1935 FORMATTER CONTROL UNIT

FIELD ENGINEERING MAINTENANCE MANUAL

PN 9357

STORAGE TECHNOLOGY CORPORATION

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CHAPTER 1

GENERAL INFORMATION

1.1 INTRODUCTION

The STC Model 1935 Formatter/Control Unit (FCU) is a self-contained electronics package (Figures 1-1 and 2) for interfacing between USER equipment and up to four STC Model 1900 Series Tape Units (TU). The FCU controls the tape units as well as formats and deformats information for storage on and retrieval from ANSI-compatible nine-track half-inch magnetic tape. The FCU is capable of formatting information in group-coded recording (GCR) format at 6250 bits per inch (bpi), phase encoded (PE) format at 1600 bpi, and, optionally, non-return-to-zero indicated (NRZI) format at 800 bpi.

This chapter provides a general description and the specifications of the FCU to familiarize the reader with the equipment. The remaining chapters of the manual provide installation instructions, interface descriptions, a description of the functional operation of the FCU, and maintenance procedures including procedures for the removal and replacement of parts.

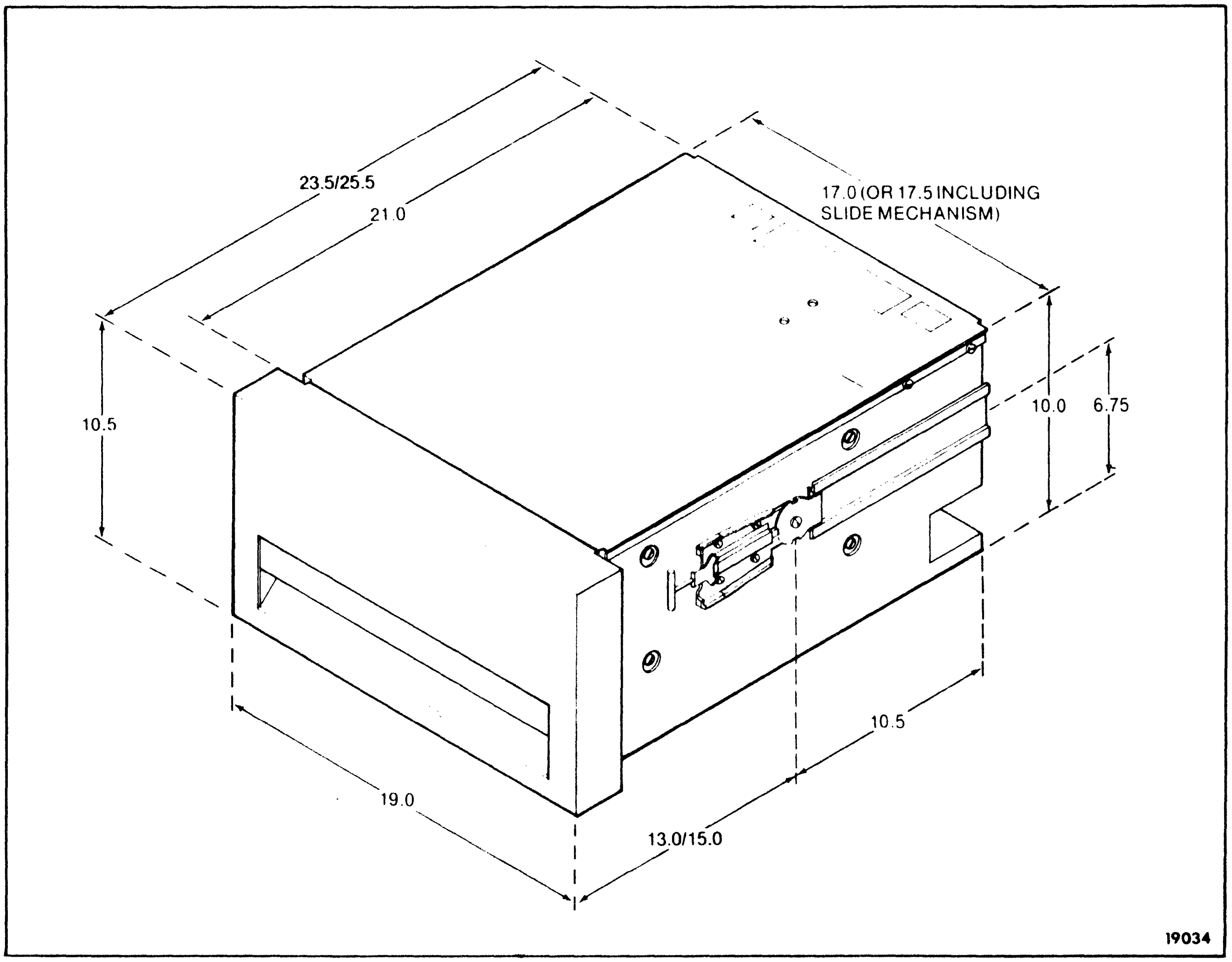


Figure 1-1. Formatter/Control Unit

1.2 SPECIFICATIONS

1.2.1 PHYSICAL DIMENSIONS

The FCU is designed to mount in a standard 19-inch RETMA or universal rack. The nominal dimensions of the FCU are:

Height	10.5 inches (26.7 cm)
Width	19.0 inches (49.3 cm)
Depth	21.0 inches (53.3 cm) behind mounting flanges
Protrusion	4.5 inches (11.4 cm) or 2.5 inches (6.4 cm) in front of mounting flanges depending on front cover
Weight	84.5 pounds (38.3 kg)

1.2.2 ENVIRONMENTAL REQUIREMENTS

Adherence to the following environmental ranges is recommended to assure equipment reliability.

Operating	10% to 90% humidity, non-condensing +50 to +95 °F (+10 to +35 °C)
Storage	10% to 90% humidity, non-condensing +36 to +122 °F, (+2 to +50 °C)
Shipping	Any humidity, non-condensing −40 to +158 °F (−40 to +70 °C)

The shipping environment should not exist outside the limits of the storage environment for longer than 72 hours. The storage environment should not exist outside the limits of the operating environment for longer than six months.

1.2.3 POWER REQUIREMENTS

The FCU is designed to operate on one of the following single-phase power sources:

120 Vac (102-132)	47-63 Hz	7.0 amps (maximum)
200 Vac (180-220)	47-63 Hz	4.5 amps (maximum)
220 Vac (187-242)	47-63 Hz	4.0 amps (maximum)
240 Vac (204-254)	47-63 Hz	4.0 amps (maximum)

1.3 GENERAL DESCRIPTION

1.3.1 SUBSYSTEM DESCRIPTION

The STC 1900 Tape Subsystem is comprised of one STC Model 1935 Formatter/Control Unit (FCU) and up to four STC Model 1900 Series Tape Units (1910, 1911, 1920, 1921, 1951, and/or 1953) in a radial bus configuration. Figure 1-2 shows the typical configuration of such a tape subsystem. Refer to the STC 1950 Series Tape Unit FEMM, PN 9360, and/or the STC 1921 Tape Unit FEMM, PN 9351, for further information regarding the tape units.

FCU to USER interface requirements may be met by one of three interfacing schemes:

1. The STC Standard Interface described in Chapter 3.
2. The STC Software Compatible Interface option to interface between some DEC systems, with appropriate software, and the STC Standard Interface. Refer to the STC Resident PDP-11 Software Compatible Interface PSM, PN 3201, for further information regarding the operation of this optional feature.
3. A custom interface designed by the user to interface between the USER system and the STC Standard Interface and contained within the FCU.

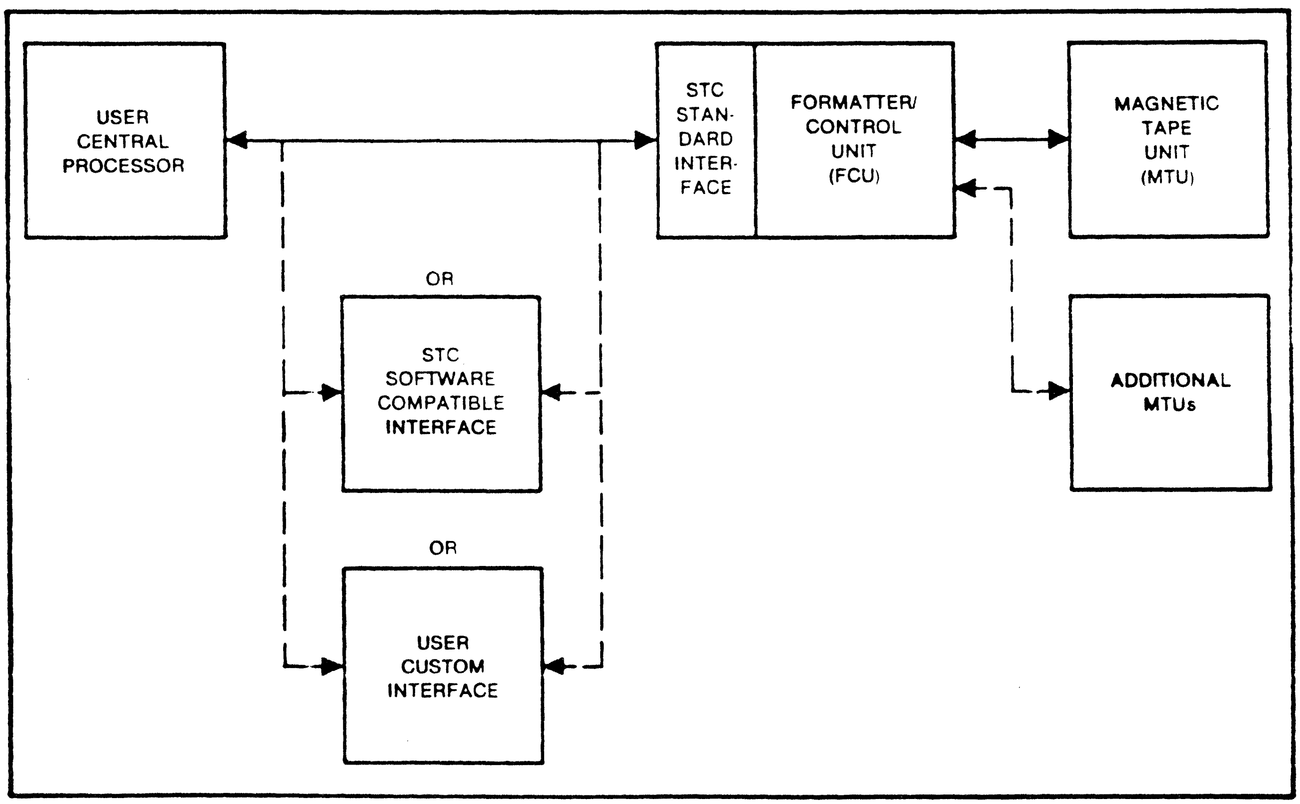


Figure 1-2. Tape Subsystem Configuration

1.3.2 FCU DESCRIPTION

The FCU decodes and directs commands from the USER system to the tape units and provides sense and status information to the USER system. Data transmission between the USER system and the tape units is controlled by the FCU which codes the data from the USER to the demands of the format to be recorded by the addressed tape unit. As data is recorded on tape, the FCU checks the format and data through the read head to assure that it has been recorded correctly. If it has not, the FCU flags the USER that an error condition has occurred so the USER can command a rewrite when the record is complete.

Read data from the tape unit is checked and any errors are corrected up to a limit of one-track errors in NRZI and PE and two-track errors in GCR. The read circuits for NRZI corrects errors only during a re-read-with-error-correction operation; the read circuits for PE and GCR can distinguish and correct errors without re-reading. If a multiple track error occurs, that is, an error in more than one track in PE or two tracks in GCR, the FCU flags the USER of an uncorrectable error, allowing the USER to command a re-read of the data.

The FCU provides complete formatting and deformatting of data and non-data characters for the GCR, PE, and, optionally, NRZI formats. Only non-return to zero (NRZ) form data characters are transferred between FCU and USER interfaces. The timing required for character recording and interblock gap (IBG) generation is controlled by and/or provided for within the FCU.

The FCU is comprised of six major functional areas: the FCU/USER interface, the microcontroller, the write data circuits, the read data circuits, the FCU/TU interface, and the power supply. Figure 1-3 shows the internal arrangement of the FCU. Refer to the general block diagram, Figure 1-4. Figure 1-5 shows the arrangement of the circuit cards in the FCU.

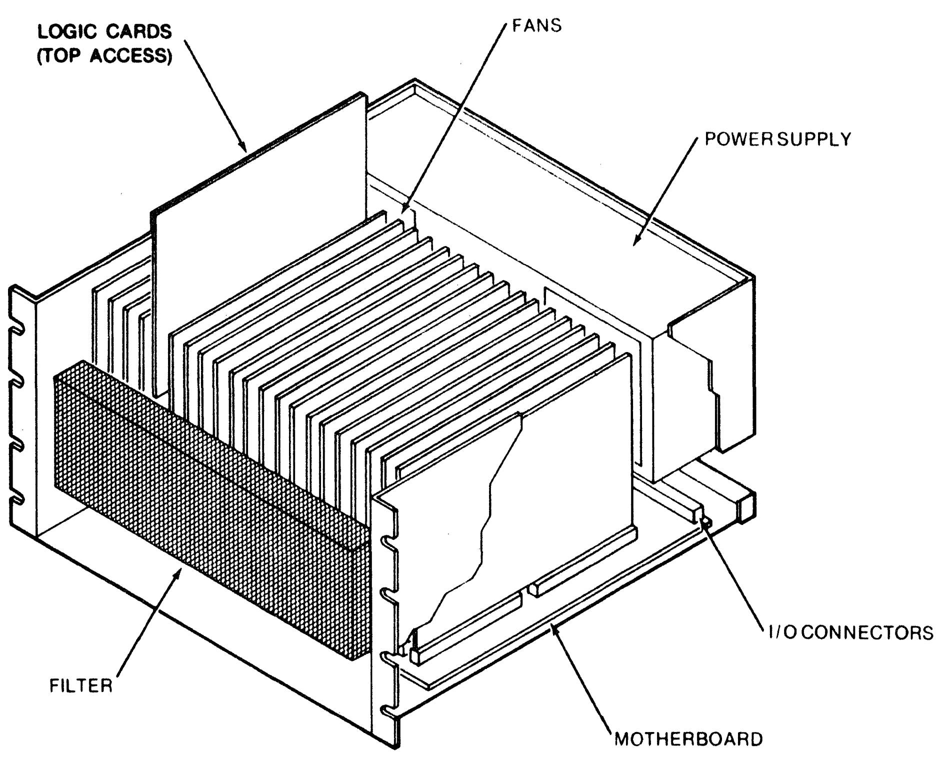


Figure 1-3. FCU Component Locations

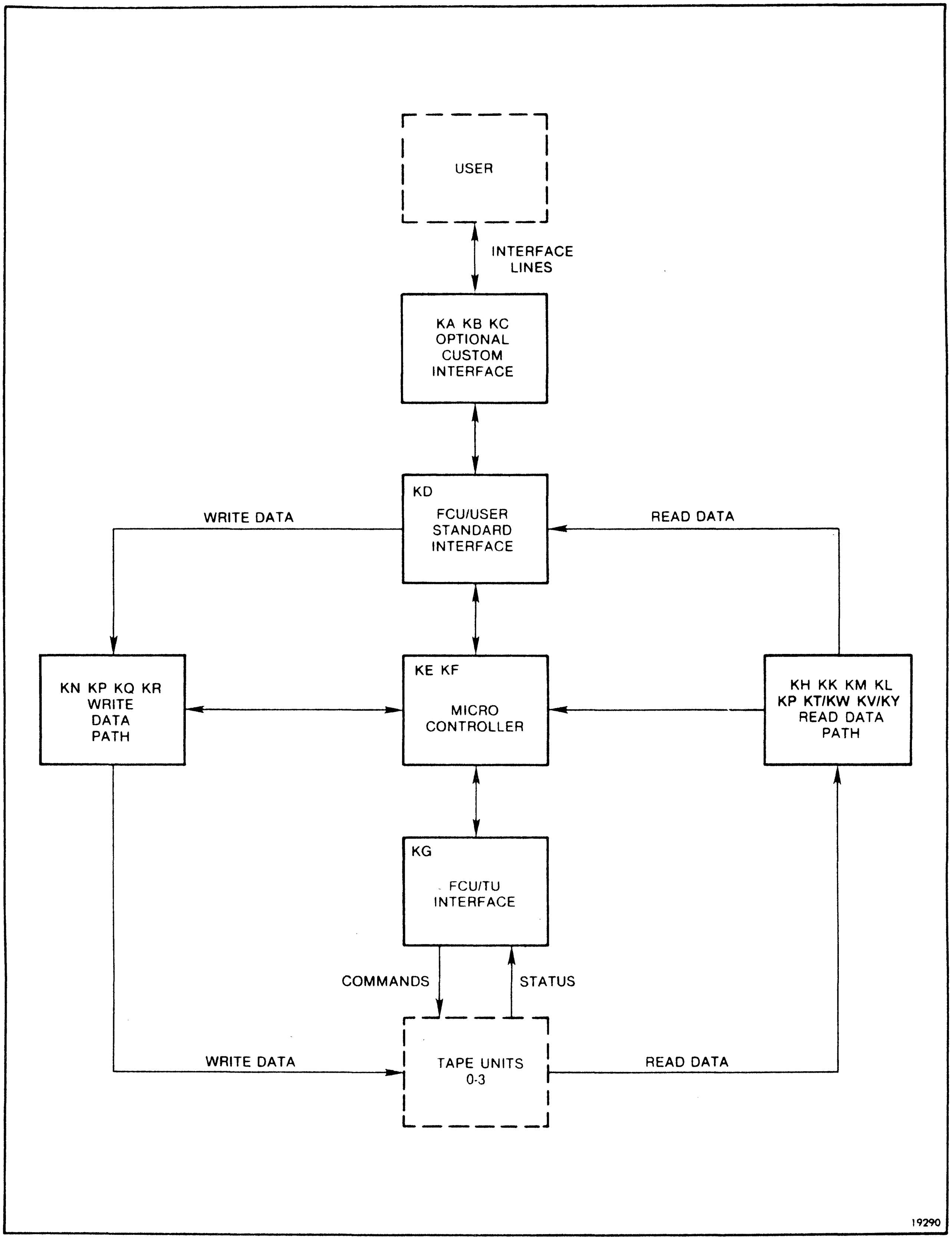


Figure 1-4. FCU General Block Diagram

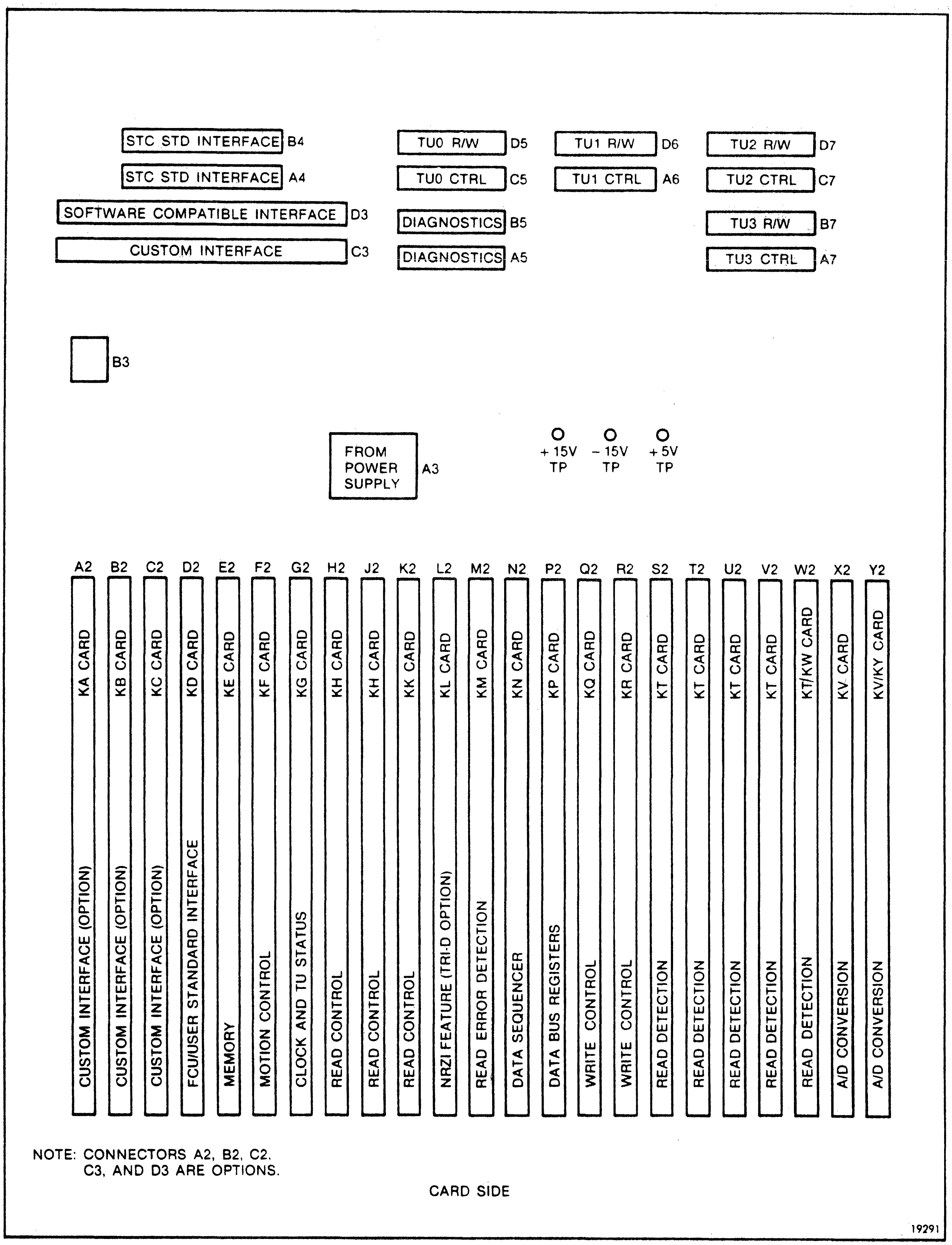


Figure 1-5. FCU Card Locations

CHAPTER 2
INSTALLATION

2.1 INTRODUCTION

This chapter contains the information necessary to unpack, inspect, install and perform the initial checkout of the FCU.

2.2 UNPACKING AND INSPECTION

The FCU is securely packaged in a cardboard container with internal packing material to assure maximum protection during shipping. Figure 2-1 provides a cutaway view of the FCU packaging.

1. Inspect the shipping carton for evidence of in-transit damage. Contact the carrier and manufacturer if damage is apparent.

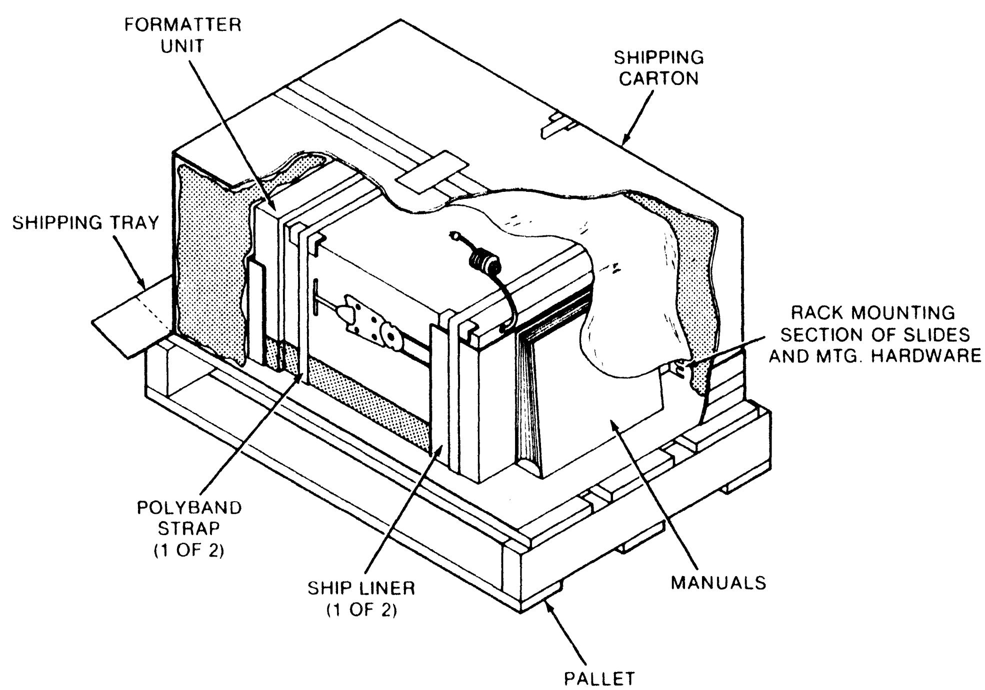


Figure 2-1. FCU Packaging

2. Sever the polyband tie-down strap and lift the shipping carton straight up. Remove enough packing material to expose the FCU. Retain all packing material until the initial checkout is completed in the event the return of the unit becomes necessary.

3. Locate and remove the manuals.

4. Locate and remove the two rack-mounting sections of the tilt slides and the small bag of mounting hardware.

5. Sever the two polyband tie-down straps. Lift the FCU from the shipping tray (gross weight is approximately 85 lbs or 39 kg) and set on a sturdy table.

6. Check the serial number on the unit and be sure that it corresponds to the serial number on the machine level control history. The serial number is located on the right side in the upper right corner.

7. Visually inspect the FCU for any indication of physical damage which may have resulted from shipping.

8. Remove the front decorative cover by placing the index fingers into the access holes under the bottom of the cover, flex the spring clips toward the center of the frame, and pull out at the bottom of the front cover.

9. Remove the power supply top cover by removing the four retaining screws located on the sides of the FCU chassis and lifting the cover straight up. The power supply top cover cannot be removed completely from the FCU because the cooling fans are attached to the cover and wired to the transformer in the FCU. Care should be taken so that no strain is put on the fan wiring.

10. Check the cooling fans to ensure there are no obstructions in the blades and the fans spin freely.

11. Check the power supply area to ensure there are no foreign objects that might cause shorts or otherwise interfere with the proper operation of the FCU.

12. Check the connections to the primary side of the transformer to be sure the voltage requirements are compatible with the AC source used. Newer model power supplies have the voltage conversion charts attached to the transformer.

13. Ensure all power supply mounting screws are tight.

14. Inspect DC power distribution connector A3 to ensure that the connector is properly mated and secure. Connector A3 is shown in Figure 1-6.

15. Reinstall the power supply top cover and securely tighten the four retaining screws.

16. Remove the FCU top cover by removing the three screws located along the front top edge of the FCU chassis and lift the cover clear.

17. Ensure that all logic cards are firmly seated in the correct motherboard locations. Figure 1-6 shows the card locations by type. The card type can be read from the top edge on the component side of a card.

2.3 CABINET MOUNTING

The FCU is designed to be mounted in a standard equipment rack. The FCU may be mounted utilizing the slide mechanism for easy access to the internal components and/or the FCU can be secured to the rack frame by utilizing the mounting flanges at the front of the unit. Either mounting scheme requires two people for the mounting procedure to be accomplished smoothly and safely.

If the FCU is to be mounted to the equipment rack without the slide mechanism, the preliminary check and interface cabling procedures must be completed first.

1. With the FCU positioned on the table or bench, check the mounting flanges and slide mounts to ensure they are not bent or otherwise damaged.
2. Attach the rack-mounting section of the slide mounts to the rack using the mounting hardware which accompanies the FCU in its packing carton. Details of the mounting slide are illustrated in Figure 2-2. Allow enough clearance above the hardware to enable the FCU to clear other equipment after mounting.
3. Align the rails of the slider with the rack-mounting sections and slide the FCU into position. The tab buttons should engage to assure secure mounting.
4. Ensure that the mounting hardware is securely fastened to the frame and that the FCU is secure in the slide mechanism.
5. If the FCU is to be secured to the rack, remove the front decorative cover and secure the mounting flanges on the front of the FCU to the rack.

2.4 PRELIMINARY CHECK

The preliminary check procedure should be performed before the interface cabling is installed.

1. Remove the bottom cover by loosening the screws located along the front bottom edge of the FCU chassis and ensure that the motherboard is mounted securely.
2. Ensure that the FCU circuit breaker on the upper rear of the chassis is in the OFF position. Connect the FCU to the AC power source and switch the circuit breaker to ON. Verify that the cooling fans are running by looking into the back of the FCU.
3. Check and adjust the power supply outputs using the procedure described in Section 6.3.
4. Switch the circuit breaker to OFF and install the interface cables.

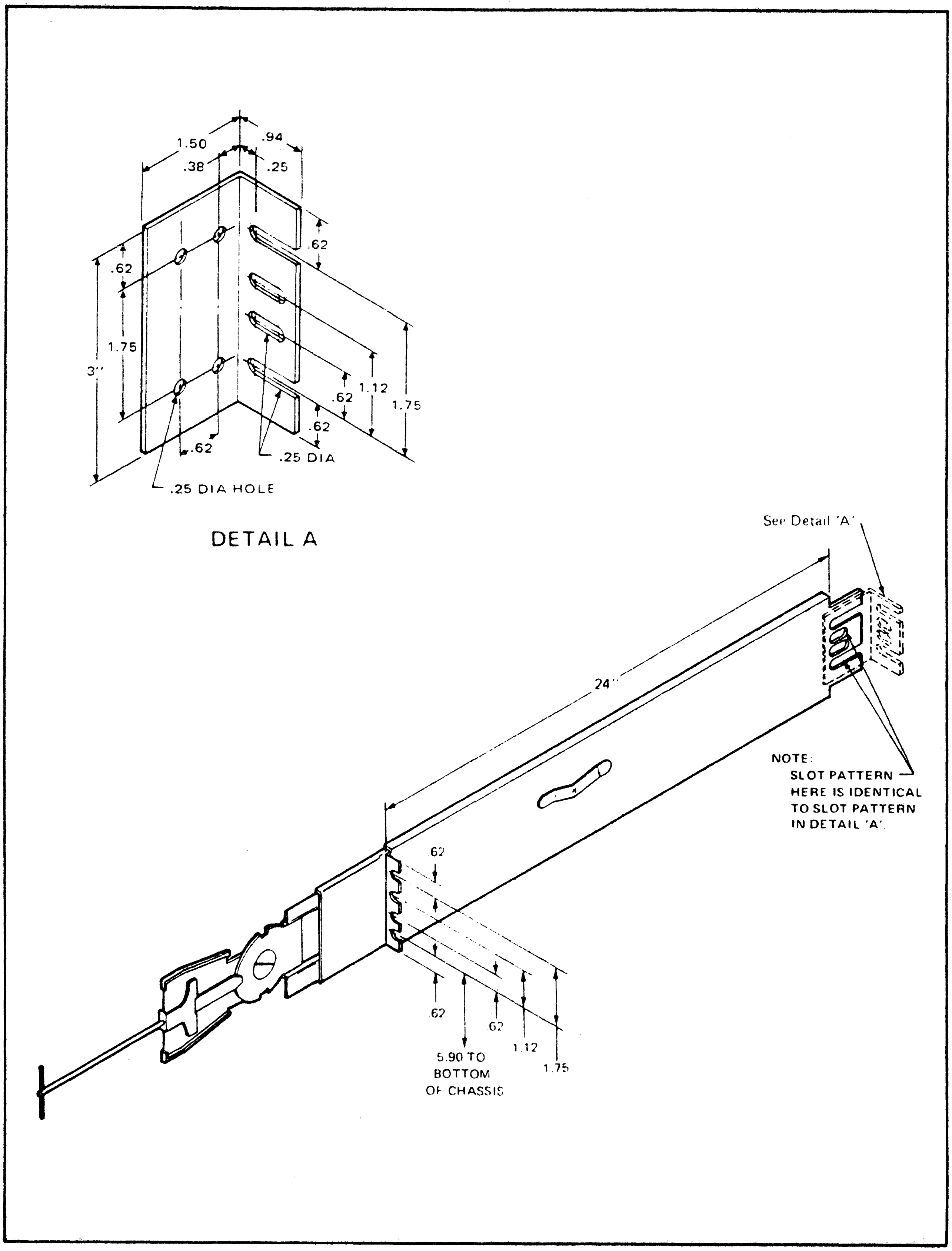


Figure 2-2. FCU Mounting Slide

2.5 INTERFACE CABLING

The interface cables should be connected only after the preliminary check of the FCU has been completed. The space restrictions in the rear of the FCU require that care be taken when installing the cables to avoid damage to the connector pins and cables. All cables should be secured under the strain relief bar.

