6 and 7 are set to indicate the tape unit density selection as follows:

Density (CPI)	Bit 7	Bit 6
200	0	0
556	0	1
800	1	0
1600	1	1

Lost Data (X4XX)

Bit 8 is set when the read/write control determines that data may have been lost in transmission. Tape motion automatically stops when bit 8 is set, and when in the interrecord gap. It cannot be restarted until the bit is cleared by a Function code or a Master Clear. Any function will clear lost data status except function codes 0050, 0051, 0054, 0055, 0056, and 0057. Function codes 0050, 0054, and 0055 presently are not used.

End of Operation (1XXX)

Bit 9 is set when the data channel terminates a Read or Write operation, when a tape unit senses the End of a Record during a Read operation, or upon completion of Tape Motion function. It remains set until a new Read or Write operation, Tape Motion function, or clearing operation is initiated.

Alert (2XXX)

Bit 10 of Status 1 is set to indicate that one or more of the conditions indicated by bits 0-4, 6, 8, 11 of Status 2 have been detected. These are:

1. Vertical and/or Longitudinal Parity Error
2. Memory Parity Error
3. Flag Bit Error
4. CRC Error (NRZI)
5. Multi-Track Error (Phase) or Uncorrectable CRC Error (NRZI)
6. Character Crowding, Dropout, False End of Operation.
7. False Postamble Detected
8. Cold Start

See the individual bit codes for conditions that generate the status bits and for clearing procedures.

Tape Unit Reserved (4XXX) (Not Used in 1X8)

Bit 11 is set when a channel attempts to connect to a reserved unit. It is cleared by performing a connect or a Master Clear.

STATUS 2 CODES

Vertical and/or Longitudinal Parity Error (XXX1)

Bit 0 is set following detection of either a vertical or longitudinal parity error or reading a file mark or tape mark in binary mode on a seven track tape unit. It is also set by detecting bits during a Skip Bad Spot operation, and when in phase, by not detecting a preamble on a data record.

Memory Parity Error (XXX2)

Bit 1 is set if a memory parity error is detected while referencing the controller memory during code conversion. The error is cleared by a Master Clear, by clearing Conversion Mode by function (0044), or by starting a new Read or Write operation.

Flag Bit Error (XXX4)

Bit 2 is set during a Code Conversion Read (8- to 6-bit) operation if an illegal address was referenced, which means that a 6-bit code was read up from a lower $000\text{-}377_8$ memory location and that the 6-bit code did not contain the flag bit, bit 6. The same conditions will clear the bit as those listed for the Memory Parity Error status.

CRC Error (XX1X)

During a nine track 800 CPI NRZI Read operation, all data characters and the CRC character from tape are processed through a register in the controller. Bit 3 is set to indicate a CRC error if the pattern in the CRC register does not equal 727_8.

Multi-Track Phase Error or Uncorrectable CRC Error (NRZI) (XX2X)

Depending on the recording mode, phase or NRZI, bit 4 set indicates that, during a Read, more than one track was found to be in error, which is an uncorrectable condition.

Character Fill (XX4X)

During certain operations, the Programmer may not be able to determine the content of the

last character read. The bit indicates that the last character consisted of meaningless information. Examples in which this condition occurs are shown in Figure 2-2.

