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END-ITEM MODEL NO. ____

END-ITEM PART NO. ____

SALES ORDER NO. ____

SERIAL NO. ____

DATE ____

2790 Series Magnetic Tape Unit

OPERATION & MAINTENANCE MANUAL

AMCOMP

686 WEST MAUDE AVENUE

SUNNYVALE, CALIFORNIA 94086

Chapter 1

GENERAL INFORMATION

1-1 INTRODUCTION

This chapter describes and illustrates the 2790 Series Magnetic Tape Unit (figure 1-1) and its major components. This chapter also defines interface capabilities and describes the optional equipment and accessories available with the unit. Performance specifications and equipment characteristics are listed at the end of the chapter.

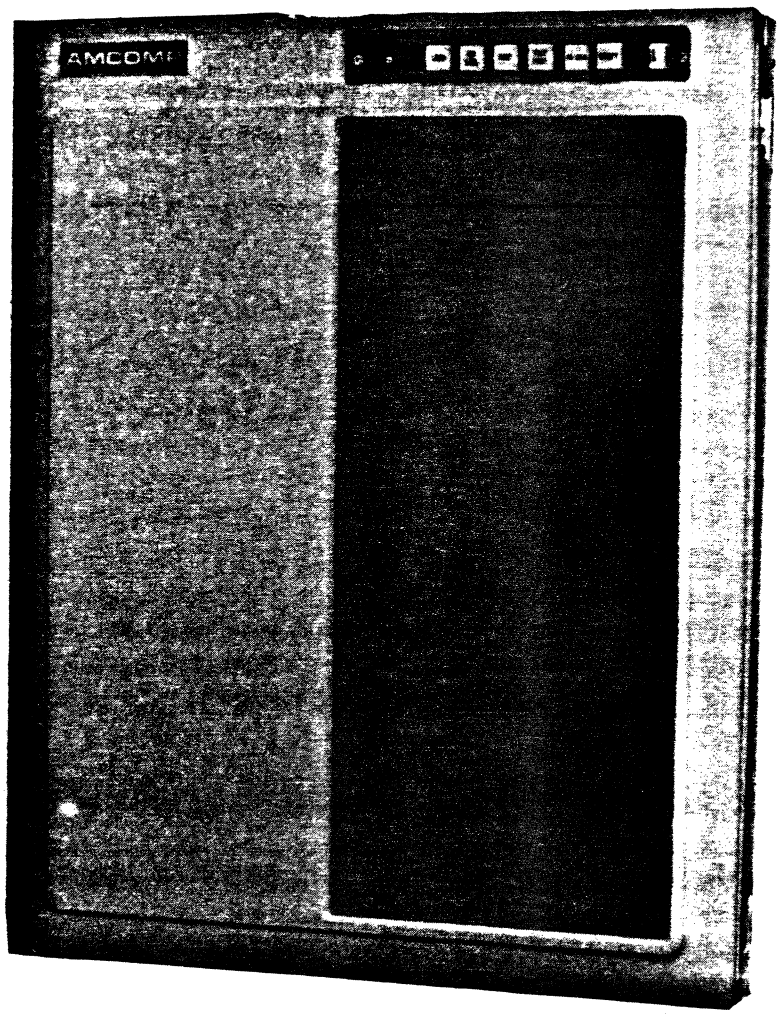


Figure 1-1. 2790 Series Magnetic Tape Unit

1-2 FUNCTIONAL DESCRIPTION

The 2790 is a highly reliable, dual vacuum column, digital magnetic tape drive which reads and writes data in ANSI and IBM compatible formats using either NRZI or phase encoded (PE) methods. Data may be recorded on 7- or 9-track tapes at 125, or 75 inches per second (ips). The 2790 can read 7- or 9-track tapes recorded on any other ANSI or IBM compatible tape unit; conversely, any such unit can read tapes recorded on the 2790. Up to four tape units can be daisy-chained and individually addressed by the same external controller.

The magnetic tape unit may be equipped with a single gap read/write head or a dual gap, simultaneous read and write head. A separate erase head is mounted ahead of the write head except on read-only tape units.

The tape unit is designed specifically for remote control of the read, write, forward, reverse, rewind, and packing density select functions. Available options are described in paragraph 1-4.

The tape unit uses dual column vacuum chambers which maintain tape tension within ANSI specifications. The position of the tape in a vacuum column is sensed by a tape position sensor covering the length of each column. The tape position sensor is driven by an oscillator and is sensed by an amplifier and a synchronous detector circuit located on the tape control board. Since the tape position sensor is the length of the column, the output of the detector is a voltage linearly related to the position of the tape.

To prevent damage to the tape, two holes located in each vacuum chamber limit the range of the tape loop. When the tape is properly tensioned, the upper hole on the supply vacuum column is at atmospheric pressure while the lower hole is at vacuum. The two holes are connected through tubing to opposite sides of a pressure switch. The contacts of the pressure switch are closed when vacuum and atmospheric pressure are across the switch. For example, if the supply tape loop drops below the lower hole in the vacuum column, the hole no longer is at vacuum, but at atmospheric pressure, causing the pressure switch contacts to open. Alternately, if the tape loop rises above the upper hole in the vacuum column, the hole no longer is at atmospheric pressure, but is at vacuum. The pressure switch contacts open, the servos are immediately disconnected from the motors, the vacuum motor turns off and write current is removed from the data board. All tape motion stops and the write electronics is prevented from erasing data.

Each tape unit contains a tape control circuit board, and a data circuit board. (More than one data circuit board may be included depending on the optional configuration selected.) The tape unit also contains a power supply module and power supply regulator circuits.

The data board provides the data reading and writing functions. Write data signals enter by an edge connector on one end of the board. They are buffered by a register which drives the write head. The write and read head connections are made through two connectors in the center of the board. The signals from the read head are amplified, differentiated, and compared to a threshold. For PE data boards, the signals are buffered and strobed out with a read strobe. The read signals are connected to the interface by an edge connector at the other end of the board.

The tape control board receives control signals from the external controller and uses these signals to drive the reel servo amplifiers, ramp generators, capstan servo, and BOT/EOT amplifiers in controlling tape movement. The tape control board also contains the voltage regulators which receive unregulated +20 and -20 Vdc from the power supply module and provide regulated +5, +10, -5, and -10 Vdc to the tape unit circuitry.

The power supply module receives 115 Vac line power and provides unregulated +20 and -20 Vdc to the voltage regulator circuits, and unregulated +20, -20, +36, and -36 Vdc to the reel and capstan servo circuits.

The tape unit logic circuitry uses negative logic; that is, logic 1 is negative relative to logic 0. The input logic levels must be compatible with this logic in order for the tape unit to operate properly. Input levels required are logic 1 = 0.0 to +0.4 Vdc; logic 0 = +2.5 to +5.0 Vdc.

1-3 PHYSICAL DESCRIPTION

The magnetic tape unit mounts in a standard 19-inch wide electrical equipment rack and requires 24 inches of vertical rack space. The tape handling components, heads, and operator controls and indicators are mounted on the front panel. A dust cover protects the tape and tape handling components from contaminants during operation.

The critical components of the tape unit (figure 1-2) are mounted on a precision machined tape unit baseplate. The capstan motor, reel servo motors, and other mechanical and electromechanical components are mounted on the back of the tape unit baseplate.

The control and data electronics are mounted on circuit boards attached to a frame which is hinged to the back of the tape unit baseplate. If the dual data board option is selected, a second data board is mounted to an additional hinged frame attached to the back of the tape unit baseplate. The power transistors are mounted on an air cooled heatsink. All external control and signal cables connect directly to the edge connectors of the circuit boards.

Each tape unit contains a minimum of two printed circuit boards: the tape control and data circuit boards. The tape control board contains the tape control logic, the reel servo amplifiers, ramp generators, capstan servo, BOT/EOT amplifier, and voltage regulators. All other mounted components, except the read/write head, also plug directly into the tape control circuit board. Options can be changed by simply changing jumpers in Molex option plugs on the board. Interface lines are connected to the control board by an edge connector.

Environmental conditions, weight, and physical dimensions are contained in table 1-2.

1-4 OPTIONAL CONFIGURATIONS

1-5 CONFIGURATION IDENTIFICATION

Since the magnetic tape unit is available in a variety of configurations depending on choice of number of tracks, type of head, packing density and

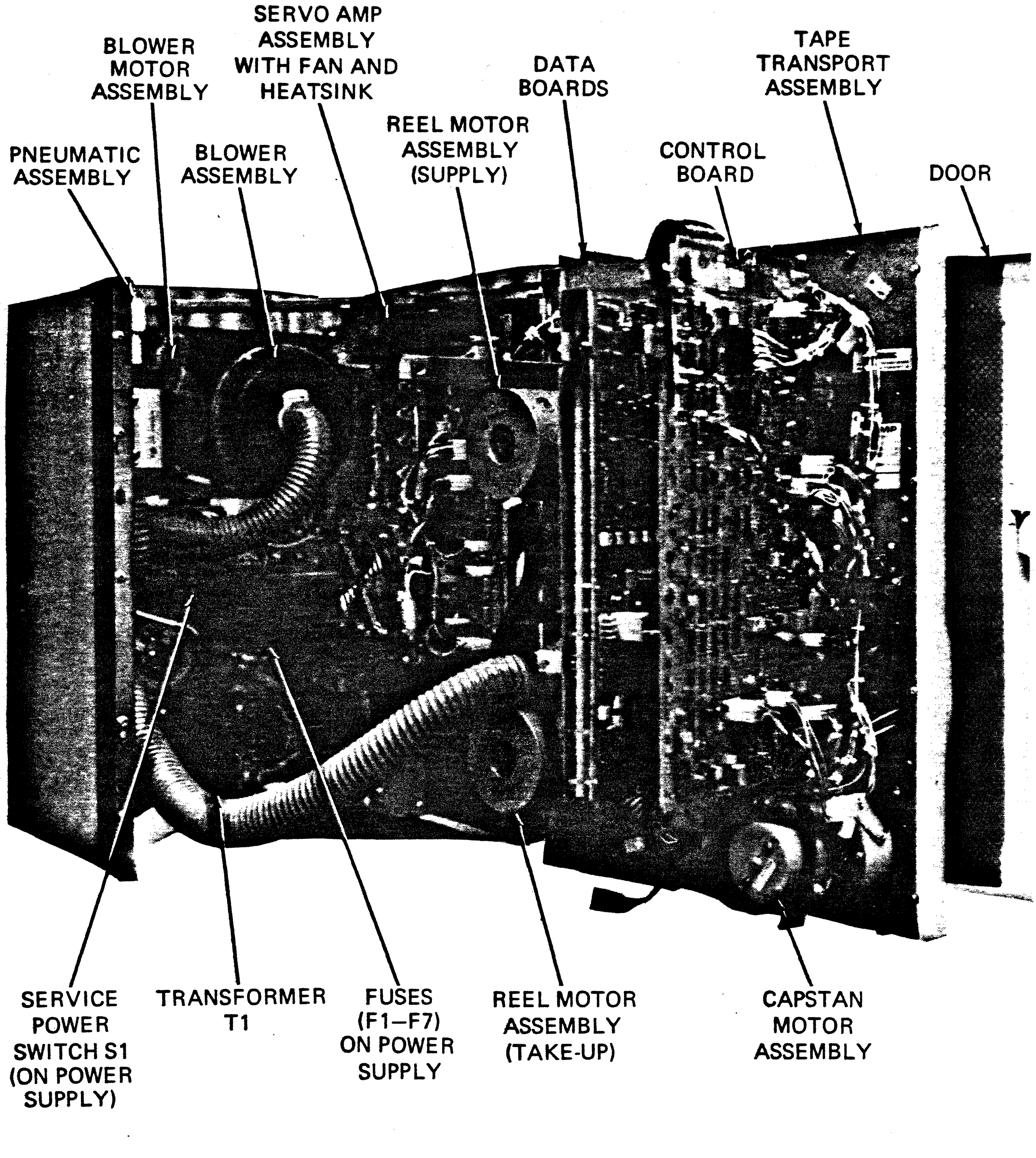


Figure 1-2. Open View of 2790 Series Magnetic Tape Unit

recording method, and tape speed, it is necessary to refer to the model number to determine the exact configuration of a particular unit. The model number is a hyphenated seven digit number located on the identifying tag attached to the back of the tape unit. The model number is composed of three base digits and four variable digits. In the example below, letters of the alphabet are used to indicate variable digits. The applicable numbers for specific configurations are listed in table 1-1.

Model 279W - X Y Z

- W — Number of Tracks
- X — Head Configuration
- Y — Packing Density and Recording Method
- Z — Tape Speeds

A "U" prefix to the model number indicates the optional UL-recognized version of the magnetic tape unit. The letter "A" after the "W" reference letter defines the current harnessing and subassembly configuration.

TABLE 1-1. OPTIONAL CONFIGURATION IDENTIFICATION LIST

REFERENCE LETTER	CHARACTERISTIC	CONFIG. NUMBER	CONFIGURATION
W	Number of tracks	7	Seven-track head
		8	Seven-track/nine-track head, read only
		9	nine-track head
X	Head configuration	1	Dual-gap head
		2	Single-gap head
Y	Packing density and recording method		Single Density
		8	800 bpi (NRZI, 7- or 9-track)
		6	1600 bpi (PE, 9-track)
			Dual Density
		7	800/1600 bpi (NRZI and PE, 9-track)
		5	800/556 bpi (NRZI, 7-track)
		4	556/200 bpi (NRZI, 7-track)
		3	800/200 bpi (NRZI, 7-track)
Z	Tape speeds (ips)	1	125
		2	125/62.6
		3	112.5
		4	125/75
		5	75

1-6 ADDITIONAL OPTIONS AND ACCESSORIES

In addition to the standard options listed in table 1-1, the following options are available.

1. Address Select Switch - a four-position thumbwheel switch, located on the front of the tape unit, for selecting the device address of a tape unit in installations where up to four tape units are daisy chained.

2. File Protect/Write-Enable - every tape unit is equipped with write protect circuits, but the front panel indicator can be selected to read FILE PROTECT or WRITE ENABLE. The indicator will be illuminated during the condition that corresponds to the name that appears on the indicator.

3. Density Select Interface Line- allows the bit density to be selected via the interface.

4. Status Lines Enable (Opt. 1) - allows the status lines (rewinding, file protect, BOT, and ready) to be enabled while the tape unit is selected and either on or off line. The remaining status lines are active only when selected and on line.

5. Status Lines Enable (Opt. 2) - allows all status lines to be enabled when the tape unit is selected and either on or off line.

6. Status Lines Enable (Opt. 3) - allows the status lines (rewinding, file protect, BOT, ready, EOT, high density, and on line) to be enabled when the tape unit is selected or not selected and on or off line.

7. EOT Status (EOTS) - an interface line that is asserted when the EOT tab passes the tab sensor. This line remains asserted until the tape is rewound or passes the EOT tab in reverse.

8. Double Load - On tape units equipped with double load circuits, the tape is tensioned first, then the operator must press LOAD to cause the tape to advance to the BOT marker. The double load sequence allows the operator to verify that the tape has been threaded and seated in the tape guides properly, before the tape is advanced to the BOT marker.

9. Tension after Power Failure - after power returns, the tape unit waits until all power supplies reach the required level. The tape unit then re-tensions the tape, loads tape into the columns and goes ON-LINE.

10. Dual Speed - this option allows the tape unit to run at two speeds. The speed is selected by one of two methods.

    a. 7-Track and 9-Track - this method allows the 7-track function to run at high speed and the 9-track function to run at low speed.

b. NRZI and PE - this method allows NRZI to run at high speed and PE to run at low speed.

11. Front Panel Disable - allows front panel switches to be disabled when the tape unit is selected and on line.

12. Off Line - this option enables pin 15 of J101 and J102 on the interface connectors. When this line is asserted for a minimum of 1 microsecond, the tape unit will go off line. This line is gated only with select (SLTA) allowing an off-line (IOFFL) command to be given after a REWIND command. The tape unit can only be placed on line (IONL) by pushing the manual ON-LINE switch.

There are numerous other detail configurations of interfacing, control and data signals that can be specified for different applications.

1-7 PERFORMANCE SPECIFICATIONS AND EQUIPMENT CHARACTERISTICS

Table 1-2 describes the electrical, environmental and mechanical specifications pertaining to the magnetic tape unit.

TABLE 1-2. PERFORMANCE SPECIFICATIONS AND EQUIPMENT CHARACTERISTICS

CHARACTERISTIC	VALUE
Type of tape storage	Vacuum Chamber - linear servo driven
Recording mode	NRZI or Phase Encoded - IBM- and ANSI-compatible
Number of tracks	7 or 9
Head configuration	Single or dual gap
Bit density	200, 556, 800, 1600 bpi
Tape speed	125 ips (maximum)
Rewind speed	375 ips
Data transfer rate	200,000 characters per second, maximum
Speed variation:	
Instantaneous	±3%
Long term	±1%
Start/stop time (milliseconds)	$\frac{375}{\text{tape speed (ips)}}$
Start/Stop displacement	0.190 (±0.02) inches

TABLE 1-2. PERFORMANCE SPECIFICATIONS AND EQUIPMENT CHARACTERISTICS (Continued)

CHARACTERISTIC	VALUE
SKEW:	
Write (NRZI)	Electronically compensated
Read	100 μ-inches, maximum
Dynamic	75 μ-inches, maximum
Tape tension	7 to 10 oz.
Reel size	10.5 in., maximum
Tape type (IBM P/N 457892 or equivalent):	Computer Grade
Width	0.5 inches
Thickness	1.5 mil
Beginning of tape (BOT) and End of tape (EOT) detectors	Photoelectric, IBM-compatible spacing
Tape cleaner	Perforated plate type
Read thresholds	NRZI: 12%, 25%, and 45% PE: 8%, 22%, and 26%
NRZI deskew window	50% of character time in Read mode. 40% of character time in Write mode.
Output signal parameter	
Asserted (True)	40 mA, maximum, current sink
Non-Asserted (False)	open collector
Power requirements:	
Line frequency	48 to 52 Hz, 58 to 62 Hz (in 2 steps)
Line voltage	95 - 125 Vac $\pm 10\%$ (in 5 steps) 190 - 250 Vac $\pm 10\%$ (in 10 steps).
Energy consumption rate	800 Watts, maximum
Environment:	
Temperature: Operating	$35^{\circ}F$ to $122^{\circ}F$
Temperature: Storage	$-50^{\circ}F$ to $160^{\circ}F$
Humidity	15% to 95% without condensating
Altitude	0 to 8,000 feet (in 4 steps)

TABLE 1-2. PERFORMANCE SPECIFICATIONS AND EQUIPMENT CHARACTERISTICS (Continued)

CHARACTERISTIC	VALUE
Dimensions	
Height	24 inches
Width	19 inches
Depth, overall	26.25 inches
Depth, from mounts	22.50 inches
Weight	185 lbs.
Shipping weight	215 lbs.

Chapter 2

INSTALLATION AND CHECKOUT

2-1 INTRODUCTION

This chapter contains installation instructions for the 2790 Series Magnetic Tape Unit. These instructions include information for installation planning, unpacking and inspection, installation, and checkout of the magnetic tape unit. Upon completion of the procedures contained in this chapter, the tape unit is ready for normal operation.

2-2 INSTALLATION PLANNING

2-3 EQUIPMENT LOCATION

The magnetic tape unit may be located adjacent to any other electronic data processing equipment provided the temperature, humidity, and other environmental characteristics are within the limits specified in table 1-2. The tape unit should not be located in a strong magnetic field because the recording head assemblies and other components can become magnetized, causing interference with the read/write operation. To obtain optimum performance from the tape unit, the ambient temperature fluctuation should be kept as small as possible and a reasonably clean and dust free environment should be provided. It is also important that a free flow of air is provided around the tape unit and through the rack in which the tape unit is mounted.

The magnetic tape unit mounts in a 19-inch electronic equipment rack cabinet and requires 24 inches of vertical rack space. When the tape unit is mounted, the rack should be located on a firm, vibration-free surface.

2-4 CABLING CONSIDERATIONS

The magnetic tape unit is shipped with all internal interconnect cabling completed and with data and control input connectors provided on the circuit boards. The data and control cabling from the formatter to the tape unit and external interconnect cabling required for daisy-chaining tape units may be ordered as an option from AMCOMP or they may be fabricated prior to installation. The connections of primary ac power terminal strip TB1 must also be checked at installation and, if necessary, re-wired. Specific cabling and power requirements are discussed in paragraphs 2-5 through 2-7; cable fabrication instructions are given in paragraph 2-8.

2-5 Data and Control Cabling

The data and control cabling from the external formatter to the tape unit normally consists of a single cable with one connector at the formatter end and three connectors at the tape unit end. The data input and output lines connect to edge connectors J301 and J201, respectively, of the data board. The control lines connect to connector J101 of the tape control board. Figures 2-1 through 2-3 show typical cabling diagrams for single data board, dual data board, and quad density options.

2-6 Cabling for Daisy-Chained Configurations

Figure 2-4 shows the cabling for four tape units connected in a daisy-chained configuration. The additional cable connectors must be ordered and external cables must be fabricated, or purchased as an option. The total length of all sets of data or control cables from the formatter to the last tape unit cannot exceed 50 feet. Table 2-1 lists the various lengths of the I/O cable to the AMCOMP 2000 Formatter and the interconnection cable between the tape units in the daisy chain. All tape units have the data and control signal output connectors (circuit card edge connectors), so that no equipment modifications need be performed; however, the signal line terminating resistors, normally installed on all units at the factory, must be removed on all except the last unit in the daisy chain. These resistor networks are 220/330 DIP type located as shown in figure 2-4. Figure 2-5 shows the schematic of the resistor networks.

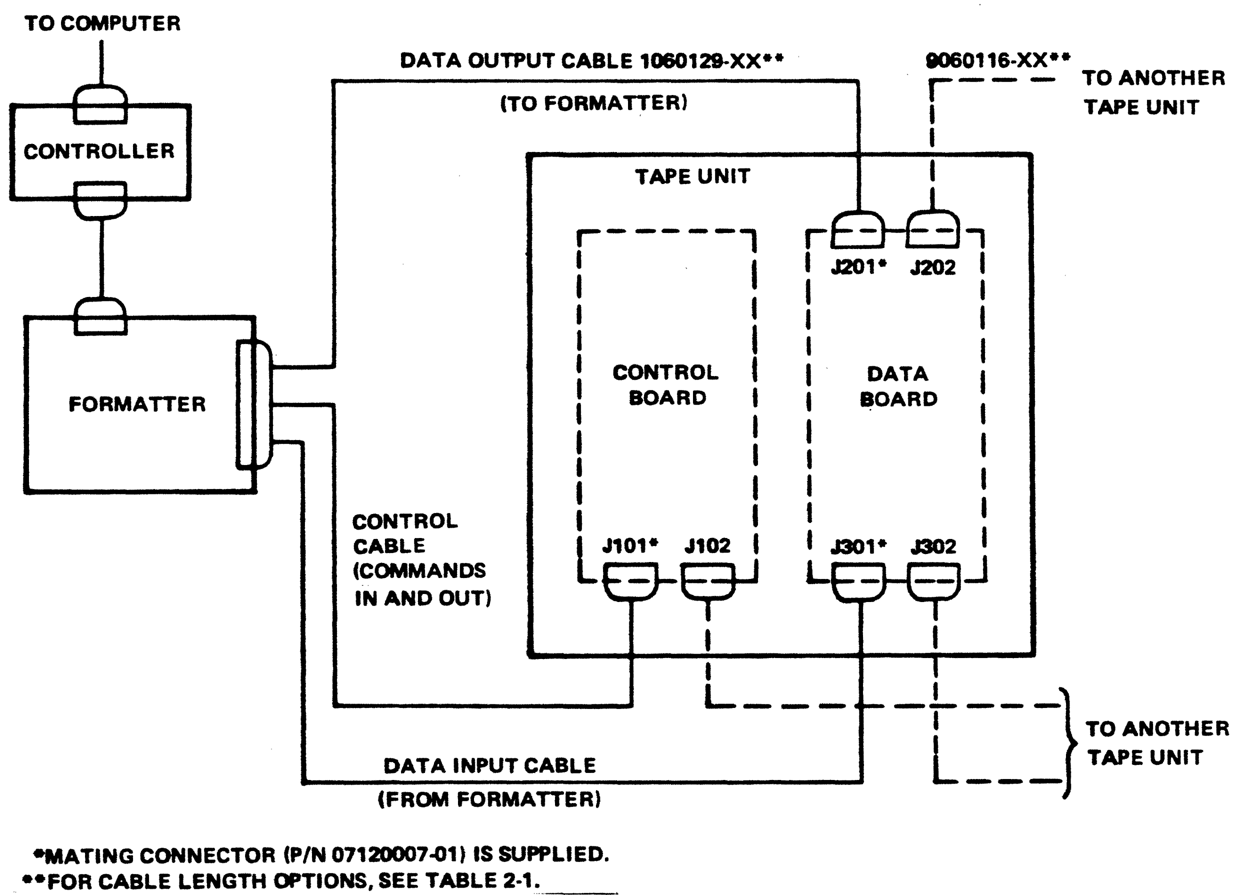


Figure 2-1. Typical Cabling Diagram, Single Data Board Option

TABLE 2-1. CABLE LENGTH OPTIONS

CABLE	LENGTH (In Feet)
I/O to AMCOMP Formatter	
1060129-01	4
1060129-02	8
1060129-03	12
1060129-04	16
1060129-05	20
1060129-06	6
Tape Interconnection	
9060116-01*	3.5 in.
9060116-02	6
9060116-03	12
9060116-04**	2

*Card interconnection cable
**Quad density

2-7 Primary AC Power Connections

Prior to application of power to the magnetic tape unit, the primary ac input power must be checked for proper connection. The connection requirements are given in figure 2-6. The ground lead in the primary ac power input cable provides sufficient grounding; no external grounding straps or other grounding devices are required.