The FCU/USER interface cabling scheme contains three options: (1) the STC Standard Interface, (2) the STC Software Compatible Interface, and (3) the user custom interface. Select the interface connection to be utilized for the system operation and install the appropriate system interface cable. Refer to Figure 2-3.

1. The STC Standard Interface is shipped fully wired and operational. The interface connectors A4 and B4 are to be connected with the data and control cables, respectively. Before the cables are connected, the connector pins should be checked and carefully straightened as necessary. Care must be taken to ensure that no connector pins are bent or broken while the cables are being connected.

2. The STC Software Compatible Interface option requires additional logic cards (KA, KB, and KC) and a unibus connector adaptor with brackets and mounting screws. Ensure the motherboard is wired in the A2, B2, C2, and D3 connector areas.

   a) Install the connector adaptor into connector D3 and secure it with the mounting hardware supplied.

   b) Install the three additional interface logic cards in their respective locations:

      KA Card - Slot A2
      KB Card - Slot B2
      KC Card - Slot C2

   c) Connect the interface cable to the connector adaptor (bottom connector).

   d) Connect the terminator (top connector).

3. The user custom interface is entirely the responsibility of the user.

When the FCU/USER interface cables have been connected, the FCU/TU interface cables may be connected according to the diagram in Figure 2-4. Refer also to the appropriate tape unit FEMM.

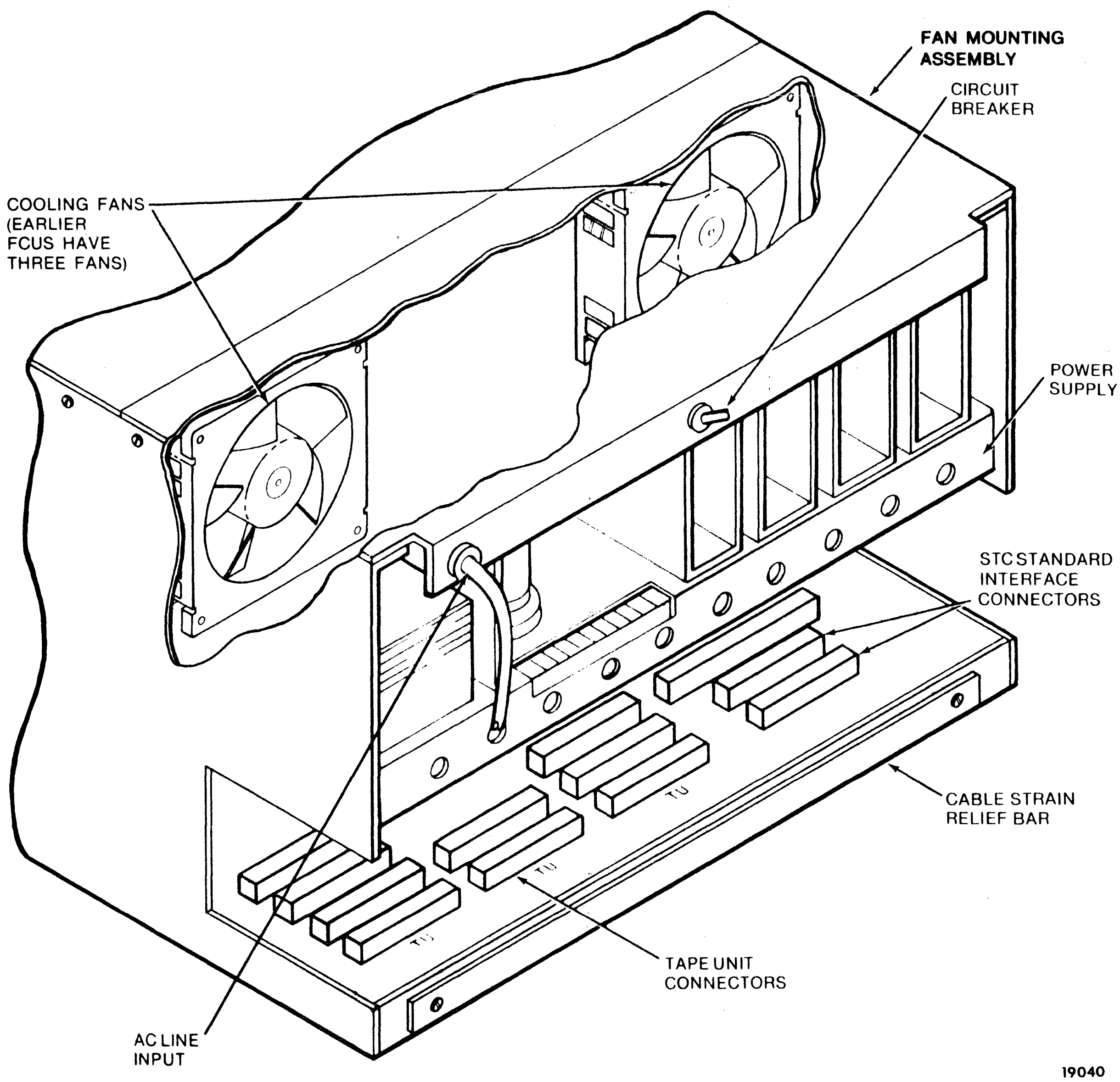


Figure 2-3. Rear View of FCU

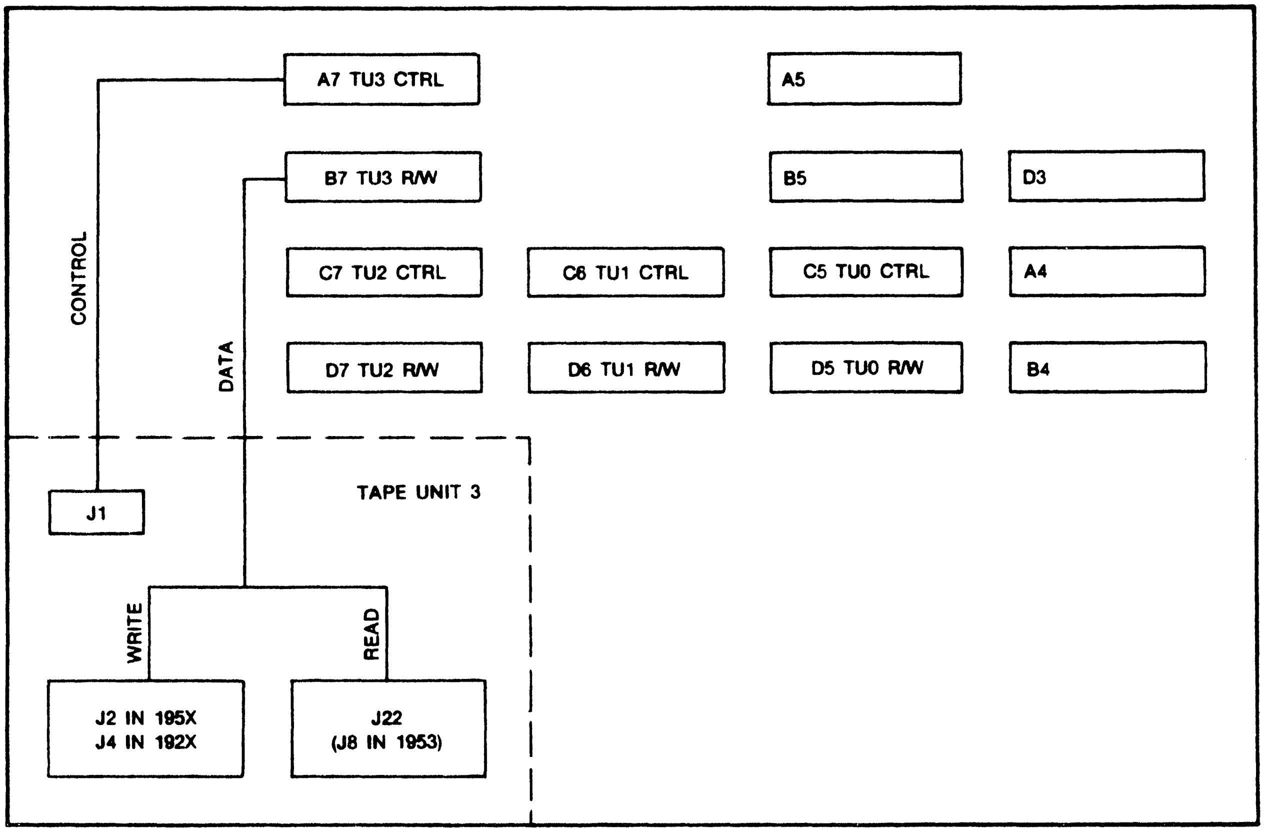


Figure 2-4. FCU/TU Interface Cable Connection

2.6 PLUGGABLE JUMPERS

2.6.1 KA CARD

The KA card (in slot A2) has pluggable jumpers installed at location HA62. These jumpers control seven of the DATA bits which comprise the Interrupt Vector Address. For normal installation, the octal Interrupt Vector Address of 224 is recognized by installing jumpers from pinholes 1-16, 3-14, and 6-11 (Figure 2-5).

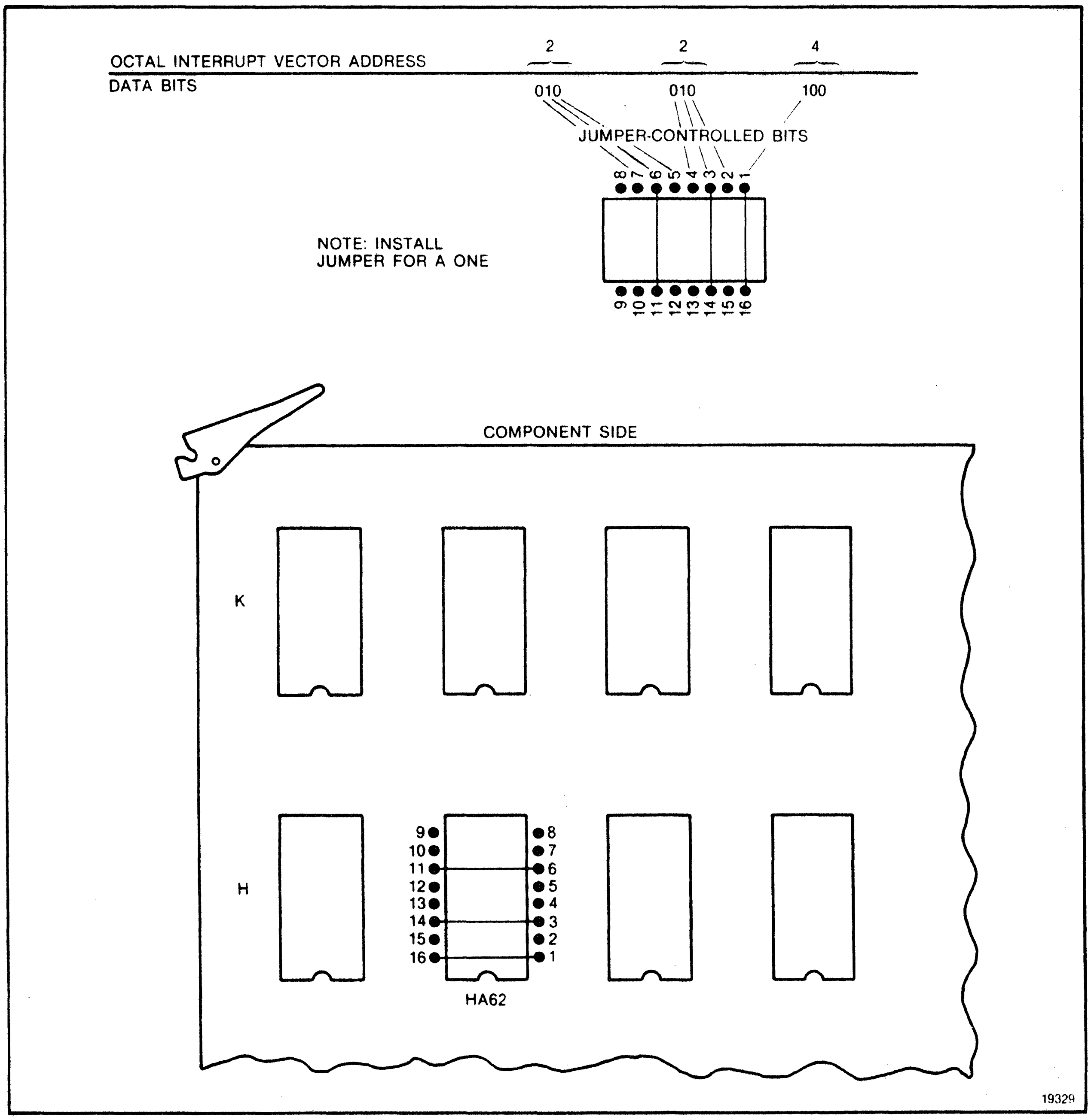


Figure 2-5. KA Card Jumper Locations

2.6.2 KB CARD

The KB card (in slot B2) has pluggable jumpers installed at location FA02. These jumpers control eight of the address bits which comprise the octal Starting Address. To recognize the normal Starting Address of 772440, jumpers must be installed from pinholes 1-16, 3-14, 5-12, and 8-9 (Figure 2-6).

If more than one FCU is being used, each additional FCU must use a unique Starting Address. Addresses available for this purpose are: 772500, 772540, 772600, 772640, 772700, and 772740.

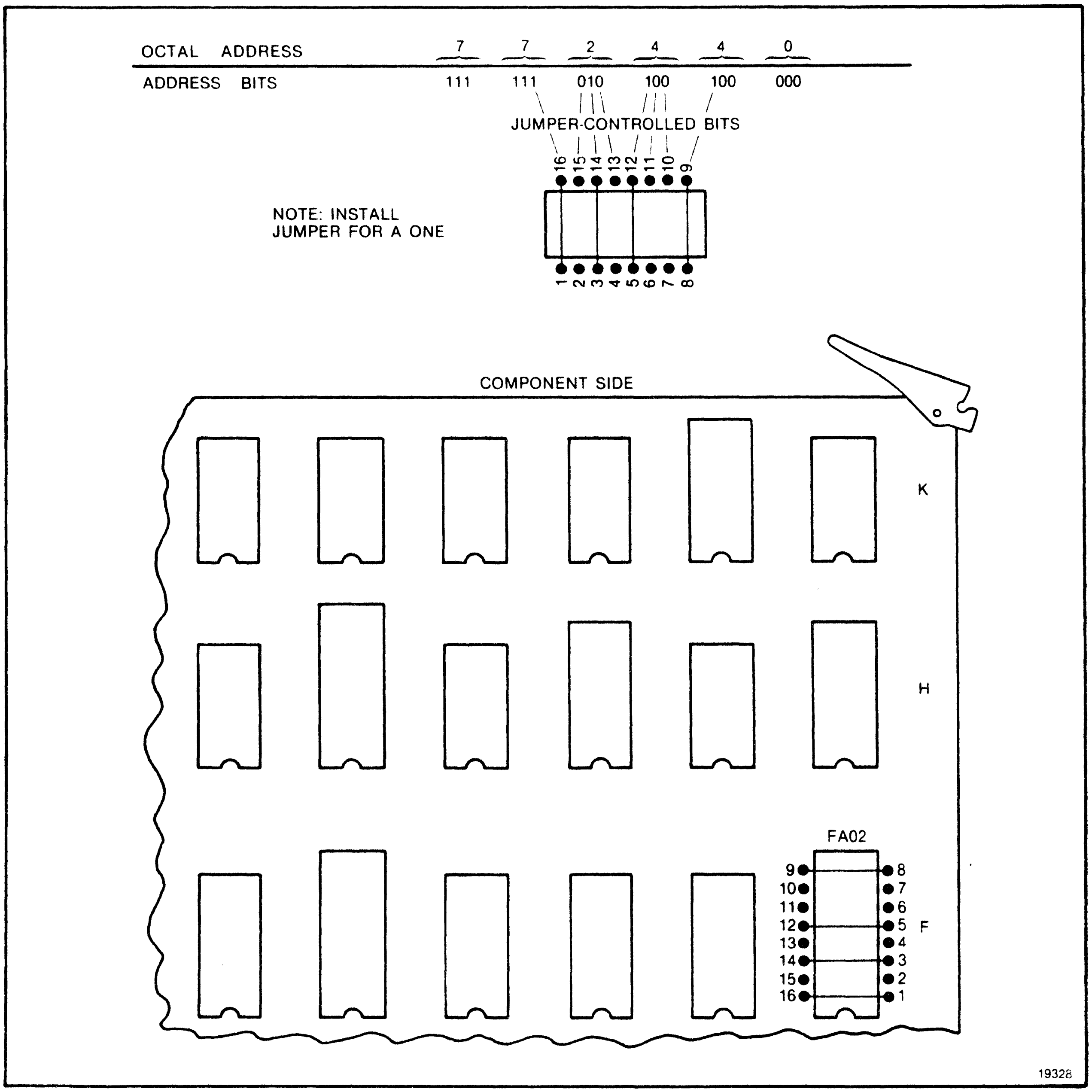


Figure 2-6. KB Card Jumper Locations

2.6.3 KG CARD

The KG card (in slot G2) has a pluggable jumper installed at location KE65 (Figure 2-7). This jumper is essential to the proper operation of the KG card and must not be removed.

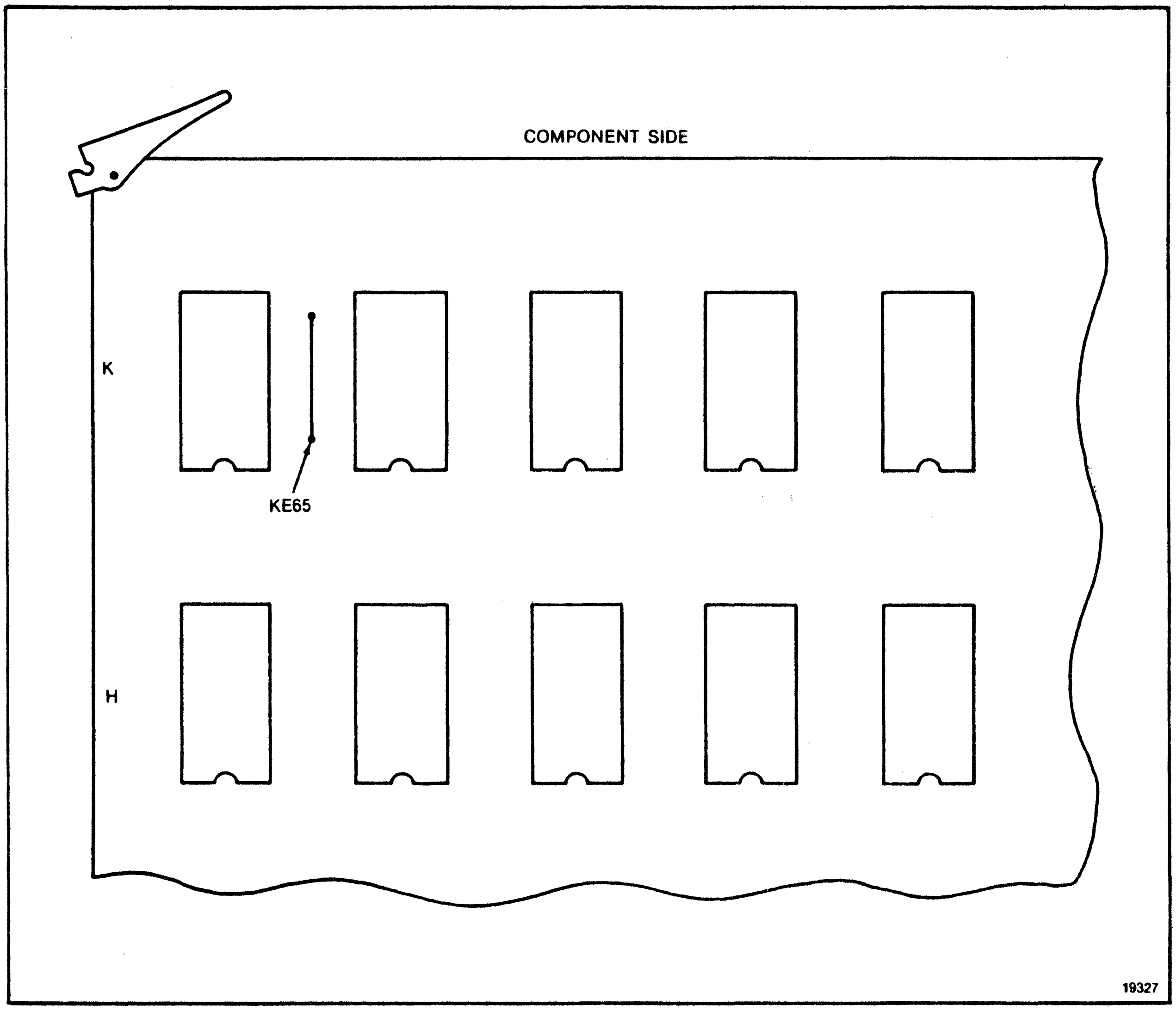


Figure 2-7. KG Card Jumper Location

2.6.4 KL CARD

The KL card (in slot L2) has three functions which are controlled by pluggable jumpers installed, if necessary, at location KA67. Refer to Figure 2-8.

Retry Correction (pinholes 5-10). This jumper (supplied with the card) is normally used. If a Read Forward command results in a Data Check and a Track In Error (TIE) can be found, a Backspace a Block (BSB) command and then a Read Forward command should correct the bad track and byte(s). Without the jumper installed, this process is bypassed.

Force Good Parity (pinholes 3-12). This jumper (supplied with the card) is normally used for all operations and forces good parity from the interface. Without the jumper installed, data is sent across the interface without correcting the P bit. This could be helpful when trying to obtain as much information as possible from a bad record.

Disable Lost Byte (pinholes 1-14). This jumper (not supplied with the card) is not normally used. Without the jumper installed, when the KL logic detects a lost byte while reading a record, a byte of zeroes is inserted and shipped to the interface with good parity. When the Data Check occurs, a sequence of a BSB followed by another read should recover the lost byte (refer to Retry Correction paragraph). With the jumper installed, the byte of zeroes is not inserted and recovery of the lost byte is impossible.

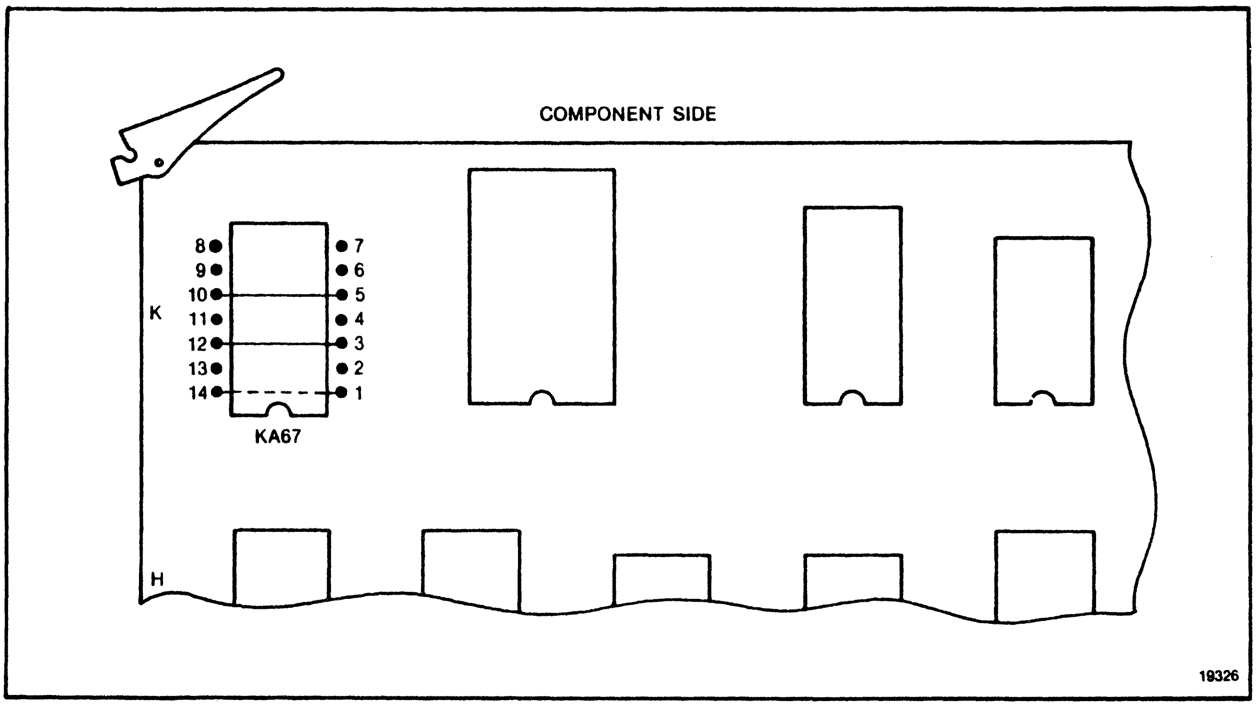


Figure 2-8. KL Card Jumper Locations

2.6 PERFORMANCE CHECK

1. Switch the MAIN POWER circuit breaker to ON and recheck the power supply outputs. There should be no significant difference in the voltage levels but slight adjustment may be necessary.
2. Run diagnostics according to the Diagnostic User's Guide. Be sure to use appropriate applicability entries. If the FCU does not have any tape units attached, only the FCU portion of the diagnostics will be performed. Replace the top, bottom, and front covers.
3. When the FCU has passed the diagnostic routines, it is ready to be put online.

CHAPTER 3

FCU/USER INTERFACE

3.1 INTRODUCTION

This chapter provides a description of the FCU to USER interface circuits, defines the FCU/USER interface signals, and describes the USER commands to the subsystem.

The FCU and USER interface connections are shown in Tables 3-1 and 3-2. The FCU and USER interface circuits are shown in Figure 3-1. The maximum cable length from the USER system to the FCU is 20 feet (6 meters).

The asserted (low) level of the interface signals is 0 Vdc to 0.7 Vdc. The typical unasserted (high) level is +3.4 (±0.3) Vdc.

The interface resistive termination for each signal line is 180 ohms to +5 Vdc and 390 ohms to ground. The termination for each signal line is provided in the FCU or required of the USER interface or both. The termination includes a ground wire connected in both the FCU and the USER interfaces.

3.2 FCU INPUT SIGNAL DEFINITIONS

The following input line definitions are for Functional Mode except when specifically identified as Diagnostic Mode definitions. The timing specifications given refer to measurements made at the FCU interface connector.

3.2.1 INITIATE COMMAND (START)

The assertion of the Initiate Command line loads the USER Address, Command, and Density Select lines into the FCU and initiates the command operation. START must remain asserted until the FCU responds by asserting BUSY, after which time START may be reset. START may be asserted to initiate a command whenever BUSY is not asserted. START assertions while BUSY is asserted will have no effect.

3.2.2 TU ADDRESS (AD0,AD1)

The two TU Address lines are decoded by the FCU to select one of the four sets of connectors used to connect a tape unit to the FCU. Refer to Table 3-3.

If the FCU is not busy (the BUSY line is not asserted), the address lines may be changed at will to select a different connector and thus view a different set of tape unit status lines. The delay time between the selection of a new connector and stabilization of the tape unit status lines is 150 nanoseconds.

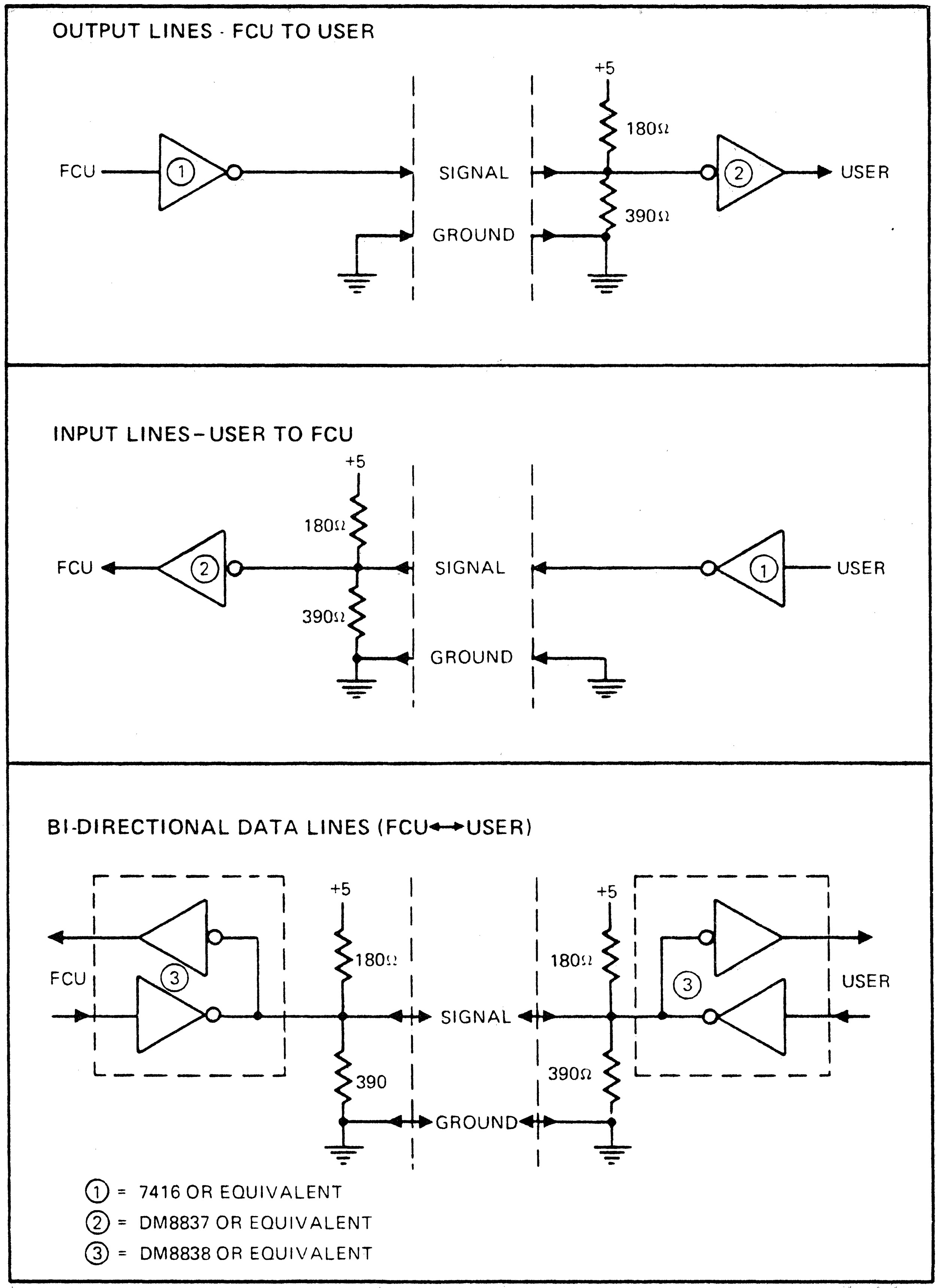


Figure 3-1. FCU-USER Interface Circuits

Table 3-1. USER-to-FCU Input Lines

DESCRIPTION	MNEMONIC	FCU CONNECTOR			TERMINATION RESISTANCE LOCATION
		NO.	SIGNAL PIN	GROUND PIN	
TU Address 0	AD0	A4	A01	B01	FCU
TU Address 1	AD1	A4	A02	B02	FCU
Command Select 0	CMD0	A4	A03	B03	FCU
Command Select 1	CMD1	A4	A04	B04	FCU
Command Select 2	CMD2	A4	A05	B05	FCU
Command Select 3	CMD3	A4	A06	B06	FCU
Density Select 0	DS0	A4	A07	B07	FCU
Initiate Command	START	A4	A08	B08	FCU
Terminate Command	STOP	A4	A09	B09	FCU
Transfer Acknowledge	TRAK	A4	A10	B10	FCU
Bi-Directional Data P	DATA-P	A4	A11	B11	Both
Bi-Directional Data 0	DATA-0	A4	A12	B12	Both
Bi-Directional Data 1	DATA-1	A4	A13	B13	Both
Bi-Directional Data 2	DATA-2	A4	A14	B14	Both
Bi-Directional Data 3	DATA-3	A4	A15	B15	Both
Bi-Directional Data 4	DATA-4	A4	A16	B16	Both
Bi-Directional Data 5	DATA-5	A4	A17	B17	Both
Bi-Directional Data 6	DATA-6	A4	A18	B18	Both
Bi-Directional Data 7	DATA-7	A4	A19	B19	Both
System Reset	RESET	A4	A20	B20	FCU
Select Multiplex 1	SLX1	A4	A21	B21	FCU
Select Multiplex 0	SLX0	A4	A22	B22	FCU
Density Select 1	DS1	A4	A23	B23	FCU
Select Multiplex 2	SLX2	A4	A24	B24	FCU

Table 3-2. FCU-to-USER Output Lines

DESCRIPTION	MNEMONIC	FCU CONNECTOR			TERMINATION RESISTANCE LOCATION
		NO.	SIGNAL PIN	GROUND PIN	
Slave Status Change	SSC	A4	A25	B25	USER
Oscillator	OSC	A4	A26	B26	USER
End of Tape Status	EOTS	A4	A27	B27	USER
Begin. of Tape Status	BOTS	A4	A28	B28	USER
File Protect Status	FPTS	A4	A29	B29	USER
Rewinding Status	REWS	A4	A30	B30	USER
Error Multiplex P	ERRMX-P	B4	A1	B1	USER
Error Multiplex 0	ERRMX-0	B4	A2	B2	USER
Error Multiplex 1	ERRMX-1	B4	A3	B3	USER
Error Multiplex 2	ERRMX-2	B4	A4	B4	USER
Error Multiplex 3	ERRMX-3	B4	A5	B5	USER
Error Multiplex 4	ERRMX-4	B4	A6	B6	USER
Error Multiplex 5	ERRMX-5	B4	A7	B7	USER
Error Multiplex 6	ERRMX-6	B4	A8	B8	USER
Error Multiplex 7	ERRMX-7	B4	A9	B9	USER
Formatter Busy	BUSY	B4	A10	B10	USER
Transfer Request	TREQ	B4	A11	B11	USER
Expecting Data	RECV	B4	A12	B12	USER
Identification Burst	ID BRST	B4	A13	B13	USER
Operation Incomplete	OP INC	B4	A14	B14	USER
End of Data Pulse	ENDATP	B4	A15	B15	USER
Tape Mark Status	TMS	B4	A16	B16	USER
Command Reject	REJECT	B4	A17	B17	USER
Overrun Status	OVRNS	B4	A18	B18	USER
Data Check	DATA CHK	B4	A19	B19	USER
ROM Parity Error	ROMPS	B4	A20	B20	USER
Corrected Error	CRERR	B4	A21	B21	USER
Block Sensed	BLOCK	B4	A22	B22	USER
NRZI Status	NRZI	B4	A23	B23	USER
Data Bus Parity Error	BUPER	B4	A24	B24	USER
On Line Status	ONLS	B4	A25	B25	USER
High Density Status	HDENS	B4	A26	B26	USER
Ready Status	RDYS	B4	A27	B27	USER
Write Status	WRTS	B4	A28	B28	USER
Reserved		B4	A29	B29	
Reserved		B4	A30	B30	

For command operations, the address lines must be stable 90 nanoseconds prior to the assertion of START and remain stable until the FCU latches in the address and responds by asserting BUSY. While BUSY is asserted, the address lines have no effect.