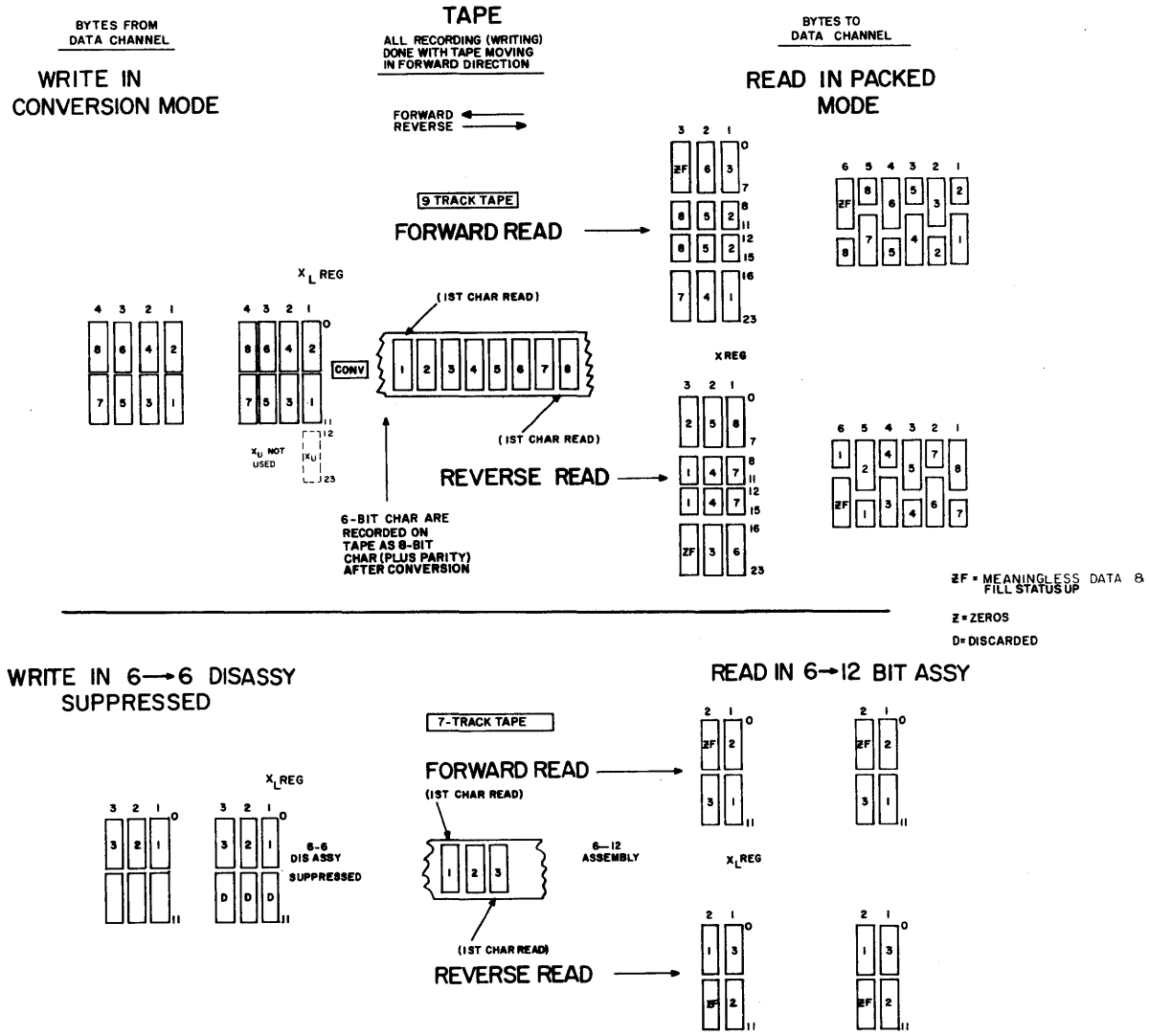


Figure 2-2. Character Transfer During Fill Status

Character Crowding or Dropout and False End of Operation (X1XX)

Note

Status bit 6 applies to NRZI mode only.

Bit 6 will be set during either a Read or Write operation in NRZI only, under the following conditions. (See Figure 2-3.)

1. During a Write operation, if two successive charcters are detected in less than 0.66 (nominal) cell time.
2. During a Read or Write operation, if any data character is not followed by another data character within 1.5 (nominal) cell times, with two exceptions. Character dropout will not occur if the dropped characters are not followed by any data characters before an End of Operation, or if the first character(s) of a record is (are) dropped.
3. During a Write operation, if the number of characters read back (during read back after write) does not equal the number of characters written with one exception. Status bit 6 will not be set if the number of characters dropped is a multiple of eight.
4. During a Write operation, if the first character written does not compare with (equal) the first character read back.
5. During a Write operation, if a controller End of Operation occurs before the Write line from the data channel drops.
6. During a Read or Write operation, if the controller End of Operation is followed by more than one character from tape.

Phase Error Correction (X2XX)

Bit 7 will be set if single track error correction (phase-encoded data only) is performed. No Alert status will occur as a result of setting bit 7.

False Postamble Detected (X4XX)

Bit 8 will be set if a false postamble is detected.