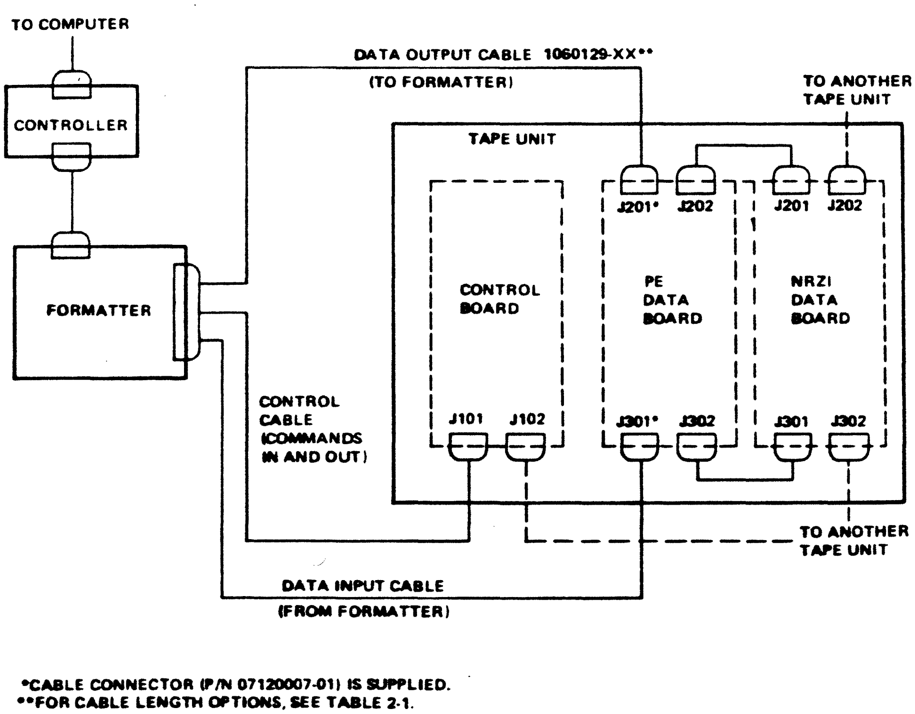
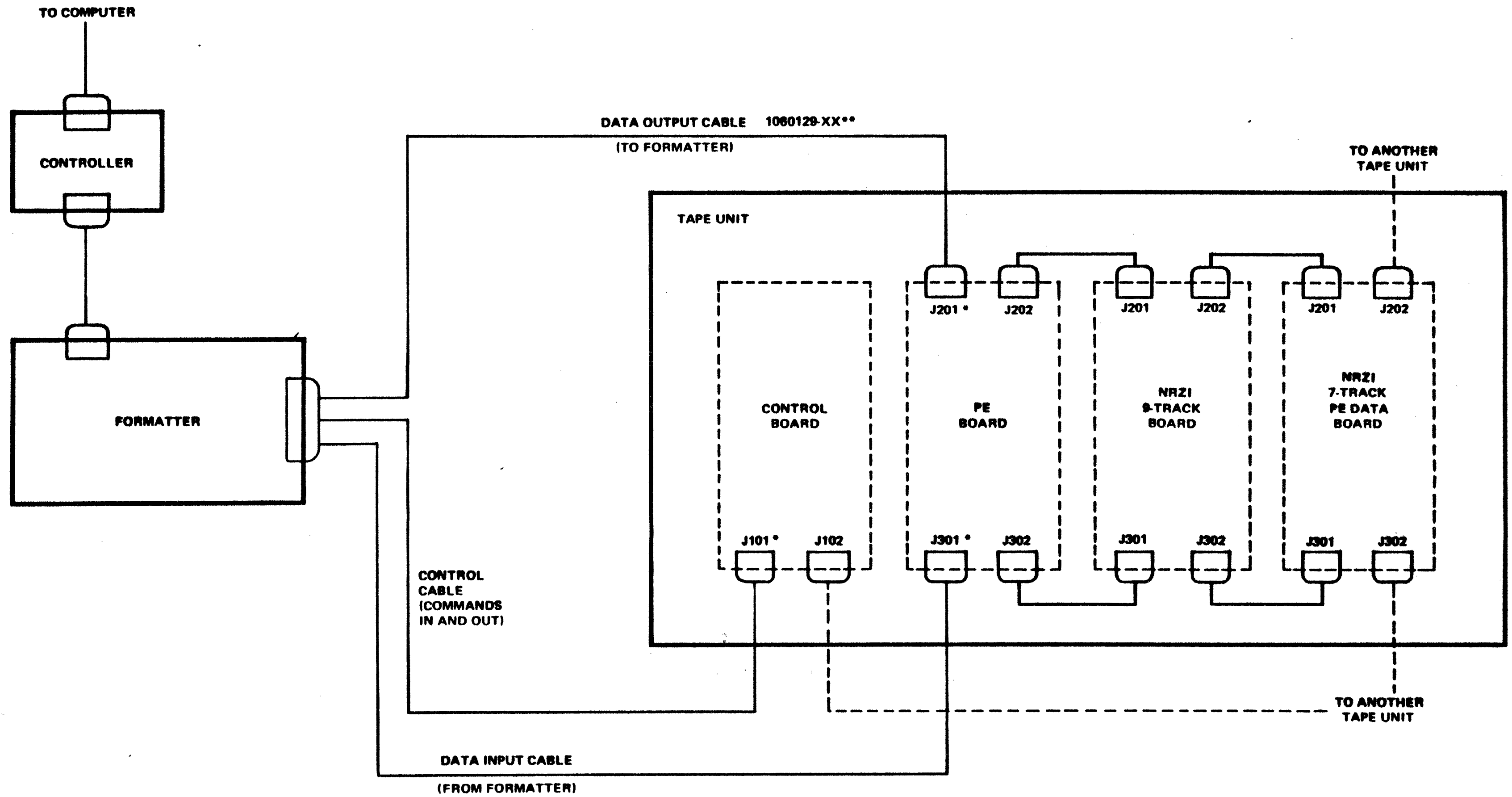
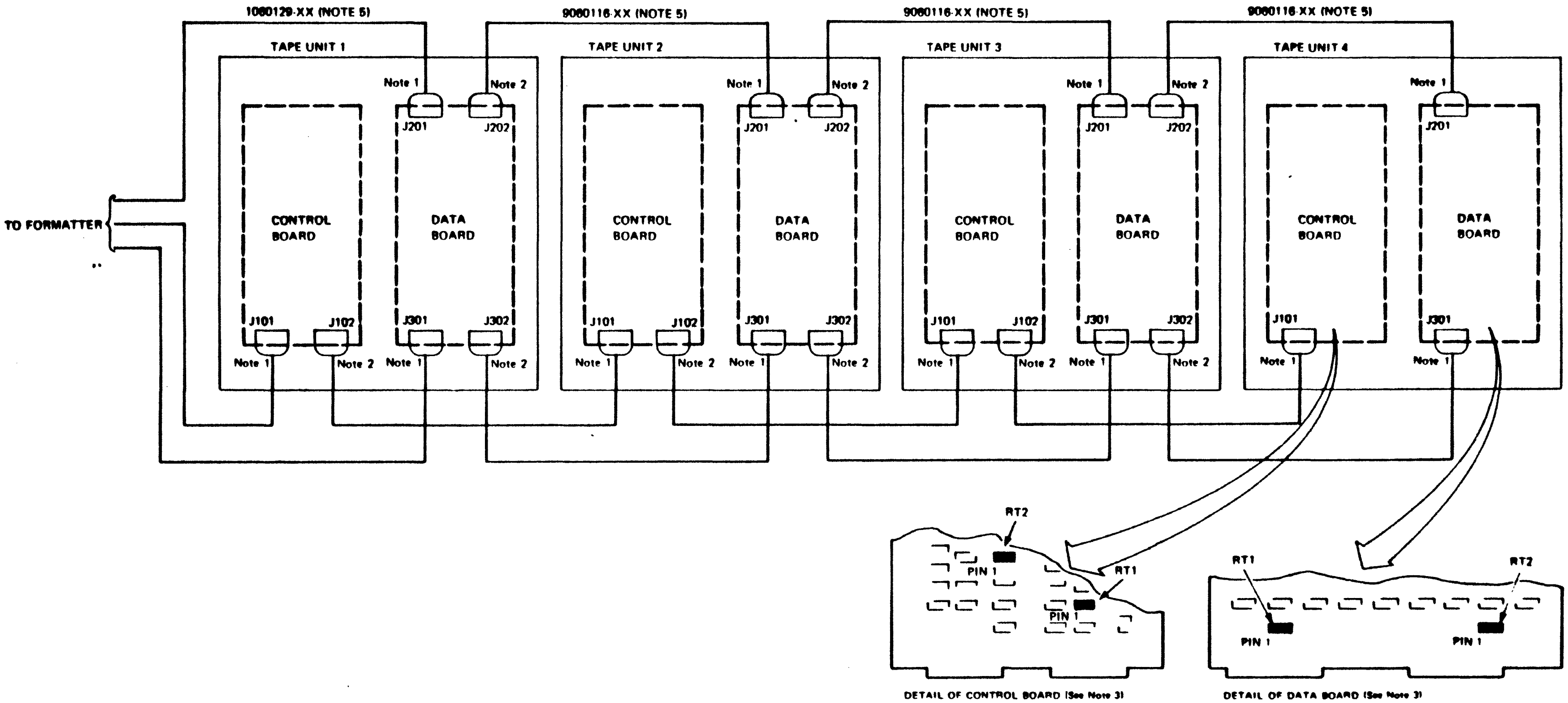


Figure 2-2. Typical Cabling Diagram, Dual Data Board Option



*CABLE CONNECTOR (P/N 07120007-01) IS SUPPLIED.
**FOR CABLE LENGTH OPTIONS, SEE TABLE 2-1.

Figure 2-3. Typical Cabling Diagrams, Quad Density Option



NOTES:
1. CABLE CONNECTOR P/N 07120007-01 (SUPPLIED).
2. CABLE CONNECTOR - SAME AS NOTE 1, BUT NOT SUPPLIED.
3. TERMINATING RESISTOR (P/N 04600001-02 NETWORKS ARE TO BE REMOVED FROM ALL EXCEPT THE LAST TAPE UNIT IN THE DAISY CHAIN.
4. UP TO FOUR TAPE UNITS MAY BE DAISY-CHAINED.
5. FOR CABLE LENGTH OPTIONS, SEE TABLE 2-1.
6. AC POWER TO THE TAPE UNIT WITH TERMINATORS (LAST UNIT) MUST BE ON WHILE THE OTHER TAPE UNITS ARE IN OPERATION.

Figure 2-4. Typical Cabling Diagram, Daisy-Chained Configuration

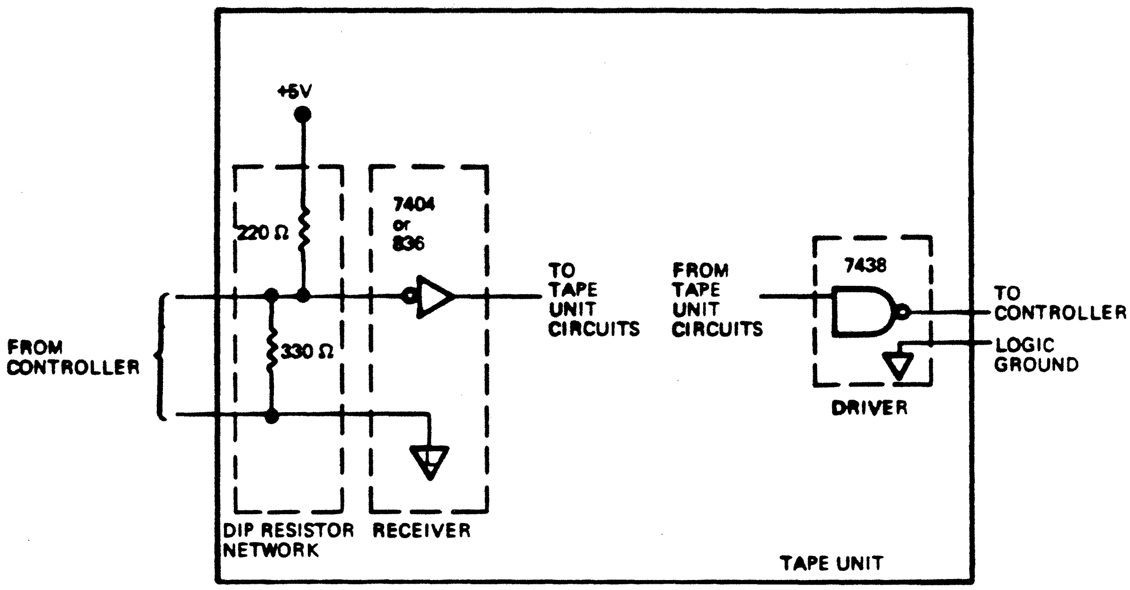


Figure 2-5. Tape Unit Interface Circuits

2-8 CABLE FABRICATION

The interface is designed for twisted pair cables with returns grounded. The wire should be 26 AWG with thin insulation and twisted about 20 turns per foot. The maximum length can be 50 feet. The twisted pairs should be grounded within a few inches of the receiver.

The mating connector is AMCOMP P/N 07120007-01 or equivalent. All connector pin assignments are contained in tables 2-2, 2-3, and 2-4.

2-9 INTERFACE CIRCUITS

The tape unit data board drivers and receivers are shown in figure 2-5. The interface must be compatible with these circuits in order for the tape unit to function correctly.

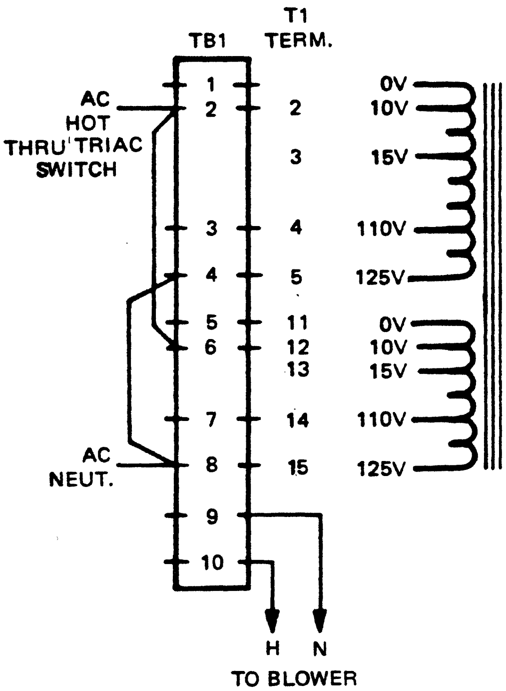
Logic Levels:

Logic 1 (true)	0.0 to +0.4 Vdc
Logic 0 (false)	+2.5 to +5.0 Vdc

2-10 INSTALLATION

2-11 UNPACKING AND INSPECTION

The tape unit is shipped in a special double packing case, which should be saved if reshipment of the equipment is planned. Within the packing case the tape unit is attached to a shipping frame which can be used to hold the tape unit upright when the unit is removed from the packing case and placed on a level surface. There is also a separate shipping kit contained in the packing case.



If The Input Volts (RMS) is	TRANSFORMER T1 Connect Input Power To Terminals	and Jumper Between	and Jumper Between
95	3 and 4	3 and 13	4 and 14
100	2 and 4	2 and 12	4 and 14
110	1 and 4	1 and 11	4 and 14
115	2 and 5	2 and 12	5 and 15
125	1 and 5	1 and 11	5 and 15
190	3 and 14	4 and 13	-
200	2 and 14	4 and 12	-
210	2 and 14	4 and 11	-
215	2 and 15	4 and 12	-
220	1 and 14	4 and 11	-
225	1 and 15	4 and 12	-
230	2 and 15	5 and 12	-
235	1 and 15	4 and 11	-
240	2 and 15	5 and 11	-
250	1 and 15	5 and 11	-

Figure 2-6. Input Power Transformer Primary Winding Diagram

TABLE 2-2. TAPE UNIT CONTROL AND STATUS CONNECTIONS (J101, J102)

SIGNAL CONNECTOR PIN	GROUND CONNECTOR PIN	SIGNAL NOMENCLATURE
		COMMAND INPUTS
J	8	ISELECT 0
A	8	ISELECT 1
18	8	ISELECT 2
V	8	ISELECT 3
C	3	ISFC (Forward)
E	5	ISRC (Reverse)
H	7	IREW (Rewind)
L	10	IREU (Rewind and Unload)

TABLE 2-2. TAPE UNIT CONTROL AND STATUS CONNECTIONS (J101, J102) (Continued)

SIGNAL CONNECTOR PIN	GROUND CONNECTOR PIN	SIGNAL NOMENCLATURE
K	9	ISWRT (Set Write)
B	2	IOVW (Overwrite)
D	4	* IDDS (Density Select)
15	10	* OFF-LINE
		STATUS OUTPUTS
T	16	IRDY (Ready)
M	11	IONL (On Line)
N	12	IRWD (rewinding)
U	17	IEOT (EOT)
R	14	IBOT (BOT)
P	13	IFPT (File Protect)
F	6	IDDI (High Density)
S	--	* +5 Volts (J-102 only)
* indicates tape unit option		

TABLE 2-3. TAPE UNIT DATA OUTPUT CONNECTIONS (J201, J202)

SIGNAL CONNECTOR PIN	GROUND CONNECTOR PIN	SIGNAL NOMENCLATURE
		DATA OUTPUTS
2	B	Read Data Strobe
1	A	Read Data Parity
3	C	Read Data 0
4	D	Read Data 1
8	J	Read Data 2
9	K	Read Data 3

TABLE 2-3. TAPE UNIT DATA OUTPUT CONNECTIONS (J201, J202) (Continued)

SIGNAL CONNECTOR PIN	GROUND CONNECTOR PIN	SIGNAL NOMENCLATURE
14	R	Read Data 4
15	S	Read Data 5
17	W	Read Data 6
18	V	Read Data 7
11	M	* Seven Track
12	N	* Single Stack
10	L	* NRZ
13	P	* Speed
5	--	+5V

NOTE: Read Data 0 and 1 are not used on seven track tape units.

* indicates tape unit option

TABLE 2-4. TAPE UNIT DATA INPUT CONNECTIONS (J301, J302)

SIGNAL CONNECTOR PIN	GROUND CONNECTOR PIN	SIGNAL NOMENCLATURE
		DATA INPUTS
E	5	Read Threshold 1
F	6	Read Threshold 2
A	1	Data Ready
C	3	LRC Strobe
L	10	Write Data Parity
M	11	Write Data 0
N	12	Write Data 1
P	13	Write Data 2
R	14	Write Data 3

TABLE 2-4. TAPE UNIT DATA INPUT CONNECTIONS (J301, J302) (Continued)

SIGNAL CONNECTOR PIN	GROUND CONNECTOR PIN	SIGNAL NOMENCLATURE
S	15	Write Data 4
T	16	Write Data 5
U	17	Write Data 6
V	18	Write Data 7
H	--	+5V
NOTE: Write Data 0 and 1 are not used on seven track tape units.		

The shipping kit contains the rack mounting hardware for the tape unit and other necessary parts.

As the equipment is unpacked, care should be exercised to prevent damage to the finished surfaces of the tape unit and all parts should be inspected for evidence of damage during shipment. If the packing case or any tape unit parts are damaged, advise AMCOMP, INC. and file a claim with the transfer company. The following procedure should be followed for unpacking and inspecting the tape unit:

a. Inspect the packing case for evidence of in-transit damage. Contact the transfer company and AMCOMP, INC. if damage is evident. Specify nature and extent of damage.

WARNING

The tape unit on shipping frame weighs over 200 pounds. To prevent personal injury or damage to the equipment, the tape unit should be lifted by two people.

b. Open the outer and inner packing case and remove the contents. Check items against the shipping list to verify packing case contents. Contact AMCOMP, INC. in the event of a packing shortage.

c. Remove any additional packing material and verify that the serial number of the unit corresponds to that shown on the shipping invoice.

d. Visually inspect the exterior of the tape unit for evidence of physical damage that may have occurred in transit.

e. Check major component assemblies to determine if any assemblies or screws have been loosened. Tighten any loose screws or mounting hardware. Inspect all Molex connectors.

2-12 MOUNTING

To mount the tape unit, refer to figure 2-7 and proceed as follows:

a. Remove the two hinge bases from the shipping kit and mount them on the rack cabinet 19.25 inches apart.

b. Place the tape unit on a level surface face up and remove the three screws that hold the unit to the shipping frame.

c. Lift the tape unit and set it on the hinges in the 90-degree open position (figure 2-7). The tape unit is now mounted in place and can be swung to closed position and latched.

NOTE:

The safety blocks should be installed if the tape unit and the rack cabinet are to be tipped over on side or back. The safety blocks keep the tape unit from slipping off the hinge bases.

2-13 INSTALLATION CHECKOUT

a. After the tape unit is installed in place, check again for any damage and missing or loose components. Check also for loose relays, and loose connectors or terminal connections on circuit boards and other assemblies.

b. Check and verify that the input power terminal strip is connected correctly to supply the primary power voltage from which the tape unit is to be operated (figure 2-6).

c. Verify that the pulley supplied is the correct one for the line frequency specified on the factory label. To adjust for high altitude, or to change power frequency, see figure 2-9 and table 2-5.

d. Check the six fuses located on the power supply at the inside back of the tape unit. These fuses are identified in figure 2-8.

e. Refer to Chapter 3 to become familiar with tape unit controls and operating procedures before applying power to tape unit.

f. Plug in the primary power cable and turn on equipment power with the ON/OFF switch on the front of the tape unit, and the service power switch at the rear of the tape unit. Verify that tape unit power comes on.