Table 3-3. Tape Unit Address Line Decode

TU ADDRESS LINES		SELECTED TAPE UNIT
AD1	AD0	
0	0	0
0	1	1
1	0	2
1	1	3

3.2.3 DENSITY SELECT (DS0,DS1)

A switch on the tape unit operator panel is used to select NRZI, PE, GCR, or Software Select recording density. With the switch in the NRZI, PE, or GCR position and tape positioned at BOT, the tape subsystem will write tapes in the selected density. With the switch in the Software Select position and tape positioned at BOT, the tape subsystem will write tapes in the density selected by the Density Select lines. These lines must be stable 90 nanoseconds prior to the assertion of START and remain stable until the FCU responds by asserting BUSY. The decode of the Density Select lines is given in Table 3-4.

The tape subsystem recording density can only be altered at the time of a write command issued with tape positioned at BOT. At all other times, the tape subsystem will read and write in the density indicated by the ID burst of the tape in use.

Table 3-4. Density Select Line Decode

DENSITY SELECT LINES		SELECTED DENSITY
DS1	DS0	
0	0	PE
0	1	GCR
1	0	NRZI
1	1	NRZI

3.2.4 COMMAND SELECT (CMD0-CMD3)

The four Command Select lines are decoded in the FCU and cause one of 16 command operations. These lines must be stable 90 nanoseconds prior to the assertion of START and must remain stable until the FCU responds by asserting BUSY. The Command Select decoding is given in Table 3-5. The detail descriptions and timing of each command operation are specified in Section 3.4.

During Diagnostic Mode operations, these four lines are used in conjunction with the SLX0, SLX1, and SLX2 lines to define the Diagnostic Mode commands. Command initiation requires that SLX0, SLX1, and SLX2 be valid and stable 90 nanoseconds prior to the assertion of START and remain stable throughout the operation. All CMD combinations can be used in Diagnostic Mode and do not necessarily relate to their Functional Mode definitions. As a result, status conditions usually associated with a CMD should not be expected. (Note: Read commands, RDF and RDB, will still perform some type of read function and transfer data from the FCU across the standard interface to the user.) Refer to the 1900 Diagnostic User's Guide, PN 9492, for a detailed explanation of the diagnostic commands.

Table 3-5. Command Select Decode

CMD0	CMD1	CMD2	CMD3	MNEMONIC	DESCRIPTION
0	0	0	0	NOP	No Operation
0	0	0	1	CLR	Drive Clear
0	0	1	0	DMS	Diagnostic Mode Set
0	0	1	1	SNS	Sense Drive Status
0	1	0	0	RDF	Read Forward a Block
0	1	0	1	RDB	Read Backward a Block
0	1	1	0	WRT	Write a Data Block
0	1	1	1	LWR	Loop Write-to-Read
1	0	0	0	BSF	Backspace a File
1	0	0	1	BSB	Backspace a Block
1	0	1	0	FSF	Forward Space a File
1	0	1	1	FSB	Forward Space a Block
1	1	0	0	WTM	Write Tape Mark
1	1	0	1	ERG	Erase Gap
1	1	1	0	REW	Rewind
1	1	1	1	RUN	Rewind and Unload

3.2.5 TRANSFER ACKNOWLEDGE (TRAK)

The assertion of the Transfer Acknowledge line by the USER is in response to the assertion of TREQ by the FCU. The assertion of TREQ by the FCU on a WRT operation indicates that the FCU is requesting data character transfer on the Bi-Directional Data bus and the responding assertion of TRAK (or STOP) by the USER indicates that the Bi-Directional Data bus contains the valid data character to be transferred.

The assertion of TREQ by the FCU on a RDF or RDB operation indicates that a data character is valid on the Bi-Directional Data bus and the responding assertion of TRAK (or STOP) by the USER indicates that the data character has been transferred.

The signal protocol for TREQ and TRAK is similar for either a write or a read operation, that is, once TREQ is asserted it will remain asserted until TRAK is asserted. TRAK must remain asserted until TREQ is reset at which time TRAK must be reset.

3.2.6 TERMINATE COMMAND (STOP)

The Terminate Command line is asserted by the USER in response to TREQ or BLOCK to indicate one of the following situations:

1. During a WRT or LWR command, in response to TREQ, that the last data character to be written in the data block has been placed on the Bi-Directional Data bus.
2. On a RDF or RDB command, in response to TREQ, that the FCU is to terminate the transfer of data characters on the Bi-Directional Data bus.
3. On a BSB or FSB operation, in response to BLOCK, that the FCU is to terminate spacing over blocks.

For the first two situations, STOP replaces TRAK (Section 3.2.5) as the USER response to TREQ. In response to STOP, the FCU will terminate the command in progress and reset BUSY, but only after the FCU has completed the necessary tape formatting, deformatting, and positioning according to the nature of the command in progress.

3.2.7 SYSTEM RESET (RESET)

The trailing edge of a pulse on the System Reset line by the USER will cause the tape subsystem to immediately terminate any command in progress. All FCU status output lines except TMS and HDENS will be reset. During termination, the FCU will discontinue formatting and deformatting, and will cause tape motion to halt without regard to IBG positioning. (Note: Partially written or erased blocks during write commands may occur when a RESET is given.) If the system is in Diagnostic Mode, it will be set to Functional Mode.

The RESET pulse from the USER must be 1 microsecond minimum.

3.2.8 SELECT MULTIPLEX (SLX0-SLX2)

The three Select Multiplex lines are decoded in the FCU and determine which of eight 9-bit registers is multiplexed to the Error Multiplex (ERRMX) output lines. The ERRMX lines are valid only as a part of 'ending status' (that is, after BUSY has been reset). The delay time between the selection of a Select Multiplex code and the stabilization of the selected MUX byte is 150 nanoseconds maximum. Table 3-6 gives the Select Multiplex decode. More complete descriptions of each byte are given in Section 3.3.15, "Error Multiplex."

During Diagnostic Mode operation, these lines define the command operation (Section 3.2.4) as well as select the MUX byte present on the ERRMX Bus.

Table 3-6. Select Multiplex Decode

SLX2	SLX1	SLX0	MUX BYTE	DESCRIPTION
0	0	0	0	Dead Tracks
0	0	1	1	Read/Write Errors
0	1	0	2	Diagnostic Aids
0	1	1	3	Drive Sense Byte
1	0	0	4	CRC-F
1	0	1	5	Reserved
1	1	0	6	Reserved
1	1	1	7	Reserved

3.2.9 BI-DIRECTIONAL DATA (DATA P-DATA 7)

The nine Bi-Directional Data lines are used to transfer the data characters between the interfaces in conjunction with the TRAK (or STOP) responses to TREQ. When a line is reset, a ZERO will be transferred. Odd parity must be maintained on these lines for all Functional Mode data transfer operations. During Diagnostic Mode, however, the USER interface must be capable of specifying the level of each DATA line independent of overall parity.

3.3 FCU OUTPUT SIGNAL DEFINITIONS

The following output line definitions are for Functional Mode only.

During Diagnostic Mode operation, any output may be asserted to transfer information from the FCU to the diagnostic software. The assertion will not necessarily be associated to the previous definition of that output. For example, during certain diagnostic test routines, Tape Mark Status will be part of an indication of a time or distance measurement.

3.3.1 TRANSFER REQUEST (TREQ)

The Transfer Request line is asserted by the FCU to indicate that the FCU is requesting data character transfer on the Bi-Directional Data bus. The signal protocol for TREQ and TRAK (or STOP) is specified in Sections 3.2.5 and 3.2.6.

3.3.2 EXPECTING DATA (RECV)

The Expecting Data line is asserted by the FCU to indicate that the Bi-Directional Data bus is under control of the USER and that the FCU will soon request data character transfers. This line is asserted on WRT or LWR command operations only. It will remain asserted until a new command is initiated.

3.3.3 BLOCK SENSED (BLOCK)

The Block Sensed line is asserted by the FCU to indicate that a data block or a tape mark block has been detected. This line is asserted during BSB and FSB commands or during any read type command detecting a tape mark block. BLOCK is a pulse of 400 nanoseconds nominal duration.

3.3.4 OSCILLATOR (OSC)

The Oscillator line is derived from the internal FCU crystal oscillator. The frequency will be 2.72 MHz (369 nanosecond period) for GCR operations at 75 ips, 2.27 MHz (443 nanosecond period) for GCR operations at 125 or 50 ips, and 2.40 MHz (416 nanosecond period) for PE and NRZI operations. The frequency is stable within .01% and the half-cycle periods will be symmetrical within 5%. The oscillator frequency reflects the density mode in effect within the FCU and not in the tape unit. It will shift frequency as the requirements of the command sequence dictates (such as ID BRST identification).

3.3.5 END OF DATA PULSE (ENDATP)

The End of Data Pulse line is asserted by the FCU to indicate that the last data character has been read from tape and transferred to the FCU. If the USER TREQ and TRAK timing has been within the specified limits, the USER should have received all data bytes by the time ENDATP is asserted. Upon assertion of ENDATP, all data transfer is halted and untransferred bytes are lost. ENDATP is asserted on read command operations (RDF or RDB) only.

3.3.6 FORMATTER BUSY (BUSY)

The Formatter Busy line is asserted by the FCU following the acceptance of the command initiated by START. This line will remain asserted until completion of the command operation or until conditions arise which cause a REJECT. A command operation maybe initiated only when BUSY is reset.

3.3.7 IDENTIFICATION BURST (ID BRST)

The Identification Burst line is asserted by the FCU to indicate that an identification burst procedure is being performed by the tape subsystem. It will be asserted on read or write commands from BOT. ID BRST is a real time signal when BUSY is asserted, that is, it is asserted only while the identification burst procedure is being performed.

On a write command, the procedure includes the writing of the ID burst, a backspace to BOT, and a read check of the written burst.

On a read command, the procedure includes the determination of the format (PE, GCR, or NRZI) of the burst.

If the ID burst procedure is performed satisfactorily, the FCU will proceed with the command initiated. If the procedure is not performed satisfactorily, REJECT and a reject code (Section 3.3.15) will be asserted. ID BRST will remain asserted. ID BRST will also be asserted if a backward operation is initiated with tape positioned off BOT and tape reaches either BOT or an ARA ID burst before the end of the operation. (Under this condition, DATA CHK is also set).

3.3.8 TAPE MARK STATUS (TMS)

The Tape Mark Status line is asserted by the FCU to indicate that a tape mark block has been detected. This line will be asserted following a Write Tape Mark command and following any read or space command when a tape mark block is detected. TMS will be reset by the next command issued unless that command is a CLR, SNS, or NOP.

3.3.9 COMMAND REJECT (REJECT)

The Command Reject line is asserted by the FCU whenever conditions inside the tape subsystem are inappropriate to the command operation. The conditions which cause the REJECT are given in Section 3.3.15 under the Error Multiplex bus definitions. After the assertion of REJECT and the reset of BUSY, Reject Codes for the conditions causing the reject are the octal contents of the Diagnostic Aids register, addressable on the Error Multiplex bus as MUX Byte 2. Read or write commands given after a REJECT is received may result in mispositioning and/or creation of an unreadable portion of tape.

3.3.10 OPERATION INCOMPLETE (OP INC)

The Operation Incomplete line is asserted by the FCU in conjunction with all Reject codes except numbers 1, 5, 7, 13, and 23 (octal). OP INC indicates that the given command was initiated but was not completed. REJECT includes those commands that were not able to be initiated as well as those not completed.

3.3.11 OVERRUN STATUS (OVRNS)

During a write operation, the Overrun Status line is asserted by the FCU when the write buffer of the FCU is not being supplied data characters by the USER as fast as the FCU requires them. This may occur when previous TREQ/TRAK responses were not within the timing requirements, or STOP was not asserted. The FCU will terminate data transfer upon detecting an overrun and complete formatting the data block. The data block written will be incorrectly encoded. If OVRNS is asserted, DATA CHK will also be asserted following the read validity checking.

During a read operation, OVRNS is asserted by the FCU when data characters supplied by the tape unit have backed up in and overflowed the read buffer due to the USER not accepting data at a high enough rate and STOP was not asserted to terminate data transfer. If STOP was not asserted and if any information remains in the read buffer when the tape subsystem is in the IBG, OVRNS will be set.

3.3.12 ROM PARITY ERROR (ROMPS)

The ROM Parity Error line is asserted by the FCU to indicate that an internal FCU microprogram word had incorrect parity. This indication points to a FCU hardware problem which should be corrected before further data processing is attempted.

3.3.13 SLAVE STATUS CHANGE (SSC)

The Slave Status Change line is asserted by the FCU to indicate that one or more tape units within the system have either gone Online, gone Offline, or gone from Not Ready to Ready. In addition, SSC will be set if one or more of the tape units was issued a REW command and tape was already positioned at BOT. SSC will be reset after issuing any command (other than a NOP or SNS) to each tape unit that had one of these three status changes.

3.3.14 DATA CHECK (DATA CHK)

The Data Check line is asserted by the FCU to indicate that one or more of the error conditions of Table 3-7 has occurred. References to more detailed descriptions of each error are included.

Table 3-7. Error Conditions Setting DATA CHK

ERROR CONDITION	REFERENCE SECTION
CRC Error	3.3.15.2, item 1
Write Tape Mark Check	3.3.15.2, item 2
Uncorrectable Error	3.3.15.2, item 3
Partial Record	3.3.15.2, item 4
End of Data Check	3.3.15.2, item 6
Velocity Error	3.3.15.2, item 7
Overrun	3.3.11
VRC Error[1]	3.3.15.2, item 6
LRC Error[1]	3.3.15.2, item 5
TIE Cannot be Found[1]	3.3.15.1
Write Skew Error[1]	3.3.15.2, item 3
Multiple Track Error[2]	3.3.15.2, item 5
BOT Reached	Note 3
PE Postamble Error	Note 4
Single Track Error	Note 5

1 NRZI mode operation only.

2 DATA CHK may not be asserted during a GCR read.

3 This error indicates that a backward command was initiated with tape positioned off BOT and BOT was reached before the command was completed. ID BRST and BOTS are also set.

4 During PE read or write operations, the postamble was not detected to be the correct length.

5 During a PE write operation, an error detected in any track will set DATA CHK.

3.3.15 ERROR MULTIPLEX (ERRMX P-ERRMX 7)

The nine Error Multiplex lines are asserted by the FCU to allow transfer of additional error and reject status information. The lines are valid only as a part of the ending status of the most recently completed command (that is, after BUSY is reset). One of the eight registers is multiplexed to the ERRMX bus as selected by SLX0, SLX1, and SLX2 (Section 3.2.8). Table 3-8 gives the ERRMX decode for Functional Mode operation.

Table 3-8. Error Multiplex Bus Decode for Functional Mode

MUX BYTE	ERROR MULTIPLEX BIT P	7	6	5	4	3	2	1	0	DESCRIPTION
0	DTP	DT7	DT6	DT5	DT4	DT3	DT2	DT1	DT0	DEAD TRACKS
1	CRC ERR	WTM CHK	UCE	PART REC	MTE	NOT USED	END DATA CHK	VEL ERR	DIAG MODE LTCH	READ/WRITE ERRORS
2	TACH	DA7	DA6	DA5	DA4	DA3	DA2	DA1	DA0	DIAGNOSTIC AID BITS
3	ERSS	EOTS	BOTS	WNHB	PROS	BWDS	HDNS	RDYS	ONLS	DRIVE SENSE BYTE 0
4	CRC-F P	CRC-F 7	CRC-F 6	CRC-F 5	CRC-F 4	CRC-F 3	CRC-F 2	CRC-F 1	CRC-F 0	CRC BYTE
5	RESERVED									
6	RESERVED									
7	RESERVED									

3.3.15.1 MUX Byte 0

ERRMX bits P through 0 are asserted upon detecting a dead track. A dead track is caused by the inability to detect correct data on a specific track on tape. These bits are reset at the start of each new command. A Diagnostic Mode Set command with SLX0 asserted will condition the FCU to indicate the occurrence of phase errors for each track on a subsequent read or write command rather than indicating dead tracks (Section 3.5.3).

During NRZI mode operation, the assertion of bits P, 6, and 7 of the dead track register indicate that the track in error (TIE) cannot be found. DATA CHK is also asserted.

3.3.15.2 MUX Byte 1

The following bits of MUX Byte 1 are asserted when the conditions defining the bit occur:

1. Cyclic Redundancy Check Error (CRC ERR)

   The internal checks of data character CRC registers indicate a loss of data integrity. This error may occur during read or write commands during PE, GCR, or NRZI operations. DATA CHK is also asserted.

2. Write Tape Mark Check (WTM CHK)

   The FCU has been unable to write a tape mark correctly (Section 3.4.13). DATA CHK and REJECT may also be asserted (Table 3-9).

Table 3-9. Status Lines Asserted With WTM CHK

	ASSERTED LINES			
MODE	**WTM CHK**	**DATA CHK**	**REJECT**	**COMMENTS**
PE,GCR	X	X		The tape mark written does not meet ANSI specifications but is readable as a TM.
PE,GCR,NRZI	X		X	The tape mark written is not readable as a TM. Noise may be left on tape but will not be detected by any read or space command.
NRZI	X	X		The tape mark written is not readable as a TM. Data left on tape appears as an illegally formatted record.

3. Uncorrectable Error (UCE)

   An uncorrectable error has been detected. This error may occur during PE or GCR read or write commands. DATA CHK is also asserted.

   An uncorrectable error during NRZI mode operation is indicated by the assertion of DATA CHK and bits P, 6, and 7 of the dead track register (Section 3.3.15.1).

   During NRZI mode operation, UCE is asserted during write commands to indicate excess skew in the record just written. DATA CHK is also asserted.

4. Partial Record (PART REC)

   An IBG is detected before detecting end-of-data characters. This error may occur during PE or GCR read or write commands. DATA CHK is also asserted.

5. Multiple Track Error (MTE)

   Two or more tracks are detected in error. This error may occur during PE or GCR read or write commands. DATA CHK will also be asserted if the MTE occurs during a PE read or write, or a GCR write operation. DATA CHK will be asserted during GCR operations if the errors encountered cannot be corrected.

   During NRZI read or write operations, this line indicates an LRC error.

6. End of Data Check (END DATA CHK)

   The end-of-data characters are not detected, or the preambles and postambles do not meet format requirements. This error may occur during PE or GCR read or write commands. DATA CHK is also asserted.

   During NRZI read or write operations, this line indicates a vertical redundancy check (VRC) error. A VRC error is present if at least one byte of data, the CRC character, or the LCR character was present with incorrect parity.

7. Velocity Error (VEL ERR)

   The tape unit speed indication was outside acceptable limits. This error may occur during PE, GCR, or NRZI write commands. DATA CHK is also asserted.

8. Diagnostic Mode Latch (DIAG MODE LTCH)

   The Diagnostic Mode of operation has been set in the FCU.

3.3.15.3 MUX Byte 2

ERRMX Bit P is the digital tachometer (TACH) from the tape unit and contains information concerning tape speed and distance. This line is used in certain diagnostic routines and is valid during commands as well as after the command is completed.

ERRMX Bits 7, 6, and 5 (DA7, DA6, and DA5) are used during Diagnostic Mode operation only.

Various Reject Codes are asserted on bits 4 through 0 under their defining conditions. The Reject Code is the octal equivalent of bits DA4 through DA0 with bit DA4 being most significant and bit DA0 being least significant. Table 3-10 defines Reject Codes 1 through 37, and indicates those that set OP INC.

3.3.15.4 MUX Byte 3

MUX Byte 3 contains certain status lines direct from the tape unit. These lines are defined in Section 4.3 and some are duplicated as separate interface output lines. Diagnostic Mode operation allows additional drive information to be present in MUX Byte 3. (Refer to the 1950 Series Tape Unit FEMM.)

3.3.15.5 MUX Byte 4

MUX Byte 4 contains the contents of the CRC-F generator and is used in certain diagnostic tests of NRZI mode operation.

3.3.16 CORRECTED ERROR (CRERR)

The Corrected Error line is asserted by the FCU to indicate the following: (DATA CHK may also be set.)

1. A single-track error has been corrected during a PE read or a PE readback check during a write
2. A single- or double-track error has been corrected during a GCR read or a GCR readback check during a write.
3. A reread of a NRZI record has been performed in order to attempt correction of a bad record.

Table 3-10. Reject Codes (Sheet 1 of 2)

REJECT CODE (OCTAL)	DESCRIPTION
1	The addressed tape unit is not in Ready Status.
2*	The FCU has detected one of its internal microprogram words having wrong parity.
3*	The TRAK responses to initiating (first two) TREQs were not received within 75 milliseconds on a write command.
4*	The FCU has detected an unimplemented word in its internal microprogram.
5	The addressed tape unit is in File Protect Status when a write command is attempted.
6*	The addressed tape unit did not go to Erase Status only.
7	The conditions necessary for the requested command were not met.
10*	The addressed tape unit did not go to Read Status.
11*	The tape subsystem does not have NRZI capability and attempted to read a NRZI tape.
	The tape subsystem does not have NRZI feature installed and was unable to read a PE or GCR ID burst during either a read operation or during a read check after writing the ID burst.
	The tape subsystem does have NRZI capability and was unable to read a PE or GCR ID burst during a read check after writing the ID burst.
12*	The addressed tape unit did not drop Write Inhibit Status.
13	The addressed tape unit is not in Online Status.
14*	The addressed tape unit did not go to Write Status after a write command was initiated.
15*	During a backward motion after writing the ID burst, BOT was not reached in the distance expected.
16*	The addressed tape unit did not go to Backward Status.
17*	Noise (possibly data) was detected during an Erase Gap command or during a write command following a read command.
	* OP INC is also set

Table 3-10. Reject Codes (Sheet 2 of 2)

REJECT CODE (OCTAL)	DESCRIPTION
20	Reserved.
21*	The addressed tape unit reset Ready Status.
22*	The PE or GCR ID burst just written was determined to have been written on the wrong track.
23	A backward type command (except a rewind or a rewind/unload command) was given, but tape was already positioned at BOT.
24*	The ARA BURST portion of the GCR ID-burst just written did not have all nine tracks active.
25*	An IBG longer than 25 feet in PE or NRZI mode or longer than 15 feet in GCR mode was detected on a read or space command.
26	Reserved
27*	The addressed tape unit failed to reset Ready Status during a rewind operation.
30*	The FCU or the tape unit did not indicate being in the recording density requested by the tape unit.
31	Reserved
32*	The addressed tape unit failed to initiate tape motion.
33*	During the read back check of a write operation, data was detected in the IBG area.
34*	There was no IBG detected following the ARA-ID burst.
35*	The addressed tape unit attempted to backspace over a bad record just written but was unable to detect the record.
36*	The ARA ID burst was unreadable during a GCR read or write command.
37*	During the read back check of a write or write tape mark command, no data was detected.
	* OP INC is also set.

3.3.17 DATA BUS PARITY ERROR (BUPER)

The Data Bus Parity Error line is asserted by the FCU to indicate that the Bi-Directional Data bus detected an even parity data character during a TREQ/TRAK data transfer. On WRT operations, assertion of this line indicates that the data written on tape is incorrect. On RDF or RDB operations, assertion of this line indicates either an uncorrectable read error or an internal malfunction of the tape subsystem read data processing system. Data transmission is not halted in either write or read operations until the normal ending point is reached.

3.3.18 ONLINE STATUS (ONLS)

The Online Status line is asserted by the FCU when the addressed tape unit is in Online Status. (A tape unit may be in Online Status when it is not in Ready Status.)

3.3.19 READY STATUS (RDYS)

The Ready Status line is asserted by the FCU when the addressed tape unit is in Ready Status. (A tape unit is in Ready Status when it has tape loaded and is not rewinding.)

3.3.20 BEGINNING OF TAPE STATUS (BOTS)

The Beginning of Tape Status line is asserted by the FCU when tape loaded on the addressed tape unit is positioned at the BOT marker.

3.3.21 END OF TAPE STATUS (EOTS)

The End of Tape Status line is asserted by the FCU when the tape loaded on the addressed tape unit is positioned on or past the EOT marker, indicating that tape is within the end of recording area.

3.3.22 FILE PROTECT STATUS (FPTS)

The File Protect Status line is asserted by the FCU when the file reel of the addressed tape unit does not contain a write enable ring.

3.3.23 WRITE STATUS (WRTS)

The Write Status line is asserted by the FCU when the addressed tape unit is in Write Status.

3.3.24 REWINDING STATUS (REWS)

The Rewindng Status line is asserted by the FCU when the addressed tape unit is in the process of rewinding tape to BOT (that is, when the addressed tape unit is in Online Status and not in Ready Status).

3.3.25 HIGH DENSITY STATUS (HDENS)

The High Density Status line is decoded along with the NRZI Status line to indicate the recording format (density) in which the FCU is operating (Table 3-12).

On read or space commands from BOT, the FCU will first set the addressed tape unit to PE mode, read the ID burst, and then set the tape unit to the format indicated.

On write operations from BOT, the FCU will set the addressed tape unit to the density selected by the USER (Section 3.2.3).

Once positioned away from BOT, the FCU will read and write in the density previously determined by reading the ID burst of the tape in use.

The tape unit will be set to PE mode whenever it has been just loaded, unloaded, or powered up.

Table 3-11. FCU Density Status Line Decode

HDENS	NRZI	MODE
0	0	PE
0	1	NRZI
1	0	GCR
1	1	GCR

3.3.26 NRZI STATUS (NRZI)

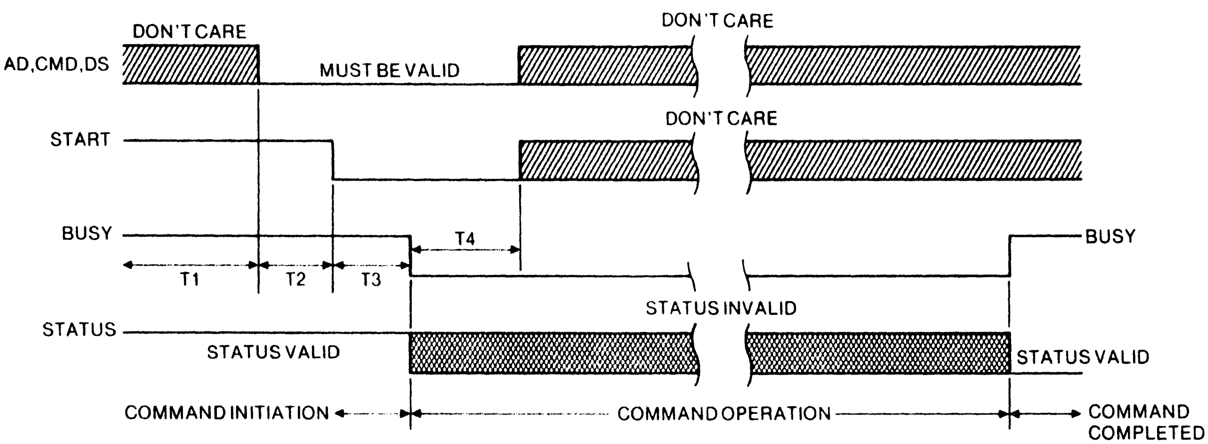
See High Density Status, Section 3.3.25.

3.4 COMMAND DESCRIPTIONS

3.4.1 GENERAL

3.4.1.1 Command Initiation

All commands are initiated by asserting the appropriate address, density, and command lines and then asserting START. The AD, DS, and CMD lines must be valid and stable for 90 nanoseconds minimum prior to the assertion of START. START must have had a reset duration of 90 nanoseconds minimum prior to assertion. Upon the assertion of START, the FCU will store the address, density, and command; assert BUSY; and reset ending status from the previous operation. START must remain asserted until BUSY is asserted. Once BUSY is asserted, the AD, DS, CMD, and START lines may change state. Refer to Figure 3-2 for command initiating timing.



T1 ≥ 90NS OF START IN RESET STATE

T2 ≥ 90NS

T3-START MUST NOT RESET

BEFORE BUSY SETS

T4 ≥ 0

BUSY AND START ARE ASSERTED IN THE LOW STATE.

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Figure 3-2. Command Initiation, Operation, and Completion

3.4.1.2 Reject Conditions

When reject conditions occur (as specified in Section 3.3.15.3) at any time during the command operation, REJECT will be asserted, BUSY will be reset, and the operation will be terminated.

3.4.1.3 Operation Completed

The command operation can only be considered as completed or terminated after BUSY is reset. A new command can be initiated only when BUSY is reset.

3.4.1.4 Ending Status Validity

All FCU status (and error) lines may change during an operation, however, all lines must be considered invalid while BUSY is asserted, and valid only after completion of the operation when BUSY is reset (Figure 3-2).

Tape unit status lines are real time signals and are valid at all times.

3.4.1.5 End of Tape Status (EOTS)

EOTS (tape positioned in the end of recording area) does not affect, inhibit, or control and command operations within the FCU. If forward commands are repeated (such as WRT) or allowed to continue (such as FSB) when EOTS is asserted and the physical end of tape is reached, the tape unit will go NOT READY, the operation will be terminated, and REJECT will be asserted. The tape will have been completely removed from the file reel and will require manual loading before a rewind can be performed.

3.4.1.6 Commands with Tape Unit in Write Status

When a backward command (BSB, BSF, REW, RDB, RUN) is initiated and the addressed tape unit is in Write Status, the tape subsystem will automatically cause an erasure of tape in the forward direction of 1.2 inches nominal before commencing the command operation.

Forward read commands (FSB, RDF, FSF) with the addressed tape unit in Write Status are considered improper command sequences (Section 3.4.1.7).

3.4.1.7 Improper Command Sequences

The tape area forward of a just completed write command (WRT, WTM, ERG) will be erased for a short distance. When this erasure impinges into another block, this block will be partially erased. Write commands followed by forward read commands are not prohibited but should be avoided, or the user tape operating system should maintain knowledge of the condition. Refer to Section 3.5.