End of Operation (1XXX)

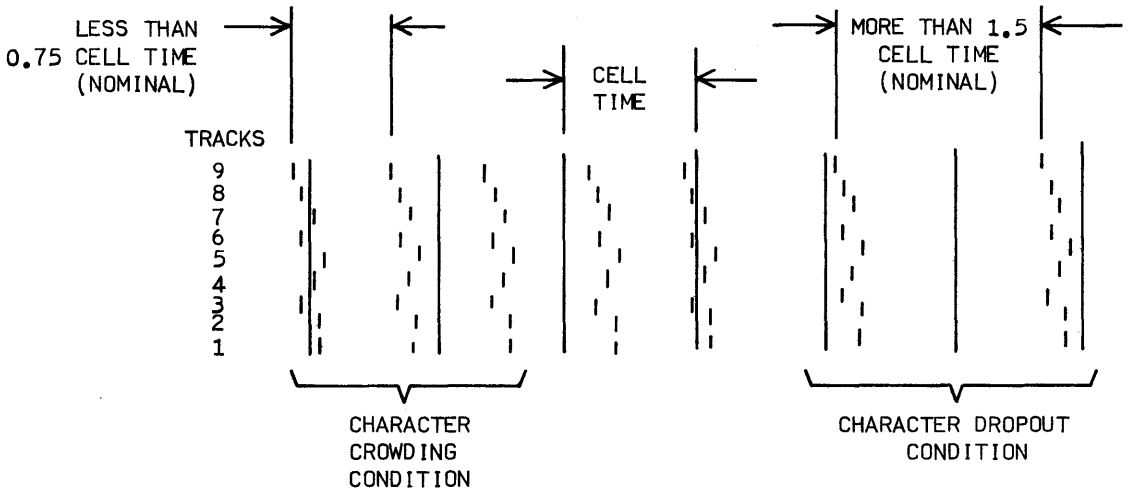
See description under Status 1 entry.

Alert (2XXX)

See description under Status 1 entry.

Cold Start (4XXX) Bit 11

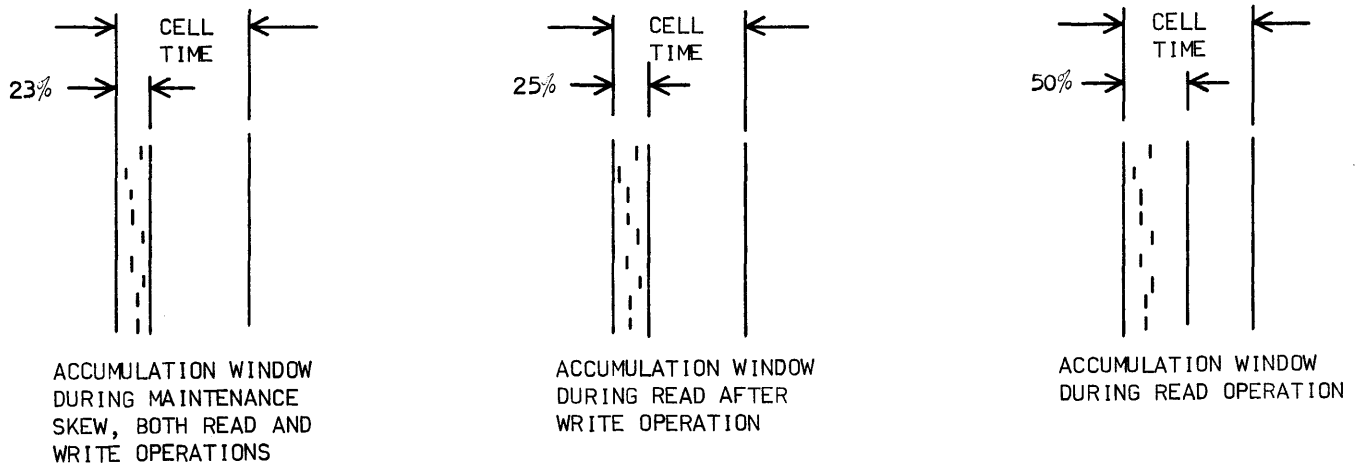
Tape did not move at proper speed from write to read Lead when output of data was performed.



NOTES:

1. CHARACTER SPACING IS MEASURED FROM FIRST-BIT-IN TO FIRST-BIT-IN OF SUCCESSIVE CHARACTERS.
2. IF CHARACTER CROWDING OCCURS, IT WILL BE MOST PROBABLE AT THE BEGINNING OF THE RECORD, BEFORE THE TAPE IS UP TO SPEED.

Figure 2-3. Character Spacing for Nine Track Tape



NOTE: IN EACH CASE, ALL BITS OF THE DATA CHARACTER MUST BE ACCUMULATED WITHIN THE PERCENTAGE OF CELL TIME SHOWN. THESE CASES APPLY TO NRZI ONLY.

Figure 2-4. Character Accumulation Windows

SWITCHES AND INDICATORS 3

INTRODUCTION

A panel on each read/write control contains switches and indicators for controlling and monitoring conditions within that equipment during maintenance and checkout. See Figure 3-1 and the following descriptions.