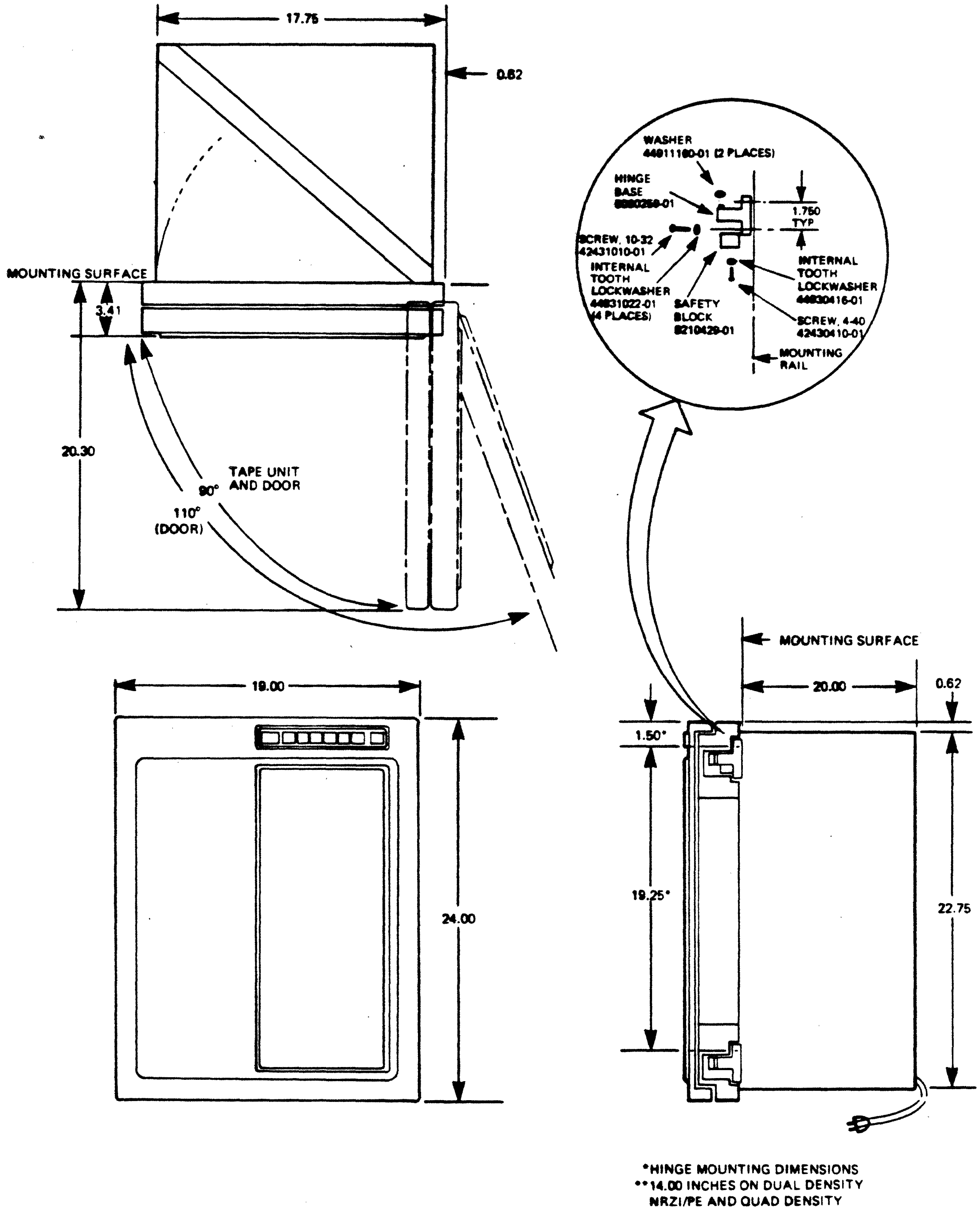


Figure 2-7. Installation Mounting Dimensions for the 2790 Tape Unit

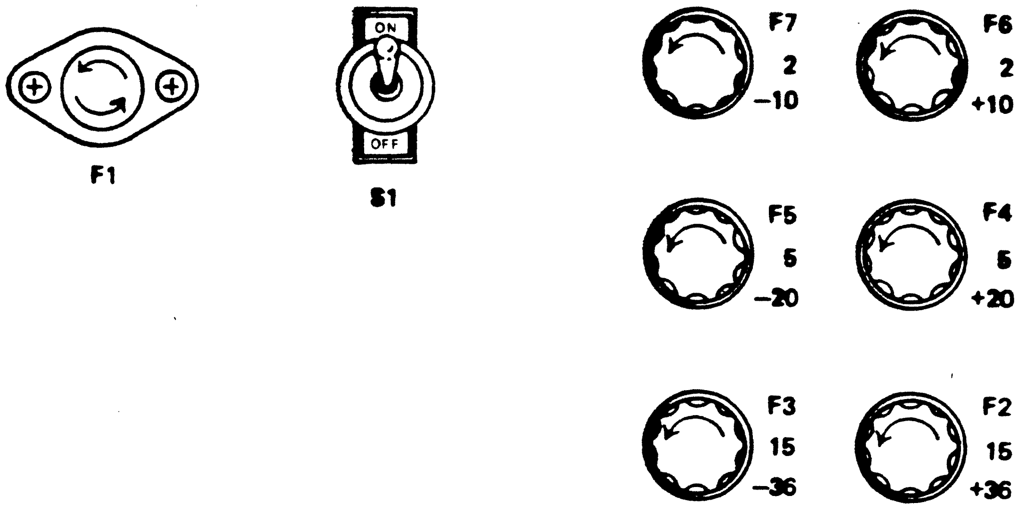


Figure 2-8. Tape Unit Fuses

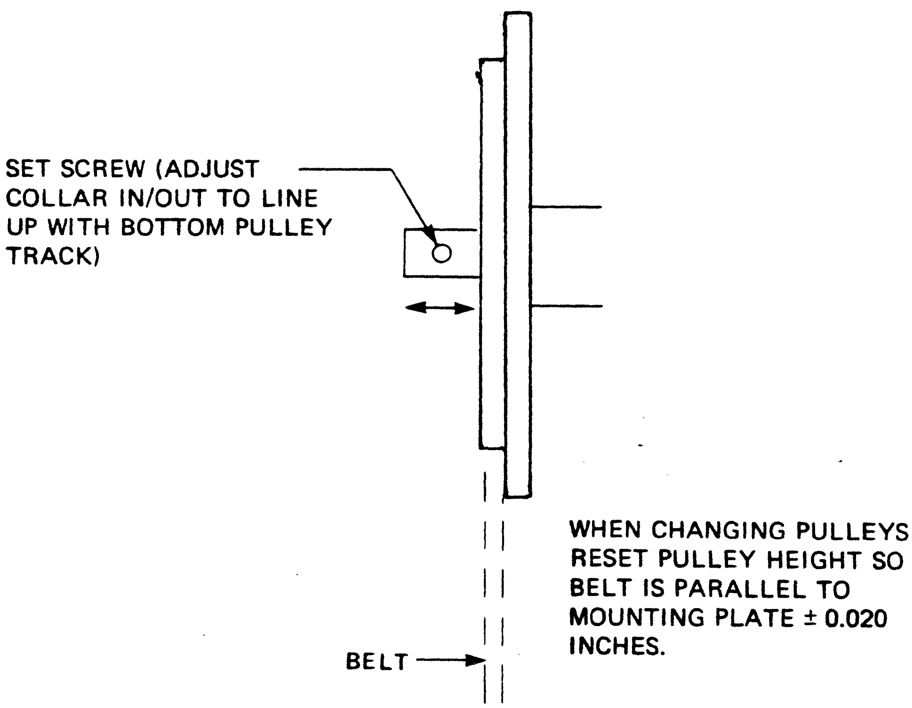


Figure 2-9. Blower Motor Pulley/Belt Positioning

g. Load a reel of tape on the tape unit according to the procedure in paragraph 3-4. This will verify that the tape unit can move tape and can execute the loading sequence properly.

h. Use the forward/reverse toggle switch on the tape control logic board to move the tape first in the forward and then in the reverse direction. This will verify that the tape unit operates properly in both directions.

i. Press the RWD pushbutton to verify that the tape properly rewinds (at 200 ips) and stops at the BOT marker.

j. Press the RWD pushbutton again to verify that the tape unit unloads tape properly.

The magnetic tape unit is now ready for normal operation. Refer to Chapter 3 for information pertaining to the operation of the tape unit.

TABLE 2-5. PULLEY AND BELT POSITIONING

FREQ. (Hz)	ALTITUDE (Feet)	PULLEY PART NUMBER	PULLEY STEP	BELT PART NUMBER	BELT LENGTH (Inches)
50	0 - 2000	9210625-01	B	32000101-	
	2000 - 4000	9210625-01	A	32000101-	
	4000 - 6000	9210625-02	B	32000101-	
	6000 - 8000	9210625-02	A	32000101-	
60	0 - 2000	9210625-03	B	32000101-01	24.5
	2000 - 4000	9210625-03	A	32000101-01	24.5
	4000 - 6000	9210625-04	B	32000101-	
	6000 - 8000	9210625-04	A	32000101-	

Chapter 3

OPERATION AND INTERFACE

3-1 INTRODUCTION

This chapter provides operating instructions and interface information for the 2790 Series Magnetic Tape Unit. Operator controls and indicators are illustrated and described and step-by-step instructions for operation of the tape unit are included. Paragraph 3-6 presents I/O interface information, including signal definitions and logic levels.

3-2 CONTROLS AND INDICATORS

The basic operating controls and indicators of the tape unit are located on the front of the unit, accessible through an opening in the cover door. Several of these controls operate in conjunction with the interface command lines so that the function of a front panel control or indicator may be affected by the status of a command line between the interface and the tape unit. Normally, manual operation of the tape unit is performed only until the unit is placed on line. Operation is then transferred to an external formatter under software control. It is then necessary to take the tape unit off line only to change tape. The front panel controls are shown in figure 3-1 and described in table 3-1.

Service power switch S1 is not located on the front panel. This switch (shown in figure 1-2) is located beside the primary power fuse on the power supply. Service power switch S1 (on the power supply) controls the application of ac line power to the tape unit.

Alternate controls and indicators may be supplied depending upon the equipment options selected. These controls and indicators are not illustrated but are described in table 3-2.

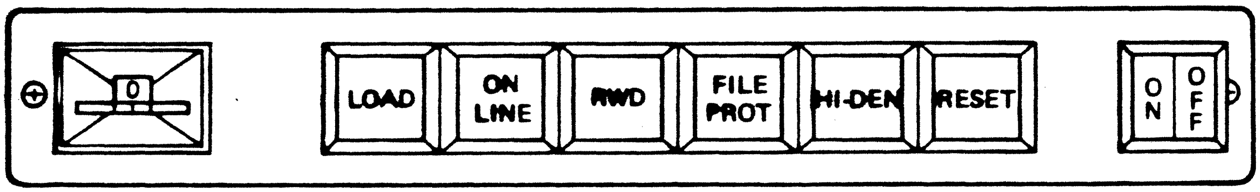


Figure 3-1. Tape Unit Front Panel Controls and Indicators

TABLE 3-1. CONTROLS AND INDICATORS

NAME	FUNCTION
LOAD	A backlighted pushbutton used in loading tape. After threading tape, press LOAD pushbutton to tension tape and advance it to the BOT tab. On double-load tape units, the pushbutton must be pressed twice. The pushbutton lights when the tape is tensioned and advanced to the BOT tab. Light goes out when the BOT tab moves off the sensor.
ON LINE	A backlighted pushbutton that is used to place the tape unit under remote control (on line). It can also be used to place the tape unit under local control (off line), but in this respect it operates in parallel both with the RESET pushbutton and the IREU interface command line; either can place the tape unit off line and extinguish the pushbutton light, but cannot place the tape unit on line. The ON LINE pushbutton lights to indicate that the tape unit is on line. Note, however, that it can be depressed and lit also when the tape unit is not selected (RESET pushbutton indicator not lit); in this case the tape unit is on line, but is not under remote control until selected.

TABLE 3-1. CONTROLS AND INDICATORS (Continued)

NAME	FUNCTION
RWD	A pushbutton used to rewind tape when the tape unit is off line. The tape will rewind past the BOT tab, then reverse and advance to the BOT tab and stop. If the tape is at the BOT tab and the RWD button is pressed, the tape will rewind slowly off the take-up reel.
FILE PROT	An indicator that lights when a write protected file reel is installed on the tape unit. This light is meaningful only after the tape has been tensioned.
HI-DEN	An alternate action indicator switch pressed to select packing density. When the switch is lit, the higher density is selected. The switch if functional in dual density NRZI/PE, or dual speed tape units, and operates in parallel with the IDDS command input line. This switch is not operational in the single density versions of the tape unit.
RESET	A backlighted pushbutton used to stop and reverse forward tape motion, and place the unit off line. The indicator light is on when the tape unit is selected by the formatter. Optionally, the indicator light can be wired so that it lights only when the tape unit is selected on line.
ON/OFF	A pivot switch that controls power to the tape unit. The switch is lit in the ON position by the -5 volt regulator.

TABLE 3-2. OPTIONAL CONTROLS AND INDICATORS

NAME	FUNCTION
1600 BPI	Alternate action indicator switch which replaces the HI-DEN switch on the optional NRZI and PE combination tape units. This switch is illuminated when 1600 bpi phase encoded operation is selected.
7/9 TRACK	On the optional 7-track and 9-track combination, this alternate action indicator switch replaces the HI-DEN or FILE PROT switches. This switch is illuminated when 9-track operation is selected.
ADDRESS SELECT	A rotary thumb switch whose first four positions (0, 1, 2, and 3) are used to select the active address for the tape unit. This switch operates in conjunction with the ISELECT 0-3 command input lines from the formatter. If the tape unit is not equipped with this switch, its address (select code) is zero. Switch position should be changed only while the tape unit is off line.

3-3 OPERATING PROCEDURES

3-4 LOADING TAPE

Verify that service power switch S1 is in the ON position and proceed as follows:

a. Press the ON side of the power ON/OFF switch on the front panel.

NOTE:

The ON indicator should light. Other indicators which may light are RESET (if the tape unit is selected by the formatter:, HI-DEN, and FILE PROT. No other indicators should be lighted.

b. Lift the upper reel hub loading latch, place a loaded reel on the hub and push it until seated. Lower the reel hub loading latch.

c. Install an empty reel on the lower reel hub.

d. Refer to the tape threading diagram inside the front cover or to figure 3-2 and thread the tape as shown.

e. Hold the tape end on the take-up reel by placing a finger through the hole in the flange. Rotate the take-up reel clockwise until the tape is on securely and the amount is enough to tension the tape.

f. Tension the tape by turning the supply reel, then press the LOAD pushbutton to activate tension arms and tension the tape. A double-load unit will stop at this point; go to step g. A single-load unit automatically advances to the BOT tab where the unit stops and the LOAD pushbutton lights; go to step h.

g. Check that the tape is properly positioned on the guides, then press the LOAD pushbutton. The tape advances to the BOT tab and stops. The LOAD indicator lights and will remain lighted until the tape is moved forward of BOT by a remote command or by manual use of the forward/reverse switch.

h. Verify that the address select thumb switch is set to the correct address.

i. If the tape unit is equipped with AUTO LOAD/ON LINE option, the tape unit will be on line when BOT is reached. Otherwise, press the ON LINE switch to enable the formatter to assume control by asserting the ISELECT address line. When the tape unit is on line, the operator should not interfere with its operation except to return it to off line status by pressing the RESET pushbutton. On units equipped with the front panel disable option, the RESET switch is used to disable the operator switches.

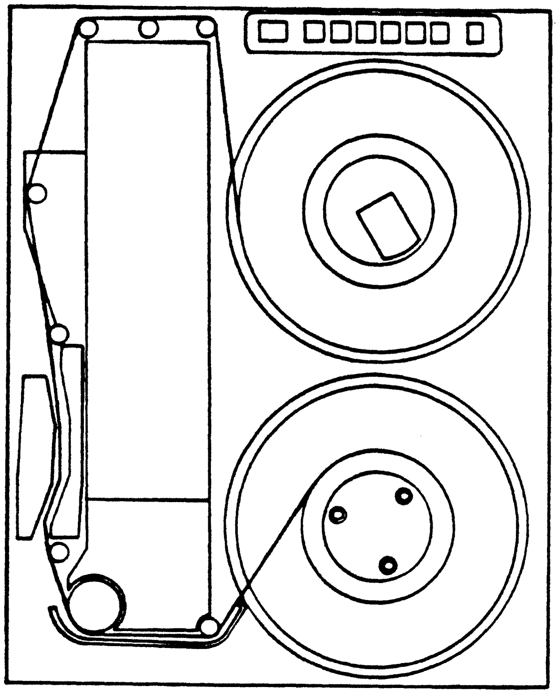


Figure 3-2. Tape Threading Path

3-5 UNLOADING TAPE

To unload tape proceed as follows:

a. Press RESET or ON LINE pushbutton to place unit off line.

b. If the tape is at BOT, press RWD pushbutton. The tape will reverse at low speed until wound on upper reel, then stop.

c. If the tape is forward of BOT, press RWD pushbutton to rewind tape to BOT. The tape will stop at BOT; press RWD pushbutton again to wind remaining tape on upper reel.

d. Lift upper reel hub latch and remove reel. Lower reel hub latch.

3-6 INTERFACE

3-7 DATA AND COMMAND INPUT AND OUTPUT SIGNALS

The tape unit has four categories of input and output lines:

a. Data Inputs - the data and parity lines, data ready line, and LRC strobe.

b. Data Outputs - data and parity lines, data strobe line, and several status lines.

c. Command Inputs - lines that select the tape unit, initiate tape motion, enable a read or write operation, and generally control operation of the tape unit.

d. Command Outputs - lines that generally indicate the status of the tape unit, the position of the tape (at BOT or EOT), and other similar information.

Descriptions of the functions and typical examples of use of these lines are listed in tables 3-2 through 3-5 and the following paragraphs. All logic levels are negative true; that is, when a signal line is asserted, its logic level is 0 to +0.4V, and when it is not asserted (cleared) the logic level is +2.5 to +5.0V. It is also important to note that several of the input/output lines operate in parallel with, or in some other way interact with, the front panel controls and indicators of the tape unit.

TABLE 3-3. TAPE UNIT DATA INPUT LINES

NAME	FUNCTION
DATA READY	This line must be asserted for a minimum of 1 microsecond during the time a data or CRC character is recorded. The tape speed and the frequency of these pulses determines the record density. For NRZI the frequency is equal to the data rate, but for PE the frequency of data ready pulses is twice the data rate. The frequency stability should be 0.25%. The write data lines should not change for 0.5 microsecond before or after DATA READY.
WRITE DATA (7 or 9 Lines)	For recording NRZI data, any of these lines must be asserted each time a logic 1 bit is to be recorded on that track. The leading edge of the DATA READY pulse transfers the data into the tape unit write register. For recording PE data the WRITE DATA lines must present data in the format described in paragraph 4-52. The data will be transferred into the write register on the trailing edge of DATA READY.
LRC STROBE	This signal must be asserted for a minimum of 1 microsecond at the end of a record of file of NRZI data. The pulse must occur four character times after the last data ready in each record of data. The signal is not used during recording PE data, except during an over-write operation, the pulse must occur after the last DATA READY to clear the over-write function in the tape unit.

TABLE 3-3. TAPE UNIT DATA INPUT LINES (Continued)

<table>
<tr><th>NAME</th><th>FUNCTION</th></tr>
<tr><td>IRDT 1, 2
(Read Threshold
1 and 2)</td><td>The status of these lines defines the read amplifier output voltage level which is recognized as a logic level change. For example, if 25% of the maximum voltage change is recognized as a change from one level to the other, the read threshold is 25%. The function of these lines depends on the configuration of the tape unit. For a tape unit with a single gap head:
<table>
<tr><th>IRDT 1</th><th>IRDT 2</th><th>READ THRESHOLD (NRZI)</th><th>READ THRESHOLD (PE)</th></tr>
<tr><td>false</td><td>false</td><td>25%</td><td>22%</td></tr>
<tr><td>true</td><td>false</td><td>45%</td><td>26%</td></tr>
<tr><td>false</td><td>true</td><td>12%</td><td>8%</td></tr>
</table>
For tape units with a dual-gap head, the high threshold (45% or 26%) is selected automatically whenever the tape unit is in write mode. The middle threshold (25% or 22%) is selected automatically during read, but the assertion of IRDT2 line will select the low threshold (12% or 8%) instead.</td></tr>
</table>

TABLE 3-4. TAPE UNIT DATA OUTPUT LINES

NAME	FUNCTION
READ DATA 9 or 7 Lines (NRZI)	On these lines the read character is output in parallel form. Each bit is at the correct logic level at the trailing edge of the READ DATA STROBE. These lines are active whenever the ISFC or ISRC command lines have been asserted.
READ DATA 9 Lines (PE)	The signals on these lines are the outputs of each peak detector, gated by the envelope detector associated with the channel. These lines are active whenever the ISFC or ISRC command lines have been asserted.
READ DATA STROBE (NRZI)	Asserted for a minimum of 1 microsecond for each data character, whenever the read data lines are active. NRZI data is to be sampled with the trailing edge of this strobe. The READ STROBE is not used during the reading of PE data.
SEVEN TRACK	A status line asserted to indicate that the tape unit has a seven-track configuration. It is not asserted for a nine-track unit.
SINGLE GAP	A status line asserted for tape units with a single gap head. It is not asserted for dual head gap units.

TABLE 3-4. TAPE UNIT DATA OUTPUT LINES (Continued)

NAME	FUNCTION
NRZI	A status line asserted for NRZI tape units; it is not asserted for PE tape units. This line is operative in the optional NRZI and PE combination tape units.
SPEED	This line may be used in installations in which two tape units of different operating speeds are connected to the same formatter. The line is asserted on the tape unit which has the lower of the two tape speeds.

TABLE 3-5. TAPE UNIT COMMAND INPUT SIGNALS

NAME	FUNCTION
ISELECT 0-3	Four address select lines that are used for selecting a tape unit. These lines function in conjunction with the front panel Address Select thumbwheel so that if the front panel switch is in 0 position and ISELECT 0 line is asserted, the tape unit is selected. Likewise, switch position 1 corresponds to ISELECT 1, etc.
ISFC (Forward)	When asserted, will cause the selected unit to accelerate to synchronous speed in the forward direction. The tape unit will automatically begin to read and output data, but tape motion will stop when this line is not asserted.
ISRC (Reverse)	When asserted, will cause the selected tape unit to accelerate to synchronous speed in the reverse direction and begin to read and output data. The ISRC command is not recognized if the IBOT command output is asserted. The tape unit will stop when this line is not asserted.
IREU (Rewind and Unload)	Must be asserted for at least 1 μsec to place tape unit off line and initiate a rewind and unload operation. The tape unit ON LINE indicator will go out. If the tape is not at BOT the tape will be rewound to BOT and then will unload onto the file reel at low speed. If the tape is at BOT the tape will unload onto the file reel at low speed.
ISWRT (Set Write)	Asserted for at least 10 μsec with ISFC to place the tape unit in write mode. Note that ISWRT must be asserted before the leading edge of ISFC.
IOVW (Over Write)	Asserted for at least 10 μsec with ISFC and ISWRT to overwrite (update) an isolated record. Overwrite is terminated by assertion of the LRC Strobe at the end of the record. Note that the LRC Strobe must be asserted also during PE overwrite.

TABLE 3-5. TAPE UNIT COMMAND OUTPUT SIGNALS (Continued)

NAME	FUNCTION
IREW (Rewind)	When this line is asserted for a minimum of 1 μsec, the tape will be rewound to BOT. When the tape is at BOT, this line is inhibited.
IDDS (Density Select)	Optional on 7 track tape units. Asserted to cause the tape unit to read the higher density data. This functions the same as the HI-DEN switch described in table 3-1, but on any tape unit either the interface line or the switch is functional, but not both. This line may also be used on the optional NRZI and PE combination tape unit and asserted to cause the unit to operate in the 1600 bpi phase encoded mode. The function in this case, is the same as the 1600 bpi switch described in table 3-2, but the interface line must be specified. Otherwise, the switch is functional. On dual speed tape units assertion of the IDDS line also causes the tape unit to move tape at the lower of the two speeds.