3.4.2 NO OPERATION (NOP) COMMAND

3.4.2.1 Description

NOP command operations perform essentially no function. The tape subsystem error status outputs will not change. The tape unit status output lines will change to those of the addressed tape unit. BUSY is asserted only for the short time necessary to accept and process the command.

3.4.2.2 Signal Sequence

Other than command initiation, no signal responses are required of the USER.

3.4.3 DRIVE CLEAR (CLR) COMMAND

3.4.3.1 Description

CLR will reset the OVRNS, DATA CHK, ID BRST, ROMPS, CRERR, BUPER, and ERRMS status outputs if they are asserted from the previous operation. The tape unit status output lines will change to those of the addressed tape unit. CLR will also reset SSC, but only if all tape units that had a status change as specified in Section 3.3.12 have been issued a CLR operation. The tape unit will remain in Online Status if previously in that state.

The functions of a Drive Clear command are always performed automatically by the FCU as the initial part of all commands except a NOP command.

3.4.3.2 Signal Sequence

Other than command initiation, no signal responses are required of the USER.

3.4.4 DIAGNOSTIC MODE SET (DMS) COMMAND

3.4.4.1 Description

The DMS command causes the mode of operation within the FCU to be shifted from Functional Mode to Diagnostic Mode. Diagnostic Mode to Functional Mode transfer is accomplished when the USER asserts RESET, or when the FCU automatically transfers mode after certain Diagnostic Mode command sequences.

3.4.4.2 Signal Sequence

Other than command initiation, no signal responses are required from the USER. The command sequences following a DMS initiation must meet specific requirements as given in the Diagnostic Test Routines and as discussed in Section 3.5.

3.4.5 READ FORWARD A BLOCK (RDF) COMMAND

3.4.5.1 Description

The RDF command causes tape to be moved in the forward direction and the next block (only) to be read. Non-data characters of the block are detected, decoded, checked for validity, and used for their specific purposes, but they are not transferred across the interface. Data characters of the block are detected, decoded, checked for validity, corrected if appropriate, and transferred across the interface. Data is transferred until end-of-data is detected or until STOP is asserted by the USER. All characters within the block are checked for validity even if they are not all transferred. Tape motion is then halted with the read head positioned in the following interblock gap. Ending status signals reflect the validity check for the entire block.

3.4.5.2 Signal Sequence

After command initiation, the FCU signals the tape unit to move tape in the forward direction. When a data block is detected and sufficient data characters have been decoded and deformatted, the FCU will assert a data character on the Bi-Directional Data bus (DATA), delay approximately 90 nanoseconds, and then assert TREQ.

The USER must then signal transfer of the data character by asserting TRAK or STOP. Upon sensing the TRAK or STOP assertion, the FCU will reset TREQ. The USER interface must then reset TRAK or STOP.

If TRAK or STOP does not respond, an FCU internal read buffer may be overloaded. If the buffer does become overloaded, data characters may be lost. Although data transfer could resume by asserting TRAK, lost data characters cannot be recovered during the in-process command operation. When data characters are lost in this type of signal sequence, CRC ERR, OVRNS, and DATA CHK will be asserted in the ending status.

Normal TREQ/TRAK responses and data character tranfer will continue until the USER interface signals STOP, until the FCU transfers the last byte of data or until the FCU sets REJECT and terminates the command. When end-of-data is decoded, the FCU will assert the End of Data Pulse (ENDATP). Unless the USER TRAK timing is greater than the specified maximum, all data will have been transferred before ENDATP is asserted.

The FCU then signals the tape unit to halt tape motion in the following interblock gap. The FCU waits for the tape unit to reach the IBG, asserts ending status, resets BUSY and the command operation is completed.

3.4.5.3 RDF/BOT

When a RDF command is initiated with tape positioned at BOT, the FCU will first process the identification area (ID AREA) before proceeding to process the first block. The processing of the ID AREA is automatic within the operation, requiring no signal responses from the USER. In the processing, the ID AREA will be detected and interpreted and the tape unit will be set to the appropriate density. The FCU will assert ID BRST during the process. The processing of the following block, according to Section 3.4.5.2, will then occur. If the ID AREA is uninterpretable, the FCU will assert the interface signals as defined in Section 3.3.7 and terminate the operation.

3.4.5.4 RDF/Tape Mark Blocks

When a RDF operation is initiated but the next block is a tape mark block, the FCU will process the block, signal the tape unit to position the read head in the following IBG, assert Tape Mark Status, assert BLOCK, and reset BUSY. A data block will not have been processed and no data characters will have been transferred across the interface. No signal responses will have been requested from the USER.

3.4.6 READ BACKWARD A BLOCK (RDB) COMMAND

3.4.6.1 Description

This operation proceeds as in Section 3.4.5.1 for RDF except that tape motion is backward and when the operation is completed the read head will be positioned in the IBG preceding (on the BOT side of) the data block.

3.4.6.2 Signal Sequence

The signal sequence is the same as described in Section 3.4.5.2 for RDF except that data will be transferred in the opposite order of the RDF command.

3.4.6.3 RDB/BOT

RDB commands initiated with tape positioned at BOT are invalid commands. REJECT will be asserted and the operation will be terminated.

RDB commands initiated, in which tape reaches the ID area without a data or tape mark block having been detected, will set DATA CHK and the operation will be terminated.

Upon completion of this command, the tape will be positioned at BOT.

For both of the above conditions, no signal responses will have been requested from the USER.

3.4.6.4 RDB Tape Mark/Blocks

This situation is the same as that described in Section 3.4.5.4 except that tape motion is backward and, when the command is completed, the read head will be positioned in the IBG preceding the tape mark block.

3.4.7 WRITE A DATA BLOCK (WRT) COMMAND

3.4.7.1 Description

The WRT command causes tape to be moved in the forward direction, the ending portion of the preceding IBG to be generated, the data block to be written, the data block to be read and checked for validity, and the beginning portion of the next IBG to be generated. The data block is written in the format as determined by the density status lines and switches (Section 3.2.3).

Non-data characters of the data block are automatically generated, encoded, formatted, and written. Data characters to be written are transferred across the interface, automatically encoded, formatted, and written.

3.4.7.2 Signal Sequence

After the command initiation, the FCU will first assert RECV, signifying that the Bi-Directional Data bus (DATA) is under control of the USER interface and that the FCU will soon request data transfer on DATA.

The FCU next asserts two initiating TREQ signal sequences. The USER interface must respond with assertions of data characters on DATA and by assertion of TRAKs. If the USER interface does not respond, the FCU will reset TREQ, assert REJECT, and terminate the command.

If the USER interface responds to the initiating TREQs, the FCU will signal the tape unit to start tape motion. When the ending portion of the IBG has been created, the FCU will automatically cause the preamble to be written (PE and GCR only). During these operations the FCU will begin requesting additional data character transfer across the interface by asserting TREQ. The USER interface must respond to TREQ by placing a data character on DATA and then asserting TRAK. The FCU will acknowledge transfer of the data character by resetting TREQ. At this time the USER interface may change DATA and must reset TRAK.

Normal TREQ/TRAK/DATA response will continue until the USER signals STOP, signifying that the last character to be written is being transferred. The FCU will then cause the remainder of the block to be formatted and written. The read-after-write checks will be performed and the beginning portion of the next IBG generated. Ending status will be asserted, BUSY will be reset, and the operation will be completed. RECV will remain asserted until a command other than a WRT or LWR command is initiated.

3.4.7.3 WRT/BOT

When a WRT command is initiated with tape positioned at BOT, the MTS will write and check the ID AREA before proceeding to the WRT command. The ID AREA will be written and checked automatically within the tape subsystem, requiring no signal responses from the USER.

If the ID AREA cannot be written and read with validity, the operation will be terminated. A data block will not have been written and the WRT command will not have been performed. Appropriate ID BRST, REJECT, and DATA CHK signals will be included in the ending status.

3.4.8 LOOP WRITE-TO-READ (LWR) COMMAND

3.4.8.1 Description

The LWR command operations provide a means of testing the read and write data circuit paths within the FCU. Read signals are derived (looped) within the FCU from the write circuits. There is no tape motion and no tape unit is required.

3.4.8.2 Signal Sequence

The signal sequence is the same as that described in Section 3.4.7.2 for a WRT command operation.

3.4.9 BACKSPACE A FILE (BSF) COMMAND

3.4.9.1 Description

The BSF command causes tape to be moved backward, passing over data blocks encountered until a tape mark block is detected. Tape motion is halted with the read head positioned in the IBG preceding (on the BOT side of) the tape mark. Tape Mark Status and Block Status are included in ending status and the operation is completed. No data characters are checked for validity or transferred across the interface. BLOCK is not asserted for any data blocks passed over.

3.4.9.2 Signal Sequence

Other than command initiation, no signal responses are required of the USER.

3.4.9.3 BSF/BOT

If the ID AREA is reached before finding a tape mark block, the operation will be terminated. Tape will be positioned at BOT. DATA CHK and BOTS will be asserted in the ending status. If BSF is initiated with tape positioned at BOT, the command is invalid, REJECT will be asserted, and the operation will be terminated.

3.4.10 BACKSPACE A BLOCK (BSB) COMMAND

3.4.10.1 Description

The BSB command operation causes tape to be moved backward, passing over data blocks until signaled to STOP by the USER. When signaled to stop, the read head will be positioned in the IBG preceding the last data block passed over. No data characters are checked for validity or transferred across the interface.

3.4.10.2 Signal Sequence

After the command initiation, the FCU will signal the addressed tape unit to begin backward tape motion. If a data block is detected, the FCU will assert BLOCK. If data block spacing is to be terminated, the USER must assert STOP. This assertion must occur within 50 microseconds of the assertion of BLOCK and must have a 1 microsecond minimum duration. If data block spacing is not to be terminated, STOP must not be asserted. Tape motion will continue. BLOCK will be reset and then reasserted when and if the next block detected is a data block. When STOP is asserted, tape motion will be halted with the read head positioned in the preceding IBG, BUSY will be reset, and the operation is completed.

3.4.10.3 BSB/BOT

If BOT is reached before STOP is asserted or before a data block is detected, the operation will be terminated. Tape will be positioned at BOT. DATA CHK and BOTS will be asserted in the ending status. If BSB is initiated with tape positioned at BOT, the command is invalid. REJECT will be asserted and the operation will be terminated.

3.4.10.4 BSB/Tape Mark

When a tape mark block is encountered during the operation, tape motion will halt with tape positioned in the IBG preceding the tape mark block. TMS and BLOCK will be included in the ending status.

3.4.11 FORWARD SPACE A FILE (FSF) COMMAND

3.4.11.1 Description

This operation is the same as that described in Section 3.4.9.1 for BSF except that tape motion is forward and, at the completion of the command, the read head is positioned in the IBG following the tape mark block.

3.4.11.2 Signal Sequence

Other than initiating the command, no signal responses are required of the USER.

3.4.11.3 FSF/BOT

When a FSF command is initiated with tape positioned at BOT, the FCU will first process the ID AREA as described in Section 3.4.5.3 for RDF/BOT before proceeding to space to the next tape mark block.

3.4.12 FORWARD SPACE A BLOCK (FSB) COMMAND

3.4.12.1 Description

This operation is the same as that described in Section 3.4.10.1 for BSB except that tape motion is forward and, at the completion of the command, the read head is positioned in the IBG following the data block.

3.4.12.2 Signal Sequence

The signal sequence is the same as that described in Section 3.4.10.2 for BSB.

3.4.12.3 FSB/BOT

When a FSB command is initiated with tape positioned at BOT, the tape subsystem will first process the ID AREA as described in Section 3.4.5.3 for RDF/BOT before commencing the FSB operation.

3.4.12.4 FSB/Tape Mark

When a tape mark block is encountered during the operation, tape motion will halt with the read head positioned in the IBG following the tape mark block. TMS and BLOCK will be included in the ending status.

3.4.13 WRITE TAPE MARK (WTM) COMMAND

3.4.13.1 Description

The WTM command causes tape to be moved forward, and a tape mark block to be written and checked for validity.

If the validity check indicates that the tape mark does not meet ANSI specifications, the FCU will automatically backspace and erase forward over the written tape mark, and rewrite the tape mark block. One (NRZI) or two (PE or GCR) rewrites may be automatically attempted. If the tape mark does not meet ANSI specifications after the rewrite attempts, WTM CHK will be asserted as described in Section 3.3.15.2.

3.4.13.2 Signal Sequence

Other than initiating the command, no signal responses are required of the USER.

3.4.13.3 WTM/BOT

When a WTM command is initiated with tape positioned at BOT, the tape subsystem will first write and check the ID AREA as described in Section 3.4.7.3 for WRT/BOT before commencing the WTM operation.

3.4.14 ERASE GAP (ERG) COMMAND

3.4.14.1 Description

The ERG command causes tape to be moved in the forward direction and a 3.6 inch nominal (PE or NRZI) or 3.4 inch nominal (GCR) section of tape to be erased. During the ERG operation, read checks are performed to verify that erasure has occurred. If read signals are detected, REJECT is asserted in ending status.

3.4.14.2 Signal Sequence

Other than initiating the command, no signal responses are required of the USER.

3.4.14.3 ERG/BOT

When an ERG command is initiated with tape positioned at BOT, the FCU will first automatically cause the generation and checking of the ID AREA as described in Section 3.4.7.3 for WRT/BOT before commencing the ERG operation.

3.4.15 REWIND (REW) COMMAND

3.4.15.1 Description

The REW command causes tape to move in the backward direction at rewind speed. Tape motion will halt with tape positioned at BOT. BUSY is asserted only until the tape unit accepts the REW command.

3.4.15.2 Signal Sequence

Other than initiating the command, no signal responses are required of the USER.

3.4.15.3 REW/BOT

No tape motion occurs and tape remains positioned at BOT. BUSY is asserted only for the short time required to check that tape was positioned at BOT.

3.4.16 REWIND AND UNLOAD (RUN) COMMAND

3.4.16.1 Description

The RUN command causes tape to move in the backward direction at rewind speed. When BOT is reached, tape motion will slow and tape will be wound onto the file (supply) reel. BUSY is asserted only until the tape unit accepts the RUN command. 1921/22 tape units will reset Online Status upon acceptance of the command. 1951/53 tape units will reset Online Status upon reaching BOT.

3.4.16.2 Signal Sequence

Other than initiating the command, no signal responses are required of the USER.

3.4.16.3 RUN/BOT

Tape is wound completely onto the file (supply) reel. The tape unit will reset ONLINE status.

3.4.17 SENSE DRIVE STATUS (SNS) COMMAND

3.4.17.1 Description

This command initiates the transfer of the various Drive Status Bytes (DSBs) through the FCU and across the Error Multiplex bus to the USER. Upon receiving a SNS command, the FCU will signal the tape unit and request that the next DSB be placed on the interface. This DSB will remain valid until the FCU is issued a NOP command. At this point the FCU may be issued a CLR command to place DSB0 on the Error Multiplex bus and return the FCU to the idle mode or the FCU may be issued a SNS command to request the next sequential DSB.

3.4.17.2 Signal Sequence

Each SNS command must be followed by a NOP command which in turn must be followed by a SNS or a CLR command. The assertion of the RESET line at any time during this sequence will place DSB0 on the Error Multiplex bus and return the FCU to the idle mode.

3.5 IMPROPER COMMAND SEQUENCES

3.5.1 READ FORWARD/WRITE PARTIAL RECORD SEQUENCE

Issuing any write type command after a command that reads tape forward can generate an unreadable tape. This situation is illustrated in Figure 3.3. After any read forward operation, tape stops with the first few bytes of the next record (refer to the shaded area in the figure) already beyond the write head. If a write operation begins from this point, the shaded portion is left on tape as a partial record. This partial record can cause numerous error conditions, both during the write operation which results in the error, and during any subsequent read type commands over the partial block. There are exceptions if the record being read is known to be followed by a long gap. The following are examples:

1. The record being read is followed by a tape mark Extended Gap.
2. The record being read is known to have been followed by an Erase Gap when written.
3. The record being read is known to be the last record written before a backward operation.

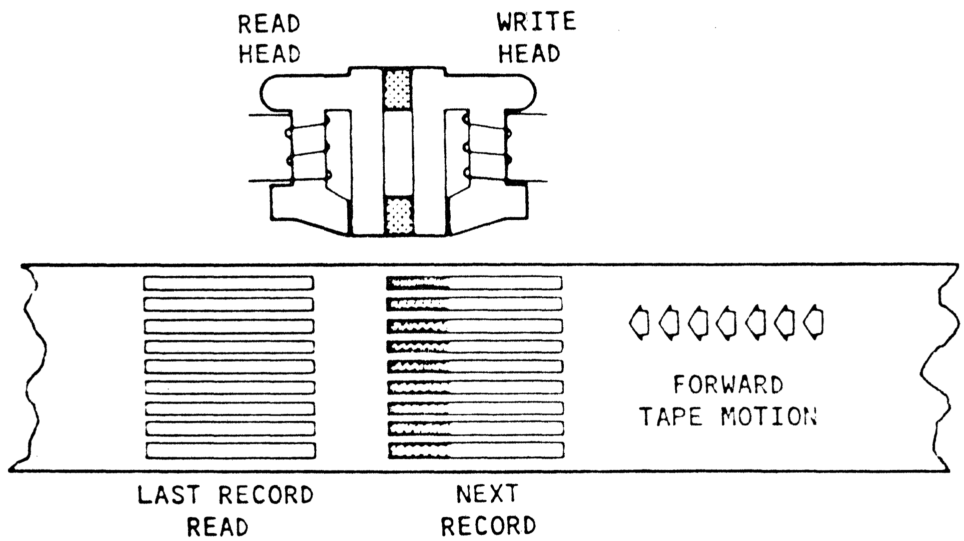


Figure 3-3. Read Forward/Write Partial Record Problem

3.5.2 WRITE/READ FORWARD SEQUENCE

Issuing any command that reads forward following a write type command is also an improper sequence. This situation is illustrated in Figure 3.4. During any write operation, the erase head is activated to erase previously written data. Thus, when the tape stops after a write operation, there is a section of erased tape between the erase head and the write head. Any attempt to read over the erased tape may result in unreliable operation.

In addition, if a record in the middle of a tape must be updated, the remainder of the tape must be rewritten. The accumulation of very small timing differences between machines makes it impossible to reliably update one record in place. It is possible that the section of tape following a write command contains no records at all. In this case, should a Read Forward command be issued, the tape may enter a runaway condition and be wound completely off the file reel. On read commands, the FCU will continue to look for data for up to 15 feet of blank tape in GCR format or up to 25 feet of blank tape in PE or NRZI format before the command will be terminated.

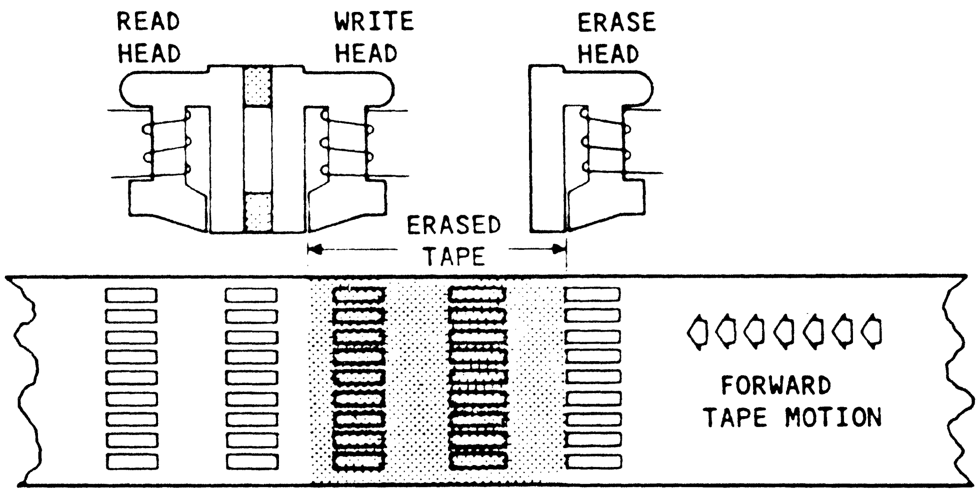


Figure 3.4. Write/Read Forward Problem

CHAPTER 4

FCU/TU INTERFACE

4.1 INTRODUCTION

This chapter provides a description of the FCU to TU interface circuits and brief descriptions of the FCU/TU interface signals. Detailed definitions of the FCU/TU interface signals are provided in the 1921/22 Tape Unit FEMM and the 1950 Series Tape Unit FEMM.

The tape unit and FCU interface circuits are shown in Figure 4-1. Two 40-conductor, flat, twisted-pair cables are provided to connect the FCU to the tape unit. Equivalent cables may be used but the maximum cable length from FCU to tape unit is 20 feet (6 meters).

The asserted (low) level of the digital interface signals is 0 Vdc to 0.7 Vdc. The typical unasserted (high) level is +3.4 (±0.3) Vdc. The DC reference level on each phase of the read data analog output interface signals is 0 volts.

The digital interface resistive termination for each signal is 180 ohms to +5 Vdc and 390 ohms to ground. The termination includes a ground wire connected in both the FCU and the tape unit. The analog interface resistive termination is 56 ohms to ground on each phase.

4.2 FCU-TO-TU SIGNAL DEFINITIONS

4.2.1 SELECT (SEL)

With the tape unit in Ready Status and Online Status, asserting the Select line allows all control and motion command input lines to be effective for the tape unit. When unasserted, all control and motion command lines are ineffective. Tape unit status lines are valid independent of Select.

4.2.2 SET FORWARD MOTION (FWD)

When the Set Forward Motion line is asserted, it commands the tape unit to move tape forward at rated tape speed.

4.2.3 SET BACKWARD MOTION (BWD)

When the Set Backward Motion line is asserted, it commands the tape unit to move tape backward at rated tape speed.

4.2.4 SET REWIND (RWD)

When the Set Rewind line is asserted, it commands the tape unit to reset Ready Status and to move tape backward at rewind speed. When BOT is detected, the tape stops and Ready Status is set again.

Table 4-1. FCU/TU Interface Lines

DESCRIPTION	MNEMONIC	FCU CONNECTOR*	SIGNAL PIN	GROUND PIN	TERMINATION RESISTANCE LOCATION
FCU OUTPUTS - DIGITAL					
Select	SEL	CX	A09	B09	TU
Set Forward Motion	FWD	CX	A01	B01	TU
Set Backward Motion	BWD	CX	A04	B04	TU
Set Write Status	WRT	CX	A05	B05	TU
Set Erase Status	ERS	CX	A07	B07	TU
Set High Density	HDN	CX	A02	B02	TU
Set Rewind	RWD	CX	A06	B06	TU
Set Rewind Unload	RWU	CX	A03	B03	TU
Reset On Line	RON	CX	A08	B08	TU
Write Bit P	WRP	DX	A13	B13	TU
Write Bit 0	WR0	DX	A16	B16	TU
Write Bit 1	WR1	DX	A18	B18	TU
Write Bit 2	WR2	DX	A14	B14	TU
Write Bit 3	WR3	DX	A15	B15	TU
Write Bit 4	WR4	DX	A17	B17	TU
Write Bit 5	WR5	DX	A12	B12	TU
Write Bit 6	WR6	DX	A20	B20	TU
Write Bit 7	WR7	DX	A19	B19	TU
FCU INPUTS - DIGITAL					
Ready Status	RDYS	CX	A15	B15	FCU
On Line Status	ONLS	CX	A18	B18	FCU
Beginning of Tape Status	BOTS	CX	A19	B19	FCU
End of Tape Status	EOTS	CX	A14	B14	FCU
File Protect Status	PROS	CX	A12	B12	FCU
Write Status	WRTS	CX	A10	B10	FCU
Erase Status	ERSS	CX	A11	B11	FCU
High Density Status	HDNS	CX	A13	B13	FCU
Backward Status	BWDS	CX	A17	B17	FCU
Write Inhibit	WNHB	CX	A20	B20	FCU
Tachometer	TACH	CX	A16	B16	FCU
FCU INPUTS - ANALOG			**PHASE A PIN**	**PHASE B PIN**	
Read Bit P	RBP	DX	A04	B04	FCU
Read Bit 0	RB0	DX	A08	B08	FCU
Read Bit 1	RB1	DX	A06	B06	FCU
Read Bit 2	RB2	DX	A05	B05	FCU
Read Bit 3	RB3	DX	A03	B03	FCU
Read Bit 4	RB4	DX	A10	B10	FCU
Read Bit 5	RB5	DX	A01	B01	FCU
Read Bit 6	RB6	DX	A09	B09	FCU
Read Bit 7	RB7	DX	A02	B02	FCU
(Spare)		DX	A07	B07	
(Spare)		DX	A11	B11	

* CX,DX, = C5,D5 for TU0; C6,D6 for TU1; C7,D7 for TU2; and A7,B7 for TU3.

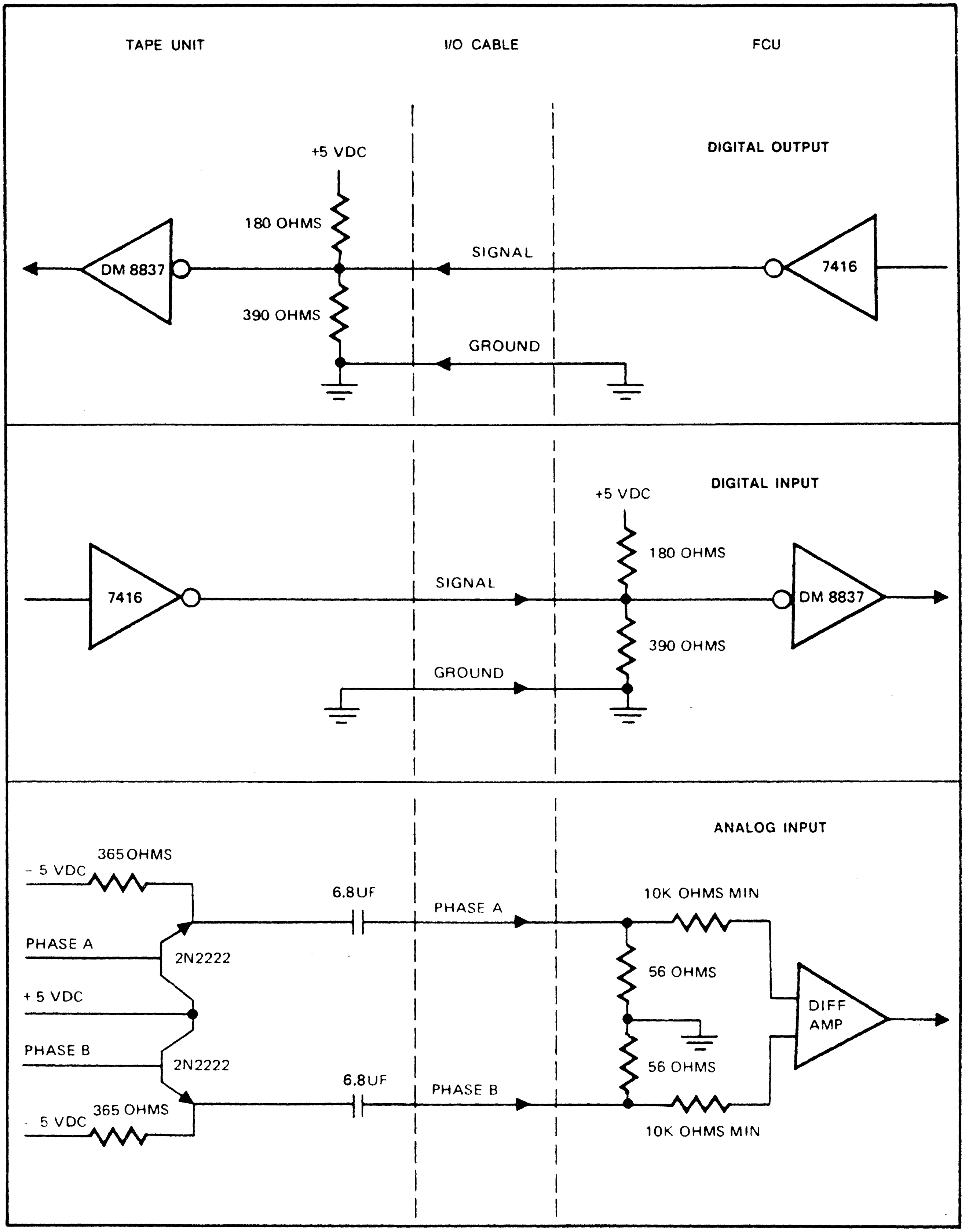


Figure 4-1. FCU/TU Interface Circuits

4.2.5 SET REWIND/UNLOAD (RWU)

When the Set Rewind/Unload line is asserted, it commands the tape unit to reset Ready Status, move tape backward at rewind speed to BOT, stop tape motion momentarily at BOT, and then unload all tape onto the file reel.

4.2.6 RESET ONLINE (RON)

Asserting the Reset Online line resets Online Status in the tape unit, causing the tape unit to go offline. The tape unit can be placed online again only by pressing the ONLINE switch on the operator panel.

4.2.7 SET HIGH DENSITY (HDN)

In 1921/22 tape units, asserting the Set High Density line when tape is positioned at BOT causes the tape unit to set to high density (GCR) mode upon assertion of Set Forward Motion.

In 1951/53 tape units, the Set High Density line is associated with the tape unit Density Mode Set. Refer to Section 4.4.1.

4.2.8 SET WRITE STATUS (WRT)

To set the tape unit to Write Enable, the Set Write Status line is asserted when the Set Forward Motion command is asserted. The tape unit goes from Write Enable to Write Status (write circuits and write head active) automatically, but only when Set Erase Status occurs simultaneously.

Write Enable is reset by issuing Set Forward Motion with Set Write Status reset or by issuing Set Backward Motion. Both Write Status and Erase Status must be reset (unasserted) when a read-only command is to be initiated. The Set Write Status is effective only if the tape unit File Protect Status output line is not asserted.

4.2.9 SET ERASE STATUS (ERS)

To set the tape unit to Erase Status, the Set Erase Status line is asserted when the Set Forward Motion command is asserted. The Set Erase Status line is effective only when File Protect Status is not asserted.

Erase Status is reset by issuing Set Forward Motion with Set Erase Status reset or by issuing Set Backward Motion.

4.2.10 WRITE DATA (WRP-WR7)

The nine Write Data lines carry the write data from the FCU to the tape unit.

4.3 TU-TO-FCU SIGNAL DEFINITIONS

All tape unit status lines are valid independent of Select and Online Status. The lines at all times represent the status that exists within the tape unit.

4.3.1 READY STATUS (RDYS)

The Ready Status line is asserted when the tape unit is able to operate with the FCU, that is, when tape is loaded and the tape unit is not performing a rewind or rewind/unload operation. This line is controlled internally by the tape unit and is asserted following a tape load operation only after tape is positioned at BOT. The line is unasserted if tape is not loaded, if tape is being loaded or unloaded, or if a rewind or rewind/unload operation is in progress.

4.3.2 ONLINE STATUS (ONLS)

The Online Status line is asserted when the tape unit has been placed online by the ONLINE switch on the tape unit operator panel provided tape is loaded in the columns. Online Status may be reset by a Reset Online command from the FCU or by the RESET switch on the tape unit operator panel.

4.3.3 BEGINNING OF TAPE STATUS (BOTS)

The Beginning of Tape Status line is asserted when tape is positioned at the BOT marker. The line is reset when a Set Forward Motion command or a Set Rewind/Unload command is received from the FCU.

4.3.4 END OF TAPE STATUS (EOTS)

The End of Tape Status line is asserted when tape is positioned at or beyond the EOT marker. The line is reset when the trailing edge of the EOT marker is detected during a backward or rewind operation.

4.3.5 HIGH DENSITY STATUS (HDNS)

The High Density Status line is asserted when the tape unit has been placed in GCR mode. High Density Status is automatically reset (unasserted) when the tape unit is powered up, and when the tape unit has just been loaded or unloaded.

4.3.6 FILE PROTECT STATUS (PROS)

The File Protect Status line is asserted after a load operation is initiated if the file reel does not contain a write enable ring. The line is unasserted when a write enable ring is present.

4.3.7 ERASE STATUS (ERSS)

The Erase Status line is asserted when the tape unit has been placed in Erase Status by a Set Erase Status command. This line cannot be asserted if File Protect Status is asserted.

4.3.8 WRITE STATUS (WRTS)

The Write Status line is asserted when the tape unit has been placed in Write Enable mode. Erase Status is asserted concurrently.