SWITCHES

EQUIP NO. ROTARY SWITCH

The setting of the Equip. No. switch (0-7) designates the read/write control used, and must correspond to the N portion of the Connect code. The number selected also specifies the interrupt line used by the equipment.

NEG EC/EC PHASE

This two-position maintenance switch in the NEG EC position negates phase error correction. The EC PHASE position is the normal (enabled) position.

9 BIT TEST/8 BIT NORMAL TRANSFER SWITCH

In the 9 BIT TEST position, this switch enables a straight 9-bit transfer between the tape unit and data channel, with no assembly/disassembly done by the controller. The parity bit from tape is transferred with the 8 data bits in one 12-bit byte. This permits the software checkout of parity checkers and error detection/correction logic. The 8 BIT NORMAL position is the normal operating position.

1600 ERROR SIMULATOR

This 11-position switch is used in checking the phase On-the-Fly error correction and discriminator logic. Switching to any position from 0 to 8 selects a corresponding track on tape. As the tape is read, the error generation logic causes occasional bits to be dropped in the selected track. Correction of the dropped bits indicates proper operation of the On-the-Fly error correction logic. The OFF position disables the error generation logic. The CAL position is used in setting the 3/4 cell time delays in the descriminator

circuits. When in this position, a steady preamble of all zeros will be written in every track which results in simplifying the 3/4 cell time adjustment. The MS position limits the read after write accumulation time to 0.23 percent of cell time, and is used as a maintenance mode (the MS selection is one position clockwise from OFF. See Figure 2-4).

INDICATORS

CONN

This indicator lights whenever a read/write control is connected to a data channel.

BIT O THROUGH BIT 8 (DATA AND PARITY BITS)

The indicators display the contents of the longitudinal parity checking register. At the end of an operation, the register should be clear.

INT

The interrupt indicator lights if one of the selected interrupts occur and remains lit until the interrupt signal drops.

FM/TM

This indicator lights whenever a file mark (seven track) or a tape mark (nine track) is read or written, and it stays lit until a new record operation begins, or until a different tape unit is connected.

XMSN P.E.

This indicator lights if a transmission parity error occurs during a Connect, Function, or Write operation. It is cleared by a Connect, Master Clear, or Channel Clear.

VERT P.E.

This error indicator lights if a vertical parity error occurs during Read or Write operations. It also lights if a bit is picked up during a Skip Bad Spot sequence or if no preamble is detected for a data record during a phase encoded operation. It is cleared whenever a new record operation is started.

LONG P.E. (NRZI ONLY)

The longitudinal parity error indicator lights if a parity error is detected when checking the LRC character, at the completion of a Read after Write check or a normal Read operation. An exception is Correct Mode, in which a parity error will not occur. It is cleared by a new record operation.

MULTI TR (PHASE)

This error indicator lights if a track error was detected in more than one track in phase recorded data. This is an uncorrectable condition. It is cleared as a new record operation begins.

UNCORR

The indicator lights if multiple-track (uncorrectable) parity errors are detected in nine track NRZI recorded data. The condition is cleared as a new record is begun.

CRC ERR

The indicator lights if a CRC error is detected during error detection in NRZI recorded data. A new record operation clears the error indication.

WRITE

This indicator lights during a Write or Write File Mark/Tape Mark operation. Initiating a new but different operation clears the indicator.

BCD

The indicator lights and remains lit as BCD mode is selected by function (0002). Any clearing operation or selection of binary mode automatically clears the BCD selection. The BCD indicator will not be lit when connected to a nine track tape unit since binary mode is a forced condition for nine track.