3-8 Data Inputs

The data input lines are used for entry of data into the tape unit from the formatter, as well as for determining the read threshold voltages. Refer to figure 4-54 for typical timing interrelationships between these lines.

3-9 Data Outputs

The data output lines are used for supplying data and data format information from the tape unit to the formatter.

3-10 Command Inputs

Functions of command inputs to the tape unit are listed in table 3-4; except for ISELECT, the command inputs are functional only when the tape unit is on line. Figure 4-54 shows typical timing interrelationships between these lines.

3-11 Command Outputs

The command output lines reflect status of the selected tape unit. The functions are listed in table 3-6 and are available on the interface whenever the tape unit is selected.

TABLE 3-6. TAPE UNIT COMMAND OUTPUT SIGNALS

NAME	FUNCTION
IRDY (Ready)	Asserted to indicate that: 1. Tape is tensioned 2. Tape is at or forward of BOT 3. Tape unit is on line 4. Tape unit is not rewinding When IRDY is asserted, the tape unit can accept a command.
IONL (Online)	Asserted to state that the tape unit is on line (under remote control) with tape under tension. IONL will be cleared by any one of the following: 1. A remote IREU assertion 2. Pressing the tape unit RESET pushbutton 3. Pressing the ON LINE pushbutton 4. Loss of tape tension 5. A remote IREU assertion
IRWD	Asserted to state that the tape unit is rewinding tape. IRWD is cleared when the tape motion stops and tape is positioned at BOT. As an option, the IRWD line can be enabled for an unselected unit.
IBOT (BOT)	Asserted to state that the tape unit has stopped motion and tape is positioned at the BOT tab.
IEOT (EOT)	Asserted to state that the tape unit is positioned at the EOT tab. Optionally, the tape unit may be wired so that this signal is asserted by passing the EOT tab and remains on until reset by passing of the EOT tab in reverse direction of tape movement.
IFPT (File Protect)	Asserted to state that the selected tape unit has a write protected tape file mounted on it.
IDDI (High Density)	Asserted to state that the tape unit has been commanded to read the higher of two densities. In the optional NRZI and PE combination tape units this line is asserted to indicate that the unit is operating in the phase encoded mode. On dual speed tape units this also indicates that the tape unit is operating at the lower speed.

Chapter 4

THEORY OF OPERATION

4-1 INTRODUCTION

This chapter provides the theory of operation for the 2790 Series Magnetic Tape Unit. The theory is presented from the functional block diagram level, supported by later detailed circuit descriptions. Included in this chapter are signal mnemonics and definitions, theory of operation of data boards, tape control board, and primary power circuitry, and tape track layout and formats. The material in this chapter should be read and understood by maintenance personnel prior to performing maintenance described in Chapter 5.

Generally, logic symbology used in this manual is drawn in accordance with MIL-STD-806C. Chapter 6 contains an explanation of drawing symbology and notation, as well as the applicable assembly drawings, schematics, and logic diagrams pertaining to the tape unit.

4-2 SIGNAL MNEMONICS AND DEFINITIONS

Table 4-1 contains a complete list of signal mnemonics and definitions used for the magnetic tape unit.

TABLE 4-1. SIGNAL MNEMONICS AND DEFINITIONS

MNEMONIC	DESCRIPTION	FUNCTION
EOTA & $\overline{\text{EOTA}}$	End-of-tape	Asserted when end-of-tape tab is detected.
EOT & $\overline{\text{EOT}}$	End-of-tape	Asserted when end-of-tape tab is detected, but not during rewind or detection of BOT tab.
FORWARD & $\overline{\text{FORWARD}}$	Forward command	Asserted when tape unit is selected, ready and on line.
HID & $\overline{\text{HID}}$	High density	Asserted when tape selected at high density by either front panel switch or interface signal.
$\overline{\text{HI DEN}}$	High density	High density command to data board.

TABLE 4-1. SIGNAL MNEMONICS DEFINITIONS (Continued)

MNEMONICS	DESCRIPTION	FUNCTION
ADDR SEL	Address select	Asserted when tape unit address is selected.
BOTA & $\overline{\text{BOTA}}$	Beginning-of-tape	Asserted when beginning-of-tape tab is detected.
BOT & $\overline{\text{BOT}}$	Beginning-of-tape	Asserted when beginning-of-tape tab is detected but not during a rewind or load sequence.
DATA READY & $\overline{\text{DATA READY}}$	Data ready	Strobes write data from interface into write register.
HOLD		Delay during which K1 is held on until interlock switches stop bouncing.
IBOT		Interface beginning-of-tape signal.
IDDI		Interface density status.
IDD		Interface density select command.
IEOT		Interface end-of-tape signal status.
IFPT		Interface file protect signal.
IOVW		Interface overwrite command.
INTLA	Interlock A	Asserted when K1 relay and interlock switches are closed.
INTL & $\overline{\text{INTL}}$	Interlock	Asserted when K1 relay and interlock switches are closed. (RC network debounces the relay).
IONL		Interface on line status.
IRDY		Interface ready status.
IREU		Interface rewind and unload command.
IREW		Interface rewind command.
IRWD		Interface rewind status.
ISEL 0 - 3		Interface select commands.
ISFC		Interface synchronous forward command.

TABLE 4-1. SIGNAL MNEMONICS DEFINITIONS (Continued)

MNEMONICS	DESCRIPTION	FUNCTION
ISRC		Interface synchronous reverse command.
ISWRT		Interface set write command.
K1DLY	K1 (Relay) Delay	Delays setting of K1 relay during a remote load and on-line operation on a vacuum tape unit.
$\overline{\text{K1LOL}}$	K1 & load and on line	Sets K1 relay during a load and on-line operation.
LDA & $\overline{\text{LDA}}$	Load flip-flop A	Asserted to tension tape.
LDB & $\overline{\text{LDB}}$	Load flip-flop B	Asserted to move tape to BOT.
$\overline{\text{LDFLT}}$	Load fault	Asserted to reset load operation if interlock switches do not close when tape enters the vacuum columns.
$\overline{\text{LDADLY}}$	Load delay	Determines when tape is to enter the vacuum columns.
$\overline{\text{LDRDY}}$	Load ready	Sets reel motors in motion to allow tape to enter vacuum column during a load operation.
LG	Logic ground	Controls operation of some front panel switches for front panel disable option.
LOLDLY & $\overline{\text{LOLDLY}}$	Load and on line delay	Sets how long offset is applied to take up servo during a load and on-line operation.
LOLFF & $\overline{\text{LOLFF}}$	Load and on line flip-flop	Set to initiate a load and on-line operation.
LOLSTR	Load and on line strobe	Sets on-line flip-flop at end of load and on-line operation.
LON & $\overline{\text{LON}}$	Load once flip-flop	Set when tape unit has completed a load operation.
LRC & $\overline{\text{LRC}}$	Longitudinal redundancy character strobes	Used on data boards.

TABLE 4-1. SIGNAL MNEMONICS DEFINITIONS (Continued)

MNEMONICS	DESCRIPTION	FUNCTION
LRC STROBE	Longitudinal redundancy character strobes	Interface input line for longitudinal redundancy character strobes.
MFWD & $\overline{\text{MFWD}}$	Manual forward or maintenance forward	Asserted when using maintenance switch to move tape in forward direction.
$\overline{\text{MINTL}}$	Momentary interlock	Momentary energize K1 during load sequence.
MOTION & $\overline{\text{MOTION}}$		When either forward or reverse commands are asserted, motion is high.
MREV & $\overline{\text{MREV}}$	Manual reverse or maintenance reverse	Asserted when using maintenance switch to move tape in reverse direction.
NRZ OR NRZI	Non-return-to-zero	Interface line used to indicate recording method.
ONL & $\overline{\text{ONL}}$	On line flip-flop	Set to allow the tape unit to accept commands.
ORS	On line ready selected	Indicates when tape unit is ready to accept a command.
$\overline{\text{PSET}}$	Power reset	Resets the control logic when power is turned on but power from power supplies has not reached safe operating levels. Also resets logic when power completely fails.
RD THRESHOLD	Read threshold voltage	Voltage used to detect data.
RDY & $\overline{\text{RDY}}$	Ready	Indicates the tape unit is ready to accept a command i.e., tape unit is loaded and not rewinding.
RDYA	Ready A	Function occurs when load sequence is complete and not rewinding.
RDYNOL	Ready and not on line	Indicates tape unit is loaded, not rewinding and not on line.
RDYONL & $\overline{\text{RDYONL}}$	Ready and on line	Indicates tape unit is loaded, not rewinding and on line.
READ DATA (0 thru 7 and PARITY)	Read data lines	Interface lines for either NRZI or PE recording format.

TABLE 4-1. SIGNAL MNEMONICS DEFINITIONS (Continued)

MNEMONICS	DESCRIPTION	FUNCTION
READ DATA STROBE		Interface line strobe used to load read data into formatter.
-READ THRESHOLD 1 (IRDT 1)		Interface threshold command.
-READ THRESHOLD 2 (IRDT 2)		Interface threshold command.
$\overline{\text{RESET}}$		Asserted when reset front panel switch is pressed. Resets selected flip-flop.
REVERSE & $\overline{\text{REVERSE}}$		Asserted when tape unit is on line, ready and selected.
REWIND (K4)		Indicates K4 relay used during rewind (not a signal).
REWD & $\overline{\text{REWD}}$	Rewind	Asserted when capstan is rewinding.
$\overline{\text{RST}}$	Reset	Resets Unload (UNL) and Load A (LDA) flip-flops when power is turned on and tape is not threaded through tape path (TPC) and load fault (LDFLT) signal is asserted.
$\overline{\text{RSTA}}$	Reset A	Resets Rewind A (RWDA) and Rewind B (RWDB) flip-flops during completion of Rewind sequence or when RSTB is asserted.
$\overline{\text{RSTB}}$	Reset B	Resets load B (LDB) flip-flop and generates $\overline{\text{RSTA}}$ during load sequence or when $\overline{\text{RSTC}}$ is asserted.
$\overline{\text{RSTC}}$	Reset C	Resets on line flip-flops, asserts ready (RDY) low, and generates $\overline{\text{RSTB}}$ during Unload sequence or when $\overline{\text{RSTD}}$ is asserted.
$\overline{\text{RSTD}}$	Reset D	Asserted by RESET pushbutton or INTL not asserted generates $\overline{\text{RSTC}}$.
RUL	Rewind and unload flip-flop	Output asserted during rewind and unload operation.
RWDA & $\overline{\text{RWDA}}$	Rewind A	Set during rewind operation.

TABLE 4-1. SIGNAL MNEMONICS DEFINITIONS (Continued)

MNEMONICS	DESCRIPTION	FUNCTION
RWHG		Rewind A and not Rewind B.
RWDL	Rewind delay	Delays start of the capstan for a rewind operation.
$\overline{RWRD}$	Rewind ramp	Input signal that generates the rewind ramp to capstan. Asserted after rewind delay, and when RWDA is set and RWDB is not set.
SELECT		Asserted when the tape unit is selected.
SETHOLD & $\overline{SETHOLD}$		Asserted when HOLD signal times out resetting LDA flip-flop.
SLTA & $\overline{SLTA}$	Select A	Select gated with on line when this signal is asserted, the command inputs ILOL, IOFFL and the internally used signal ORS are quilified.
SLTB	Select B	Qualifies the command outputs (status) IEOT, IDDI and IONL.
SLTC	Select C	Qualifies command outputs IBOT, IFPT, IRWD and IRDY.
SPEED		Data PWBA status output; signifies a low speed tape unit is selected when asserted low. This is used when asserted low. This is used when two different speed tape units are daisy-chained together to a signal formatter.
$\overline{SPD}$	Low speed	When asserted low, the tape unit will operate at the lower speed. (Used on dual speed units only.)
SUPPLY DET & SUP DET	Supply detector	Supply vacuum column transducer output.
SWRT	Set Write flip-flop output	This flip-flop is set to start a write operation.
TAKE UP DET & TU DET		Take-up column transducer output.

TABLE 4-1. SIGNAL MNEMONICS DEFINITIONS (Continued)

MNEMONICS	DESCRIPTION	FUNCTION
$\overline{\text{TPC}}$	Tape path complete	Low when both BOT and EOT signals are high, meaning there is no tape in the tape path.
UNL & $\overline{\text{UNL}}$	Unload flip-flop	Asserted during unload sequence.
WRT DATA PARITY, 0, 1, ...7		Write data interface lines.
$\overline{\text{WRT ENA}}$	Write enable	See $\overline{\text{WRT ENABLE}}$
WRITE ENABLE & $\overline{\text{WRT ENABLE}}$	Write enable	Asserted when write flip-flop is set and tape motion is true. The write electronics is enabled.
WRT PWR	Write power	+5 volts applied to write electronics when interlock switches are closed, K1 relay is energized and write lockout switch is closed.
ENV PWR	Envelope power	Applies power to envelope detector circuitry.
WRT PWR SW	Write power switched	+5 volts to write circuitry when write enable and hi-density are true.
$\overline{\text{GAP}}$		Clears write data flip-flop when motion stops.
I WRT CNTRL	High current boost	Sets write current amplitude to NRZI level when switching to write mode.
VTH	Threshold voltage	Dynamically switched threshold voltage reference applied to the envelope detector.
SUM DATA		Read data sum output.
HI-CURRENT		When asserted causes I WRT CNTRL.
SINGLE STACK		Indicates one head for write and read operations.
RWDAD & $\overline{\text{RWDAD}}$	Rewind A inverted	Used for load distribution.
RWDB & $\overline{\text{RWDB}}$	Rewind B	Resets LDB flip-flop and causes rewind ramp to ramp toward zero (0) volt level.

TABLE 4-1. SIGNAL MNEMONICS DEFINITIONS (Continued)

MNEMONICS	DESCRIPTION	FUNCTION
BOTDLY & $\overline{\text{BOTDLY}}$	Beginning of tape delay	Timing delay allowing forward tape motion for a specific length of time in search of the BOT marker.
LDC & $\overline{\text{LDC}}$	Load C flip-flop	During load sequence, LDC clock the RWDA flip-flop and the ONL flip-flop. LDC also disables unload.
$\overline{\text{LDRST}}$	Load reset	During load sequence after tape has loaded in columns, $\overline{\text{LDRST}}$ resets LDA flip-flop.
K3DLY	Relay K3 delay	Delays energizing relay K3 which turns on the blower motor.
LDBDLY	Load B delay	Generates a delayed $\overline{\text{RSTB}}$.
LDTEN	Load tension	Causes relay K1 to be energized during a load sequence to tension tape.
TLDLY	Tension load delay	TLDLY delay provides a .5 second delay for tape tensioning.
$\overline{\text{FPDS}}$	Front panel disable	Indicates unit is on-line selected and the control panel switches are disabled.
REW RAMP	Rewind ramp	When asserted, controls capstan direction of rotation and the velocity.
IOFFL	Off line	When asserted it causes the on-line flip-flop to be reset.
REW FET SW	Rewind FET switch	Increases the gain of the supply and take-up amplifiers. Controls tape position in vacuum column.
HG FET SW	Vacuum FET switch	Modifies the gain as a function of loop of the position supply and take-up amplifier during a 62.5/75 ips operation.
LUNL FET SW	Load/unload FET switch	Controls the tape position in the vacuum columns during an unload operation.

TABLE 4-1. SIGNAL MNEMONICS DEFINITIONS (Continued)

MNEMONICS	DESCRIPTION	FUNCTION
TU OFFSET	Take-up offset	Controls the tape position in the vacuum columns during an unload operation.
SUP OFFSET	Supply offset	Controls the tape position in the vacuum columns during an unload operation.
REW OFFSET	Rewind offset	Controls the tape position in the vacuum columns during a rewind operation.

4-3 FUNCTIONAL BLOCK DIAGRAM DESCRIPTION

Figure 4-1 shows a functional block diagram of the magnetic tape unit. The tape unit functions may be considered to consist basically of three general areas: data read/write, control and status, and power. Circuitry for these functions is contained on the tape control board, the data board, the power supply module, and other deck-mounted components that plug into the boards. The following paragraphs contain a brief discussion of the circuit boards. Detailed circuit descriptions are contained in paragraph 4-7.

4-4 Tape Control Board

The tape control board contains most of the circuitry necessary to implement the status and control functions. Tape control logic processes the control signals from the external formatter or controller and reports tape unit status to the formatter. The control signals are routed to the data boards for use in read/write operation and to the tape drive circuits on the tape control board for electromechanical operation of the tape unit. The tape control board also contains the voltage regulator circuitry to furnish regulated power to the tape unit. Detailed circuit descriptions are contained in paragraph 4-8.

4-5 Data Board

The data board provides the data read/write functions. Write data signals enter the board by an edge connector on one side of the board. They are buffered by a register which drives the write head. The write and read head connections are made through two connectors in the center of the board. The signals from the read head are amplified, differentiated and compared to a threshold voltage. For PE data boards the digitized signals are driven directly on the interface lines. For NRZI data boards the signals are buffered and strobed out with a read strobe. The read signals are connected to the interface by an edge connector at the other end of the board. Data board control signals are received from the formatter via the tape control board. Detailed circuit descriptions are contained in paragraph 4-35.

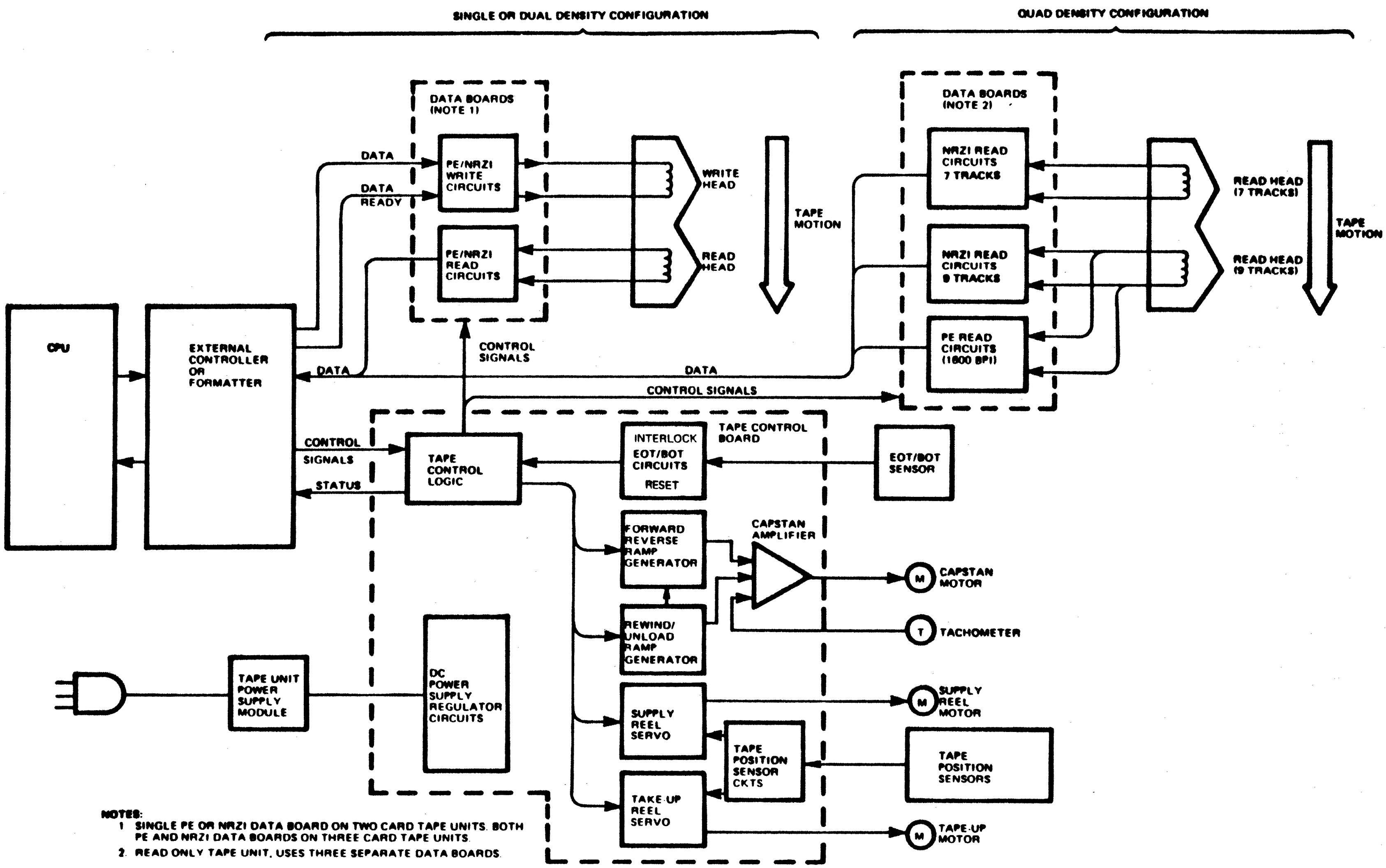


Figure 4-1. Magnetic Tape Unit Functional Block Diagram

4-6 Primary Power Circuits

The primary power circuits consist of a power supply module mounted on the tape unit baseplate and the power supply regulator circuits located on the tape control board. The power supply module supplies unregulated ±36 volts to the reel and capstan servos, and unregulated ±20 volts to the relay drivers, solenoid driver and the power supply regulator circuits. The power supply regulator circuits on the tape control board consist of two separate regulator circuits which supply +10 volt, +5 volt, -10 volt and -5 volt outputs. In addition, the power supply regulator circuits also provide a reset ($\overline{PSET}$) signal to the tape unit control circuits. Detailed circuit descriptions are contained in paragraph 4-44.

4-7 DETAILED CIRCUIT DESCRIPTIONS

4-8 TAPE CONTROL BOARD ELECTRONICS

The following paragraphs describe the operation of the circuits contained on the tape control board. These circuits consist of the load logic, reel servo, capstan servo, on-line/off-line logic, addressing logic, and the tape control circuits. A complete schematic diagram of the tape control board is contained in Chapter 6. Simplified schematics of the various tape control board circuits are contained in the following paragraphs where necessary for clarity of explanation.

4-9 Load Logic Circuits

The load logic circuits have differences depending on whether the single load or double load option is in use. The following paragraphs discuss both the single and double load options.

4-10 Vacuum Column Load (OFF LINE)

Figure 4-2 shows the simplified schematic diagram for a vacuum column load sequence with the single and double load options. The timing diagram (figure 4-3) shows the timing for a single load sequence. Momentary actuation of the LOAD switch causes a positive pulse output from LOAD LATCH. The negative going edge of the LOAD LATCH pulse sets LDA flip-flop M2, U30. The LDB flip-flop is not set until the VACUUM INTERLOCK switches are closed.

The low $\overline{LDA}$ output at M2, U30-2 is applied to the TLDLY delay circuit which starts a 0.5 second signal delay. With the TLDLY output low and LDA high, a low is established at F6, U17-11, which causes a high at F6, U17-8 (LDTEN). The LDTEN signal starts K1 delay timing. When the K1DLY circuit times out and goes high, relay K1 is energized connecting the motors to the servo amplifiers. The take-up reel moves forward to take up any tape slack. When the TLDLY delay times out and goes high, LDA is high, and a low is established at D6, U10-8 (LOADLY) which starts K3 delay timing. With TLDLY high, a low is established at F6, U17-8 (LDTEN) causing relay K1 to be de-energized. After K3DLY times out and goes high, relay K3 is energized, turning on the vacuum motor.