4.3.9 BACKWARD STATUS (BWDS)

The Backward Status line is asserted when the command in progress or just completed was a backward motion command. If the previous or current command is Set Forward Motion, this line is unasserted.

4.3.10 WRITE INHIBIT (WNHB)

The Write Inhibit line is asserted when the read/write head is positioned in the interblock gap (IBG). The line changes to unasserted in write mode when the proper IBG distance has been traversed. Write data transfer from the FCU should begin immediately after the line is unasserted in order to generate a nominal IBG.

4.3.11 TACHOMETER (TACH)

The Tachometer signal switches at a rate proportional to capstan velocity.

4.3.12 READ DATA (RBP-RB7)

The nine pairs of Read Data lines carry the amplified analog data from the tape unit to the FCU during a read-only or read-after-write operation.

4.4 SPECIAL LINE EXTENSIONS (1951/53 TUs ONLY)

In order for the FCU to accommodate the different speed and density models within the family of 1950 Series Tape Units and also to accommodate the special diagnostic programs, additional subsystem commands are used. Descriptions of these commands follow. For more information, refer to the 1950 Series Tape Unit FEMM.

4.4.1 DENSITY MODE SET

To select the recording format (density) of the tape unit, the FCU asserts Select, then one of three lines to select the desired density (Set High Density to select NRZI mode; Set Write Status to select PE mode; or Set Erase Status to select GCR mode), and then asserts Rewind/Unload. The tape unit signals that it has accepted the mode set by changing Write Status from unasserted to asserted.

4.4.2 SET DIAGNOSTIC COMMAND

To perform certain diagnostic tests on the tape unit, the FCU asserts Select and Set Write Status, and then asserts Rewind. This signals the tape unit that the remaining control lines contain the command code for a diagnostic operation. The tape unit signals that it has accepted the command by changing Write Status from unasserted to asserted.

4.4.3 DIAGNOSTIC SENSE COMMAND

To demand the transfer of an additional tape unit status information across the FCU/TU interface, the FCU asserts Select and Set Write Status and then asserts Rewind. The tape unit then places the next Drive Sense Byte (DSB) on the eight least significant tape unit status lines of MUX Byte 3 and indicates that this byte is valid by changing Write Status from unasserted to asserted. To request the next Drive Sense Byte, the FCU resets and then sets Rewind and the tape unit responds as before. Each byte remains valid until the next byte is requested or until Set Write Status is reset.

CHAPTER 5

FUNCTIONAL DESCRIPTION

5.1 INTRODUCTION

This chapter provides a functional description of the microprogram, control electronics, data formats and other electronic details of the FCU.

Data, controls, and commands from the USER enter the FCU through the interface. The FCU is informed of the operation required by the USER. The microcontroller fetches instructions which set up control logic for an appropriate data path. A tape unit is addressed and prepared to read or write data. On a write operation, data is formatted and gated to the tape unit write head. Formatting includes the creation of gaps and error detection and recovery data. On a read operation, data is detected, deskewed, and deformatted. If errors are detected and correction is possible, data is corrected.

Figure 5-1 is a block diagram showing the inter-relationship of, and the data flow through, the circuit cards.

5.2 CARD FUNCTIONS

5.2.1 KA CUSTOM INTERFACE (OPTION)

The optional KA custom interface card (slot A2) contains:

Command decode
Data drivers and receivers
Address and count registers
Writable registers
Data MUX and tri-state bus
Error MUX
Format and density control
Interrupt vector

5.2.2 KB CUSTOM INTERFACE (OPTION)

The optional KB custom interface card (slot B2) contains:

Register load decoding
Address receivers
Interrupt control
Address compare decode logic
Unibus control
Data control and steering
Tri-state bus control

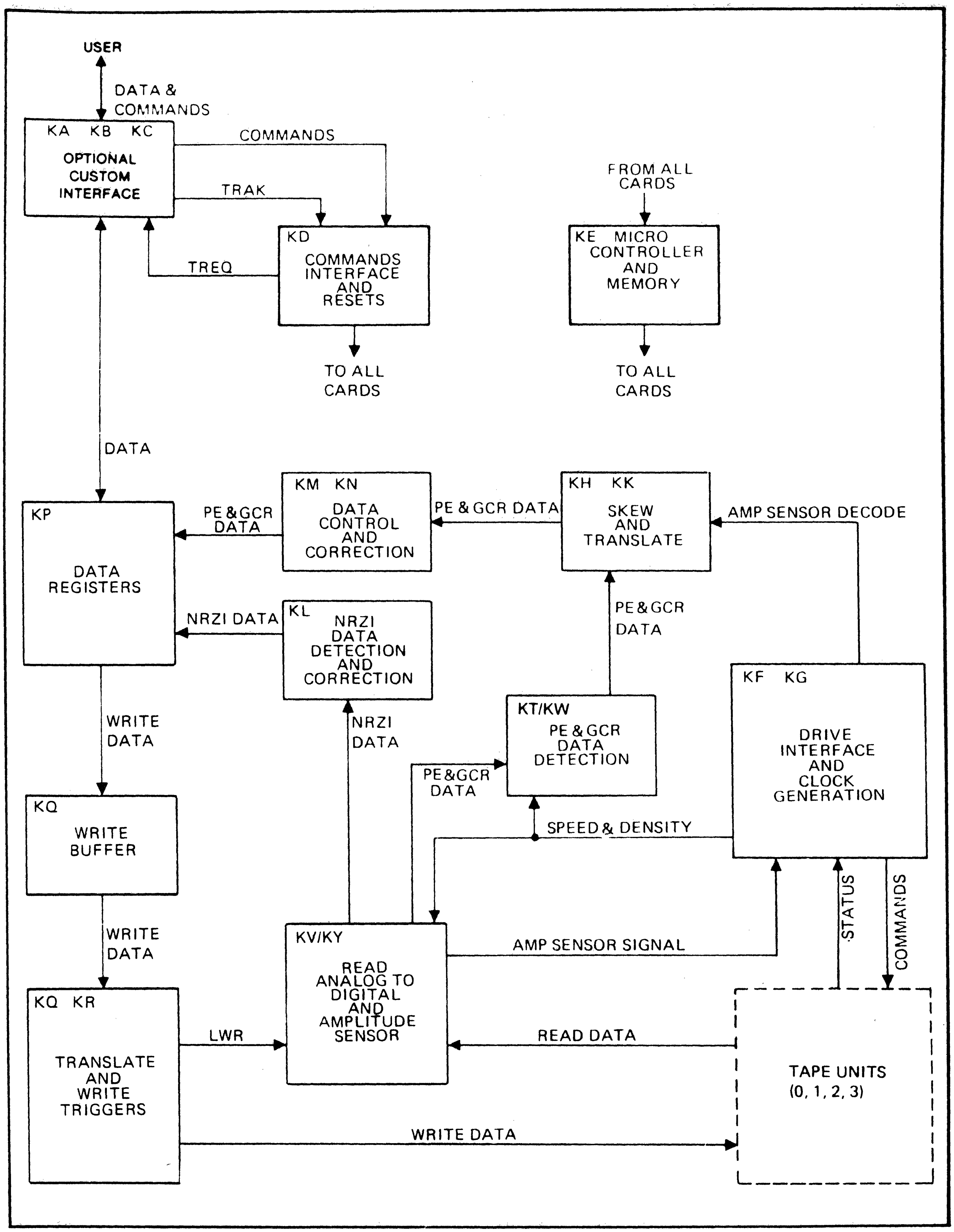


Figure 5-1. FCU Functional Block Diagram

5.2.3 KC CUSTOM INTERFACE (OPTION)

The optional KC custom interface card (slot C2) contains:

Read parity generation and check
FCU status
Interrupt control
Data trickle buffer and controls
Tri-state error MUX
Error conditions
TU status
RDF/RDB controls

5.2.4 KD FCU/USER STANDARD INTERFACE

The KD FCU/USER standard interface card (slot D2) contains:

Command and density registers
Interface drivers
Branch circuits
Tape unit select control
Reset generation
Power on/off sense
TREQ/TRAK sequencer

5.2.5 KE MEMORY

The KE memory card (slot E2) contains:

PROM memory
ROM data register
Memory addressing
Operation encoder and decoder
Branch group and micro-order decode

5.2.6 KF MOTION CONTROL

The KF motion control card (slot F2) contains:

GPC, BCC, and VCC
Control lines to tape units
Status from tape units
Clocked micro-orders and branch conditions
Velocity checking

5.2.7 KG CLOCK AND TU STATUS

The KG clock and TU status card (slot G2) contains:

Clock generation
Amp sensor decode
TM, ID burst, IBG, BOB, GCR, and LP marker latches
Status from tape units
Branches and conditional micro-orders

5.2.8 KH READ CONTROL

The KH read control card (slots H2 and J2) contains:

Deskew
Phase hold and subgroup counter
5-to-4 translate
Read sequence and resync detection

The card in slot H2 is for tracks 0 through 3; the card in slot J2 is for tracks 4 through 7.

5.2.9 KK SINGLE-TRACK READ CONTROL

The KK single-track read control card (slot K2) contains:

Deskew for track P
Phase hold for track P
5-to-4 translate for track P
Read sequence and resync detection for track P
Skew timer, data transmission latch
Pointer vote, outgate skew buffer
ECR full latch, end of data, divide by five
Subgroup counter
Control for KH cards

5.2.10 KL NRZI FEATURE (OPTION)

The optional KL NRZI feature card (slot L2) contains:

NRZI skew register
First bit or byte counter
Error pattern register
NRZI read clock
LRC check and resets
NRZI branches

5.2.11 KM READ ERROR DETECTION

The KM read error detection card (slot M2) contains:

ECR shift register and found TIE
PE/GCR data switch
Read ECC/EC parity generator
ECPG register
MST and LST correction
Track separation and LST latches
PE and GCR correction bus

5.2.12 KN DATA SEQUENCER

The KN data sequencer card (slot N2) contains:

GCR read sequencer
ECR, shift register full TGR
Read backward byte count less than seven controls
Allow I/O ingate and EC bus parity bit
CRC control
GCR correction shift register
Data buffer control

5.2.13 KP DATA BUS REGISTERS

The KP data bus registers card (slot P2) contains:

Write sequencer
I/O data transceivers and parity check
MUX A - MUX B compare bus
End write and write overrun latches
Subgroup A full; subgroup B full
Bus parity detection and check
Data buffer
AUX CRC generation
CRC-F generation
AUX CRC-C generation

5.2.14 KQ WRITE CONTROL

The KQ write control card (slot Q2) contains:

Write AUX CRC generation
Write ECC generation
Write buffer
Write translation P,0,1,2,3
Write triggers P,0,1,2,3

5.2.15 KR WRITE CONTROL

The KR write control card (slot R2) contains:

Write translation 4,5,6,7
Write triggers 4,5,6,7
Format control
Write trigger gating
Write sequencer

5.2.16 KT READ DETECTION

The KT read detection card (slots S2 through W2) contains:

PE/GCR read data detection
Variable frequency clock
Phase pointer generation

The card in slot S2 is for tracks 0 and 1; in slot T2 for tracks 2 and 3; in slot U2 for tracks 4 and 5; in slot V2 for tracks 6 and 7. The KT card may also be used in slot W2 for track P.

5.2.17 KV READ A/D CONVERSION

The KV read A/D conversion card (slot X2) contains for tracks 2,3,5,7 and P:

Analog-to-digital conversion
Envelope detection
Loop write-to-read detection and gating

The KV card may also be used in slot Y2 for tracks 0, 1, 4, and 6.

5.2.18 KW READ DETECTION

The KW read detection card (slot W2) contains for track P the same circuits as the KT card.

5.2.19 KY READ A/D CONVERSION

The KY read A/D conversion card (slot Y2) contains for tracks 0,1,4, and 6 the same circuits as the KV card.

5.3 MICROCONTROLLER

When the FCU receives a command from the USER, the microcontroller (Figure 5-2) controls the FCU until the command is successfully executed or an error condition arises. The FCU sends tape unit and FCU status to the USER before initiating the command. However, once the command is initiated, the FCU is entirely under the control of the microcontroller until the operation is completed or terminated. The microcontroller is located on the KE card.

5.3.1 CONTROL MEMORY

The microcontroller control memory is a 4K by 16-bit word array. The microprogram is stored in the control memory and is accessed by the microprogram sequencer. Figure 5-3 is a block diagram of the microprogram sequencer.

5.3.2 MICROPROGRAM

The microcontroller performs the following general types of operations:

1. Establishes the next instruction address by:
    a. Incrementing the present instruction address by one.
    b. Branching to any instruction address within the current 256 word sector. The branch may be unconditional or depend on selected test conditions.
    c. Branching unconditionally to any address within a 4K span (16 sectors).
    d. Jumping to a subroutine address previously stored in the link register.
    e. Returning from a subroutine and going to an address that is one greater than the address of the last 'jump-to-subroutine' (JSR) instruction.
    f. Being trapped to address 000 when a power up or system reset occurs.
2. Set or reset addressable latches to control data flow or for miscellaneous program storage.
3. Take values from the micro-word and load them into the General Purpose Counter, Velocity Check Counter or Branch Group Register for use in timing, counting and certain other control functions.
4. Set and reset hardware functions via set/reset micro-orders.
5. Test specific system conditions and take appropriate action by branching on the test result.

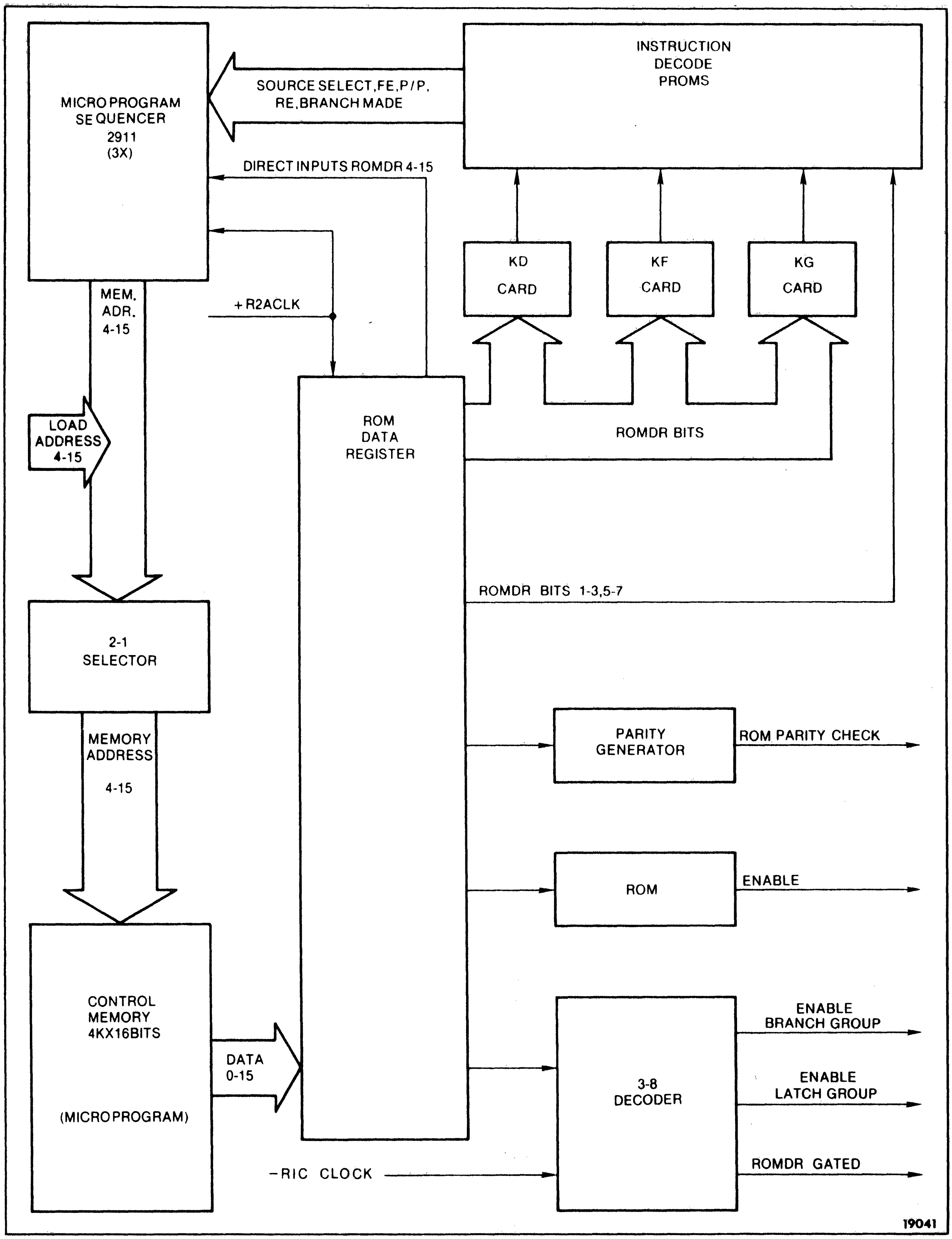
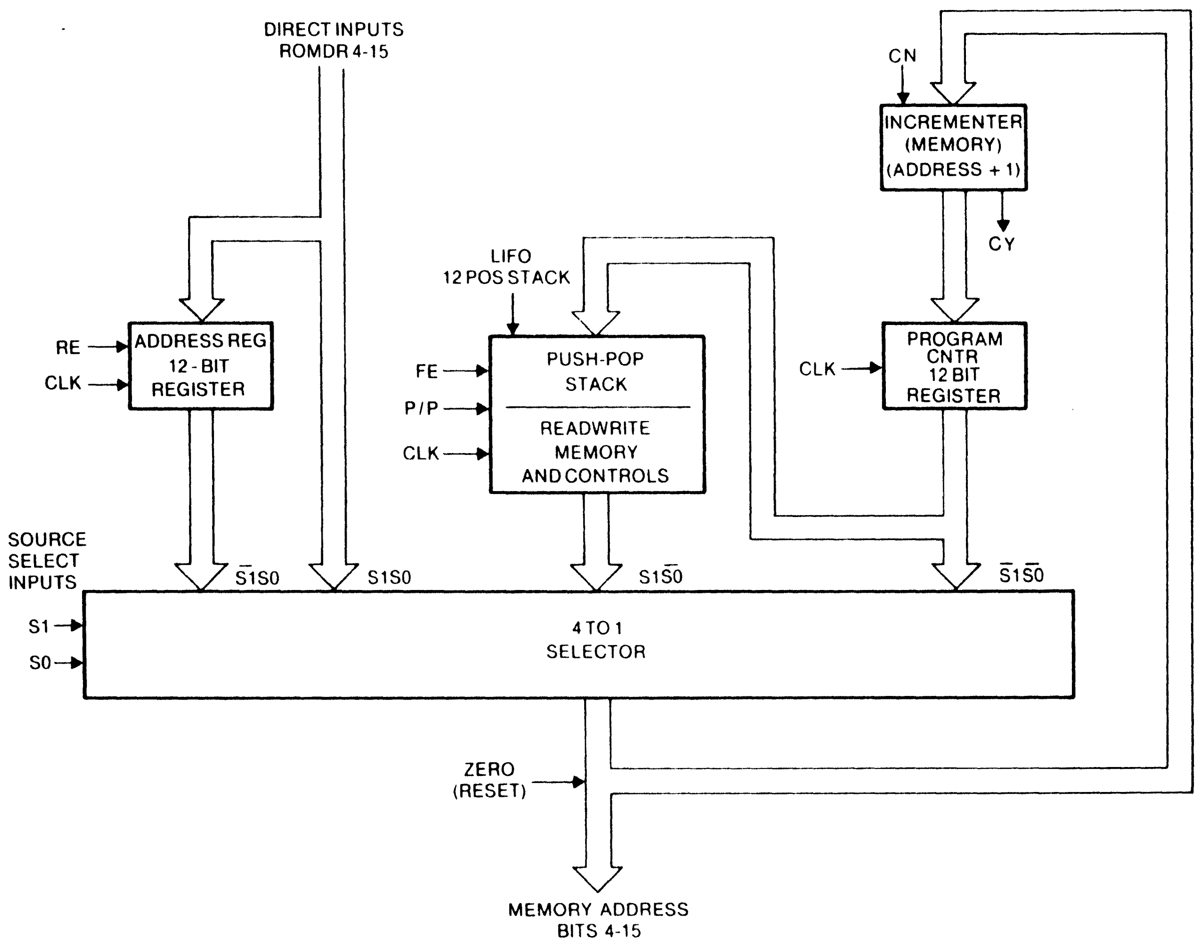


Figure 5-2. Microcontroller Block Diagram



FE	P/P	CLK	PUSH-POP STACK FUNCTION
H	X	X	NONE (DISABLED)
L	H	↑	PUSHSTACK
L	L	↑	POPSTACK

RE	CLK	ADDRESS REGISTER FUNCTION
H	X	NONE(DISABLED)
L	↑	DIRECT INPUTS STORED IN REGISTER

S1	S0	ADDRESS SOURCE
L	L	PROGRAM CNTR
L	H	ADDRESS REGISTER
H	L	PUSH-POP STACK
H	H	DIRECT INPUTS

19056

Figure 5-3. Microprogram Sequencer Block Diagram

Table 5-1 is an example of source language. It is divided into seven columns (A through G) for explanation purposes. The contents of each column is given in the following text.

Column A Lists the ROM address where the machine stores the instructions for this line in the listing. Valid addresses are 000-FFF(4K).

Column B Lists the instruction contained in the location specified by the address in Column A. The low order bit is 15, the high order bit is 0. Bit 0 is the instruction word parity bit. The contents are listed with bit 0 = 0.

Column C Lists the symbolic name of this instruction or subroutine starting at this address.

Column D Lists the mnemonic representation of the machine language instruction.

Column E Lists the mnemonic representation of the operands of the instructions.

Column F Lists the symbolic name of the branch destination that is used if the branch conditions are satisfied.

Column G Lists programmers notes.

5.3.3 MICROPROGRAM SEQUENCER

The microprogram sequencer receives inputs from the instruction decode PROMs. A list of microprogram sequencer commands is shown in Table 5-2. The instruction decode PROMs monitor the ROMDR bits 1-3 .. 5-7 and the KD, KF, KG .. KL branch inputs. These inputs allow the microprogram sequencer to be steered by the events that occur in the FCU.

5.3.4 ADDRESSABLE LATCH

The microcontroller activates latch address lines as the result of a set addressable latch (SAL) command. One output on the addressed latch becomes an active level and is used to control a function in the logic.

5.3.5 MICRO-ORDER FUNCTIONS

The microcontroller pulses micro-order address lines as the result of a set micro-order (SMO) command. One micro-order is gated out of the micro-order block and used to control a function in the logic.

5.3.6 MEMORY TIMING

The clock generation circuit is on the KG card (Logic Sheet KG030). Figure 5-4 is a memory timing chart showing the relationship of the clock pulses to one another and the timing of selected microcontroller operations.

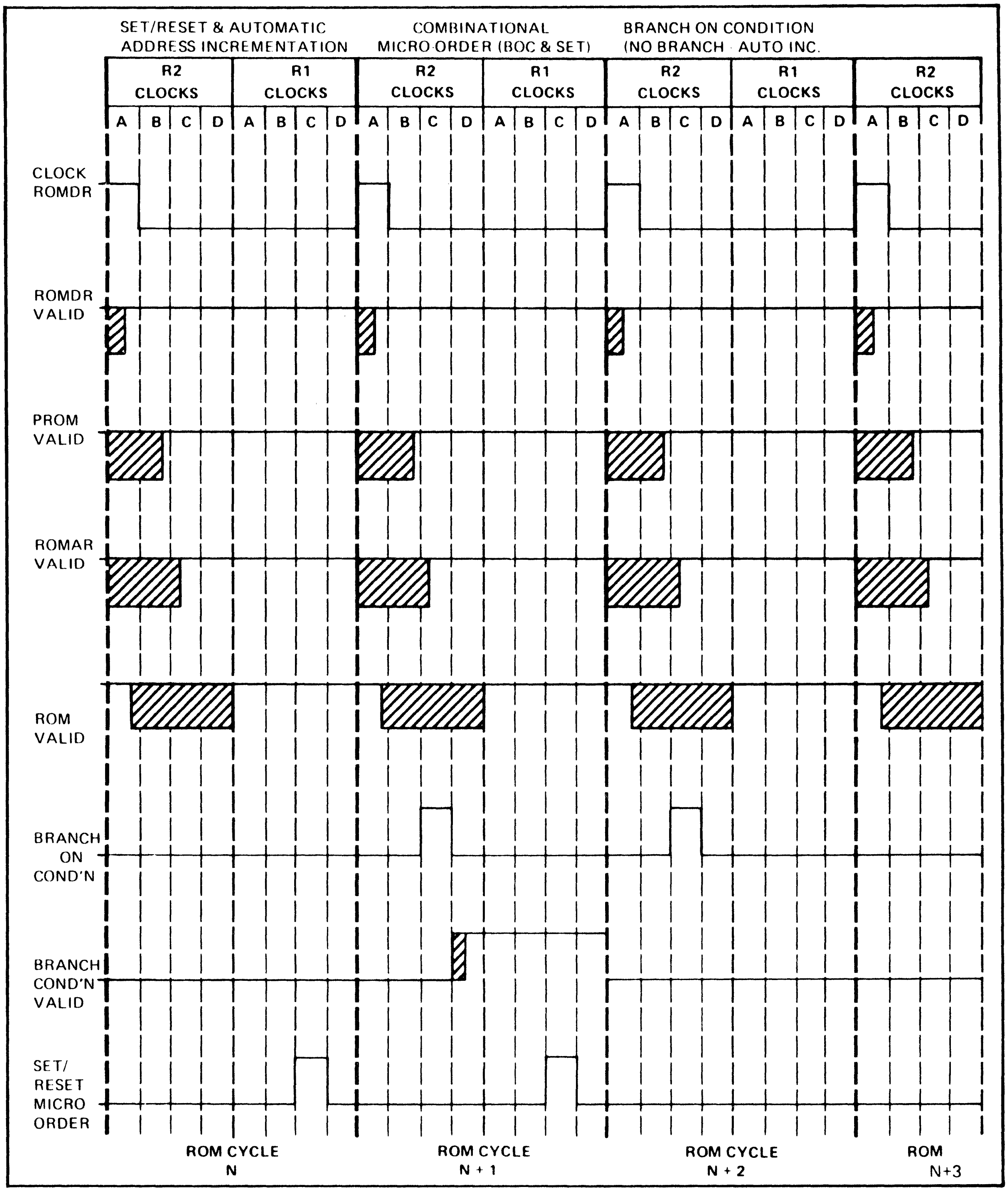


Figure 5-4. Memory Timing

Table 5-1. Source Language Statements

A ADDR	B CONTENTS	C	D	E	F	G
0000	7012		BRU		INIT	
0001	3000	TOIDLE:	LBG	0		
0002	4004	IDLE:	LBRC	START	DOIT	IDLE LOOP
0003	7002		BRU		IDLE	
0004	4A17	DOIT:	LBRC	DIAG/MDL	DIAGTST	
0005	5015		HBRC	NO/DP	NOPCMD	
0006	141B		SMO	R/DIAG/A		
0007	1415		SMO	SEL/RST		SELECTIVE RESET
0008	5218		HBRC	DIAG/MDS	SETDIAG	
0009	5115		HBRC	DRV/CLR	NOPCMD	
000A	571B		HBRC	LWR	LWRCMD	DR NOT REQD
000B	3020	DIAGWRT:	LBG	2		
000C	5025		HBRC	N/RDYS	CODE1	
000D	4E1A		LBRC	ONLS	ONLN	
000E	101B		SAL	DA/3		
000F	101B	CODE3:	SAL	DA/0		
0010	1019	CODE2:	SAL	DA/1		
0011	1008	REJCT:	SAL	RJT		REJCT CMD
0012	1419	INIT:	SMO	R/DIAG/M		
0013	142C		SMO	R/RCD		
0014	200E		RAL	SEL		
0015	1414	NOPCMD:	SMO	R/START		
0016	7001		BRU		TOIDLE	
0017	73F7	DIAGTST:	BRU		DIAG	
0018	1418	SETDIAG:	SMO	S.DIAG/M		
0019	7015		BRU		NOPCMD	

Table 5-2. Microsequencer Commands (Sheet 1 of 2)

INST. WORD	MNEMONIC	FUNCTION
00 XX 80 XX	NOP	No operation; next address is present plus one. (XX = don't care.)
01 XX 81 XX	PUSH	
02 XX 82 XX	POP	Retrieves previously stored data from the 'stack'.
03 XX 83 XX	JSR	Jump to subroutine. Address has been stored in the register by a previous LLR instruction. Present address plus one is stored in the LIFO stack.
10 LL 90 LL	SAL	Set Addressable Latch (LL = which latch). Next address is present plus one.
11 LL 91 LL	SAL/JSR	Performs all of the functions of JSR and SAL above.
12 LL 92 LL	SAL/RSR	Set Addressable Latch and return from subroutine. Return address is to the address stored in the stack by the most recent JSR instruction.
13 LL 93 LL	RSR	Return from subroutine. Performs RSR function as outlined above.
14 MM 94 MM	SMO	Set Micro-Order (MM = which micro-order to execute). Next address is present plus one.
15 MM 95 MM	SMO/JSR	Set Micro-Order and jump to subroutine. See above.
16 MM 96 MM	SMO/RSR	Set Micro-Order and return from subroutine. See above.
20 LL A0 LL	RAL	Reset addressable latch (LL = which latch). Next address is present plus one.
21 LL A1 LL	RAL/JSR	Reset addressable latch and jump to subroutine. See above.
22 LL A2 LL	RAL/RSR	Reset addressable latch and return from subroutine.
27 VV A7 VV	LVCC	Load the Velocity Check Counter (VCC) with the value VV. Next address is present plus one.

Table 5-2. Microsequencer Commands (Sheet 2 of 2)

INST. WORD	MNEMONIC	FUNCTION
30 GX B0 GX	LBG	Load Branch Group Register (G = which group) for use in subsequent branches. (X = don't care).
31 GX B2 GX	LBG/JSR	Load Branch Group Register and jump to subroutine.
34 VV B4 VV	APC	Load the General Purpose Counter bits 0 - 7 to value VV. Next address is present plus one.
35 VV B5 VV	APC/JSR	Load GPC high and jump.
36 VV B6 VV	GPC	Load the General Purpose Counter bits 8 - 15 to the value VV. Next address is present plus one.
37 VV B7 VV	GPC/JSR	Load GPC and jump to subroutine.
38 YY B8 YY	FWT/EWR	Flip the Write Triggers and branch on End Write to address YY. Triggers flipped are established by the Format Counter and the mode (PE or GCR).
39 YY B9 YY	FWT/GPC0	Flip Write Triggers and branch on General Purpose Counter = 0. See above.
3A YY BA YY	FWT/GOEW	Flip and branch on either GPC = 0 or End Write.
3B YY BB YY	DGPC/GP0	Decrement the GPC and branch on GPC = 0.
3C YY BC YY	FWT/D/GO	Flip the Write Triggers per the data and branch on GPC = 0.
4N YY CN YY	LBRC	Low Branch On condition. Branch to YY if the tested condition (N) in the previously selected Branch Group is active.
5N YY DN YY	HBRC	High Branch On condition. Branch to YY if the tested condition (N) in the previously selected Branch Group is active.
6Y YY EY YY	LLR	Load the Link Register to address YYY for use by the next JSR instruction. Next address is present plus one.
7Y YY FY YY	BRU	Branch unconditional (go to) address YYY. This instruction allows access to any address in any sector of storage.

5.4 DATA FLOW

Data flow through the FCU is directed by the microcontroller. Formatting, deformatting, and error detection and correction are under the control of the program. A description of the method by which the program controls the specific operations of the data flow is of little value, therefore circuit operations are described but not control functions.

5.4.1 WRITE DATA FLOW

After initiation is complete, data is sent to the FCU via the Bi-Directional Data bus (Figure 5-5). The data enters the bus receiver where it is sent through a 4-to-1 (Logic Sheet KP060) to the data buffer. The 4-to-1 allows the same data buffer to be used for both read and write data. Since the data buffer is used for both read and write data, its outputs go to both the bus driver and a 4-to-1. However, the lines to the bus driver are electronically disabled while writing and the data flows into the 4-to-1 only. This 4-to-1 allows other data to be entered into the data stream at the appropriate time.

The remainder of the write data path is shown in Figure 5-6. After the data leaves the data buffer it remains on the KQ and KR cards until it is sent to the tape unit.