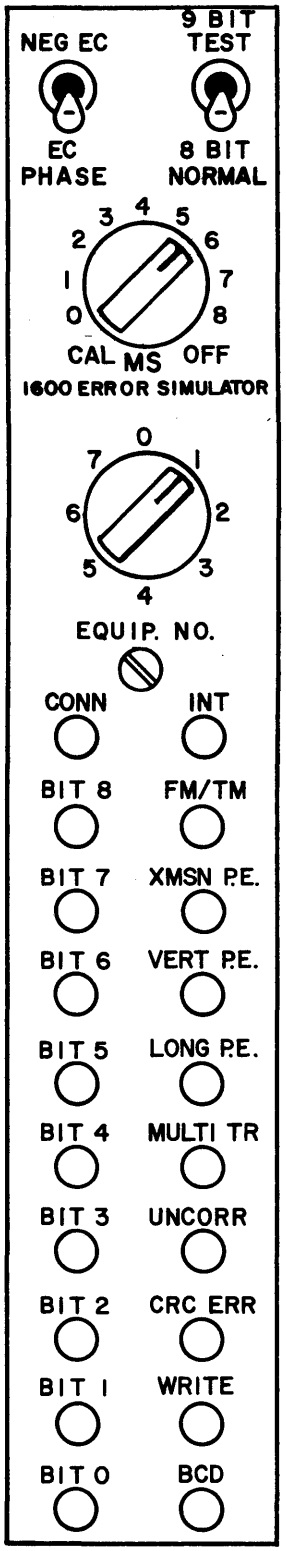


Figure 3-1. Maintenance Panel

SUBSYSTEM CLEARING

Various conditions in the controller/tape unit subsystem can be cleared as follows:

1. The execution of a Clear Channel instruction or an external Master Clear results in the following taking place.

   NOTE

   In lower 3000 Series computers, this is an IOCL instruction.

   a. Clears all activity in the data channel.

   b. Clears the present connection read/write control N may have with a tape unit, together with any existing transmission parity errors.

   c. Releases all tape units (i.e., clears reserve logic) which control N may have reserved.

   d. Performs a Master Clear on control N read, write, and function logic. No status signals are available to the data channel after executing this instruction.

2. Clear Function Code (0005)

   This code clears the tape unit connected to the channel from which the clear was initiated. It clears all reserves for the channel on which the clear is initiated.

3. Release Function Code (0000)

   For the 1X8 controller, this code performs the same function as the Clear code, 0005. For the 2X8 controller, it clears the existing tape unit connection and the channel reserve on that unit, but it does not clear the reserve logic in any other tape units reserved by that data channel.

This code may also be used to clear the 2X8 reserve logic of the last connected (but still reserved) tape unit, proveded the code is accompanied by a Connect attempt to the tape unit. The connect could have dropped due to the tape unit being inadvertently cleared, or malfunctioning, but the tape unit is still reserved by the original channel. The following two examples describe uses of the Release code.

a. After the channel connects to tape unit A, the unit inadvertently becomes cleared. The channel then connects to the next reserved unit, tape unit B, and begins operations. However, the 2X8 logic will still have tape unit A reserved. The Release code (with a Connect) will clear the reserve. This frees tape unit A for use on another channel.

b. If the tape unit is Not Ready during a Connect attempt, or if Ready is lost during some other operation, another Connect will be required after the unit is made Ready. (Ready status should not be looped on without a Connect.) However, if the Ready condition cannot be regained, a Release code will clear the reserve logic for that tape unit.

4. Power-On Master Clear

When power is applied to the controller, all tape units connected and reserved by all controls are cleared. Logic in all controls is also cleared. No status signals are available to the data channel after power is applied. The effect is the same as the application of an external Master Clear.

NOTE

With the exception of the Release code, execution of any of the above clearing operations places the controller in the binary data format.

5. Clear Opposite Channel (0051)

   This is a special purpose function for use in the 2X8 controller only. It has the same effect as a Master Clear on the opposite channel from which it is initiated. This function must never be used except in the event that one subsystem is down and cannot clear and release its reserved tape units. In this case, the opposite subsystem (channel) can use this function to assume control of the tape units.

CLEARING PARITY ERRORS

Several types of parity errors can be detected by the controller. The conditions recorded upon detection, plus the display indications given on the controller are either cleared by a manual or program clearing operation, or automatically when a new record is begun.

TRANSMISSION PARITY ERROR

If the controller detects a parity error during an input/output or function operation, the XMSN P. E. indicator lights and an External Parity Error signal is returned to the controller. A parity error detected in a Connect code causes only the indicator to light. A Connect operation, a Master Clear or Channel Clear instruction, or Power-On Master Clear will clear the External Parity Error condition.

OTHER PARITY ERRORS

Other parity errors detected in the controller cause the appropriate indicator on the maintenance panel to light and the condition to be recorded. The conditions, which include longitudinal and vertical parity error, memory parity error, and CRC error, are cleared by a Master Clear, or by starting a new record operation. The new operation may be Read or Write, or a Search File Mark/Tape Mark (forward or reverse) operation.