When sufficient vacuum is reached, the VACUUM SENSE switch closes, applying a high at V4, U48-8. With VACUUM INTERLOCK low, $\overline{INTL}$ and K3DLY are high

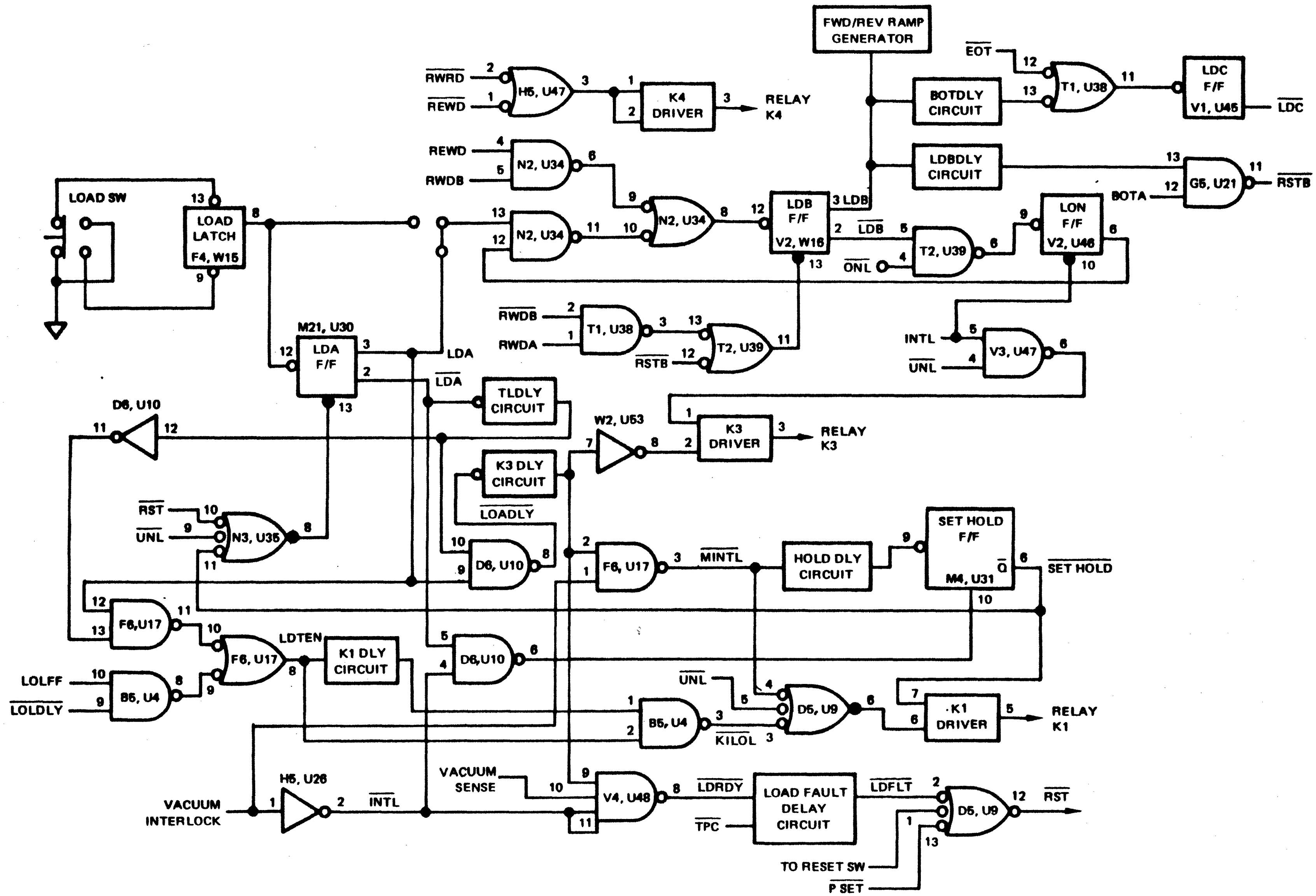


Figure 4-2. Load Circuits Simplified Diagram

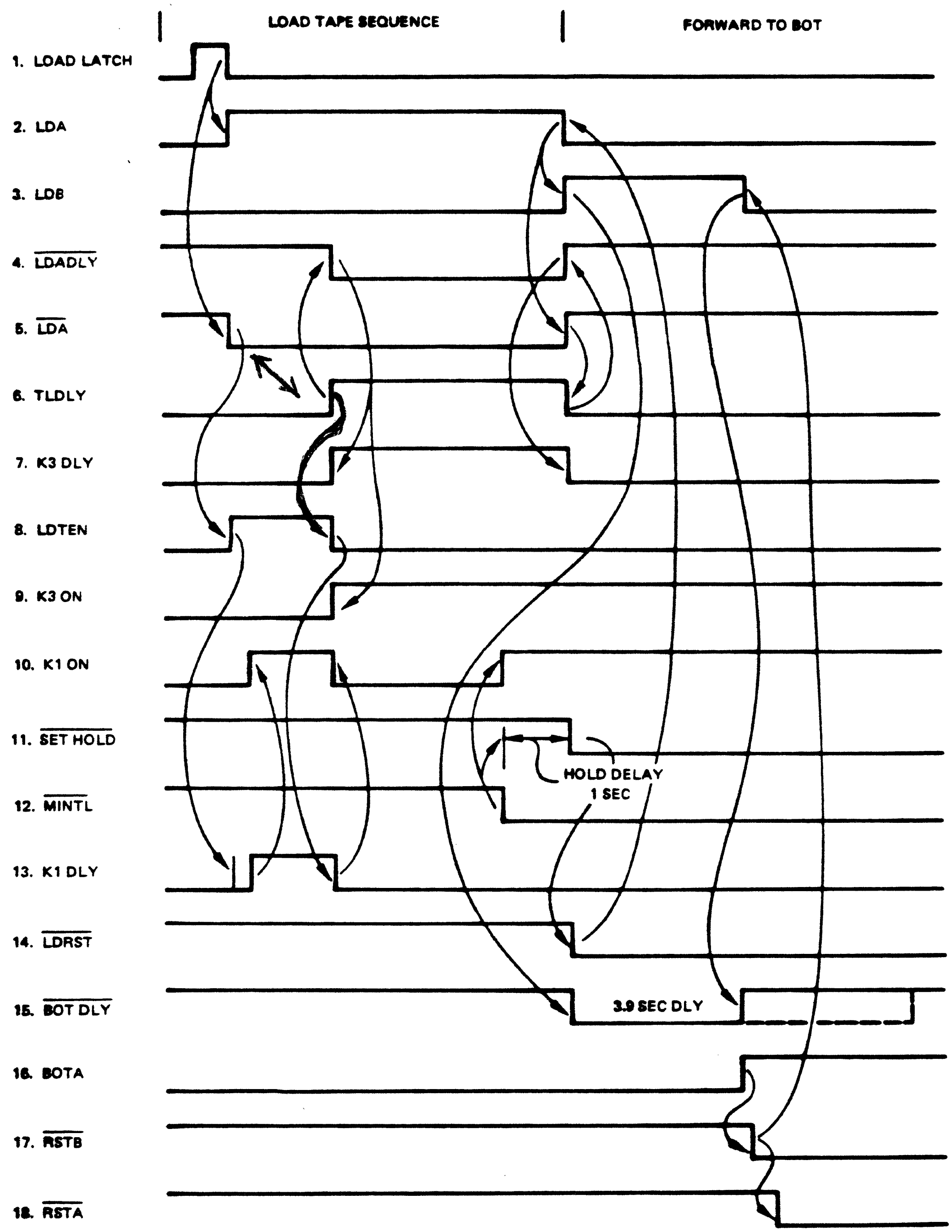


Figure 4-3. Single Load Sequence (OFF LINE) Timing Diagram

causing a low at V4, U10-8 (LDRDY). LDRDY going low starts the load fault delay timing and the tape starts loading into the vacuum columns. If the vacuum interlock switches are not closed before the load fault delay times out, LDFLT goes low at D5, U9-2 causing RST to go low. RST going low resets the LDA flip-flop and terminates the load sequence. If the vacuum interlock switches are closed before the load fault delay times out, then MINTL at F6, U17 is set low, causing relay K1 to be energized and starting the HOLD delay timing.

During the timing sequence of the HOLD delay, relay K1 connects the reel and capstan motors to their amplifiers and positions the tape in the center of the vacuum columns. The vacuum interlock switches remain closed as long as the tape loop stays in the operating range, holding MINTL low and energizing relay K1.

When the HOLD delay times out, SET HOLD flip-flop M4, U31 is set. The low SET HOLD signal applies a low to N3, U35-11, resetting the LDA flip-flop.

For the single load configuration, resetting LDA flip-flop applies a low to N2, U34-13 causing N2, U34-8 to go low and set LDB flip-flop V2, U46. LDB going low applies a low to T2, U39-5 and clocks LON flip-flop V2, U46, causing the LON flip-flop to set. A high at V2, U50-3 starts the BOTDLY delay timing (3.9 SEC). During this delay, relay K1 and K3 are held on. LDB is an input to the forward ramp generator which causes the capstan to move the tape forward in search of the BOT marker.

For the double load option, momentary actuation of the LOAD switch a second time causes a positive pulse output from X0, U59-3 which is gated with LON at N2, U34-12. This pulse sets LDB and LON flip-flops. LDB going low causes the tape to move forward in search of the BOT marker. If the BOT marker is not sensed before the BOTDLY delay times out, the tape unit must go into a rewind sequence in search of the BOT marker.

If the BOT marker is sensed before BOTDLY times out, BOTA goes high at G5, U21-12, generating RSTB. RSTB going low resets the LDB flip-flop and stops forward motion of the tape. The load sequence is completed.

If BOT is not sensed before the BOTDLY delay times out, BOTDLY goes high causing LDC flip-flop V1, U45 to set. Refer to figures 4-2, 4-4, and 4-21. LDC going low causes a low to be applied to the clock input of RWDA flip-flop T4, U41, setting RWDA T4, U41-3 high. RWDA going high resets LDB flip-flop V2, U46 and starts the RWDL delay timing. When RWDL delay times out and goes high, RWRD V4, U48-12 is set low causing the rewind ramp generator to start ramping on. RWRD going low also causes relay K4 to be de-energized. With relay K4 de-energized, a resistor is placed in series with the reel motors to protect the power amplifiers from excessive power dissipation. When the rewind ramp voltage reaches the appropriate level, REWD goes high. REWD going high at V4, U48-5 causes relay K2 to be energized which moves the motor return from ground to the power supply. REWD is applied to the capstan amplifier causing the capstan to reverse the tape in search of the BOT marker.

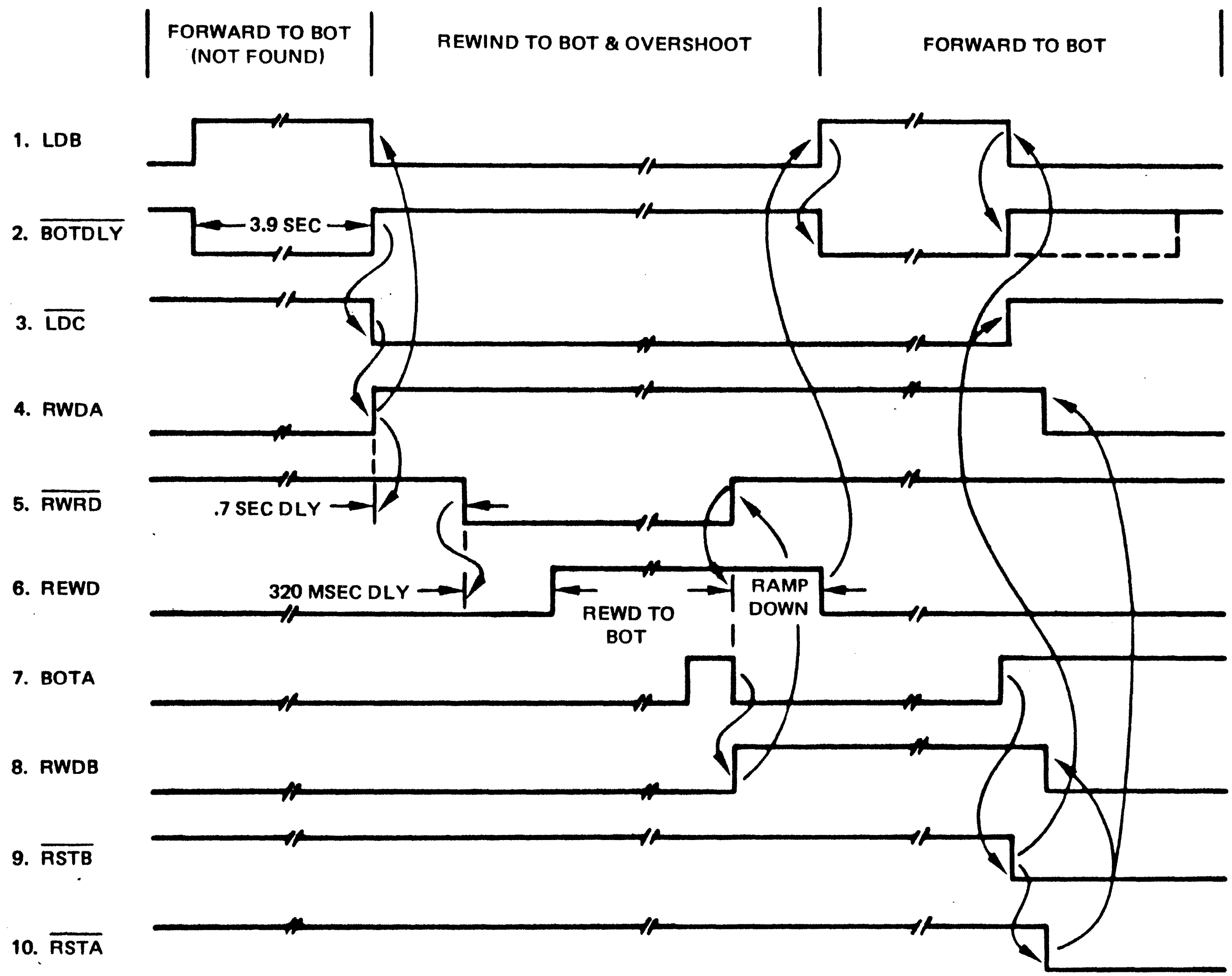


Figure 4-4. Rewind to BOT Load Sequence Timing Diagram

When the BOT marker is reached, a positive pulse is generated on the BOTA signal line. The negative going edge of the BOTA pulse sets RWDB flip-flop T4, U41. RWDB goes low at T4, U41-6 causing RWRD to go high at V4, U48-12 and starting the rewind ramp. With RWDB low, relay K2 is de-energized.

Due to the ramping off time of the rewind ramp, the tape overshoots the BOT marker. When the rewind ramp voltage reaches the appropriate level, REWD is set low causing N2, U34-6 to go high. Since LDA is low, N2, U34-11 is high, therefore a low is applied to the LDB flip-flop, causing LDB to be set high. LDB going high starts the BOTDLY delay timing and causes the tape to move forward in search of the BOT marker.

When the BOT marker is sensed, BOTA goes high at G5, U21-12, generating RSTB. RSTB going low resets the LDC flip-flop, sets RSTA, and resets the LDB flip-flop which stops forward motion of the tape. RSTA going low resets RWDB and RWDA flip-flops. The load sequence is completed.

4-11 Tape at BOT Load (OFF LINE)

When loading tape with the BOT marker under the BOT head, the vacuum column load sequence is the same as outlined in paragraph 4-10. The search for BOT sequence is shortened considerably and is determined by the LDBDLY delay timing, (figures 4-2 and 4-5).

At the point where the LDA flip-flop is reset and the LDB flip-flop is set, LDB V2, U46-3 goes high starting the BOTDLY delay and the LDBDLY delay timing. Since the BOT marker is under the BOT head, BOTA is high at G5, U21-12 and as soon as the LDBDLY delay times out and goes high, F5, U16-8 goes low (RSTB). RSTB going low resets the LDB flip-flop and completes the load sequence.

4-12 Mid-Tape Load Sequence (ON LINE)

Figures 4-2 and 4-6 show the simplified schematic and timing diagram for a mid-tape vacuum column load sequence. A negative pulse at the input to B6, U5-9 sets LOLFF high B6, U5-8 and LOLFF low B6, U5-11. LOLFF going low starts LOLDLY delay timing and LOLFF going low applies a low to F6, U17-9 causing F6, U17-8 to go high (LDTEN). LDTEN going high starts K1DLY timing.

When K1DLY times out and goes high, relay K1 is energized. The take-up reel turns in the forward direction causing the tape to be tensioned. LOLDLY times out and goes low setting F6, U17-8 (LDTEN) low and starts K3DLY timing. LDTEN going low causes relay K1 to be de-energized. When K3DLY times out, relay K3 is energized and turns on the vacuum motor.

Tape is loaded into the vacuum columns and the vacuum interlock switches close, setting MINTL F6, U17-3 low. MINTL going low energizes relay K1 and starts HOLD delay timing. When HOLD times out, the SET HOLD flip-flop is set causing LDRST to go low. LDRST going low sets LOLFF low and LOLFF high. LOLFF going low sets K3DLY low and LDLFF going high sets LOLDLY high, terminating the load sequence.

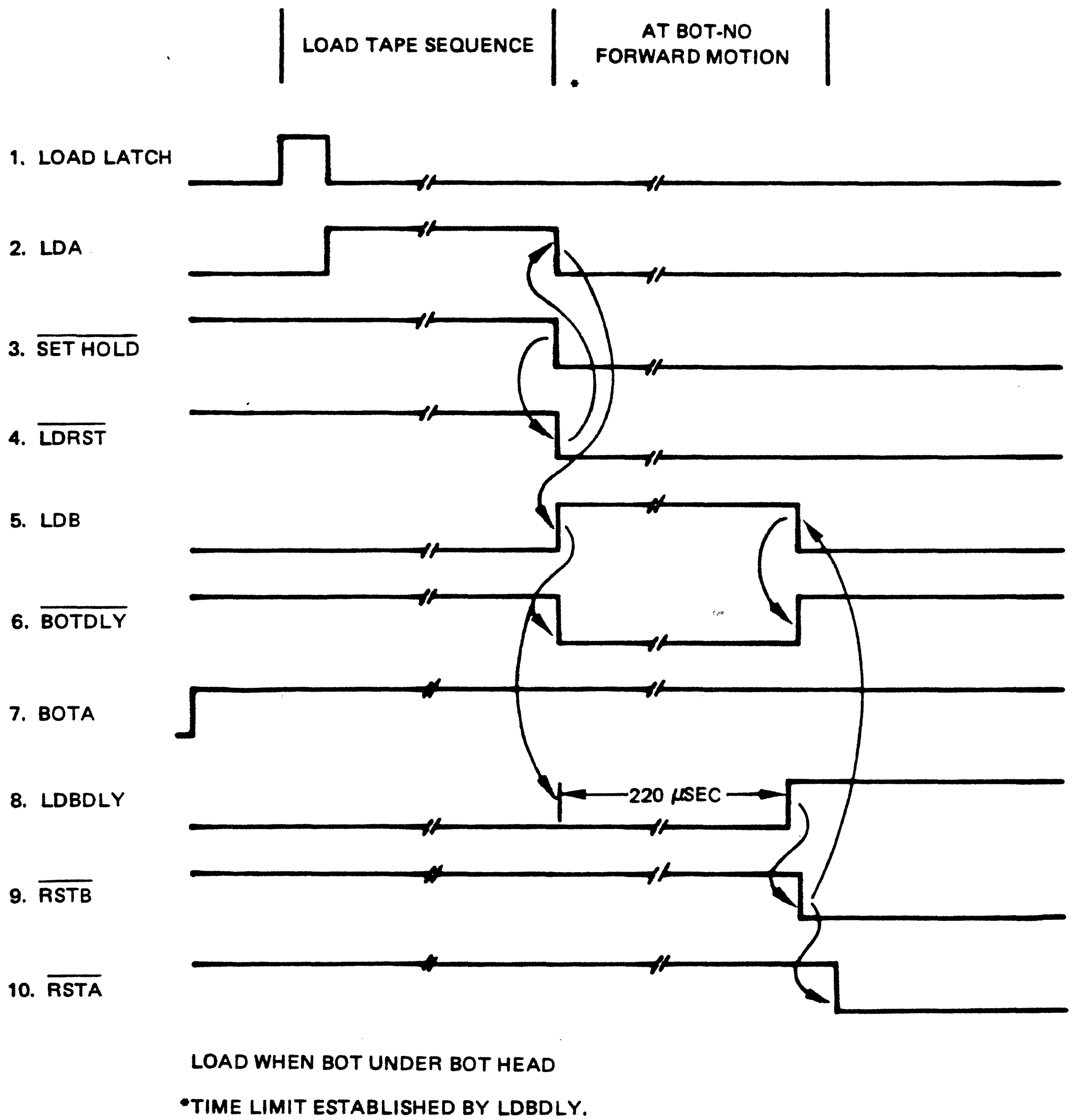


Figure 4-5. Load Tape at BOT, Timing Diagram

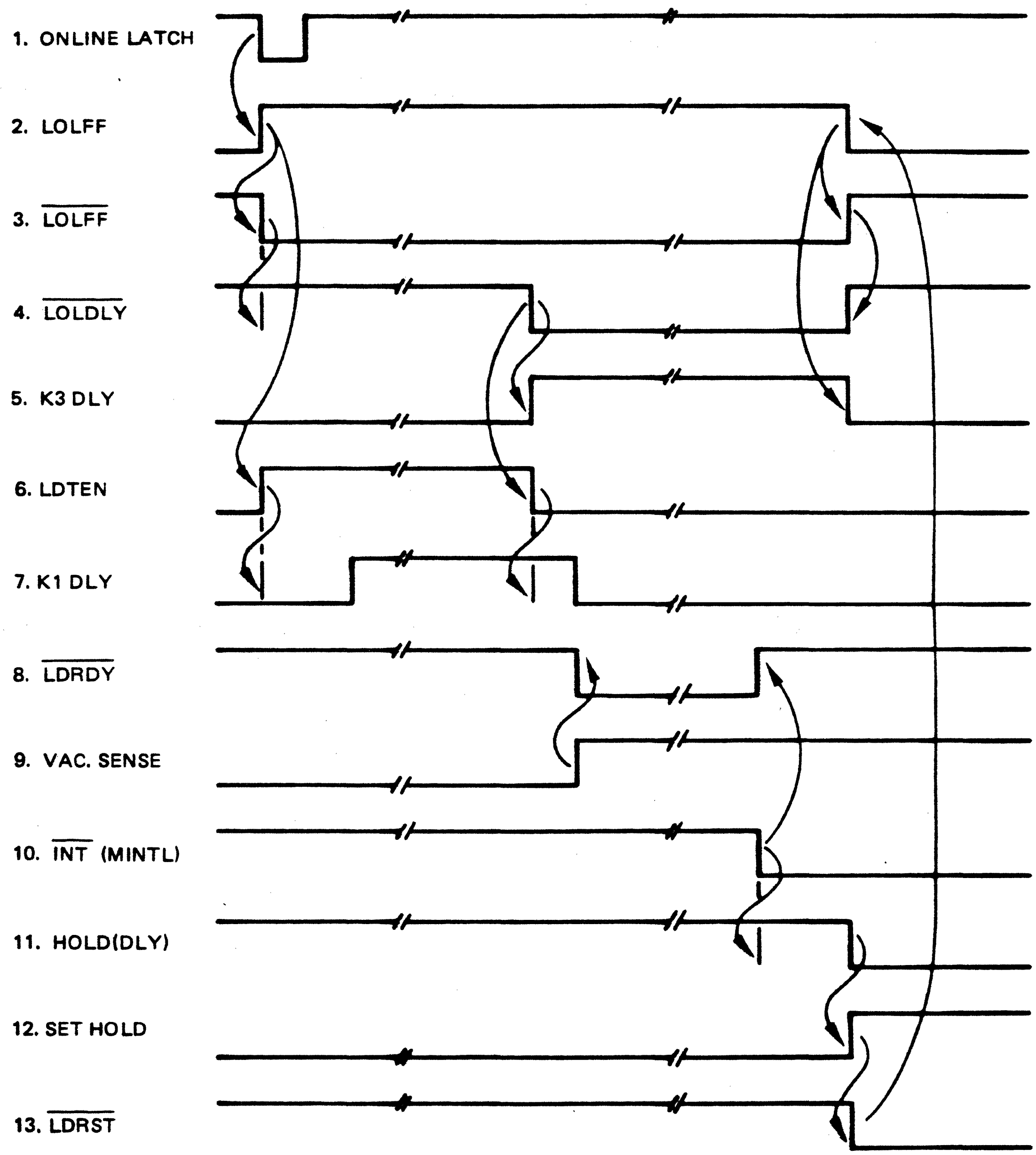


Figure 4-6. Mid-Tape Loading, Timing Diagram

4-13 Blower Motor Control

Figure 4-7 shows a simplified diagram of the blower motor circuit. When relay K3 on the tape control board is energized during the tape loading sequence, relay K3 contacts 8 and 9 close. This connects the triac output circuit to the gate of triac CR1 through resistor R1. This turns on triac CR1 and allows ac operating voltage from power supply transformer T1 to be applied through the triac to blower motor M1. When relay K3 is de-energized, triac CR1 turns off and removes the ac operating voltage from the blower motor.