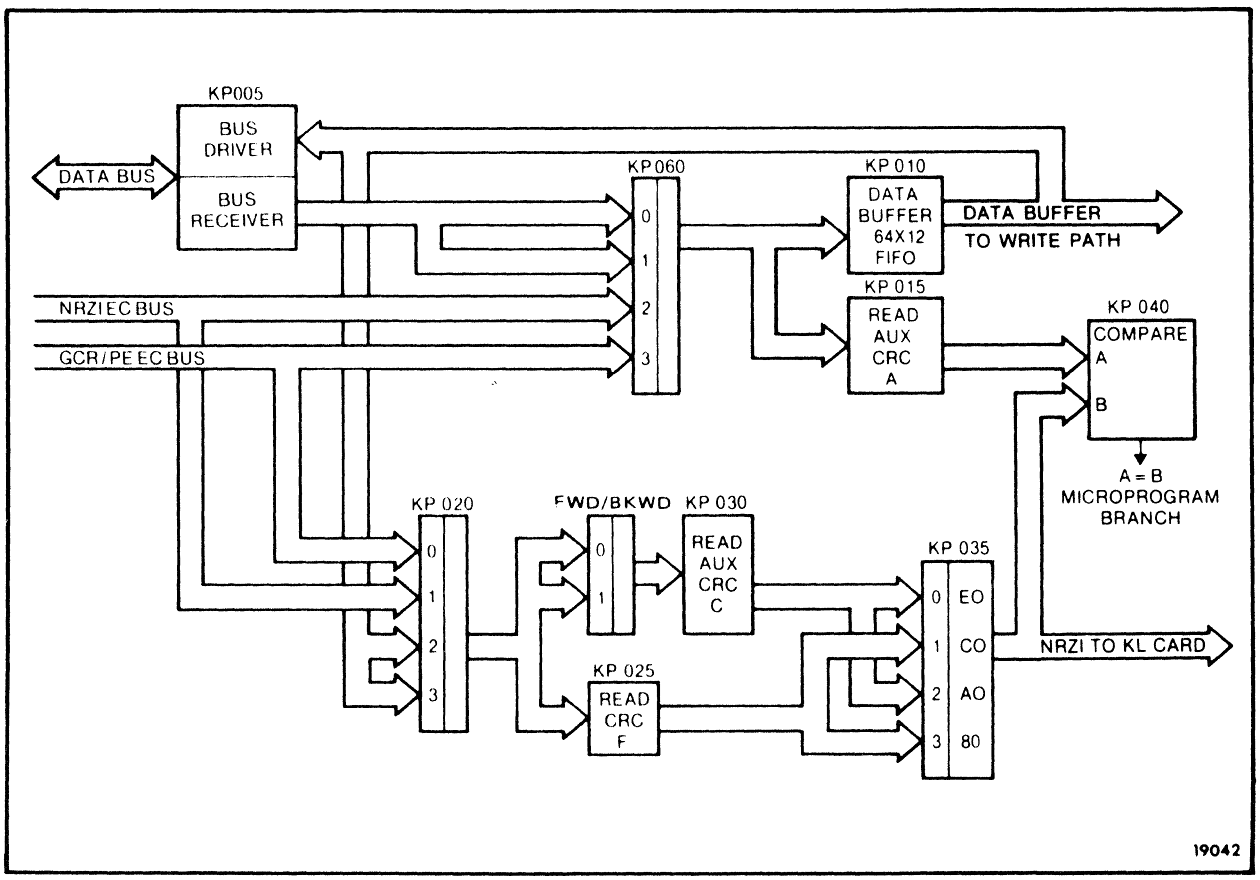


Figure 5-5. Data Path (KP Card)

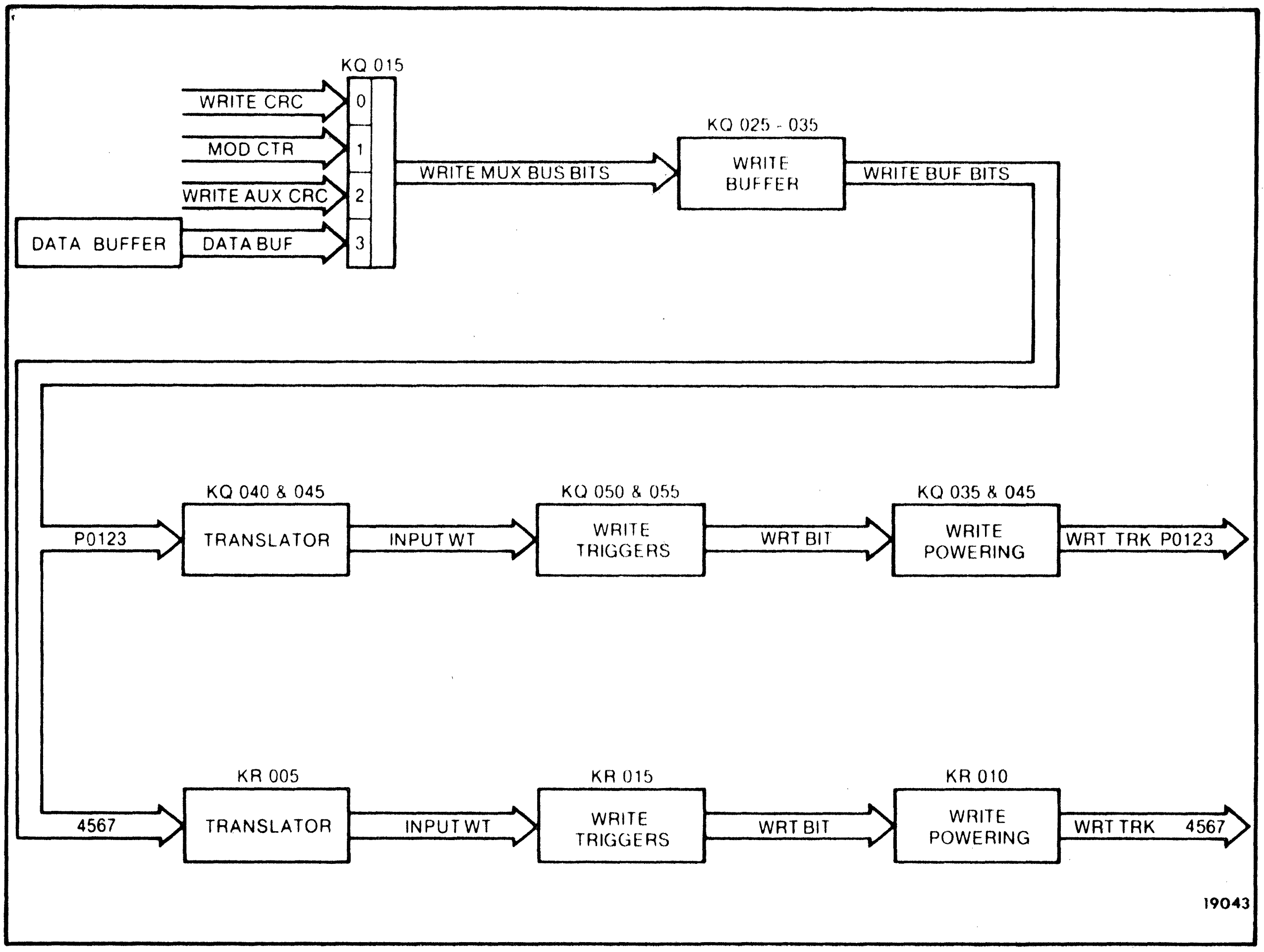


Figure 5-6. Write Data Path

All write data follows the same path through the logic, but the GCR translation and formatting logic is turned off during PE and NRZI write operations. The PE and NRZI data is timed for the appropriate density and generation of write triggers and sent to the tape unit.

5.4.1.1 GCR Write Data Flow

The first logic encountered on the KQ card is a 4-to-1 data selector (Figure 5-7). This 4-to-1 allows the CRC, AUX CRC, and residual byte data to be entered into the 1x9 buffer. The output of the 4-to-1 also goes to the CRC and auxiliary CRC generators. The 1x9 buffers provide buffering for the assembly of data subgroups. The output of the 1x9 buffers goes to the 4-to-5 translators.

The 4-to-5 translator takes four bits and develops a five bit code (Figure 5-8). The data undergoes a parallel-to-serial conversion as it is output from the 4-to-5 translator and input to the five-bit shift register. The five-bit shift register simply shifts out the data in serial form to the write triggers.

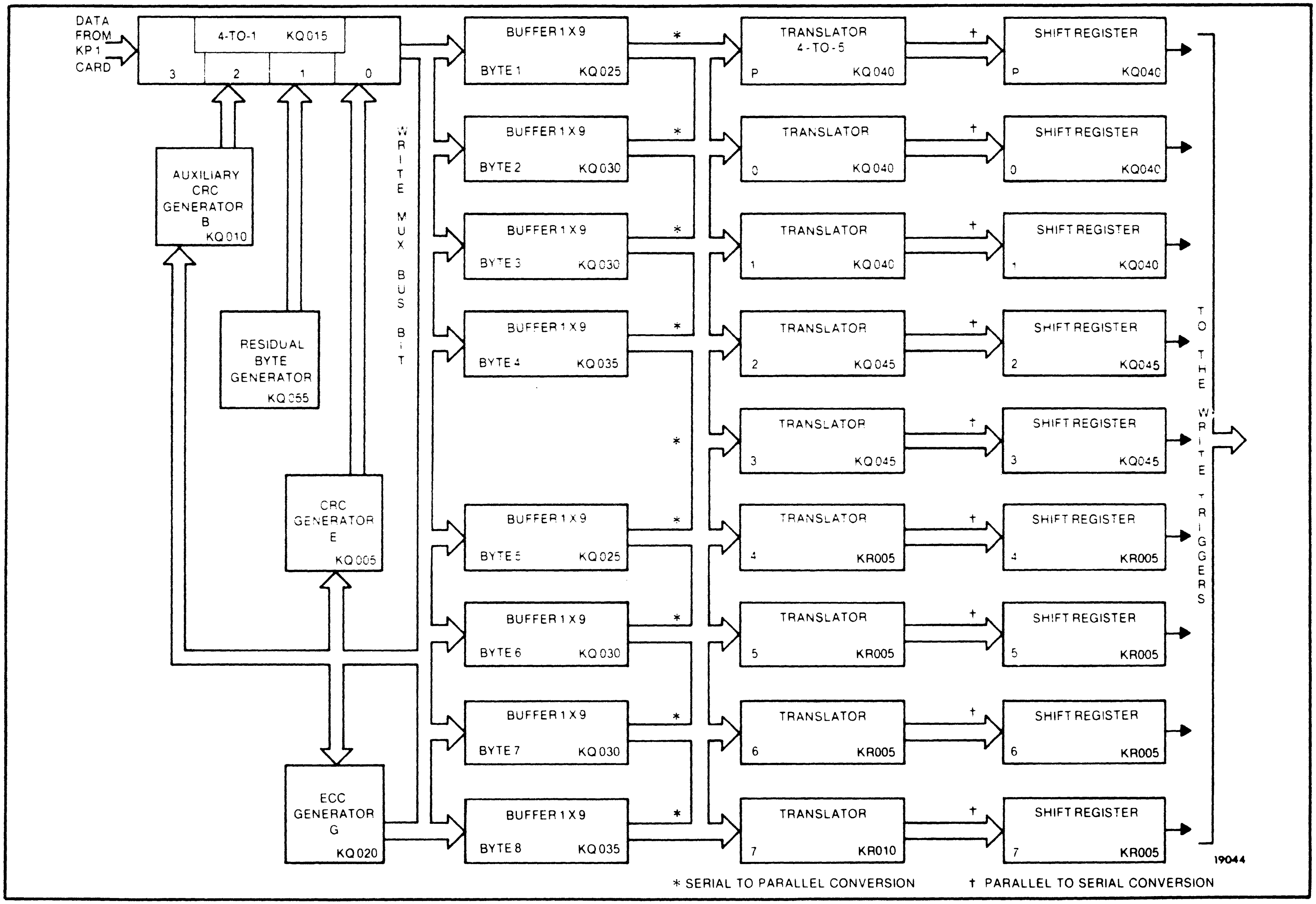
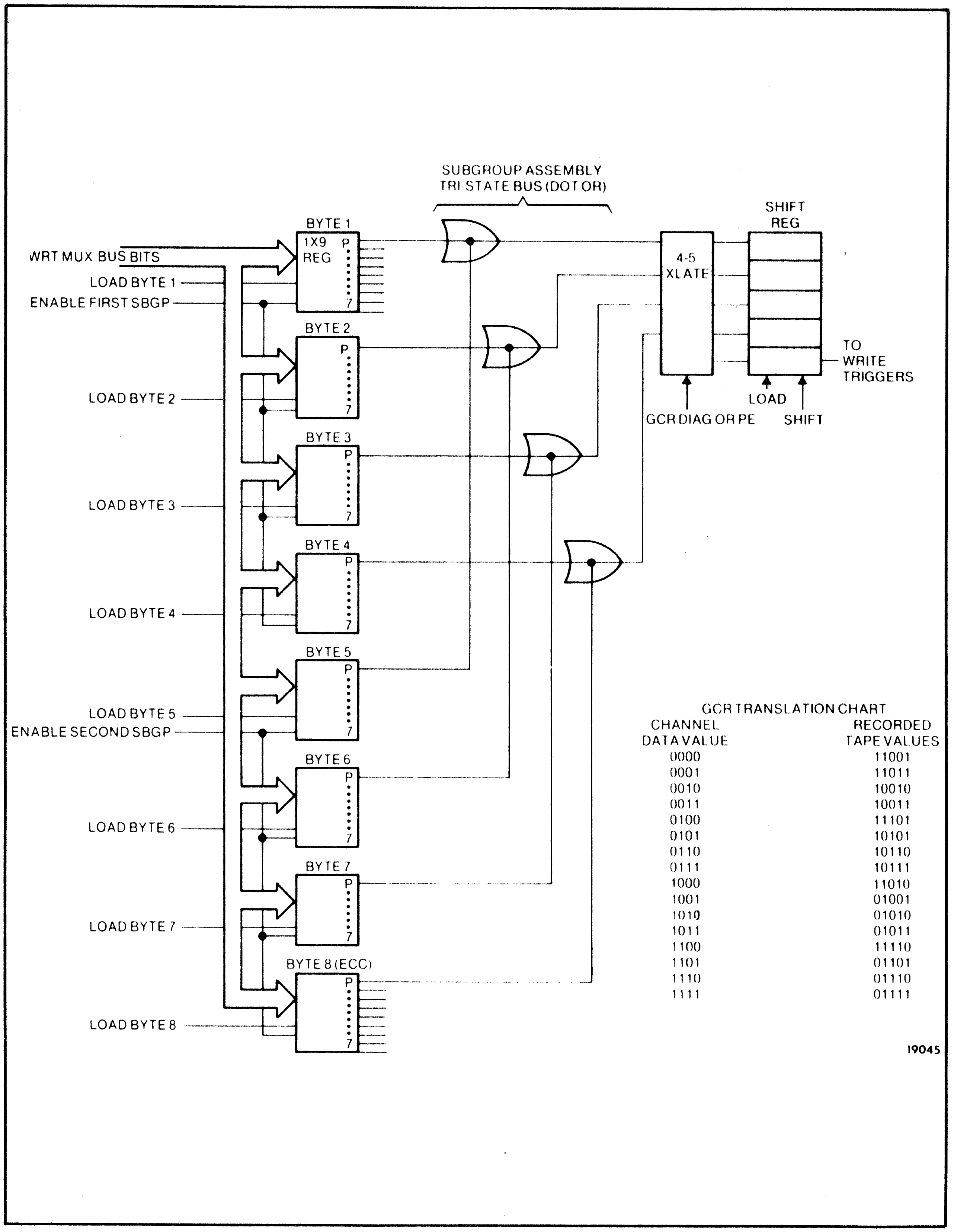


Figure 5-7. Write Data Path (GCR Only)



CHANNEL DATA VALUE	RECORDED TAPE VALUES
0000	11001
0001	11011
0010	10010
0011	10011
0100	11101
0101	10101
0110	10110
0111	10111
1000	11010
1001	01001
1010	01010
1011	01011
1100	11110
1101	01101
1110	01110
1111	01111

Figure 5-8. Write Translation (GCR Only)

5.4.1.2 Readback Checking Write Operation

The read head and read detection circuits are used to verify that the data written on tape during all write operations is correct.

GCR Readback Checks. The following checks are made during GCR readback operations. Error indicators are set if any of the following conditions occur. (Note that a two-track error correction is flagged as an error during the readback check of a write.)

a) Two or more pointers are detected or unable to find track in error (MTE, DATA CHK).

b) IBG is found within 30 bit cells after End of Data (PART REC, DATA CHK).

c) There is no End of Data within 0.15 inch after the record has been written (END DATA CHK, DATA CHK).

d) Either the AUX CRC register or the CRC register does not contain the match pattern (CRC ERR, DATA CHK).

e) The number of data bytes read back during any tach period is different from nominal by more than a fixed percentage (VEL ERR, DATA CHK).

PE Readback Checks. The following checks are made during a PE write command. Error indicators are set if any of the following conditions occur.

a) The data from the USER (AUX CRC A register) does not match the data from the readback check (AUX CRC C register) after the readback check is complete (CRC ERR, DATA CHK).

b) One or more dead tracks (DATA CHK).

c) The number of data bytes read back during any tach period is different from nominal by more than a fixed percentage (VEL ERR, DATA CHK).

d) End of Data is not found (END DATA CHK, DATA CHK).

e) No data is detected by the time the end of the record should appear (REJECT).

f) IBG occurs within 32 bit cells or later than 64 bit cells following End of Data (END DATA CHK, DATA CHK).

g) Three out of nine amplitude sensors drop, indicating a potential crease condition (PART REC, END DATA CHK, DATA CHK).

h) No IBG found for 0.4 inches after End of Data (REJECT).

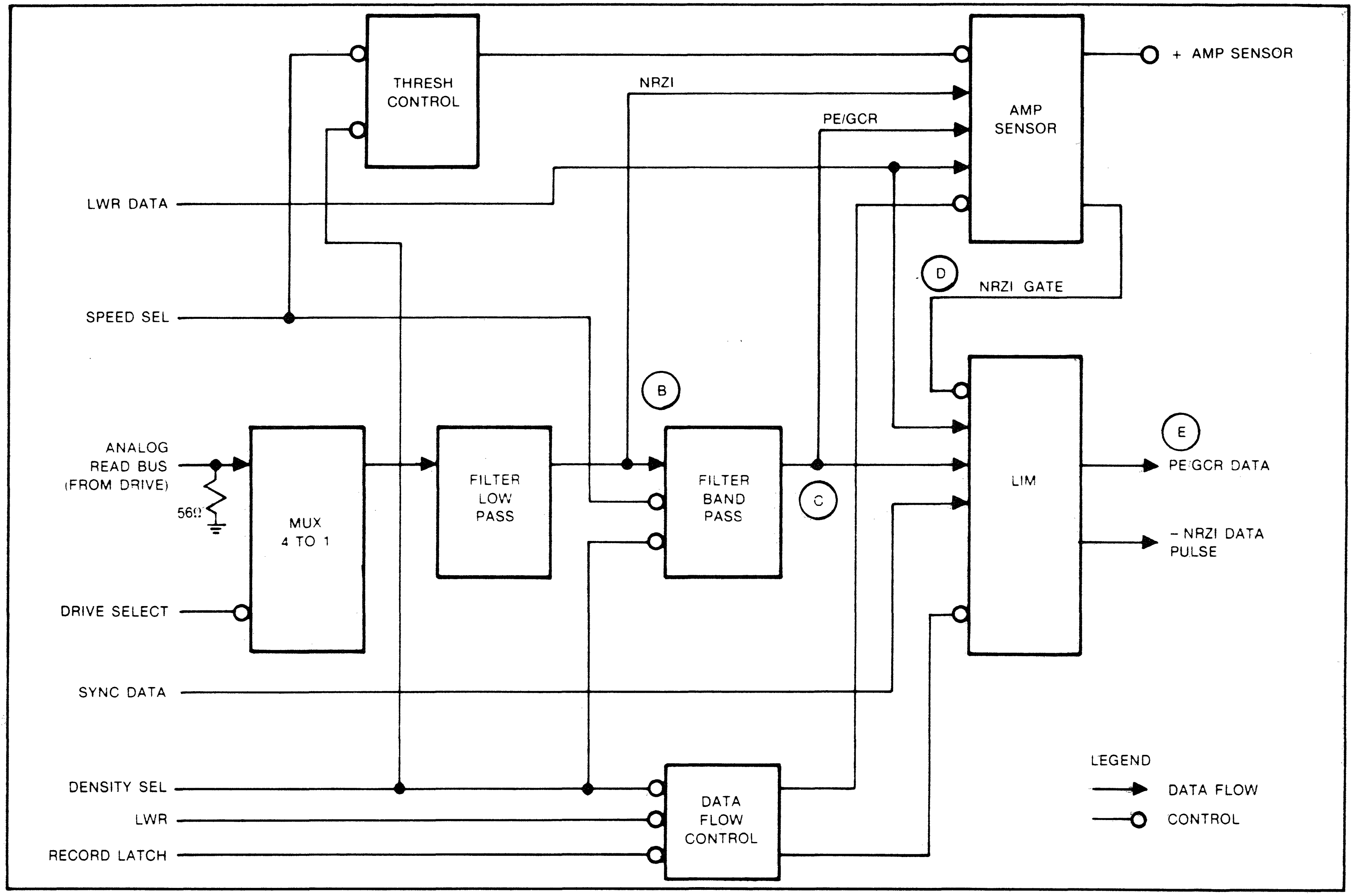


Figure 5-9. Read Analog-to-Digital Conversion (One Track)

NRZI Readback Checks. The following checks are made during NRZI write command. Error indicators are set if any of the following conditions occur.

a) The data from the USER (AUX CRC A register) does not match the data from the readback check (AUX CRC C register) after the readback check is complete (CRC ERR, DATA CHK).

b) One or more dead tracks (DATA CHK).

c) The number of data clock pulses during any tach period differ from nominal by more than a fixed percentage (VEL ERR, DATA CHK).

d) The CRC-F register does not contain the match pattern (CRC ERR, DATA CHK).

e) No data is detected (REJECT).

f) At least one data byte was written with skew in excess of one-fourth bit cell (MTE, DATA CHK).

g) A parity (VRC) error was detected on tape (END DATA CHK, DATA CHK).

5.4.2 READ DATA FLOW

The read analog-to-digital circuits located on the KV and KY cards recover the analog read data, generated at the tape unit read head, in digital form as it was recorded on tape. Refer to Figures 5-9 and 5-10.

Density selection allows operation in PE, GCR, or NRZI recording modes. Speed selection is for 50, 75, or 125 ips data processing.

The analog read data, selected from one of four drives via the 4-to-1 analog switch, is filtered, differentiated, and then converted to a digital output via the limiter.

Due to recording constraints, the PE and GCR analog read data is contiguous and is detected by the same method (data flow) on the KV cards. The amp sensor output (only used in PE and GCR) will pick when ten successive data signals above the selected threshold occur, and will drop after five have been detected as absent.

NRZI analog read data, being in the form of isolated pulses, requires amplitude discrimination at the limiter to distinguish signals from noise. The NRZI Gate, generated from the NRZI analog read signal before it is differentiated via the amp sense function, provides the amplitude discrimination.

A loop write-to-read (LWR) data path is provided for diagnostic operations. Sync Data, used only when in PE/GCR mode, is gated to the KT and KW cards variable frequency clock for synchronization during a gap or dead track condition when Record Latch is inactive.

The PE/GCR and NRZI data paths are separate from the limiter output to the KP card. The NRZI data goes to the KL card and the PE/GCR data goes to the KT and KW cards.

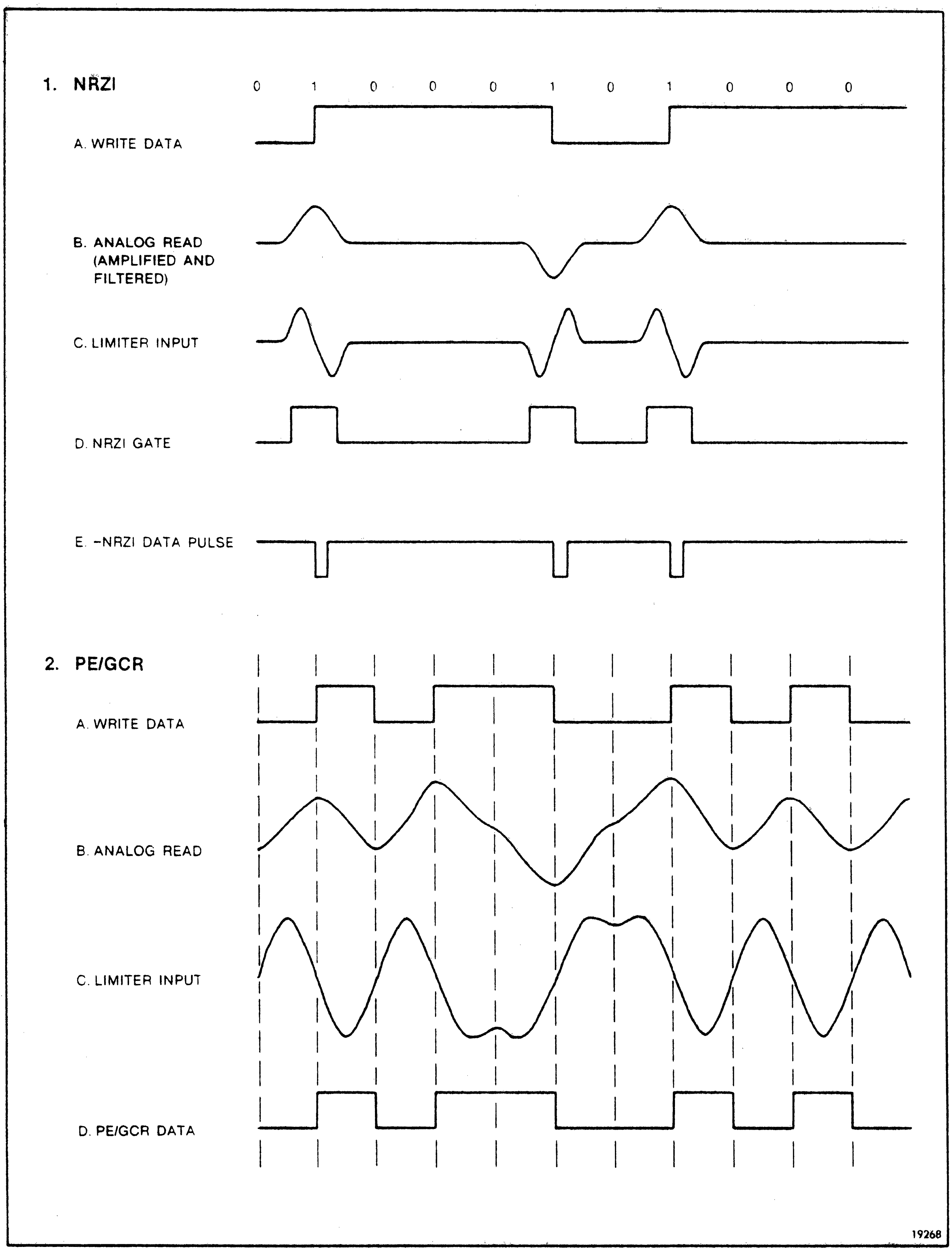


Figure 5-10. Read Waveforms

5.4.2.1 PE/GCR Read Data

The PE/GCR read data is detected on the KT and KW cards and sent to the KK and KH cards (Figure 5-11). Both the PE and GCR data are deskewed, then the GCR data is translated and processed. Track pointers are developed and sent to the KM card. The data is labeled ECR TRK and is sent to the KM card.

The KN card provides control functions for the KM and KP cards. The ECR TRK data enters the ECR shift register and the Read EC/ECC parity generator on the KM card (Figure 5-12). The TRK pointers also enter KM and generate error correction factors. Data bits are taken from two different positions of the ECR shift registers. Which position is dependent on PE or GCR operation.

Correction information is introduced and ECR BITS are sent to the correction bus. The bus sends signals to the KH card and EC bus bits to the KP card. The KP card buffers the data and sends it to the bus driver.

5.4.2.2 NRZI Read Data

The NRZI read data is detected in the data register on the KL card (Figure 5-13). The first bit or gate starts a bit cell time out, and bits accumulate in the data register until the bit cell period has elapsed. Parity is checked and Tape Marks detected when the full data byte should be in the data register. The data byte moves through the EC bus to the read register. The data is sent to the data buffer on the KP card and on to the bus driver.

The LRC register looks for even parity in each track by toggling a flip-flop for each ONE bit in a track. There is a flip-flop for each track. Since the LRC is written by resetting the write triggers, an even number of bits were put on tape in each track, therefore, an even number of bits should be read back leaving the LRC register empty.

The CRC register creates a special character from the data block as it is written and this character is stored on tape with the data block. When the read data and the CRC character pass through the CRC register, they should leave it set with a match pattern of 727(8).

When a parity error is detected, the error pattern register (EPR) forms a pattern for each error and is used in conjunction with the CRC register to find the track in error (TIE). After the read operation is complete, the CRC is shifted in the CRC register. At the same time the dead track register (DTR), which had been preset to nine, is being decremented, a character is being shifted in the EPR. When the CRC register contents match the EPR contents, the shifting stops and the DTR has been decremented to contain the track in error. If no match can be obtained in eight shifts, the error is uncorrectable.

To correct NRZI data, the USER must issue a backspace command and read the record forward with error correction. The previously stored DTR contents are returned from memory and point to the track in error. The record is read in and each time a parity error is detected, a bit is complemented in the track indicated by the DTR.