OVERLAPPING OPERATIONS

As soon as Rewind, Rewind Unload, Backspace, Search FM/TM Forward, or Search FM/TM Reverse functions are transferred to the tape unit and the tape unit becomes Busy, other tape units may be connected and other operations performed. In the case of a Backspace off load point, or a Reverse function following a Write operation on the same tape unit, a slight delay will result before connect attempts will be accepted by the controller. This is because the read/write control is busy controlling a jog or, in the case of the Backspace off load

point, determining what density or mode of operation is required if connected to a dual unit. During this time, connect attempts will be rejected. The length of the delay will vary with the speed of the unit and will be approximately as follows:

Delay (ms)	Tape Speed (IPS)
5.0	150
6.4	112.5
11.0	75
19.0	37.5

These figures include 3 ms for the tape unit to go Not Busy before sending the function (after the jog operation is completed).

REVERSE READ

If the Set Reverse Read function is selected and a Read operation is initiated, data is read backwards starting with the last character written on tape. The controller reverses assembly procedures and the 12-bit bytes are returned to the channel in the reverse order from which they were written. The first byte received by the data channel should be stored in the last memory location of the block if it is desired to have the 12-bit bytes in the same relative position in the block as when the information was outputted. A Reverse Assembly signal is sent to the data channel to indicate this situation.

During an NRZI Reverse Read, if an error occurs in the CRC character itself, error correction will be impossible. Parity checking and error detection/correction are performed as in a forward Read operation. Also, interrupts are handled in the same manner. If the Reverse Read is attempted from load point, the operation hangs up. A Clear must be performed before continuing.

LOST DATA

The Lost Data condition occurs in two cases:

1. When the data channel cannot supply or accept data at the rate required by the tape unit due to competition from other devices for access to storage.
2. When certain malfunctions occur in the data channel.

A Lost Data condition causes data transfer to stop, stops tape motion (at the next record gap), and sets the Lost Data status bit. A new Read or Write operation cannot begin until the Lost Data condition is cleared by a Master Clear, Clear Channel instruction, or

issuing a new Function code. In most cases, the Lost Data condition leaves the data channel active (i.e., the Read or Write operation remains uncompleted). Thus, a new Connect or function operation cannot be initiated until the channel activity is cleared.

FILE MARK/TAPE MARK

For NRZI recorded data, file mark (tape marks in nine track) can be read and compared as data in programs. In phase data no distinct code is transferred when a tape mark is encountered and hence compare action is impossible. However, bit 3 of Status 1 is set and can be sensed. File marks and tape marks cannot be written and then read in conversion mode due to the memory translation. The Clear Conversion Mode function code should be selected before attempting a Write File Mark/Tape Mark function.

LOADING MEMORY

To perform code conversion with the controller, the user must set up an area of central storage such that each 6-bit character code corresponds to an address that holds an 8-bit equivalent, and similarly, such that 8-bit codes address areas that contain 6-bit equivalents. The codes are then loaded into the controller memory by selecting a Set Memory Mode function (0043) and doing a normal byte addressed output instruction from the area set up in central storage. The controller memory can hold 320 (500_8) 12-bit words. Sixty-four locations are reserved for 8-bit codes which are stored at addresses equal to their equivalent 6-bit codes plus 400_8. There are 256 locations (of which 64 are used) for 6-bit codes which are stored at addresses equal to their equivalent 8-bit codes. Unused addresses are zero except for the parity bit (bit 8). Each 6-bit code must be supplied a flag bit (bit 6) which identifies it as a legitimate code. Bit 8 is supplied as needed to give the lower nine bits, including flag and parity bits, odd parity. The 6-bit character is in bits 0 through 5 of the 12 bit byte, bit 7 is zero, and bits 9, 10, and 11 are not used. Parity is checked on all codes written into memory to verify the presence of odd parity. If an error exists, Memory Parity Error status will be indicated in Status 2. This condition can be cleared by initiating the Clear Conversion Mode function, 0044, or by a Master Clear. The loading of memory will cause no tape motion and no tape unit need be connected to perform the operation. The stored codes will remain in the controller memory until intentionally replaced with new codes. Refer to Set Memory Mode in Section 2.

The following load memory procedure should be used. The example referred to in step 1 illustrates central storage table arrangement of a 6 bit BCD/8 bit ASCII conversion application. Other 6/8-bit character set conversion is possible if limited to a 64 character subset of an expanded character set, such as ASCII.

1. Set up tables in central storage as shown in Figure 4-1.

NOTE

Locations that hold 6-bit codes must have bit 6 set. This is a flag bit to indicate legal referencing during Read operations. Also, odd parity must be generated for all codes stored, with bit 8 the parity bit.