4-14 Reel Servo Electronics

Figure 4-8 shows a simplified diagram of the reel servo electronics. The reel servo electronics consist of two identical circuits: the supply reel servo circuits and the take-up reel servo circuits. Since the operation of both circuits is identical, only the supply reel servo circuit is described.

The input to the reel servo amplifier is a tape position sensor and detector which provides a voltage that is linearly related to the position of the tape in the operating range.

4-15 Vacuum Chamber Tape Position Sensor Circuits

The tape position sensor uses an oscillator that drives the variable capacitor transducer, the output of which is detected and amplified by a

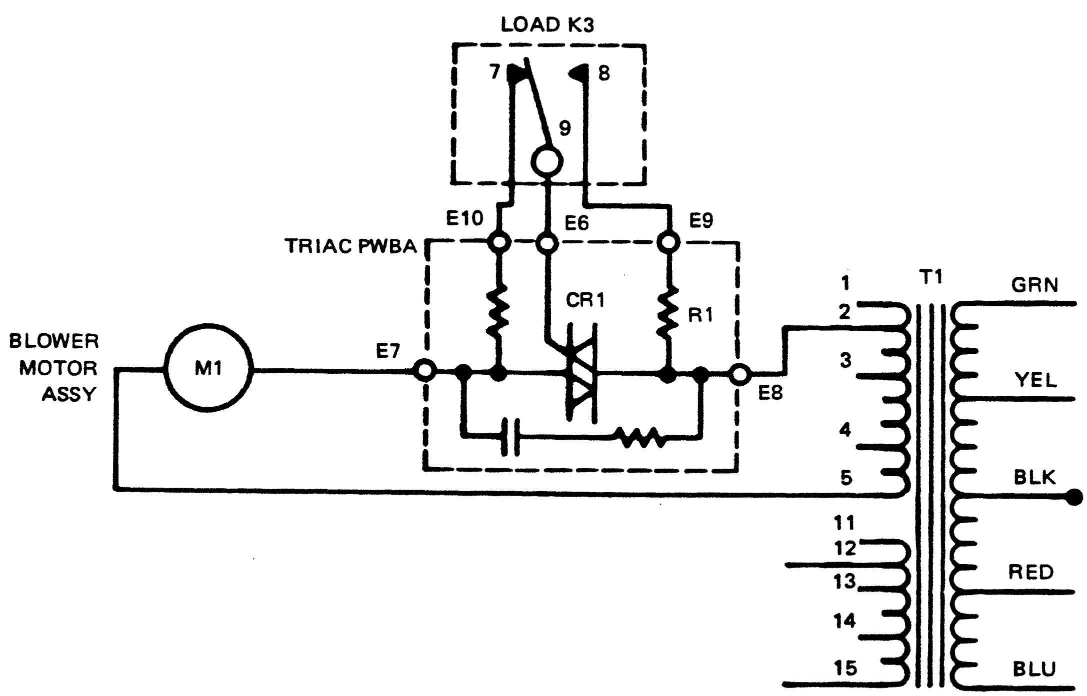


Figure 4-7. Blower Motor Control Simplified Diagram

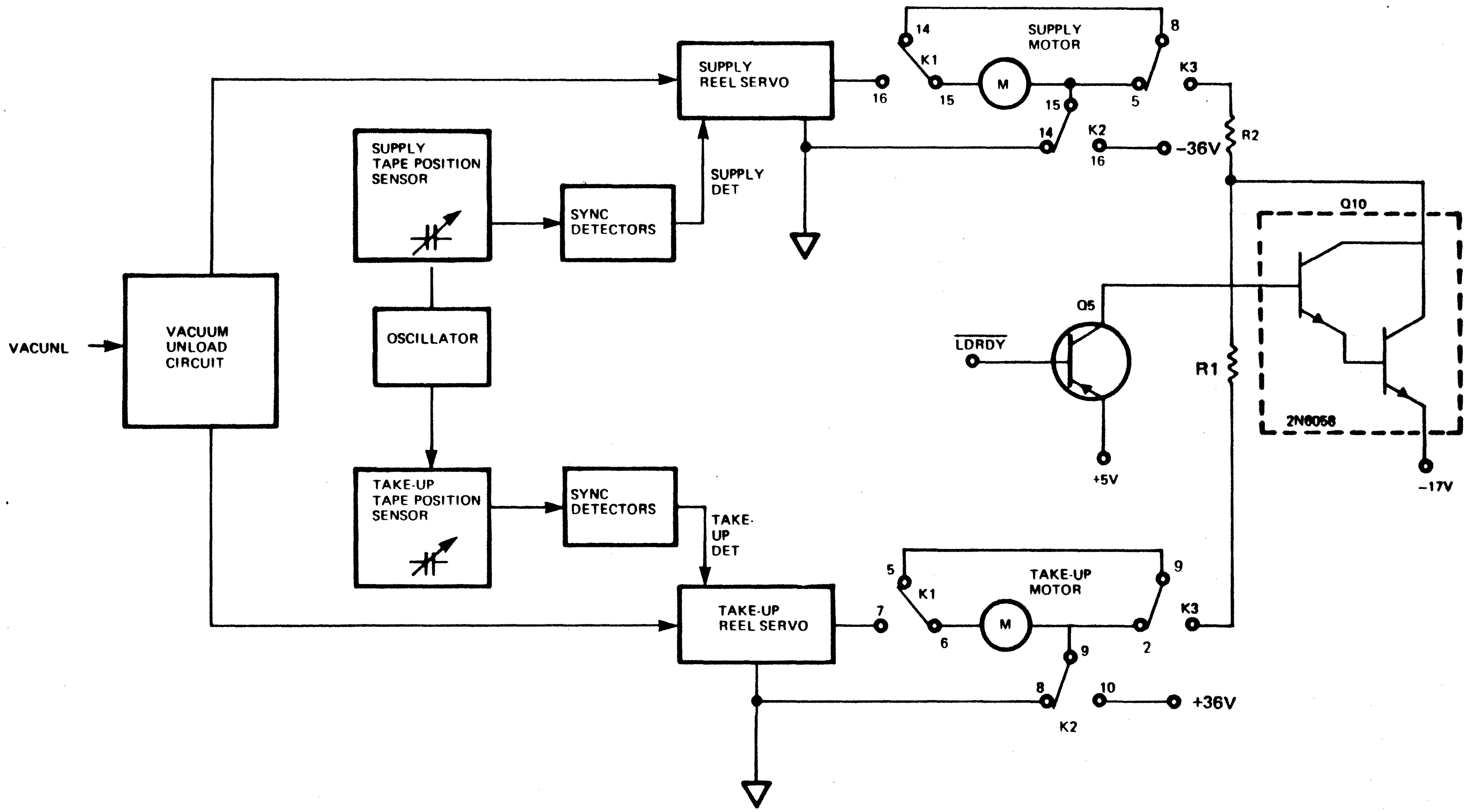


Figure 4-8. Reel Servo Electronics Simplified Diagram

synchronous detector. Figure 4-9 shows a simplified schematic diagram of the vacuum chamber tape position oscillator and sync detector circuits. Figure 4-10 contains the timing diagram.

The output of the oscillator is a triangular wave that is determined by the integration of a square wave with W8, R104, W10, C103, and X7, U62. When W7, Q101 and W7, Q103 are turned on and the output of X7, U62 is at +5 volts, the collector of W7, Q101 is at +5 volts and current flows through W8, R104, charging capacitor W10, C103. This causes the output of X7, U62 to decrease as capacitor W10, C103 is charged. Capacitor W10, C103 charges until the output of X7, U62 reaches -5 volts. At this time, the base of W7, Q103 is less than the base voltage of W7, Q102, turning transistors W7, Q103 off and W7, Q102 on. Transistor W7, Q101 is also turned off, since W7, R116 is connected to -5 volts and the output of X7, U62 increases toward +5 volts. Since the charging rate of W7, C103 is constant, the output of X7, U62 is a triangular waveform with a period of 75 microseconds.

The triangular waveform is applied to the vacuum chamber transducers. The transducers are variable capacitors with a capacitance that varies according to the position of the tape in the vacuum chambers. The other plate of the capacitor is connected to an amplifier, one for each chamber. Since the circuits are also identical, only the supply sync detector is described.

The plate of the variable capacitor transducer is connected to pin 2 of amplifier X10, U64. Amplifier X10, U64 has a gain that is the ratio between W10, R120 and the transducer capacitive reactance. The amplifier gain increases at 20 dB per decade. This is the characteristic of differentiator amplifier. As the capacitance of the transducer varies, the gain of the amplifier also varies. The output of the amplifier is a square wave since the triangular wave output of the oscillator is differentiated and the amplitude of the square wave varies according to the transducer capacitance.

The output of amplifier X10, U64 is connected to a synchronous full wave rectifier composed of W10, U58 and W9, Q105. A square wave signal from the oscillator is applied to the base of W9, Q105 through W9, R124. The negative half of the square wave saturates W9, Q105, setting pin 3 of W10, U58 at ground potential. At the same time, the output of X10, U64 is also negative and is applied to the inputs, pins 2 and 3, of W10, U58 through W10, R121 and W10, R123. Since pin 3 of W10, U58 is grounded, and W10, R121 and W10, R122 are equal, the output of W10, U58 is the inverted output of U73 with unity gain.

The positive portion of the oscillator square wave turns off W9, Q105. At this time the output of X7, U62 is also positive. Since the input impedance of W10, U58 is high, very little voltage drop occurs across W10, R123 and the output of X10, U64 is applied without reduction to pin 3 of W10, U58. The open loop gain of W10, U58 is also very large, so pin 2 of W10, U58 has to also be equal to the output of X10, U64. This occurs only when there is very little voltage drop across W10, R121 and almost no voltage drop across W10, R122. This occurs only if the output of W10, U58 is equal to the output of X10, U64. Consequently, the output of X10, U64 is rectified with the unity gain of W10, U58 applying a positive voltage level output of the supply reel servo circuit.

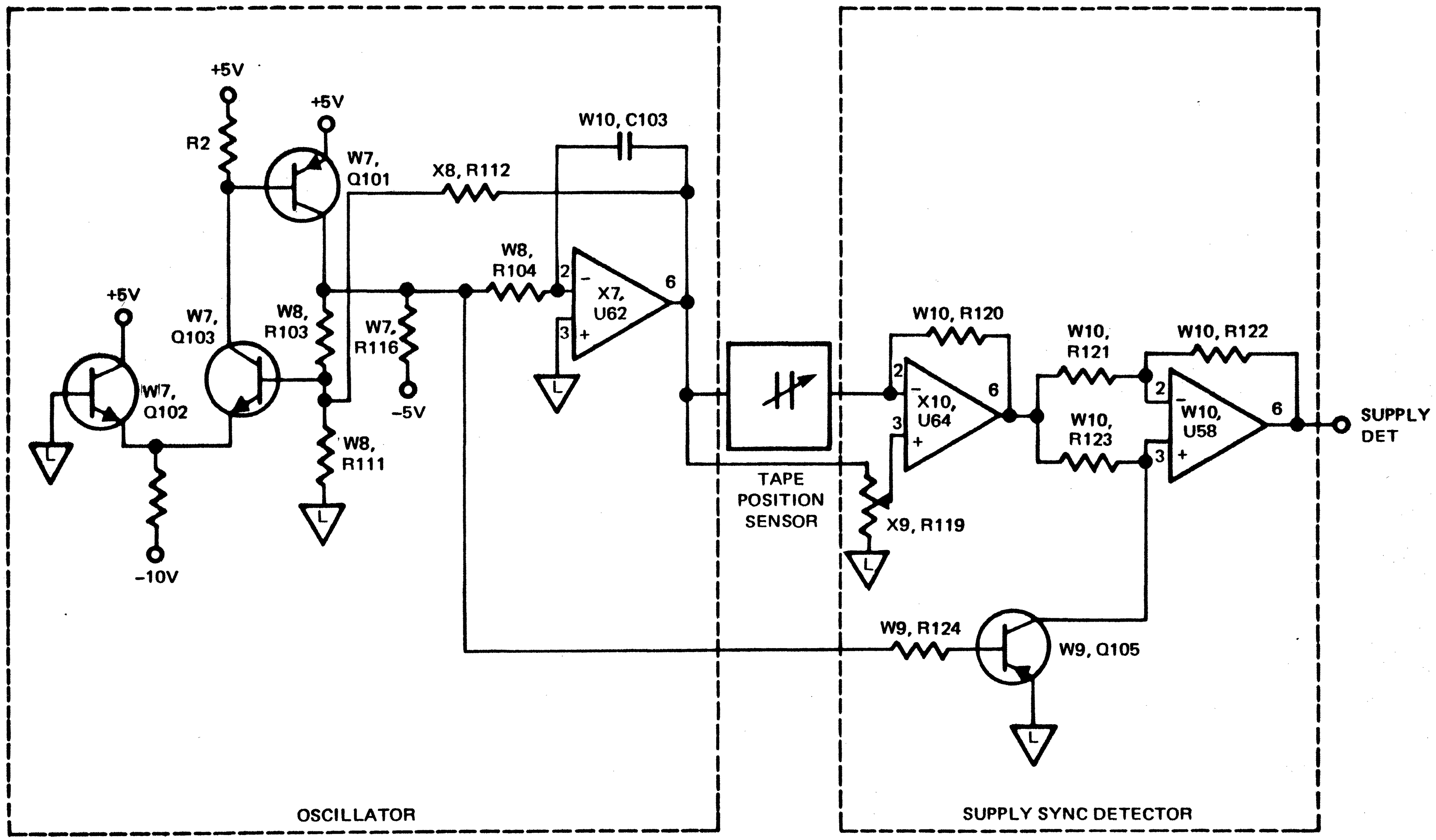


Figure 4-9. Vacuum Chamber Position Sensor Control Simplified Diagram

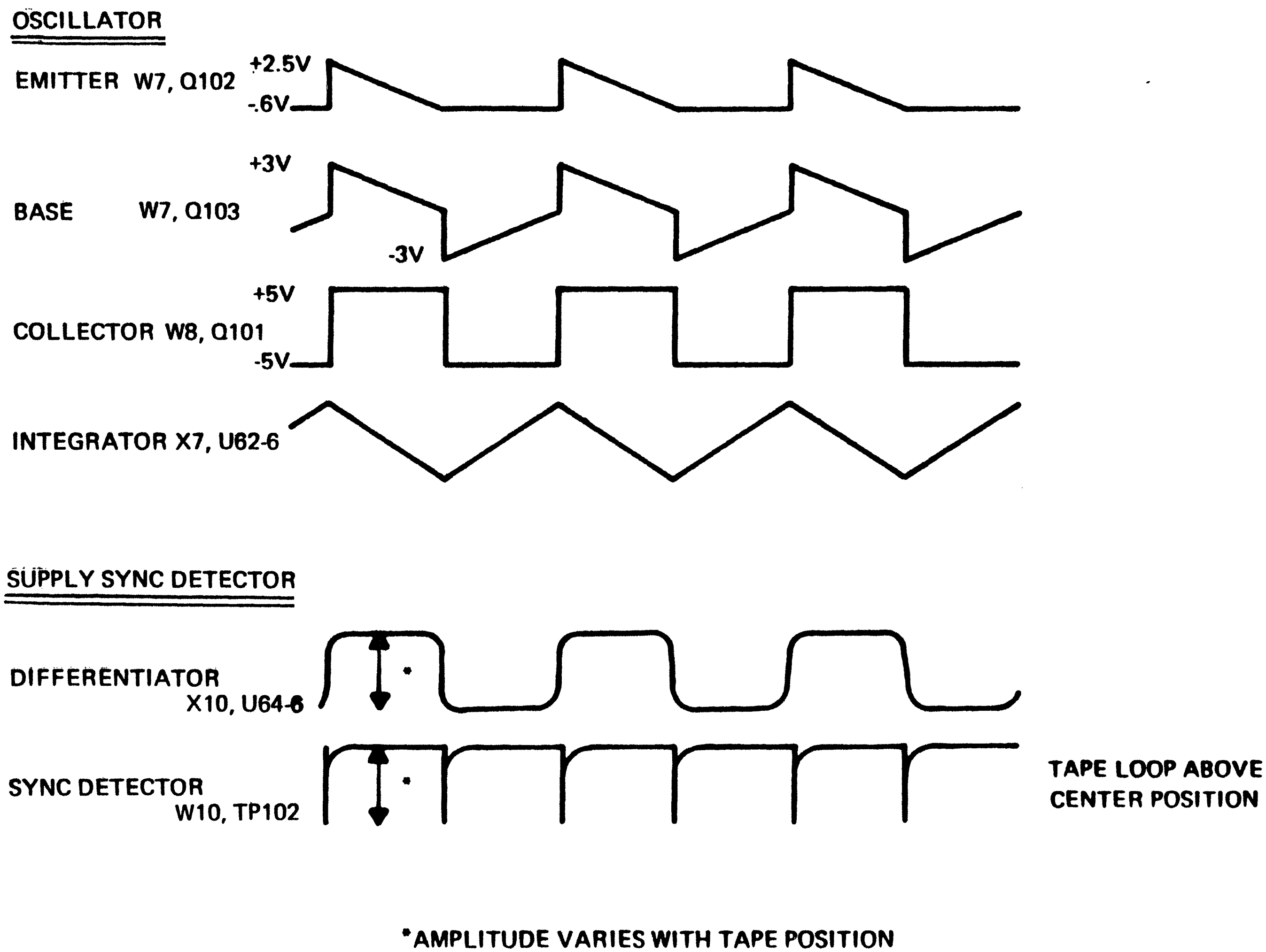


Figure 4-10. Tape Position Sensor Circuit Timing Diagram

4-16 REEL SERVO CIRCUITS

Figure 4-11 shows a simplified diagram of the supply reel servo circuits. The output of the sync detector is connected to V10, U50-2 through an input filter network of V10, R613, V8, C605, and V8, R614. The feedback around V10, U50 is the series connection of V9, R607 and potentiometer V9, R608. The closed loop gain of V10, U50 is changed by adjusting the potentiometer.

The power amplifier stage is composed of T10, U43, N10, Q601, N10, Q605 on the control PWBA and Q3 and Q1 on the servo amp PWBA. N10, R601 and N10, R602 are feedback resistors for the amplifier. The output of V10, U50 is connected to T10, U43 by either T9, R615 or T9, R621 through FET V10, U50. Since T9, R621 has a lower resistance than T9, R615, the gain of the power amplifier stage is about five times greater when T9, R621 is the input resistor. V9, R622 is the input resistor when the output of V10, U67 is greater than +1.7 volts, or when the tape unit is reqinding. T6, Q507 is turned off when $\overline{RWDC}$ and $\overline{REWD}$ are high when the tape unit is not rewinding, and the collector of T6, Q507 is at -10 volts as are both sides of V6, R520 since V6, CR502 is forward-biased. This biases the gate of FET T9, Q603 at -10 volts, turning off T9, Q603. When $\overline{RWDC}$ or $\overline{REWD}$ go low, T6, Q507 is saturated and its collector goes to +5 volts. The bias voltage at the gate of T9, Q603 is increased at a rate determined by the time constant of V6, R520 and V6, C503. When the voltage becomes greater than -0.5 volt, V9, CR602 is back-biased, turning on FEC T9, Q602 and connecting the output of V10, U50 to T9, R621. When $\overline{RWDC}$ and $\overline{REWD}$ are high again, T6, Q507 is again turned off and V6, C503 is quickly discharged through V6, CR502, turning T9, Q602 off.

The output of V10, U50 is also connected to resistor networks N4, R603/T9, R609 and V9, R622/T9, R620. Since the operation of the networks is identical, only the V9, R622/T9, R620 network is described. When there is no current flow through T9, R621 and T10, U43-2 is at virtual ground potential, the cathode of T9, CR603 is also at ground potential. When the output of V10, U50 increases to 1.7 volts, T9, CR603 is forward-biased. Any further increase in the output of V10, U50 causes the cathode of T9, CR603 to increase correspondingly. Consequently, T9, R621 is connected to the output of U67 whenever the output is greater than 1.7 volts.

Potentiometer N8, R606 is connected to input of T10, U43 through R9, R611 and FET N9, Q602 and is used to adjust the output of the power amplifier stage to create a torque in the reel motors to compensate for tape tension, keeping the tape in the center of the range.

During all operations, except unload, FET N9, Q602 is held in the on condition. During a tape unload sequence, the UNL signal goes high, turning off N9, Q602 and disconnecting the output of V10, U50 from T10, U43.