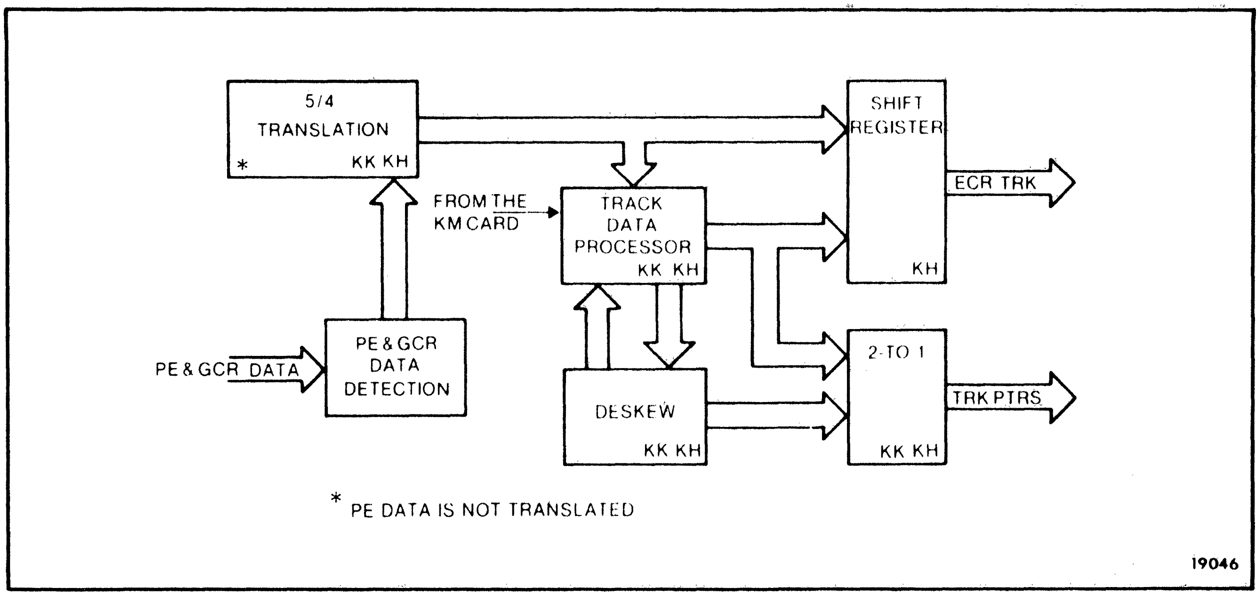


Figure 5-11. PE/GCR Read Detection

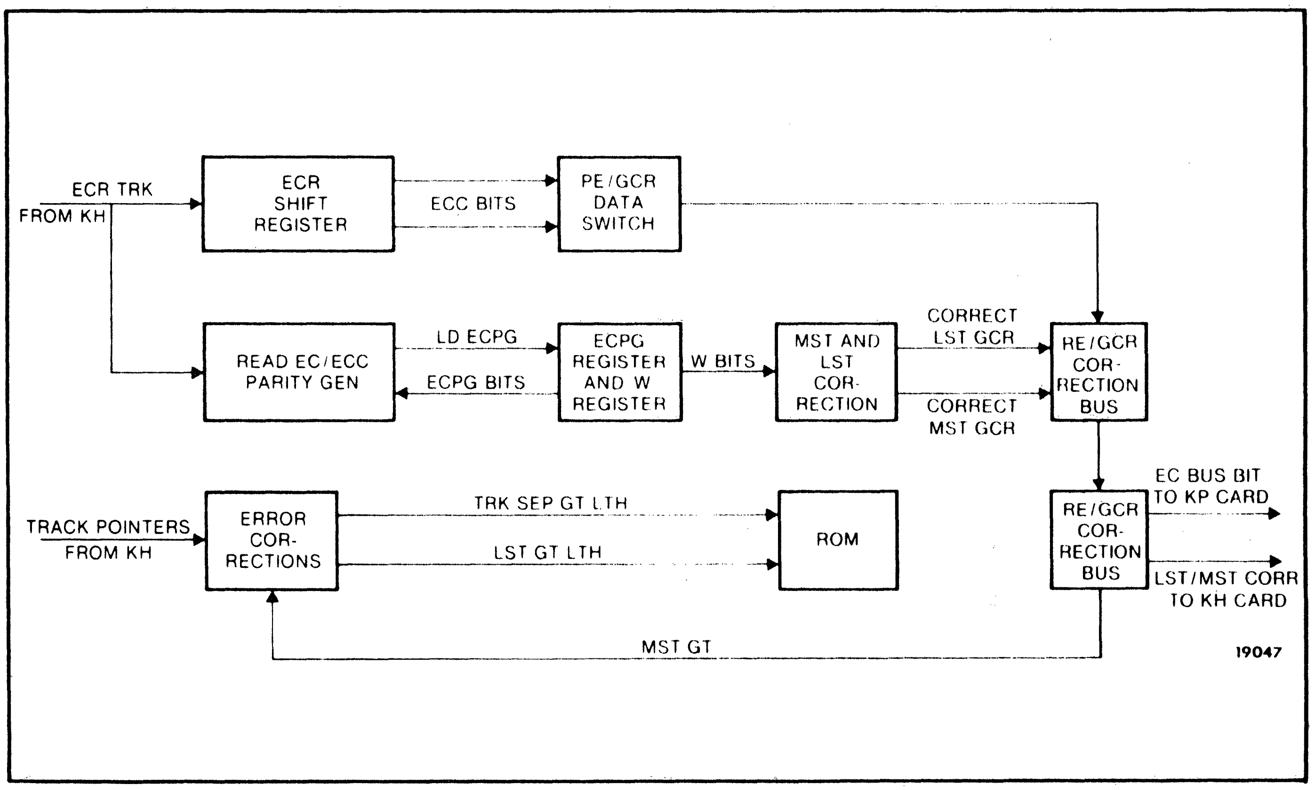


Figure 5-12. PE/GCR Read Data Path (KM Card)

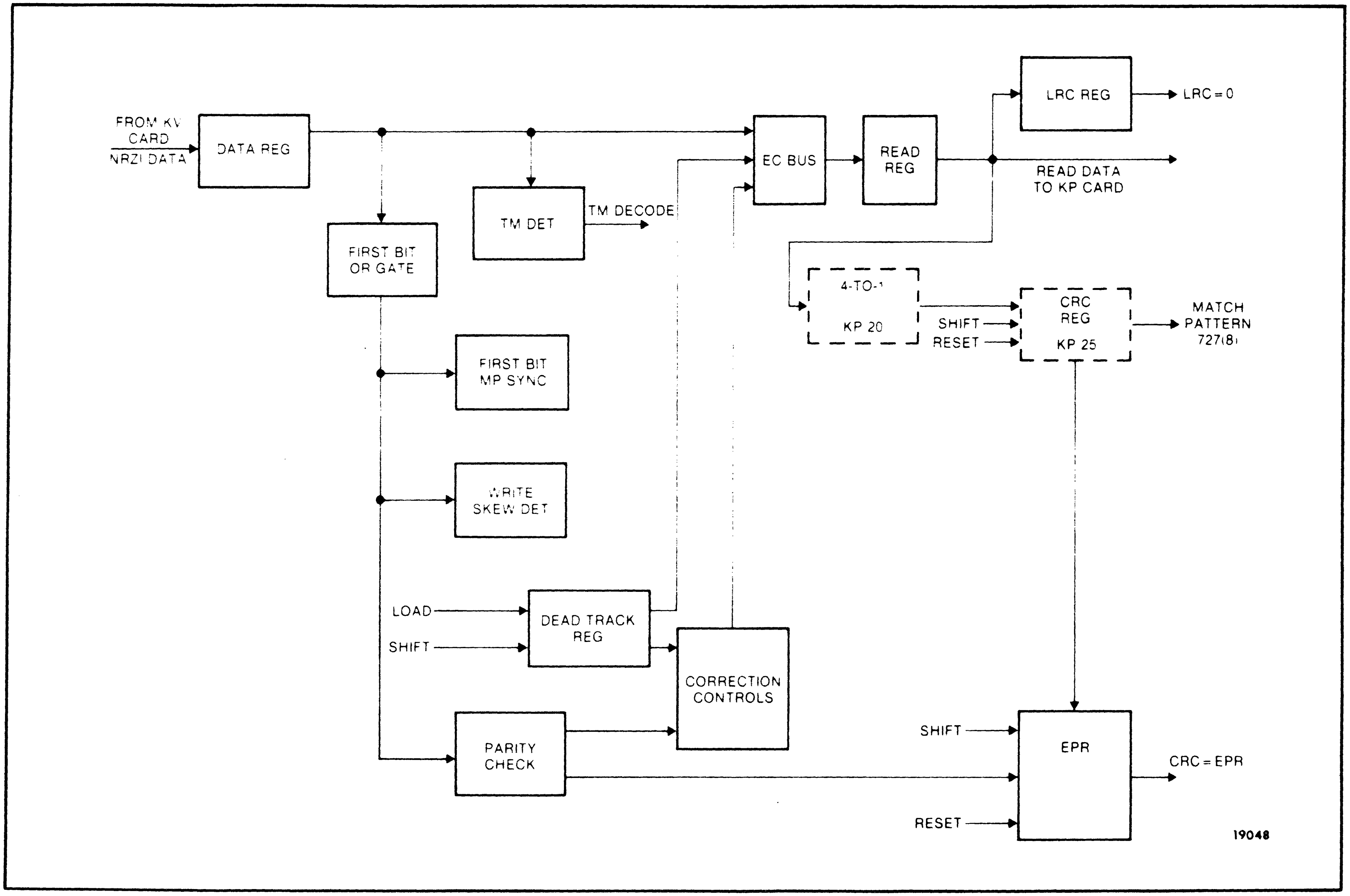


Figure 5-13. NRZI Read Data Path (KL Card)

5.5 POWER SUPPLY

The FCU is equipped with a power supply to provide DC logic voltages. The supply offers short circuit and overload protection through a designed-in foldback characteristic. Recovery from a short circuit or overload condition is automatic. Some models offer overvoltage protection designed to trip the FCU circuit breaker if +5V goes above about 5.8 Vdc or if the difference between +15 and −15 volts exceeds about 32 volts. Once the circuit breaker is tripped, it must be manually reset.

CHAPTER 6

MAINTENANCE

6.1 INTRODUCTION

This chapter provides the following information:

- Preventive Maintenance Schedules
- Power Supply Adjustment Procedure
- Diagnostic Test System Description
- Removal and Replacement Procedures

The preventive maintenance schedules list the procedures to be regularly performed by trained personnel. The power supply is the only component of the FCU which requires periodic adjustment.

The purpose, capabilities, and operation of the STC Diagnostic Test System are described and a list of available diagnostic guides is provided.

Should there be a defective part, the removal and replacement procedures provide instructions for changing field replaceable parts.

6.2 PREVENTIVE MAINTENANCE

6.2.1 MONTHLY MAINTENANCE

1. Check fans for proper operation and replace as necessary to correct noisy operation or binding.
2. Run diagnostics. (Refer to Section 6.4.)

6.2.2 QUARTERLY MAINTENANCE

1. Check air filter. The filter should be cleaned or replaced quarterly. (Refer to Section 6.5.2 for the removal procedure.)
2. Check all connectors for snug and secure connection.
3. Check power supply output levels and adjust as necessary. (Refer to Section 6.3 for procedure.)
4. Run diagnostics. (Refer to Section 6.4.)

6.3 POWER SUPPLY ADJUSTMENT

The power supply output levels should be checked with the AC input voltage level at nominal.

The power supply has three adjustable voltage outputs: +5, +15, and −15 volts. The +15 volts must be adjusted first. Be aware that the voltages can be adjusted into a limit condition, in which case the FCU circuit breaker must be turned off in order to reset the power supply. If this occurs, the three voltage adjustment pots must be backed off (CCW) before power is reapplied.

Check the voltage levels at the test points on the back of the FCU back panel and adjust as necessary. The +5 volt level should be within 0.1 volts of nominal; the 15 volt levels should be within 0.3 volts of nominal. Refer to Figure 6-1 for the adjustment locations and to Figure 6-2 for the test point locations. Use any ground on the FCU back panel.

6.4 DIAGNOSTIC TEST SYSTEM

The STC Diagnostic Test System is a complete package of test programs that can be loaded and executed at the site to test the STC 1900 Tape Subsystem. The test routines can be used to diagnose I/O errors, isolate problems, verify repairs and engineering changes, and verify proper operation. The listings for the Diagnostic Test Routines are available in both PE-recorded half-inch tape, 5-inch floppy disk, and printed copy. The distributed tape and disk include the library of test routines and the Diagnostic Monitor.

The library of test routines allows fault isolation, parameter measurement, artificial stressing, functional checkout, and reliability testing. The routines are designed to test and diagnose for fault through the FCU alone (no tape unit required), a tape unit (through the FCU), and the tape subsystem as a whole. The test routines check system operation not only under nominal conditions, but also allow internal parameters to be varied under FCU and tape unit microprogram control to check the margins of correct system operation.

The library of test routines is structured into a building block approach: circuit elements are first tested then employed to reach and test other circuits. The initial tests verify the USER/FCU interface. The tests that follow check that the write path is operational. Loop write-to-read is then used to test the read detection circuits and the read path of the FCU. After completing the FCU test, the FCU/TU interface, tape motion control, and read/write sections of the tape unit are tested in that order.

After the initial system checkout, artificial stressing techniques are used to certify the error correction characteristics of the system. Error correction circuits are tested by the insertion of various types of flawed data into the data path and the results are checked for proper correction. Excessively flawed data is also inserted to verify that the system does not attempt correction on data that cannot be reliably corrected.

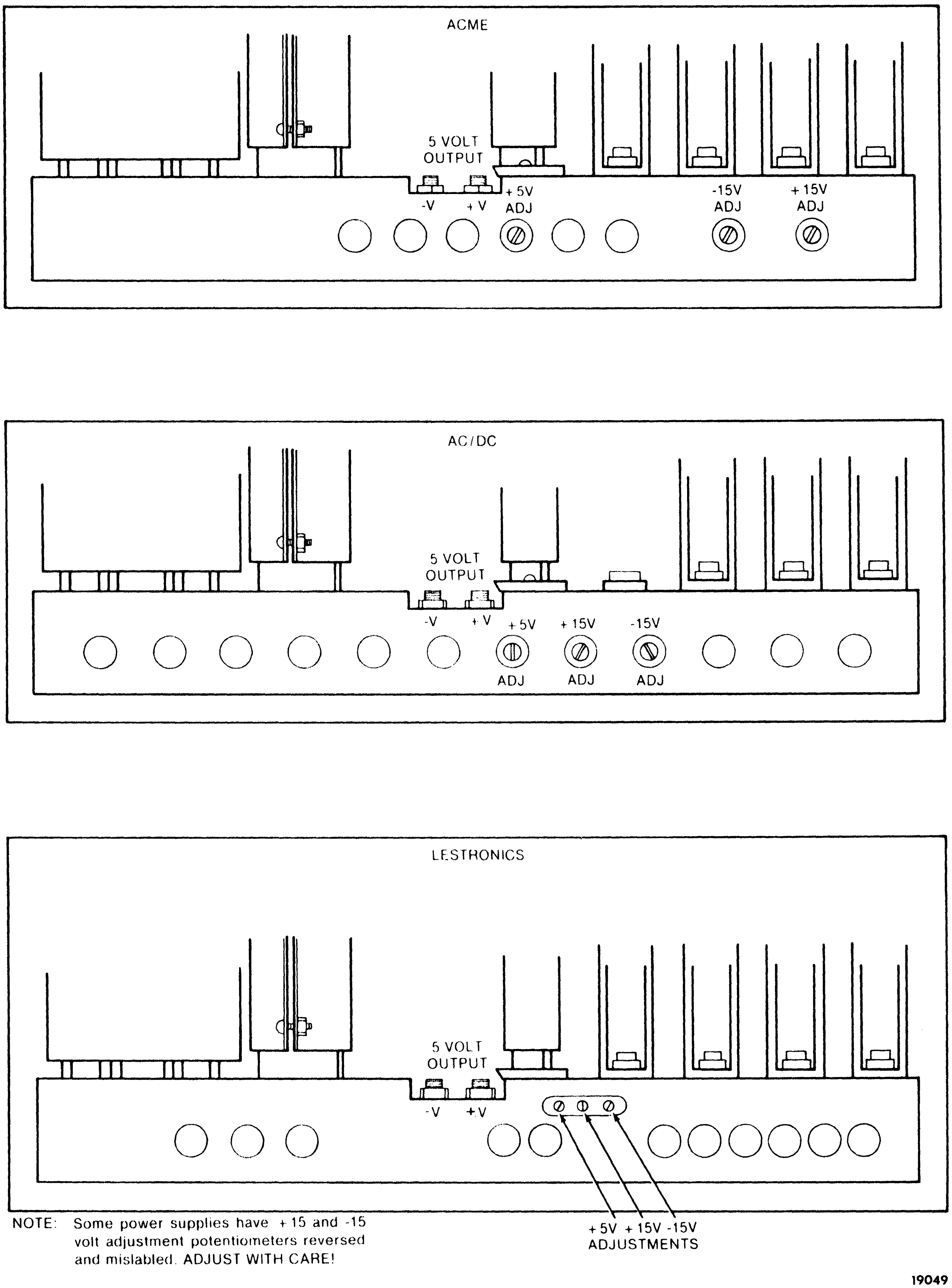


Figure 6-1. Power Supply Adjustment

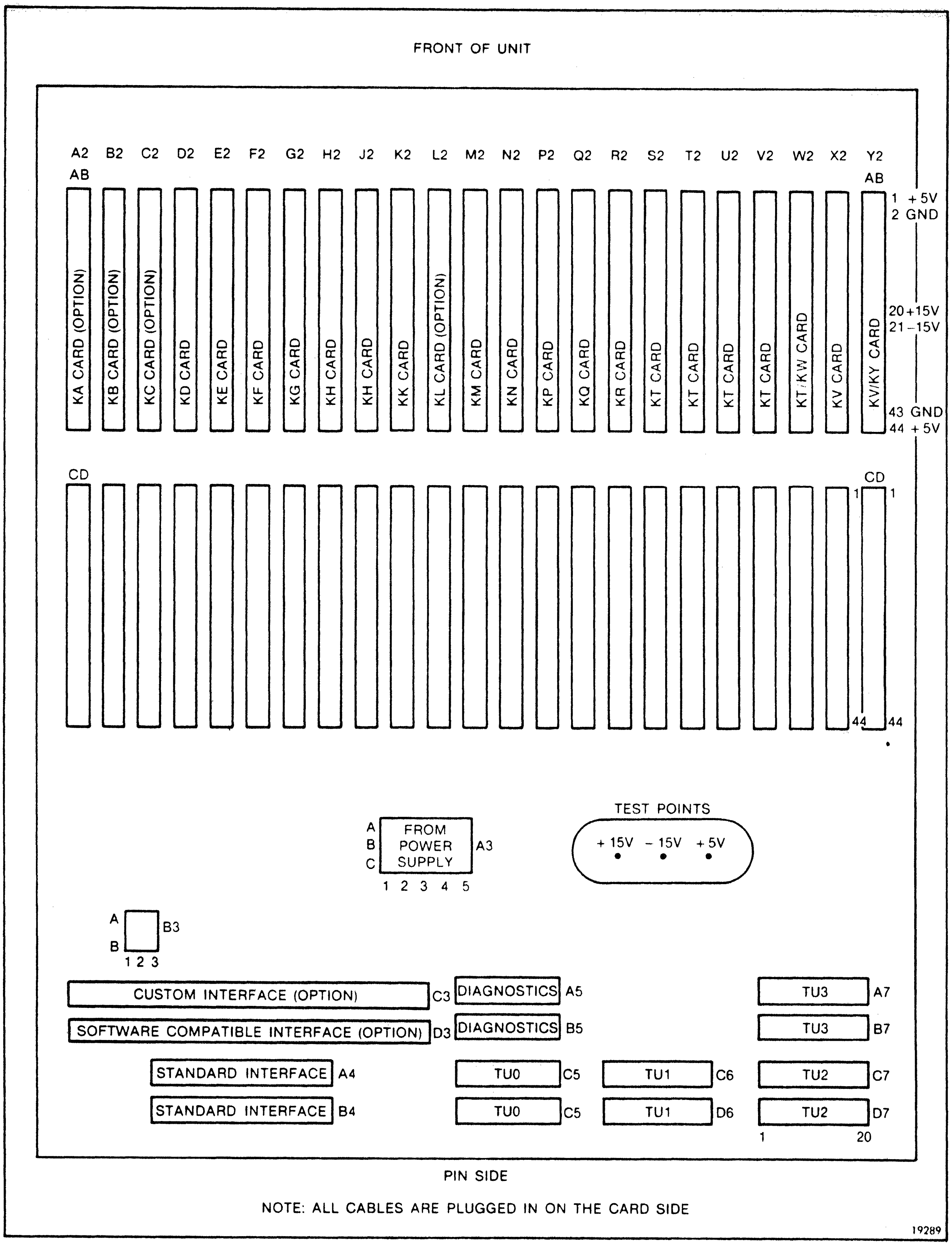


Figure 6-2. FCU Back Panel

Analog and mechanical characteristics of the system, such as bit cell integration and tape unit capstan performance, are then measured to assure that they meet specifications.

A comprehensive group of functional and reliability tests are then employed to certify the overall integrity of the system. In these tests, operational use is extensively simulated including actions of sorts and file maintenance. Error recovery actions are duplicated. Command intermix is also tested.

The diagnostic package is coded in a special diagnostic command language. The command language repertoire includes approximately 60 commands designed to perform many types of tape operations, generate and compare data patterns, and test for error and status conditions. The commands are used to operate a 'pseudo machine' that establishes and maintains the test environment. The command language is designed to be processor-independent.

The command language allows the user to write new test routines and/or modify the existing routines. The following STC Diagnostic User's Guides are available, containing the higher level command language in which the test routines are written:

STC 1900 Tape Subsystem Diagnostic User's Guide, PN 9492
STC 1900 FORTRAN Diagnostic Monitor User's Guide, PN 9477
STC 3910 User's Guide for 1900 Diagnostics, PN 9613

The Diagnostic Monitor performs the function of interpreting and controlling the Command Language System of the diagnostic routines. Other functions of the Diagnostic Monitor include operational control of the diagnostic library, utility functions associated with test operations, and a maintenance facility for the diagnostic package. The following STC Diagnostic Coder's Guides are available for reference and contain program listings and flow charts:

STC 1900 Tape Subsystem Diagnostic Coder's Guide, PN 9493
STC 1900 FORTRAN Diagnostic Monitor Coder's Guide, PN 9646

6.5 REMOVAL AND REPLACEMENT

6.5.1 CIRCUIT CARD REPLACEMENT

Any circuit card removed from the FCU must be replaced by a card of compatible type and EC level. (Refer to the PN Compatibility Listing, PN 9588.)

1. Remove power from the FCU.
2. Slide the FCU forward until the access cover is clear of the rack.
3. Remove the front cover then remove the screws securing the access cover and remove the cover.
4. Remove the appropriate circuit card and insert the replacement card.
5. Turn power on and check the power supply outputs to ensure that the replacement card is not adversely affecting the power supply outputs.
6. Reinstall the access cover and slide the FCU into the rack.

6.5.2 FILTER REMOVAL

1. Remove power from the FCU.
2. Remove the front decorative cover by placing the index fingers into the access holes under the bottom of the cover, flex the spring clips toward the center of the frame, and pull out at the bottom of the front cover (Figure 6-3).
3. Remove the filter retainers by sliding the lower end of each retainer sideways until it clears the filter tray and then manipulate the upper end of each retainer through the mounting holes in the chassis.
4. Remove the filter.
5. Install the replacement or cleaned filter by reversing this procedure.

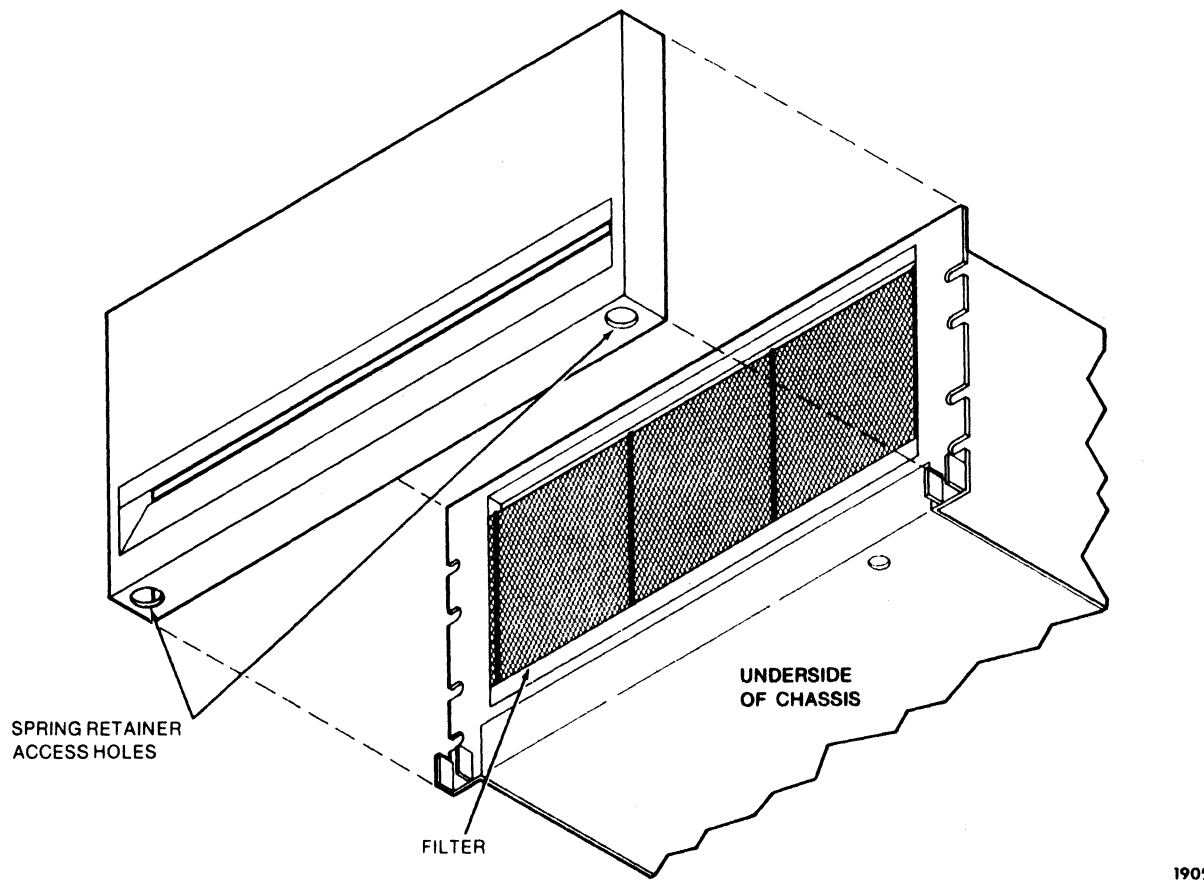


Figure 6-3. Filter Removal

6.5.3 COOLING FAN REPLACEMENT

1. Disconnect power from the FCU.
2. Remove the fan mounting bracket (Figure 6-4).
3. Remove the fan mounting screws.
4. Disconnect the power connector on the fan and connect it to the replacement fan.
5. Use the original mounting hardware to secure the replacement fan.
6. Reinstall the fan mounting bracket.

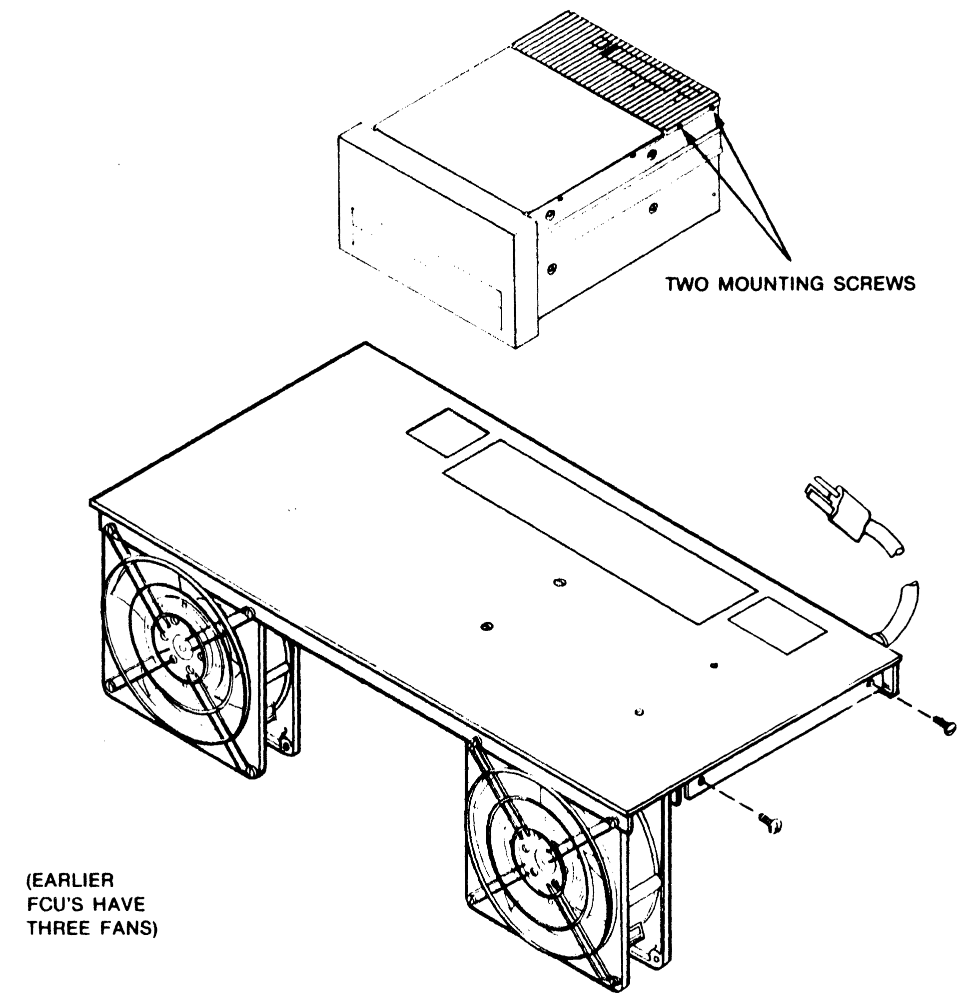


Figure 6-4. Cooling Fan Replacement

6.5.4 POWER SUPPLY REPLACEMENT

1. Disconnect power from the FCU.
2. Remove the fan mounting bracket (Figure 6-4).
3. Remove the three ground straps secured to the FCU chassis.
4. Disconnect the power supply cable from connector A3 on the back panel.
5. Loosen the four screws securing the power supply to the FCU chassis. These screws are located underneath the power supply.
6. Lift the power supply away from the FCU chassis.
7. Install the replacement power supply by reversing this procedure.
8. Perform the power supply adjustment procedure (Section 6.3).

APPENDIX A
DATA FORMATS

A.1 INTRODUCTION

The FCU is capable of formatting and deformatting data for PE, GCR, and (optionally) NRZI recording methods. The following is a description of how each recording method is formatted and an outline of the function of the FCU in each operation.

A.2 NON-RETURN-TO-ZERO INDICATED (NRZI) FORMAT

A ZERO (0) bit is defined as no transition during the bit cell period. A ONE (1) bit is defined as a transition during the bit cell period.

A.2.1 ANSI COMPATIBILITY

When the FCU is operated in the tape subsystem, it writes and reads magnetic recording tapes as specified by ANSI X3.22-1973.

A.2.2 RECORDED FORMAT

The NRZI recorded format is shown in Figure A-1. The density of recording is 800 data characters per inch nominal.

A.2.3 BLOCK LENGTH

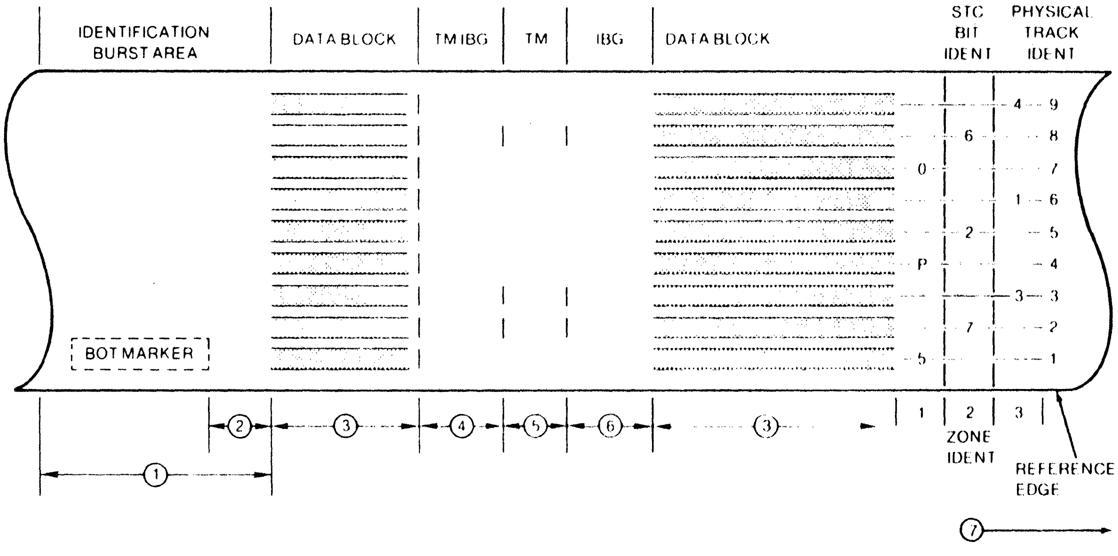
The FCU does not control or limit the number of data characters per block except to disallow the writing of data blocks containing no data characters. The USER may thus generate blocks outside the ANSI specified minimum and maximum block length if desired.

A.2.4 MAXIMUM INTERBLOCK GAP (IBG)

The USER may generate extended length IBGs by repeated Erase Gap (ERG) commands. The FCU does not control or limit the number of repetitions. The USER may thus exceed the ANSI specified 25 foot maximum. However, upon detecting a 25 foot gap during read operation, the FCU will halt tape motion and set REJECT.

A.2.5 END OF RECORDING AREA

The FCU does not control or limit operations past EOT (end of the recording area).



NOTES:

A. Tape is shown with oxide side up.

B. Areas shown without recording, including IBGs, are magnetized so that the rim end of the tape is a north seeking pole.

1 Identification Burst Area - NRZI recording is identified by an area of tape, totally erased, extending a minimum of 1.3 inches before the trailing edge of the BOT marker and extending to the initial gap.

2 Initial Gap - The gap between the trailing edge of the BOT marker and the first recorded character is 3 inches minimum and 25 feet maximum.

3 Data Block - ANSI specifies this shall contain a minimum of 18 or a maximum of 2048 characters. Actual block length is under USER control. Within each data block and following the data characters a CRC character is written on tape and spaced 0.005 inches ±10% from the last data character. Within each data block and following the CRC character is an LRC character spaced 0.005 inches ±10% from the CRC character.

4 Tape Mark/Interblock Gap - The IBG immediately preceding a tape mark is 3.6 inches nominal.

5 Tape Mark - A tape mark is a single data character consisting of ONEs written in tracks 2, 3, and 8 followed by a CRC character of all ZEROs and an LRC character, both spaced as for a normal data block.