2. Connect Equipment.

3. Select Set Memory Mode Function (0043).

4. Execute Byte Addressed Output, of 320_{10} 12-bit Bytes (starting at 2000_8 in Example).

5. Select Clear Memory Mode Function (0042).

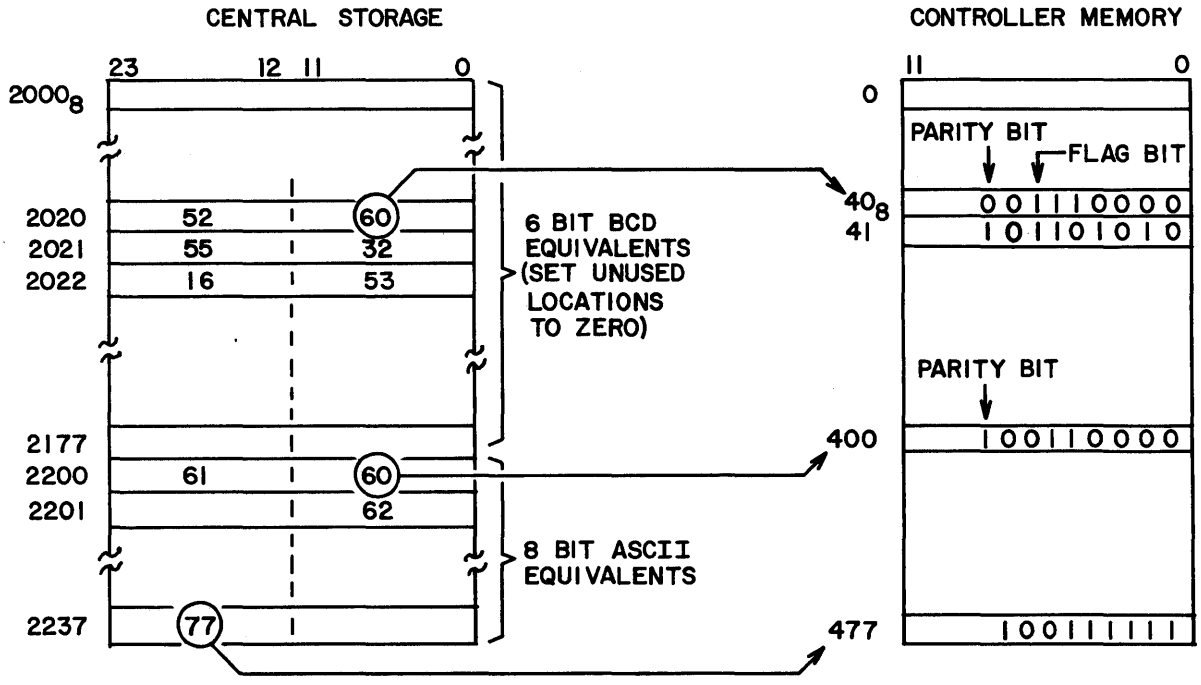


Figure 4-1. Load Memory Example

DENSITY SELECTION

DENSITY SELECT RESPONSES

Selection of various densities with an intermix of tape units results in the Reply and Reject conditions listed in Table 4-1.

TABLE 4-1. DENSITY SELECT RESPONSES

TAPE UNIT	OPERATION	CONTROLLER RESPONSE
Seven-Track multi-density (200/556/800 CPI NRZI)	Select 200, 556, or 800 CPI density	Reply (On or off load point)
	Select 1600 CPI density	Reject
Nine-track phase only (1600 CPI)	Select 200, 556, or 800 CPI density	Reject
	Select 1600 CPI density	Reply (On or off load point)
	a. If Write initiated	Write 1600 CPI
	b. If Read initiated	If tape is 1600 CPI recorded, read 1600 CPI. If tape is 800 CPI recorded, read with errors.
Nine-track dual mode (800 CPI or 1600 CPI)	Select 200 or 556 CPI	Reject. Density status 1600.
	Select 800 CPI at load point	Reply. Density status will remain 1600 until movement off load point.
	a. If Write initiated	Write 800 CPI. Density status will switch to 800.
	b. If Read initiated	If tape is 800 CPI recorded, read in 800 density. Status will indicate 800 after moving off load point. If tape is 1600 CPI recorded, controller will recognize ID burst and read in first record in 1600 density. Status will indicate 1600 CPI.
	Select 1600 density at load point.	Reply
	a. If Write initiated	Write 1600 CPI Phase Encoded.
	b. If Read initiated	If tape is 1600 CPI recorded, controller will recognize ID burst and read in first record in 1600 density.
	Select 800 or 1600 density but not at load point	Reject (Density select must be done at load point on dual unit.)