The output of T10, U43 is connected to the bases of N10, Q601 and N10, Q605. If the output of T10, U43 increases positive, N10, Q601 is turned on, its collector drops and the base of power transistor Q2 also drops. Power

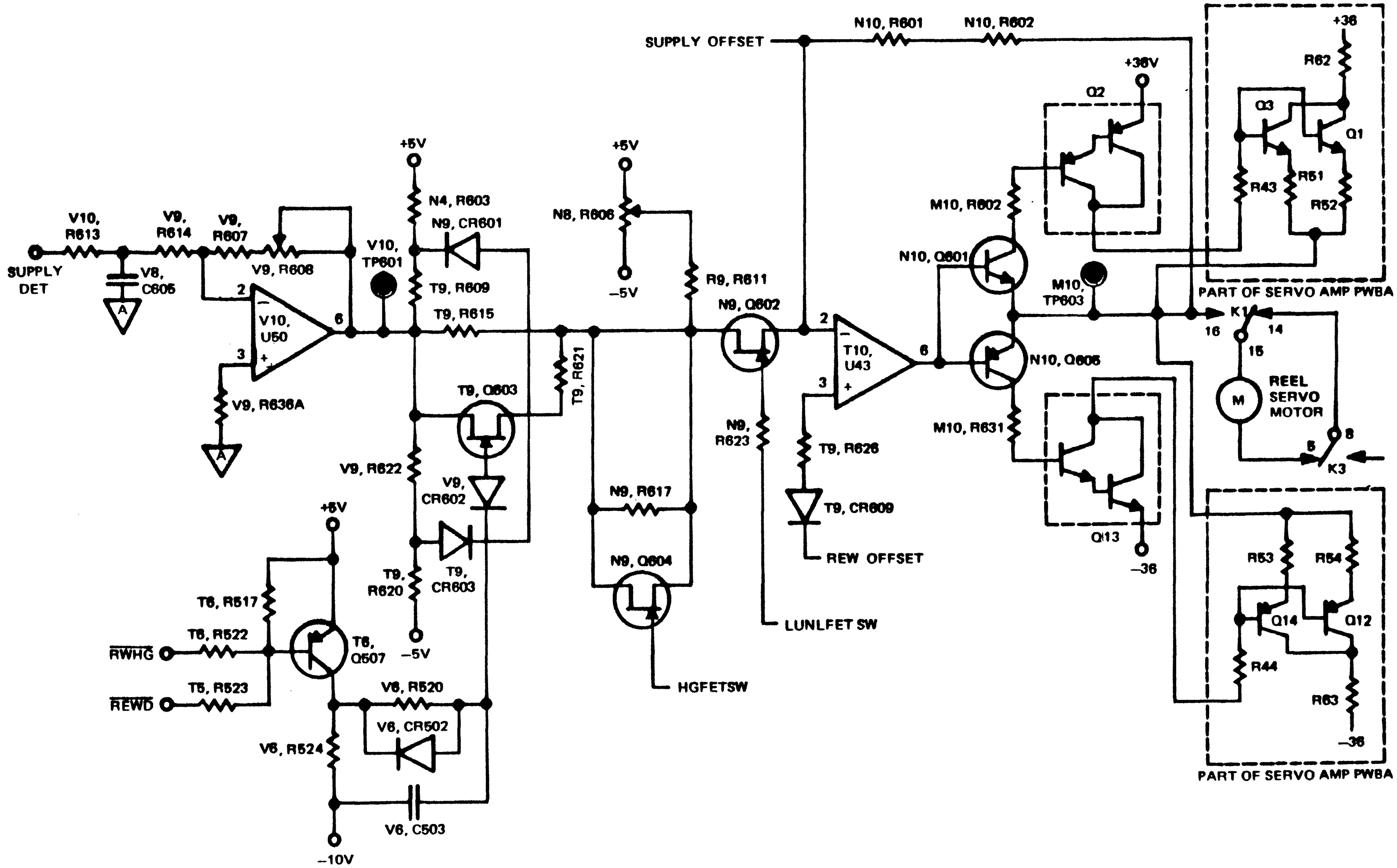


Figure 4-11. Supply Reel Servo Circuits

transistor Q2 is turned on causing its collector potential to increase. As the current through R43 increases greater than 0.6 amps, Q1 and Q3 are turned on. This causes the output at M10, TP603 to increase and drives the supply reel motor current positive. When the output of T10, U43 goes negative, N10, Q605 and power transistor Q13 are turned on, causing power transistors Q12 and Q14 to turn on. This causes M10, TP603 to be driven negative.

The output of the reel servo power stage is connected to the supply reel servo motor through relays K4 and K1. When power is first applied to the tape unit, relay K4 is energized and connects the output of the power stage to relay K1. The motor return goes through relay K2 to ground.

When the tape unit starts to rewind, relay K4 is de-energized by the control board logic and relay K2 is energized. This connects -36 volts to the supply reel servo motor through relay K2. This provides the voltage required for the increased rewind speed of 375 ips.

4-17 Capstan Servo Electronics

The inputs to the capstan amplifier come from the forward/reverse ramp generator and the rewind ramp generator. These generators determine the speed, direction and the rise times for the capstan motor and the tape motion. The following paragraphs describe the operation of the two generators and the capstan amplifier. Figure 4-12 contains the capstan servo block diagram.

4-18 Forward/Reverse Ramp Generator

The forward/reverse ramp generator has five inputs: two reverse, and three forward. Figure 4-13 shows a simplified schematic of the forward/reverse ramp generator circuits. These inputs are normally high, and Z2, Q619, Z0, Q622, and AA2, Q623 are turned off. When $\overline{\text{FORWARD}}$ is set low, Z2, Q619 conducts at saturation and its collector voltage goes 59 +5 volts. This biases AA2, Q623 into saturation and its collector goes to -5 volts. AA2, Q623 is connected to pin 3 of Z3, U68 through AA3, R633A, causing the amplifier output to switch to -10 volts. The -10 volts output is connected through Z4, R683 to the cathode of X3, CR607, pulling the cathode toward -10 volts. However, since the anode of X3, CR607 is at -5 volts, the voltage at the cathode is clamped at -5.6 volts. This -5.6 volts is applied across potentiometer Z4, R688 or Z4, R693, depending on the speed selected and on AA3, C674.

Current flows through Z4, R688 or Z4, R693 and charges AA3, C674 at a constant rate. Since the other plate of AA3, C674 is connected to the output of the amplifier which has a large open loop gain, the output at AA3, U71-6 increases at a rate determined by Z4, R688 or Z4, R693 and AA3, C674. Adjusting the potentiometer consequently changes the rise time at the output of the amplifier. Feedback resistor AA3, R672 is connected between the output of AA3, U71 and the input of Z3, U68 and is equal to the resistance of AA3, R633A. Therefore, when the output of AA3, U71 reaches +5 volts it balances the -5 volts generated by AA2, Q623 at input pin Z3, U68-3. Because of the high gain of Z3, U68, its output switches to zero volts and the output of AA3, U71 is stablized at +5 volts. Any decrease in output of AA3, U71 is regulated by an increase in the output voltage of Z3, U68 and charges AA3, C674 back to +5 volts.

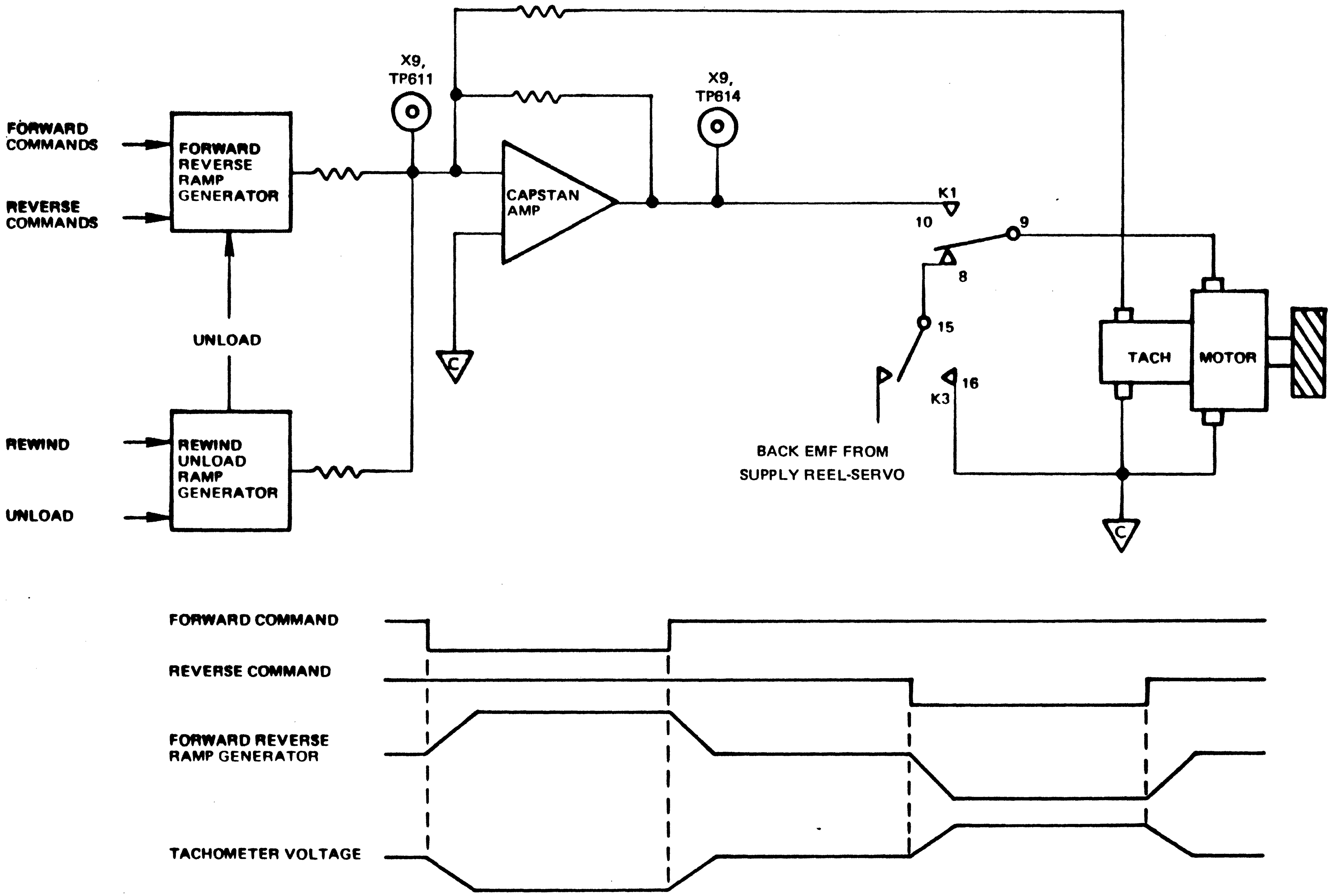


Figure 4-12. Capstan Servo Block Diagram

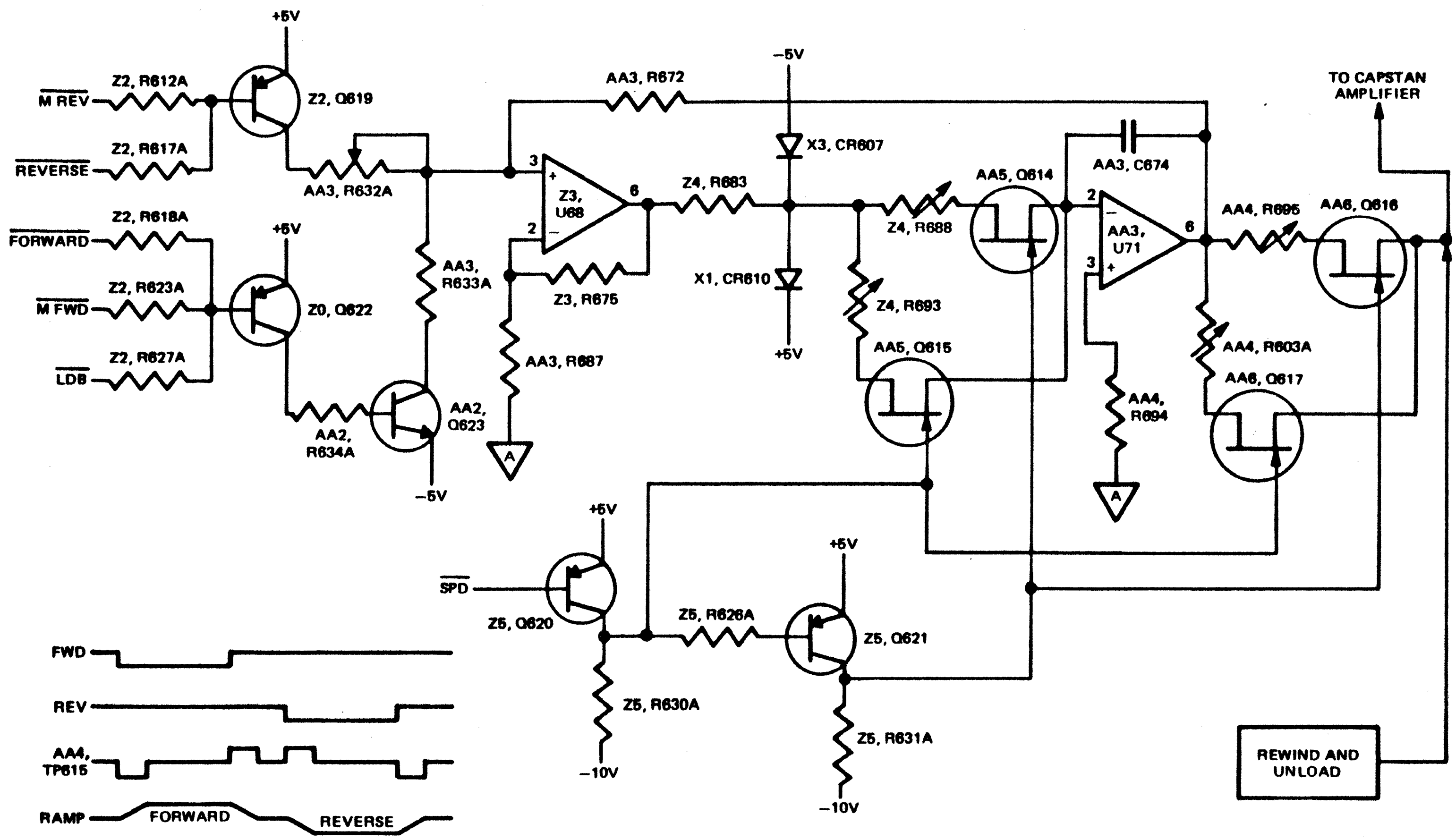


Figure 4-13. Forward/Reverse Ramp Generator Simplified Diagram

The output of AA3, U71 is connected through potentiometer AA4, R695 or AA4, R603A, depending on the speed selected, to the capstan amplifier. The selected potentiometer sets the forward/reverse capstan speed. When FORWARD goes high, Z0, Q622 and AA2, Q623 are turned off, removing the -5 volts from Z3, U68-3. This leaves feedback resistor AA3, R672 with positive voltage at Z3, U68-3 and the amplifier output switches to +10 volts. The anode of X1, CR610 is clamped to +5.6 volts, causing current flow through Z4, R688 or Z4, R693 to discharge AA3, C674, and decrease the output of AA3, U71. When AA3, U71-6 reaches zero volts, the input voltages of Z3, U68 are zero and its output switches to zero volts. The fall time is determined by the discharge rate of AA3, C674 and is equal to the rise time.

The rise/fall ramps and the output of AA3, U71 are accurately controlled by the dedicated ±5 volt ramp generator power supply which is independent of the dc power supply adjustments.

When the REVERSE input is set low, Z2, Q619 conducts at saturation, applying +5 volts through AA3, R632A to Z3, U68-3. Z3, U68-6 switches to +10 volts. Therefore, the operation of the ramp generator is the same as for a forward, except the polarity of the voltages are reversed. Potentiometer AA3, R632A can be adjusted to compensate for the differential of the forward and reverse speed.

The dual-speed option FET's (AA5, Q614 - AA5, Q615 and AA6, Q616 - AA6, Q617) are used to select non-interacting ramp and speed controls. For low speed, SPD is high causing Z5, Q620 to be off. This applies a negative voltage which turns off AA5, Q615 and AA6, Q617. The negative voltage at Z5, R626A turns on Z5, Q621 causing a positive voltage which turns on AA5, Q614 and AA6, Q616 and selects the appropriate circuits for the low speed operation.

For high speed, SPD is low, turning on Z5, Q620 and turning off Z5, Q621. This causes AA5, Q615 and AA6, Q617 to be on and AA5, Q619 and AA6, Q616 to be off, thereby selecting the appropriate circuits for the high speed operation.

4-19 Rewind Ramp Generator

The second input to the capstan amplifier comes from the rewind ramp generator. During rewind operations, the rewind ramp generator is used to generate a negative ramp output to the capstan amplifier. A switching transistor causes the forward/reverse ramp generator to generate a negative ramp output during both rewind and unload operations. Figure 4-14 shows a simplified schematic of the rewind ramp generator. Inputs to the ramp generator are the rewind (RWRD) and unload (UNL) signals. These two signals are normally high. Consequently, during normal operation W5, Q708 conducts at saturation and W5, Q709 and Z6, Q618 are turned off, and the REWD output is low.

During a rewind operation a low input from RWRD sets the anode of W4, CR733 low, turning off W5, Q708 and allowing W6, C721 and W6, C722 to charge toward -10 volts through W5, R744. The potential at W6, U56-4 moves toward -10 volts, causing it to go more negative than W6, U56-5. This causes the output of W6, U56 and REWD to switch high. As W6, C721 and W6, C722 continue to charge, the base of W5, Q709 becomes negative, turning on W5, Q709. As

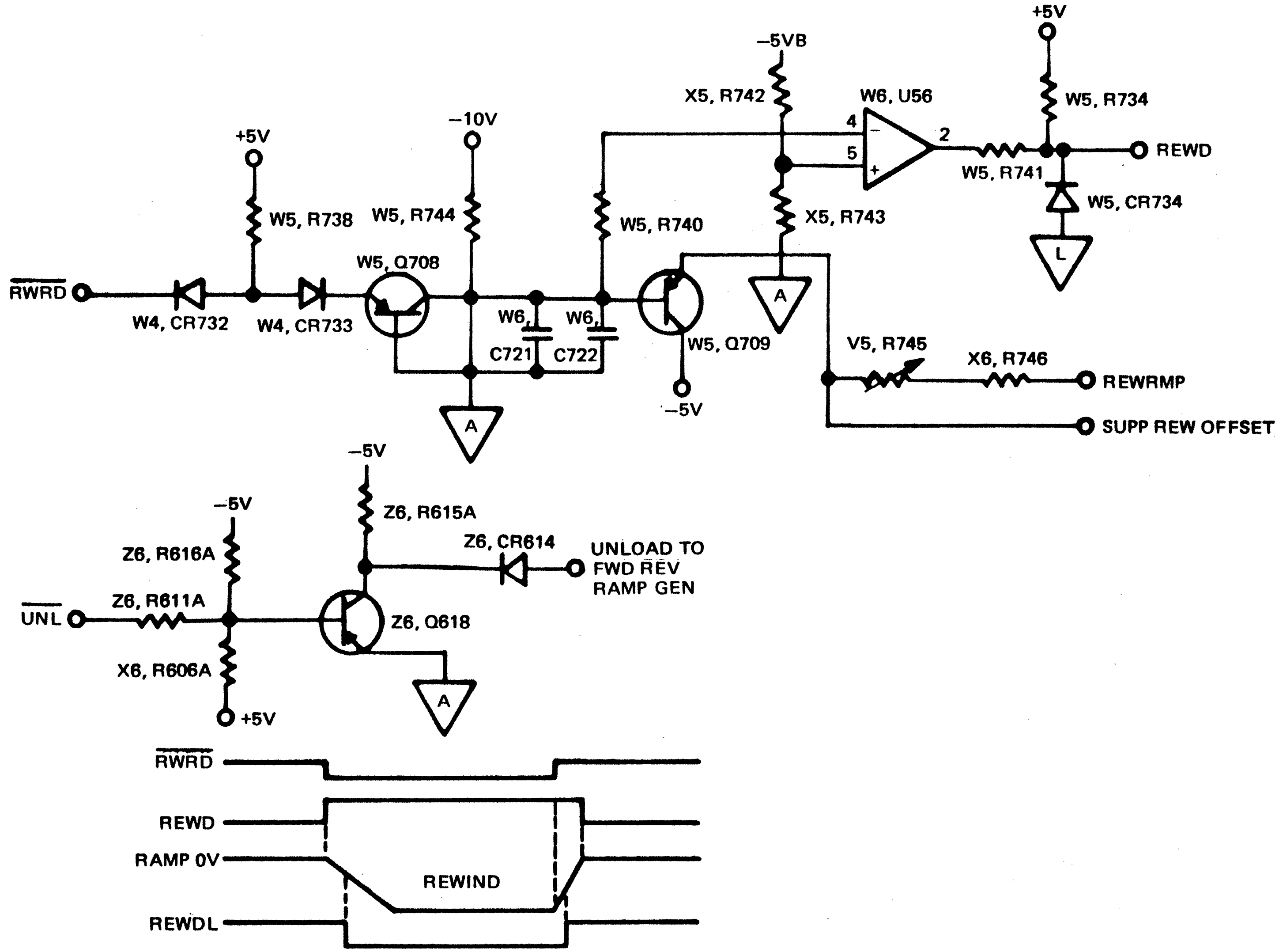


Figure 4-14. Rewind Ramp Generator Control Simplified Diagram

W6, C721 and W6, C722 continue to charge, the potential at the emitter of W5, Q709 increases at the same rate until W5, Q709 conducts at saturation, holding the emitter at -5 volts. The input resistors to the capstan amplifier are V5, R745 and potentiometer X6, R746 which set the rewind speed.

When UNL goes high Z6, Q618 is turned on causing Z6, CR614 to be forward biased. With Z6, CR614 forward biased, a low is established at Z7, U69-2 (figure 4-15) of the capstan drive circuitry causing the capstan to drive in reverse and unload the tape.

4-20 Capstan Amplifier

The outputs of the two ramp generators are connected to Z7, U69-2. Since pin 2 is the summing junction of the capstan amplifier, the adjustment of the ramp generator output potentiometer sets the capstan amplifier output voltage and, consequently, the tape speed (figure 4-15). Offset potentiometer R1252 is connected to U76-2 through R1251. The output of U76-6 is set to zero by R1252, compensating for component variations. Feedback resistor R1249 sets the gain of U76. U76 drives the bases of Q47 and Q48 creating a null region since Q47 and Q48 are turned on only when the output of U76-6 has reached ±0.6 volt. Since both halves of the power amplifier are identical, only one half is described.

When the output of U76-6 is greater than +0.6 volt, Q47 is turned on. The base of the 2N6051 power transistor is lowered and the collector increases the voltage at the output (E). Consequently, a positive output at U76-6 causes the output of the capstan servo to be positive.

The output of the capstan amplifier is connected through relay K1 to the capstan motor. The capstan motor return is connected to ground through a .1 ohm resistor. Current feedback is accomplished by R321 which senses the voltage drop across the .1 ohm resistor. A tachometer is attached to the capstan motor and the output is connected to the capstan amplifier summing junction through R331 and R333. The tachometer allows the capstan servo to accurately regulate the capstan speed.

4-21 <u>On-Line/Off-Line Logic</u>

Figure 4-16 shows a simplified diagram of the on-line/off-line logic. After completion of the load sequence, when LON is set, the tape unit is put on line by momentarily engaging the ON LINE switch. As a result, flip-flop G4, U20 produces a negative pulse output at pin 8 which toggles flip-flop M4, U31-12 through gate H4, U25-8. Flip-flop M4, U31 is set because it was reset during the load sequence by the low $\overline{\text{RSTC}}$ signal at M1, U29-5. The ON LINE lamp driver is driven by a low at M4, U31-2 which turns on the ON LINE indicator. When gate M0, U28 is enabled by the SLTB signal, the output at pin 11 is low, asserting the IONL signal. If the ON LINE switch is pressed again, flip-flop M4, U31 resets. Flip-flop M4, U31 can also be reset by pressing the RESET switch, causing $\overline{\text{RSTC}}$ to go low at N3, U35-5. This causes a low output at N3, U35-6, resetting M4, U31.

The external controller can also set the tape unit off line by asserting the IOFFL signal input through J101. When IOFFL is asserted, M1, U29-6 goes low, causing N3, U35-6 to go low, resetting flip-flop M4, U31.