6 Interblock Gaps - IBGs are 0.6 inches nominal, 0.5 inches minimum. Extended length IBGs may be generated by the USER.

7 End of Recording Area - The end of recording area starts at the leading edge of the EOT marker.

Figure A-1. 9-Track NRZI Format

A.3 PHASE-ENCODED (PE) FORMAT

A ZERO (0) bit is defined as a transition in the middle of the bit cell away from the erased magnetization. A ONE (1) bit is defined as a transition in the middle of the bit cell toward the erased magnetization.

A.3.1 ANSI COMPATIBILITY

When the FCU is operated in the tape subsystem, it writes and reads magnetic recording tapes as specified by ANSI X3.39-1973.

A.3.2 RECORDED FORMAT

The PE recorded format is shown in Figure A-2. The density of recording is 1600 data characters per inch nominal.

A.3.3 BLOCK LENGTH

The FCU does not control or limit the number of data characters per block except to disallow the writing of data blocks containing no data characters. The USER has control of the byte count and may thus create blocks outside the ANSI specified minimum and maximum if desired.

A.3.4 MAXIMUM INTERBLOCK GAP (IBG)

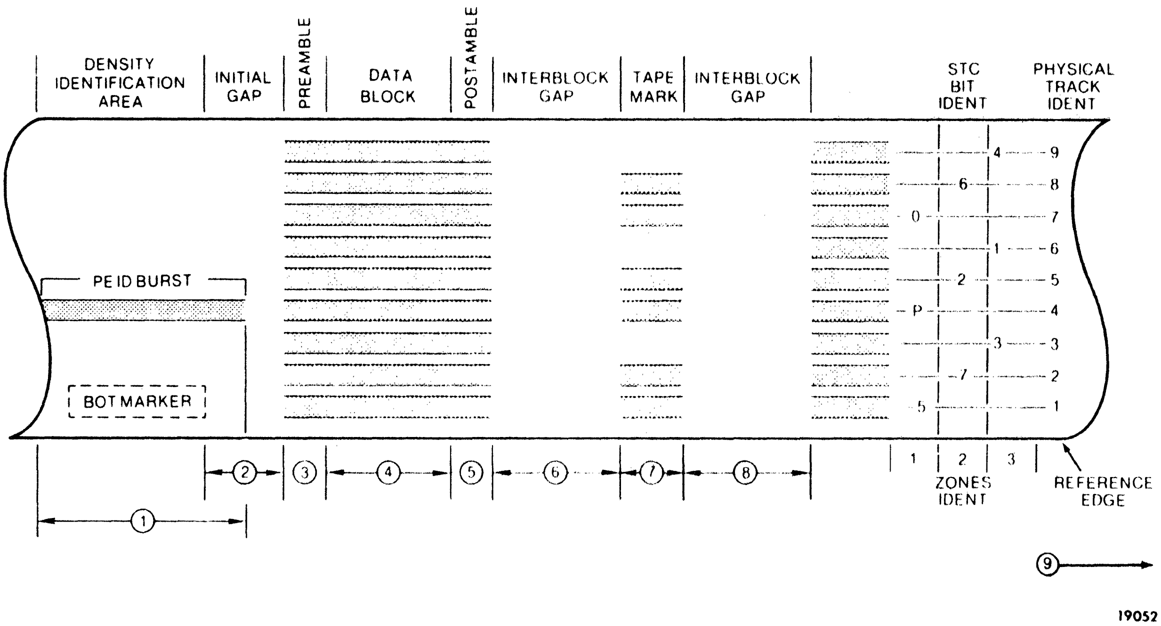
The user may generate extended length IBGs by repeated Erase Gap (ERG) commands. The FCU does not control or limit the number of repetitions. The USER may thus exceed the ANSI specified 25 foot maximum. However, upon detecting a 25 foot gap during operations, the FCU halts tape motion and sets REJECT.

A.3.5 END OF RECORDING AREA

The FCU does not control or limit operations past EOT (in the end of recording area).

A.3.6 TAPE MARK

A tape mark is detected upon reading sufficient appropriate contiguous characters in either zone 1 or zone 2, in conjunction with zone 3.



NOTES:

A. Tape is shown with oxide side up.

B. Areas shown without recording, including IBGs, are magnetized so that the rim end of the tape is a north seeking pole.

1 Density Identification Area - PE recording is identified by an ID burst of recording at the BOT marker consisting of 1600 FCI on track 4 and erasure on all other tracks. This burst begins 1.7 inches minimum before the trailing edge of the BOT marker, continues past the trailing edge, ending at least 0.5 inches before the first block.

2 Initial Gap - The gap between the trailing edge of the BOT marker and the first recorded character is 3 inches minimum and 25 feet maximum.

3 Preamble - Preceding data in each block, a preamble is written consisting of 41 characters, of which the first 40 characters contain ZEROs bits followed by a single character containing ONEs in all tracks.

4 Data Block - ANSI specifies this shall contain a minimum of 18 or a maximum of 2048 characters. Actual block length is under USER control.

5 Postamble - Following data in each block, a postamble is written consisting of 41 characters of which the first character contains ONEs in all tracks followed by 40 characters containing ZEROs in all tracks.

6 Tape Mark/Interblock Gap - The IBG immediately preceding a tape mark is 3.6 inches nominal.

7 Tape Mark - The tape mark written is 64 to 256 flux reversals at 3200 FCI in tracks 1, 2, 4, 5, 7 and 8. Tracks 3, 6 and 9 are DC erased.

8 Interblock Gaps - IBGs are 0.6 inches nominal, 0.5 inches minimum. Extended length IBGs may be generated by the USER.

9 End of Recording Area - The end of recording area starts at the leading edge of the EOT marker.

Figure A-2. PE Format

A.4 GROUP CODED RECORDING (GCR) FORMAT

A.4.1 ANSI COMPATIBILITY

When the FCU is operated in the tape subsystem, it writes and reads magnetic recording tapes as specified by ANSI X3.54-1976.

A.4.2 RECORDED FORMAT

The GCR recorded format is shown in Figures A-3 and A-4. The density of recording is 6250 data characters per inch nominal.

A.4.3 BLOCK LENGTH

The FCU does not control or limit the number of data characters per block except to disallow the writing of data blocks containing no data characters. The FCU formats the USER input data, independent of total number of data characters, into the data group and/or residual data group ANSI specified format. The USER may thus generate data blocks outside the ANSI specified minimum and maximum length if desired.

A.4.4 MAXIMUM INTERBLOCK GAP (IBG)

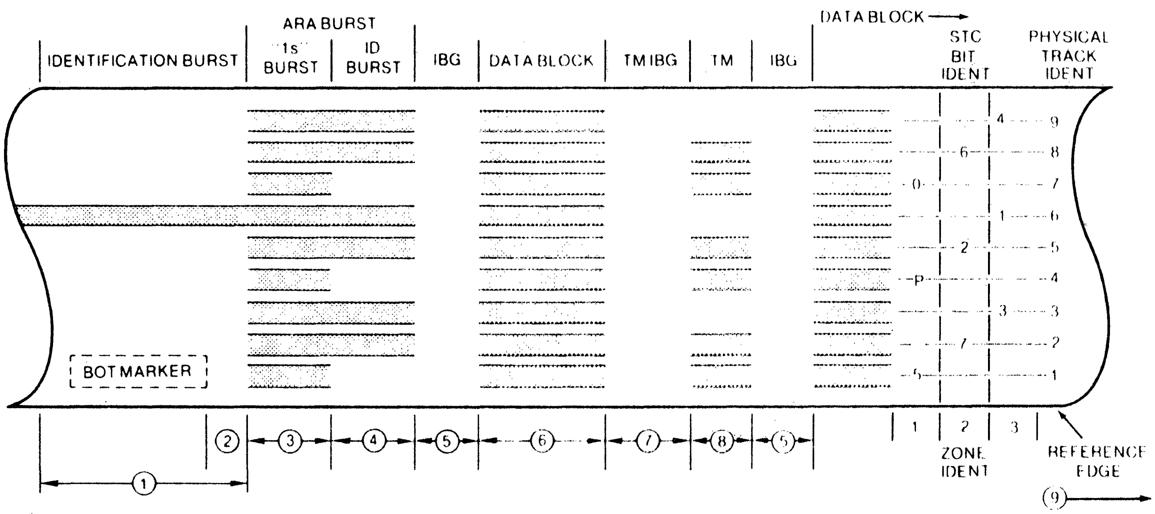
The USER may generate extended length IBGs by repeated Erase Gap (ERG) commands. The FCU does not control or limit the number of repetitions. The USER may thus exceed the ANSI specified 15-foot maximum. However, upon detecting a 15-foot gap during read operations, the FCU halts tape motion and sets REJECT.

A.4.5 END OF RECORDING AREA

The FCU does not control or limit operations past EOT (in the end of recording area).

A.4.6 TAPE MARK BLOCK

A tape mark is detected upon reading sufficient appropriate contiguous characters in either zone 1 or zone 2, in conjunction with zone 3.



NOTES:

A. Tape is shown oxide side up.

B. Areas shown without recording, including IBGs, are magnetized so that the rim end at the tape is a north-seeking pole.

1 Identification Burst - The GCR recording method is identified by a burst of recording at the BOT marker. The burst is in the PE frequency range (1600 BPI) on track 6 and erasure on all other tracks. The ID burst begins 1.7 inches minimum before the leading edge of BOT and continues past the trailing edge of the BOT marker.

2 ARA Burst - The ARA burst enables the capability of writing all tracks to be verified. It begins no sooner than 1.5 inches and no later than 4.3 inches as measured from the leading edge of the BOT marker.

3 ARA '1s' Burst - Immediately following the ID Burst there is an ARA Burst (all ONEs in all tracks) which is separated from the ID Burst by an undefined gap. It ends no sooner than 9.5 inches and no later than 11.5 inches as measured from the leading edge of the BOT marker.

4 ARA ID Burst - Appended to the end of the ARA '1s' Burst is an ID character consisting of ONEs in tracks 2, 3, 5, 6, 8, and 9 and erasure in tracks 1, 4, and 7. This ID character is approximately 2 inches long. (At least a contiguous 1/4-inch section of this 2-inch long burst must be error-free in all tracks simultaneously.) There is a normal IBG between the ARA ID character and the first data block.

5 Interblock Gaps - IBGs are 0.285 inch minimum and 0.3 inch nominal. Extended length IBGs may be generated by the USER.

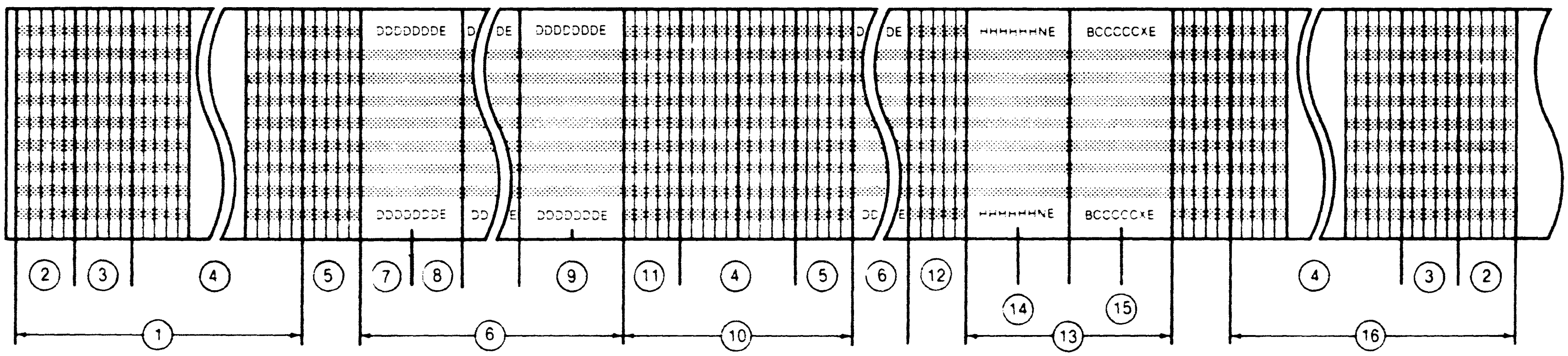
6 Data Block - See GCR Data Block Format illustration.

7 Tape Mark Interblock Gap - The IBG immediately preceeding a tape mark is 3.3 inches nominal.

8 Tape Mark - The tape mark written consists of 400 flux changes (all ONEs) at 9042 FCI in physical tracks 2, 5, 8, 1, 4 and 7 and no recording in physical tracks 3, 6, and 9.

9 End of Recording Area - The end of recording area starts at the leading edge of the EOT marker.

Figure A-3. GCR Format



B	CRC OR PAD CHARACTER
C	CYCLIC REDUNDANCY CHARACTER (CRC)
D	DATA CHARACTERS
E	ERROR CORRECTION CHARACTER ECC
H	PAD OR DATA CHARACTER
L	LAST CHARACTER
N	AUXILIARY CRC
X	RESIDUAL CHARACTER

DATA VALUES	RECORD VALUES
0 0 0 0	1 1 0 0 1
0 0 0 1	1 1 0 1 1
0 0 1 0	1 0 0 1 0
0 0 1 1	1 0 0 1 1
0 1 0 0	1 1 1 0 1
0 1 0 1	1 0 1 0 1
0 1 1 0	1 0 1 1 0
0 1 1 1	1 0 1 1 1
1 0 0 0	1 1 0 1 0
1 0 0 1	0 1 0 0 1
1 0 1 0	0 1 0 1 0
1 0 1 1	0 1 0 1 1
1 1 0 0	1 1 1 1 0
1 1 0 1	0 1 1 0 1
1 1 1 0	0 1 1 1 0
1 1 1 1	0 1 1 1 1

NOTE:

DATA GROUPS ARE SHOWN PRIOR TO ENCODING AND RECORDING.

19053

Figure A-4. GCR Data Block Format (Sheet 1 of 3)

The following are notes that explain sheet 1 of the Figure. These notes are numbered to correspond with the numbers on the illustration.

NOTES:

(1) Preamble - Sixteen subgroups of five bytes each. The subgroups initiate the read circuits and synchronize them.

(2) Terminator Control Subgroup - The data pattern in this subgroup provides for a long wave length input to the read detection circuits, thus ensuring high level inputs into the circuits at the beginning of a read operation. These inputs in turn ensure that the Read Detectors are turned ON before they are synchronized.

The Terminator Control Subgroup is one set of nine parallel 5-bit serial values of 10101 in all tracks located at the BOT end of each block and 1010L at the EOT end of each block, where L represents the resetting of the last character (which restores the Write Triggers to the erase state).

(3) Second Control Subgroup - This is a part of sync, explained below. The Second Control Subgroup consists of 5 bit serial values of 01111 in all tracks for the BOT end of the block and 11110 for the EOT end of the block.

(4) Sync Control Subgroups - These are fourteen five-byte subgroups which synchronize the Read Reference Oscillator. Each subgroup consists of 5-bit serial values of all '1s' in all tracks.

(5) Mark 1 Control Subgroup - This subgroup marks the coming of data. It ensures that the buffer counters are properly initiated so the data being read is formatted into the correct five-byte groups. This is necessary for correct decoding (retranslation from five to four bit codes) of the data which is being read. The Mark 1 Control Subgroup is one set of 5-bit serial values of 00111 on all tracks. On backward operations, the Mark 1 becomes the Mark 2 Subgroup.

(6) Data - Any recorded section of the tape which has only data and the ECC recorded on it (no Control Subgroups). The data is formatted into groups and the groups are divided into subgroups. These data subgroups are identified as data subgroup A and data subgroup B.

Data Values/Record Values - During GCR recording, four bits from each track are translated into the five-bit code. After translation, the five-bit code is moved serially to the TU for recording. The data values and record values show the bit patterns before and after translation. During read operations, the five-bit code is reconverted to the original four bits. Thus, the data sent to the CPU is in its original form.

(7) Data Subgroup A consists of four data bytes before translation (the storage group).

(8) Data Subgroup B consists of three data bytes and one ECC (Error Correction Character) before translation. The ECC is used for data correction. All data correction in GCR is done on the eight-byte data groups (Byte 8 is the ECC).

(9) There may be no more than 158 contiguous data groups in a recorded data block. If there are more than 1112 data bytes (before translation) in an incoming record, resynchronization is necessary before the recording can be continued.

(10) Resync Burst - This burst is used to resynchronize the data of failing tracks when a data record is longer than 1112 data bytes (before translation). See Notes 6 through 9.

(11) Mark 2 Control Subgroup - This subgroup marks the ending of data and the coming of nondata information. The Mark 2 Control Subgroup consists of one set of 5-bit serial values of 11100 on all tracks. On backward operations, the Mark 2 becomes the Mark 1 Subgroup.

(12) End Mark Control Subgroup - This control subgroup warns of the approach of the Residual Data Group, which is defined in Note 14. The End Mark Control Subgroup consists of one set of 5-bit serial values of 11111 on all tracks.

(13) RES/CRC Data - This data includes both the Residual Data Group and the CRC Data Group (these groups are described in Notes 14 and 15). These two groups are written at the end of a data record.

Figure A-4. GCR Data Block Format (Sheet 2 of 3)

(14) Residual Data Group - This group is formed when there are six or less data bytes remaining in a data record. If six data bytes remain, the seventh byte of the Residual Data Group is the Auxiliary CRC Character (a data validity check character) and byte eight is the normal ECC. If there are less than six residual data bytes, pad characters of all zeros with correct parity are added to the data group to pad it to six bytes. Thus, the Residual Data Group consists of the remaining data bytes, the pad characters, the Auxiliary CRC Character (N), and the ECC (E). (All data groups must have eight bytes total in GCR mode.)

(15) Before this data group is written, the CRC character normally has odd parity if there was an odd number of data groups and even parity if there was an even number of data groups. If the record had an odd number of data groups the CRC character is even. Since an even parity byte is not allowed in a GCR Data Group, the CRC character must be made odd. To accomplish this, an additional pad byte consisting of all zeros and a parity bit (B) is added to the record. The addition of this byte changes the number of bytes in the CRC generation and provides an odd parity CRC character.

The next five bytes of the CRC Data Group are identical CRC characters. The additional CRC characters serve to fill the CRC Data Group, since there is no more data to be read.

Next in the CRC Data Group is the Residual character (X). By definition, this character is used as a record data counter. Bits 3-7 are the modulo 32 counter. These bits are used by STC in a proprietary manner. Bits 0-2 are used as a module 7 counter to indicate how many of the Residual Data Group bytes are data. The modulo 7 count of the Residual character indicates how many data bytes are to be retrieved from the Residual Data Group.

The ECC in this data group, as in all other data groups, is used to verify the correctness of data in the group and to isolate the error, if any, during read operations for data correction.

(16) Postamble - The Postamble is the mirror image of the Preamble except for the terminator control subgroup. In read backward operations, the Postamble is used the same way the Preamble is used in read forward operations. See the description of Preamble in Notes 1 through 4.

Check Characters - Three Check Characters are used in the GCR tape format: CRC (B), Auxiliary CRC (N), and ECC (E).

The CRC characters are used to verify data validity during write and read back check operations. The ECC is used to verify data validity and for data error identification and correction during read operations.

Figure A-4. GCR Data Block Format (Sheet 3 of 3)

APPENDIX B

FCU MICROPROGRAM

B.1 INTRODUCTION

This appendix shows how to locate the microprogram within the FCU and how to identify what level of microprogram is present. A brief description of microprogram associated problems and errors is also included.

A more detailed description of the microprogram, its operations and its source language statements, is provided in Section 5.3.

A microprogram listing is available to those users requiring it. Request the 1935 Microprogram Listing. Be sure to indicate the EC level and listing assembly PN of the microprogram present to ensure receiving the corresponding level of microprogram listing.

B.2 OPERATIONS

The FCU microprogram performs the following general types of operations:

1. Sets or resets addressable hardware latches to control data flow or for miscellaneous program storage.
2. Takes values from the micro-words and loads them into counters and registers for use in timing, counting, and control functions.
3. Sets, resets, and pulses hardware functions via set/reset micro-orders.
4. Tests specific system conditions and branches within the microprogram, depending upon the result.

By performing these operations, the microprogram controls all data flow, formatting, deformatting, and status sensing taking place within the FCU.

EC 44539
KIT PN 98783-3

9357

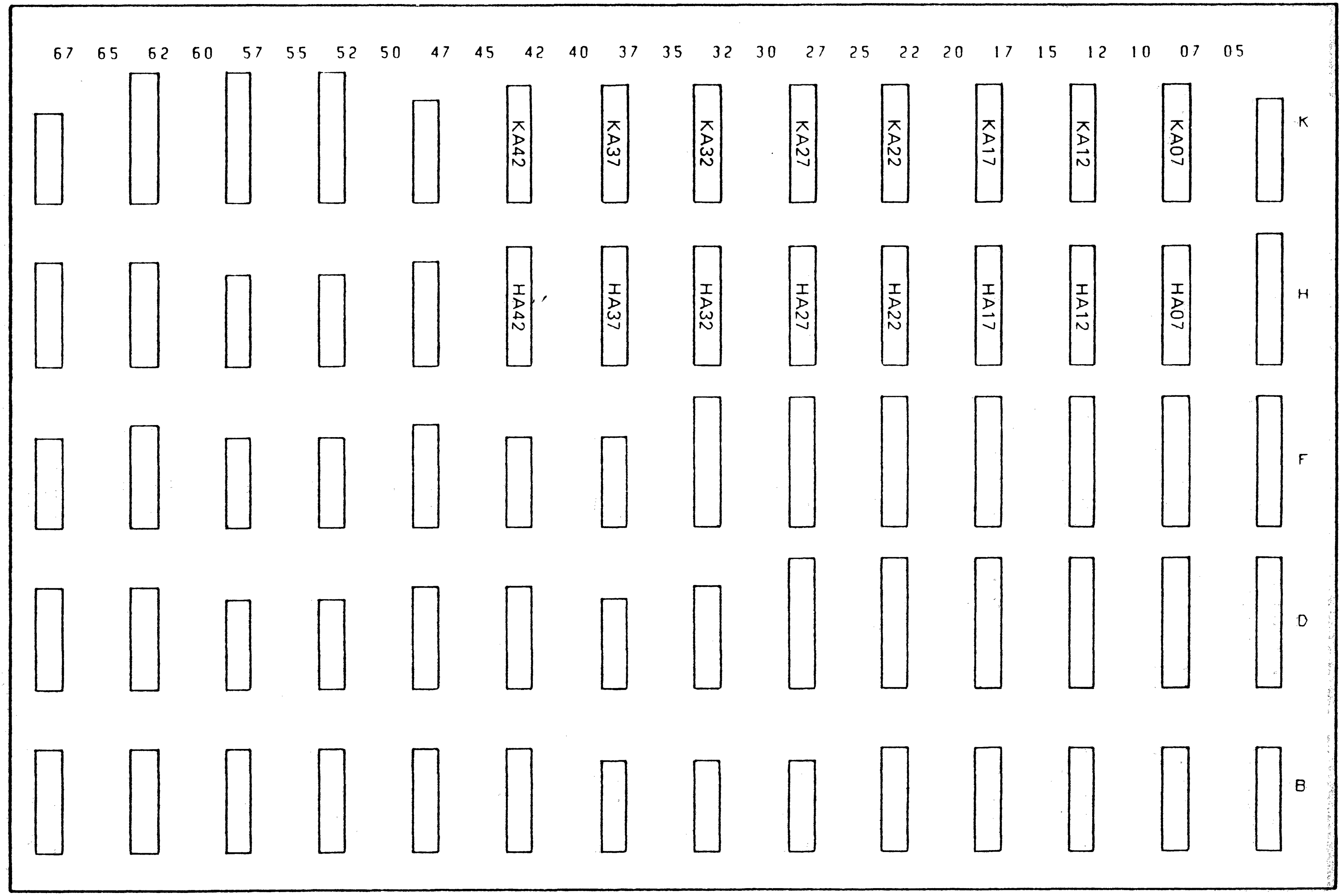


Figure B-1. Microprogram PROM Locations

B.3 LOCATION

The microprogram is stored in 1K by 4-bit ROMs located on the KE logic card in slot E2. The microprogram is divided into four 1K sections:

Addresses 000 to 3FF contain the 1st K (K1)
Addresses 400 to 7FF contain the 2nd K (K2)
Addresses 800 to BFF contain the 3rd K (K3)
Addresses C00 to FFF contain the 4th K (K4)

Each microprogram address contains a 16 binary bit word. The bits are labeled P, 1, 2, 3,....15 with bit 15 being the least significant. Table B-1 lists the microprogram ROM locations and the microprogram word bits stored at each location. Figure B-1 shows the component side of the KE card and indicates the physical locations of the ROMs on the card.

Table B-1. Microprogram Bit Storage Locations

ROM LOCATIONS	SECTION	BITS
KA07	K1	P, 1, 2, 3
KA17	K1	4, 5, 6, 7
KA27	K1	8, 9, 10, 11
KA37	K1	12, 13, 14, 15
KA12	K2	P, 1, 2, 3
KA22	K2	4, 5, 6, 7
KA32	K2	8, 9, 10, 11
KA42	K2	12, 13, 14, 15
HA07	K3	P, 1, 2, 3
HA17	K3	4, 5, 6, 7
HA27	K3	8, 9, 10, 11
HA37	K3	12, 13, 14, 15
HA12	K4	P, 1, 2, 3
HA22	K4	4, 5, 6, 7
HA32	K4	8, 9, 10, 11
HA42	K4	12, 13, 14, 15

B.4 FUNCTION ISOLATION

The microprogram is organized so that many sections of the microprogram are used in more than one mode of operation. However, some generalizations can be made regarding the operations controlled in each section of memory. Table B-2 summarizes this information.

Table B-2. Microprogram Function Isolation Chart

MICROPROGRAM SECTION	FUNCTION
K1	Idle loop power up reset Power up reset GCR write data PE write preamble and postamble PE/GCR read and space commands
K2	PE/GCR read back check PE/GCR write ID-BURST GCR write preambles and postambles PE write data Write prefetch TREQ/TRAK control Bit cell timing ID-BURST determination LWR speed set CRC check Mode set Initial routing to all diagnostic sections Check drive status Diagnostic operation
K3	Diagnostic operation
K4 (This section of memory may not be present in PE/GCR-only FCUs)	NRZI read and write NRZI spacing NRZI diagnostic operation

B.5 LEVEL

To determine the microprogram level present in a given FCU, examine the microprogram ROMs and compare the ROM part numbers to the compatibility listing in Table B-3.

The microprogram level is also stored within the microprogram and may be determined by viewing the diagnostic aid bits, after a given command sequence. Two different levels are used to describe the total microprogram level. The first 3K of memory (sections K1, K2, and K3) are given one level. This level can be obtained by issuing a DMS command followed by an ERG command both with the Select Multiplex lines set to zeros and the Density Select lines set to PE or GCR. The 4th K of memory controls NRZI operations exclusively and is given a separate, NRZI, microcode level. This level is obtained in the same manner as the PE/GCR level except the Density Select lines should select the NRZI mode of operation. The Diagnostic Aid Bits 3, 2, 1 and 0 (Bit 0 is the least significant) represent the microprogram level. In addition, Bit 7 is always asserted and Bit 6 is asserted to indicate that the FCU is capable of NRZI operation.

Table B-3. Microprogram Compatibility List (Sheet 1 of 3)

RELEASE	PRE-RELEASE SHIP LEVEL 0 (JF)	PRE-RELEASE SHIP LEVELS 1-4 (KE)	PRE-RELEASE SHIP LEVELS 5-7 (PF)	SHIP LEVELS 8-16 (RN)
PROM PN				
KA07				401293201-0
KA17				401293301-8
KA27				401293401-6
KA37				401293501-3
KA12				401293601-1
KA22				401293701-9
KA32				401293801-7
KA42				401293901-5
HA07				401294001-3
HA17				401294101-1
HA27				401294201-9
HA37				401294301-7
HA12	NOT PRESENT	NOT PRESENT		401294401-5
HA22	NOT PRESENT	NOT PRESENT		401294501-2
HA32	NOT PRESENT	NOT PRESENT		401294601-0
HA42	NOT PRESENT	NOT PRESENT		401294701-8
ENG LEVEL (DA BITS)				
PE/GCR	81 HEX	81 HEX	82 HEX	83 HEX
NRZI	NA	NA	C2 HEX	C3 HEX
EC NUMBER	NA	NA	NA	EC 44251
LISTING ASSY PN	NA	NA	NA	91535
DESCRIPTION	Capable of running 1920 TUs only.	Runs 1950 TUs at 125 ips in PE and GCR and 1920 TUs. Capable of booting diagnostics from tape.	Adds NRZI code and eliminates diagnostic read commands unless data is transferred. Requires Release 3 or higher diagnostics	Runs Release 3 diagnostics (Level 4). Allows setting SSC for REW at LP (future hardware change required). NRZI: Eliminates reject code 17 near BOT. Eliminates velocity errors near BOT. Fixes WRT INHBT test. Forces VRC ERR when LRC=0. Allows finding tie if CRC=0. PE/GCR: Corrects access time test for 50/150 ips. Sets phase thresholds to 40% in functional mode (requires KD with EC 44345 installed). Allows writing ROT tapes at 50/75 ips. Delays PE/GCR EOD PLS to std interface. Eliminates TRK P splash in ARA-ID burst at 75 ips. Shortens TM to 144 transitions in PE and 400 in GCR.

Table B-3. Microprogram Compatibility List (Sheet 2 of 3)

RELEASE	SHIP LEVEL 17 (RP)	SHIP LEVEL 17 - 22 (SX)
PROM PN		
KA07	401293201-0	401293202-8
KA17	401293301-8	401293302-6
KA27	401293401-6	401293402-4
KA37	401628801-3	401293502-1
KA12	401293601-1	401293602-9
KA22	401293701-9	401293702-7
KA32	401293801-7	401293802-5
KA42	401293901-5	401293902-3
HA07	401294001-3	401294002-1
HA17	401294101-1	401294102-9
HA27	401294201-9	401294202-7
HA37	401294301-7	401294302-5
HA12	401294401-5	401294402-3
HA22	401294501-2	401294502-0
HA32	401294601-0	401294602-8
HA42	401294701-8	401294702-6
ENG LEVEL (DA BITS)		
PE/GCR	83 HEX	86 HEX
NRZI	C3 HEX	C6 HEX
EC NUMBER	EC 44556	EC 44511
LISTING ASSY PN	91660-1	91620-5
DESCRIPTION	GCR: Eliminates possibility of losing data on rewrites of good records.	General: Eliminates FCU "hang" if TU reset. Allows more time to buffer data before a WRT. Corrects mispositioning if STOP set outside spec on block commands. Eliminates delay for successive backward commands if timer bit expired. Eliminates false REJECT code 17 when writing first record from BOT. Decreases TU stop delay to speed data through-put. Eliminates false tach lines at TU start up. Corrects amp sensor diagnostic at 50/75 ips. Eliminates possible mispositioning for BSB after a bad WRT. Changes PROM PNs to correct intermittent ROMPS errors. Eliminates setting BLOCK on SNS commands. Allows reading records with shorter preambles or more preamble skew. Increases discrimination between a "crease" and a true IBG. Prevents Data Detected on erase for NRZI WRT TM. Adds setting DATA-CK if unsuccessful. Corrects timeout counts for BSB after bad WRT. These require concurrent 1950 TU code EC44432 or higher: Corrects TU runaway on SNS command. Adds DSE capability. Adds REJECT code 7-DSE not executable. NRZI: Resets ID BRST before writing first record from BOT. Adds test to read LRCC. Eliminates setting BLOCK on WTM; and FSF and BSF over records. PE: Corrects timing on last byte of WTM. Eliminates check for GCR ARA-ID in backward mode.

Table B-3. Microprogram Compatibility List
(Sheet 3 of 3)

RELEASE	SHIP LEVEL 23 - (TA)
PROM PN KA07 KA17 KA27 KA37 KA12 KA22 KA32 KA42 HA07 HA17 HA27 HA37 HA12 HA22 HA32 HA42	 401293503-9 401293403-2 401293303-4 401293203-6 401293602-9 401293702-7 401293802-5 401293902-3 401294303-3 401294203-5 401294103-7 401294003-3 401294703-4 401294603-6 401294503-8 401294403-1
ENG LEVEL (DA BITS) PE/GCR NRZI	 86 HEX C6 HEX
EC NUMBER	EC 44813
LISTING ASSY PN	402555201
DESCRPTION	Corrected NRZI gap after first record off BOT from 0.43 inch to 0.6 inch. Corrected positioning problem on a NRZI rewrite of a bad record. Corrected future exposure to an incorrect error message callout in the media defect diagnostic routine.

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