DENSITY SELECT CONSIDERATIONS

1. When the controller responds with a Reject signal to a density function, a Read or Write operation should not be attempted.
2. The type of tape units available can be identified by their replies and rejects to density functions as follows:
   a. Seven Track - replies to 200 or 556 CPI density select.
   b. Nine Track Phase only - replies to 1600, rejects 800 CPI density select.
   c. Nine Track Dual - at load point replies to both 800 and 1600 CPI density selects.

PROGRAMMING CONSIDERATIONS

WRITE FM/TM OR SEARCH FUNCTIONS

Write FM/TM or Search functions should not be performed in conversion mode.

DETECTING A PREAMBLE OR POSTAMBLE

Phase records written over certain types of physically damaged tape may cause false postambles and will be indicated by status 2 bit 8 and alert.

Failure to detect a preamble or postamble during Write or Read operations will be indicated by alert and parity error status.

LOST DATA STATUS

Lost Data status will be cleared by selecting any function except 0056 and 0057. (Set and Clear Status 2.)

SWITCHING TO 800 CPI AT LOAD POINT

When the controller models without phase capability (3518-1, -2, and 3528-1, -2) are connected to dual tape units, the tape units will be switched to 800 CPI NRZI when the tape moves off load point for a Write operation. However, status at load point will indicate 1600 CPI.

DENSITY INDICATIONS ON NINE TRACK CONTROLLERS

On nine track controllers with both phase and NRZI capability, and interfacing seven track and nine track dual tape units, the dual tape unit will always revert to 1600 phase encoding at load point. The density status from the connected tape unit controls the density of the controller.

In any Write Operation starting off load point, the density will be the last one selected by program control. This is true whether the density was selected for the tape unit on which the current operation is being performed, or the unit on which the immediately preceding operation was performed (if switching from tape unit to tape unit).

After the initial movement off load point the dual unit cannot be changed from phase to NRZI except by returning to load point. Therefore, other than the first Write off load point, density for the dual unit will be maintained for future Write operations.

On a Read operation, density is automatically selected and maintained. One example of a possible problem during a Write operation is if this sequence of operations is performed. An 800-CPI NRZI record is written coming off load point on a dual unit, and a Rewind operation is initiated. During the Rewind, a phase (Read or Write) operation is started on another dual unit. After the phase operation, the controller returns to the first tape unit and repeats the Write operation. The Write operation will also be in phase unless the 800 CPI NRZI density is reselected upon returning to the first unit.

CHANNEL HANG CONDITION

If the channel is hung for some reason, such as attempting a read operation on a blank tape, control can be recovered by manually clearing the connected tape unit and making it ready again. Clearing channel activity will then make it possible to connect to a tape unit.

PARITY ERROR CONDITIONS

Refer to Table 4-2 for a list of operations and the conditions in which a parity error may occur.

TABLE 4-2. PARITY ERROR CONDITONS

OPERATION	CONDITIONS	PARITY ERROR
Write FM/TM	7 track binary	Yes
	7 track BCD	No*
	9 track NRZI/Phase	No*
Read FM/TM (Forward)	7 track binary	Yes
	7 track BCD	No*
	9 track NRZI/Phase	No*
Read FM/TM (Reverse)	7 track binary	Yes
	7 track BCD	No*
	9 track NRZI/Phase	No*
Backspace (over Data)	7 track binary/BCD	No
	9 track NRZI/Phase	No
Backspace (over FM/TM)	7 track binary	No
	9 track NRZI/Phase	No
	7 track BCD	No
Forespace Backspace in reverse read (Over data)	7 track binary/BCD	No
	9 track NRZI/Phase	No
Forespace (over FM/TM)	7 track binary/BCD	No
	9 track NRZI/Phase	No
Search Forward	7 track binary	No
	7 track BCD	No
	9 track NRZI/Phase	No
Search Reverse	7 track binary	No
	7 track BCD	No
	9 track NRZI/Phase	No
Skip Bad Spot	If bit picked up	Yes
Backspace	Into Load Point, Phase only	No
Search Reverse	Into Load Point, Phase only	No
Rewind	Into Load Point, Phase only	No
Reverse Read	Into Load Point, Phase only	Yes

No* -- No Parity error if data is correct. Yes if bad data.

COMMENT SHEET

MANUAL TITLE CDC 3518 & 3528 Magnetic Tape Controller

Reference Manual

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