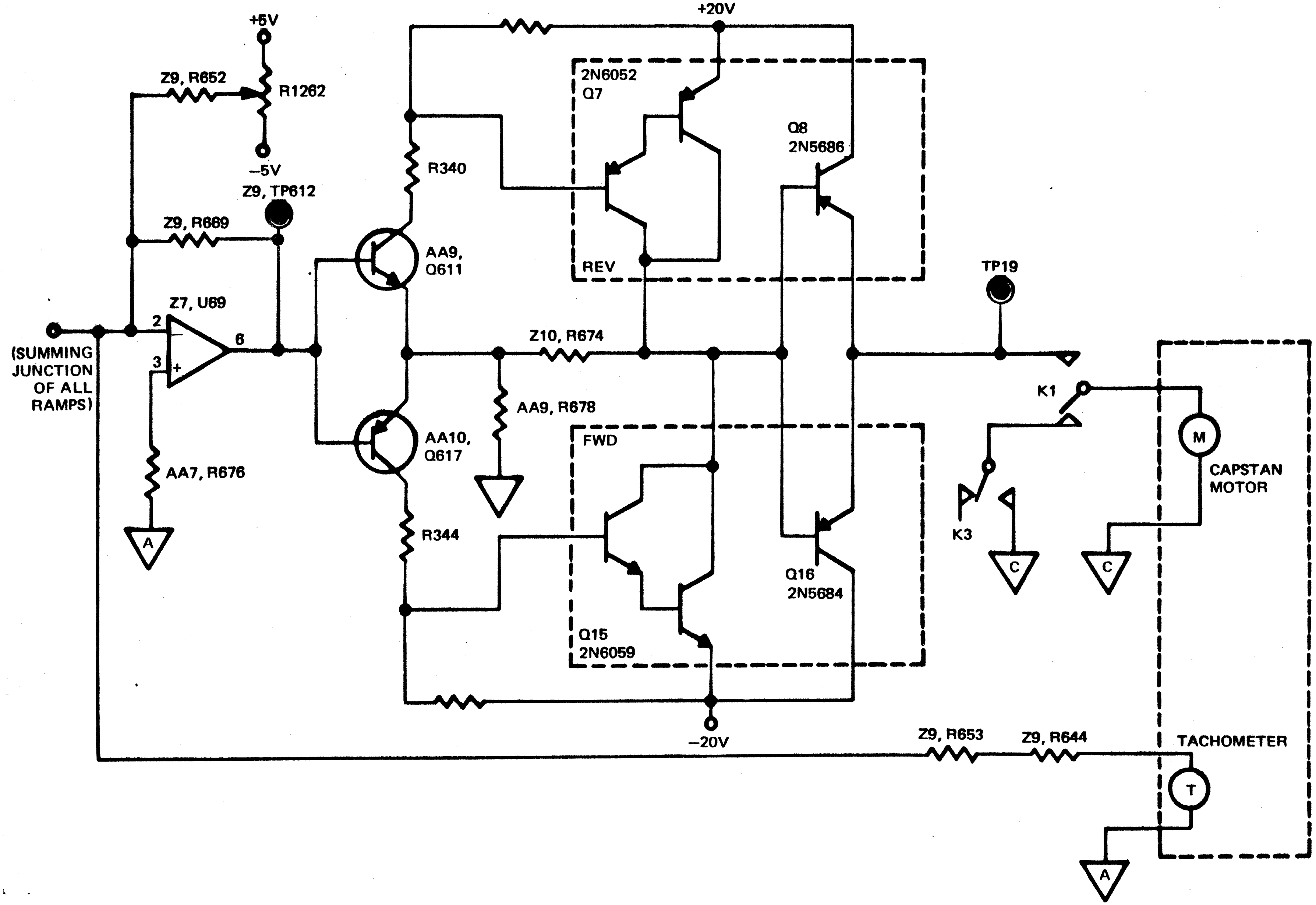


Figure 4-15. Capstan Amplifier Circuit Simplified Diagram

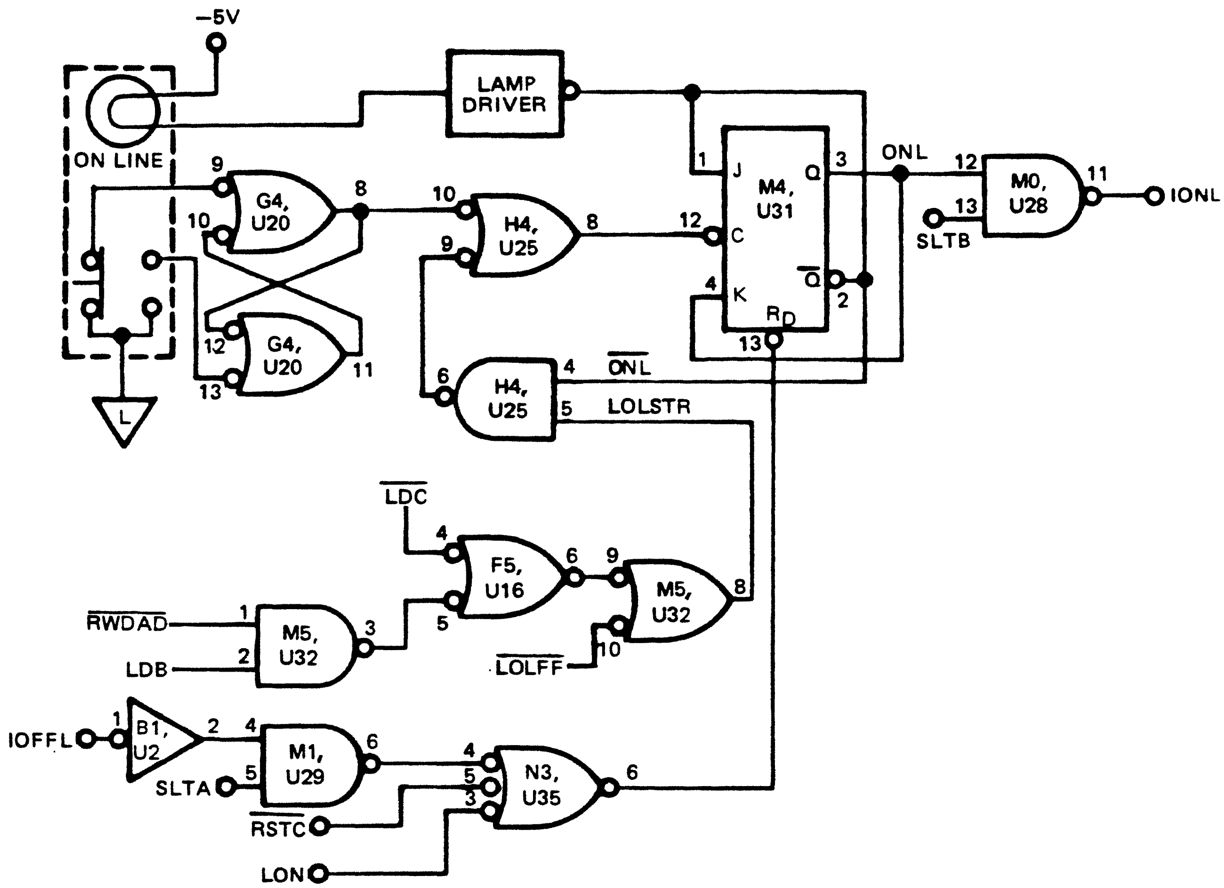


Figure 4-16. On-Line/Off-Line Logic Simplified Diagram

When the tape unit is equipped with the auto load on-line option, the tape unit is automatically placed on line after the tape has been loaded on the tape unit. When the tape has been loaded, the LDB flip-flop is set as previously described in the circuit description for the load logic circuits. The LDB signal is an input to the forward ramp generator and causes the capstan to move the tape toward the BOT marker. The setting of the LDB flip-flop also produces a high input at M5, U32-2. Since a rewind operation is not taking place, the RWDAD signal at M5, U32-1 is also high. This causes the LOLSTR signal at F5, U16-6 to go high. The high LOLSTR signal is applied to H4, U25-5. Since flip-flop M4, U31 is not set at this time, the ONL signal at H4, U25-4 is also high. This results in a low output at H4, U25-6 which enables flip-flop M4, U31 with a high input at M4, U31-1. The tape is stopped at the BOT marker when LDB is reset (refer to the circuit description for the load logic circuits, paragraph 4-10). LDB low causes the LOLSTR signal to go low, setting flip-flop M4, U31. The low output from M4, U31-2 causes the ON LINE indicator to illuminate. When the STLB signal at M0, U28 is high (tape unit address selected or continuous high), the IONL signal to the controller is asserted.

4-22 Address Logic

Figure 4-17 shows a simplified diagram of the address logic. The address logic circuits, after recognizing the tape unit address, enables the tape unit to

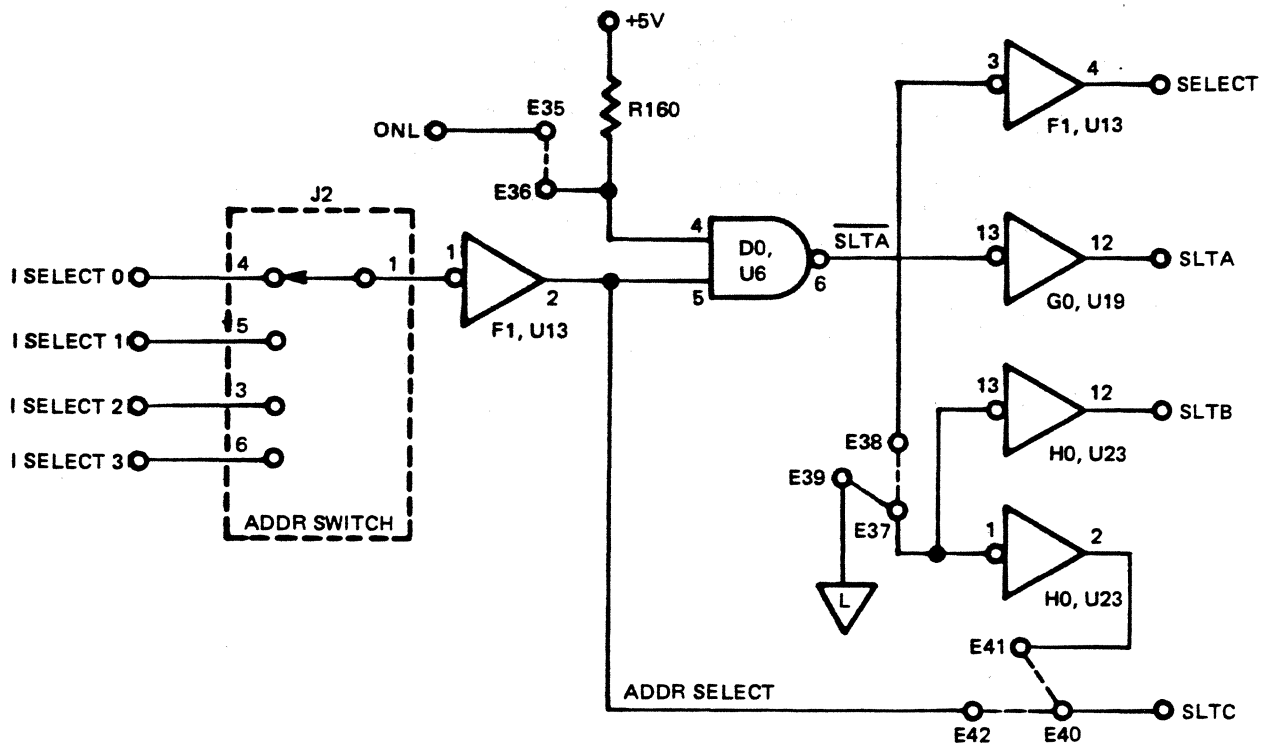


Figure 4-17. Address Logic Simplified Diagram

respond to external commands and to drive the interface lines. If only one tape unit is connected, the external controller must still assert the correct ISELECT input. When the tape unit is addressed, the low input at F1, U13-1 is inverted and a high is applied to D0, U6-5. If E35 and E36 are connected, the tape unit must be on line with ONL high at D0, U6-4 before gate D0, U6 can respond to the input. When D0, U6-6 output $\overline{\text{SLTA}}$ goes low, the SELECT output to the data electronics at F1, U13-4 goes high, as does the SLTA output to the control electronics at G0, U19-1. $\overline{\text{SLTA}}$ also drives the RESET light, indicating the tape unit is selected. The SLTB output at H0, U23-12 is either continuously high, pins E37 and E39 connected, or it is gated high in the same manner as the SLTA output. If pins E40 and E42 are connected, the SLTC output from F1, U13 is high when the unit is addressed. If pins E41 and E40 are connected, the SLTC signal duplicates the SLTB signal at H0, U23-2.

4-23 Forward/Reverse Control Logic

Figure 4-18 shows a simplified diagram of the forward/reverse control logic. When the tape unit is on line, selected, not rewinding or loading, and all interlock conditions are set, it is able to respond to external command inputs. At this time ORS is high. When ISFC is asserted by the external controller, gate W1, U52-6 produces a low output that goes to the forward/reverse ramp generator which produces a positive-going ramp output to the capstan amplifier. This ramp output eventually stablizes at some dc voltage suitable for the tape speed requirements of the specific tape unit.

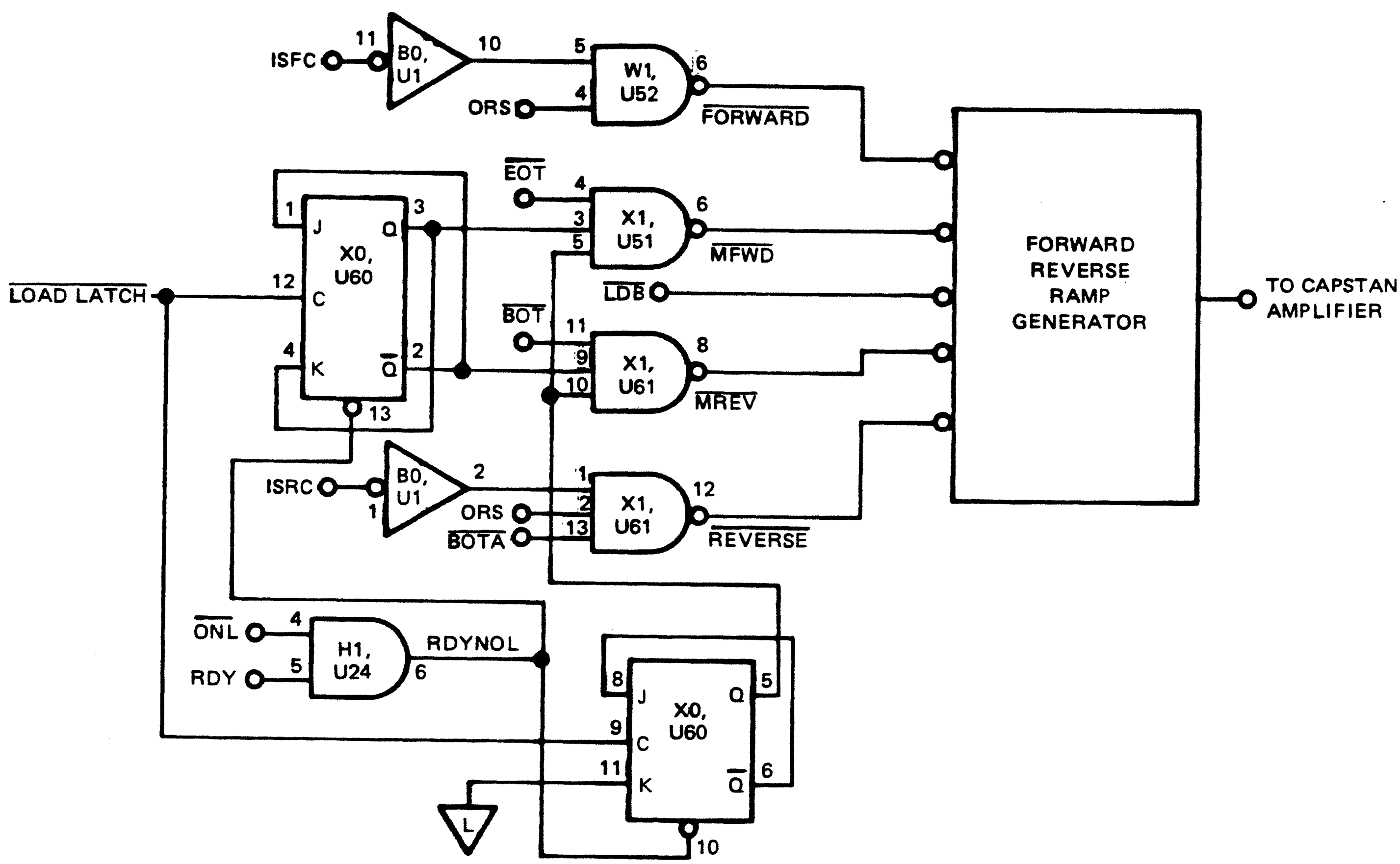


Figure 4-18. Forward/Reverse Control Logic Simplified Diagram

Tape movement in the reverse direction, at synchronous speed, is initiated when the external controller asserts the ISRC signal. The forward/reverse ramp generator responds by producing a negative-going ramp output, driving the capstan motor in the reverse direction.

When the tape unit is not on line, ONL, RDY, and RDYNOL are high. This condition enables flip-flops X0, U60-3 and X0, U60. When LOAD LATCH momentarily goes low, the flip-flop sets, causing X1, U51-6 to go low (MFWD) initiating forward tape movement.

When the load switch is pressed a second time, LOAD LATCH momentarily goes low resetting, which stops forward tape movement. X0, U60-5 remains set, therefore X1, U61-8 (MREV) goes low initiating reverse tape movement.

The tape can be moved forward or reverse by each actuation of the load switch. Pressing the reset switch resets flip-flops X0, U60-3 and X0, U60-5, terminating the manual forward/reverse control.

The manual forward command is gated with EOT which prevents the tape from being run off the end of the reel. BOT is gated with the manual reverse to prevent the tape from running off the beginning of the reel.

4-24 Write/Overwrite Control Logic

Figure 4-19 shows a simplified diagram of the write/overwrite control circuit, and figure 4-20 shows the write/overwrite timing diagram. To write data, the ISFC and ISWRT signals must be asserted. When the ISFC signal is asserted, the low FORWARD input at W1, U32-10 causes a high output at W1, U32-8 which produces a high MOTION signal input to T0, U37-5 and a low MOTION output to the data electronics. The MOTION signal at T0, U37-4 is delayed by the V0, R201/ V0, C202 time constant and differentiated by T0, C201, T0, R203, and T0, R204. This generates a pulse at F1, TP205 that is used as the clock input to the flip-flops. With the ISWRT input asserted, the SWRT output of U9-3 is clocked high. With IOVW not asserted, a high is applied to D1, U7-11 which results in the D1, U7-6 output being clocked high. The two levels force a low output at F0, U12-3. This low is gated by F0, U12-6 and inverted at F1, U13-6, producing a low WRITE ENABLE output to the data electronics.

To perform an overwrite operation, the ISFC, ISWRT, and IOVW inputs must all be asserted. When these signals are asserted, flip-flops D1, U7-3, D1, U7-5, and F0, U12-11 are set. Gate F0, U12-3 is inhibited by the Q output of D1, U7-6. However, all inputs to gate D0, U6 are high and a WRITE ENABLE output to the data electronics is produced. Near the end of a record in which the overwrite sequence is occurring, the LRC input at F0, U12-9 is set low, resetting F0, U12-11. Consequently, WRITE ENABLE is set high, ending the overwrite operation.

4-25 Rewind/Unload Control Logic

Figure 4-21 shows a simplified diagram of the rewind/unload circuits. A rewind operation is initiated when the external controller asserts the IREW signal or when the rewind switch is pressed. If the BOT marker is at the BOT/EOT sensor and the rewind switch is pressed, the tape unit unloads the tape. If the tape is at mid-tape and the rewind switch is pressed, the tape unit rewinds to the BOT marker. If the rewind switch is pressed a second time while the tape is rewinding, the tape unit unloads the tape when it reaches the BOT marker.

4-26 Rewind (OFF LINE)

Figure 4-22 shows the timing diagram for a tape rewind sequence when the tape is positioned at mid-tape. Momentarily actuating the rewind switch produces a position pulse at the output of rewind latch setting RWDA high, and RWDAD low. RWDAD going low starts the RWDL delay timing. When the RWDL delay times out, RWDL goes high, setting RWRD low, and turning on relay K4. This starts rewind ramping toward -5 volt level. When the rewind ramp reaches the appropriate level, REWD goes high, REWD goes low and relay K2 is energized. With K2 energized the tape unit rewinds to BOT and overshoots the BOT marker.

When the BOT marker is reached, a positive pulse is produced at T4, U41-9 (BOTA). The negative going edge of BOTA sets RWDB low and RWRD high, conditioning the rewind ramp to start ramping toward the 0-volt level. When the rewind ramp reaches the appropriate level, REWD goes low and REWD goes high, which turns off relay K2. REWD going low sets the LDB flip-flop, which starts BOTDLY and LDBDLY delay timing. LDB is an input to the forward ramp generator which causes the capstan to move the tape forward.

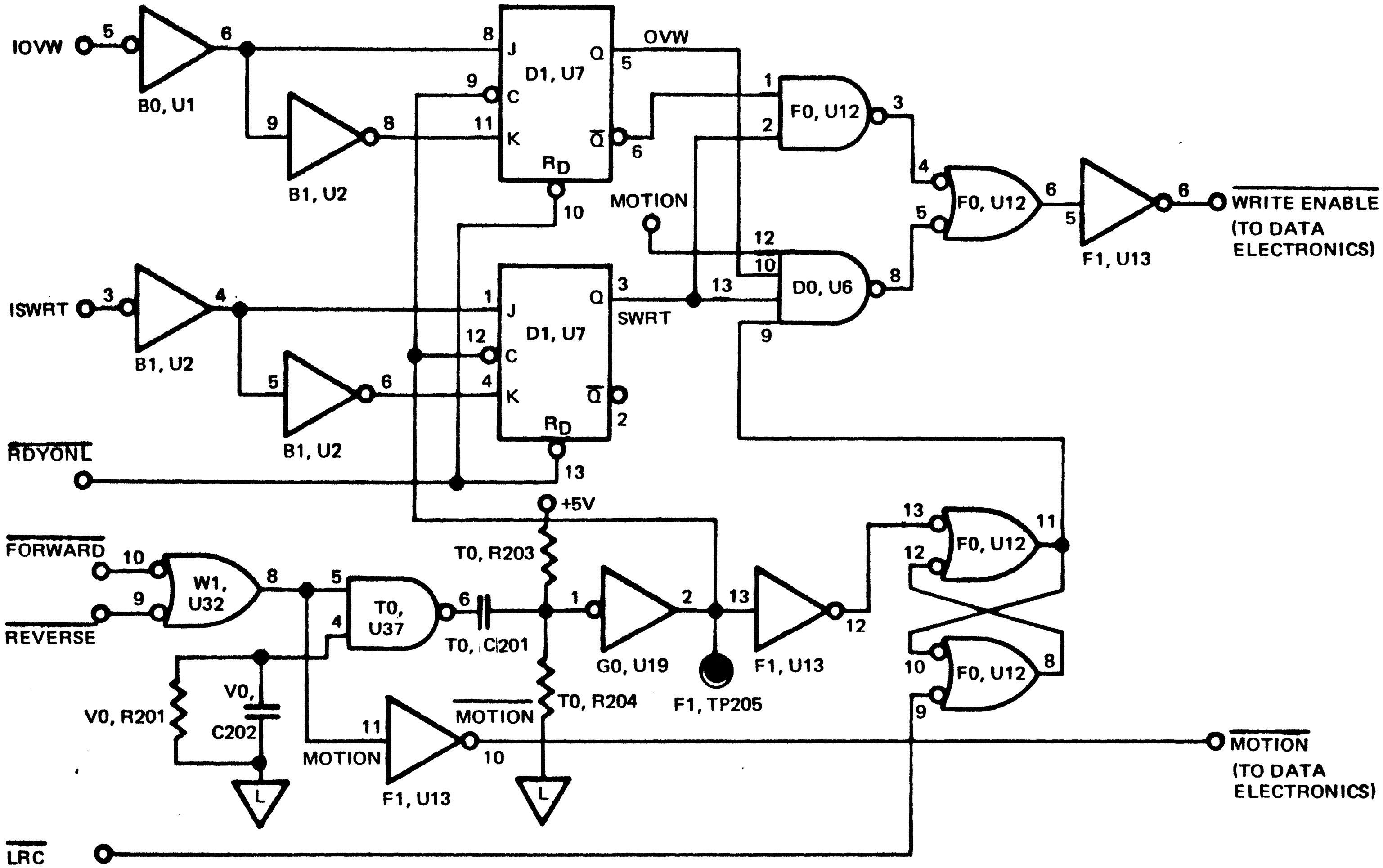


Figure 4-19. Write/Overwrite Control Logic Simplified Diagram

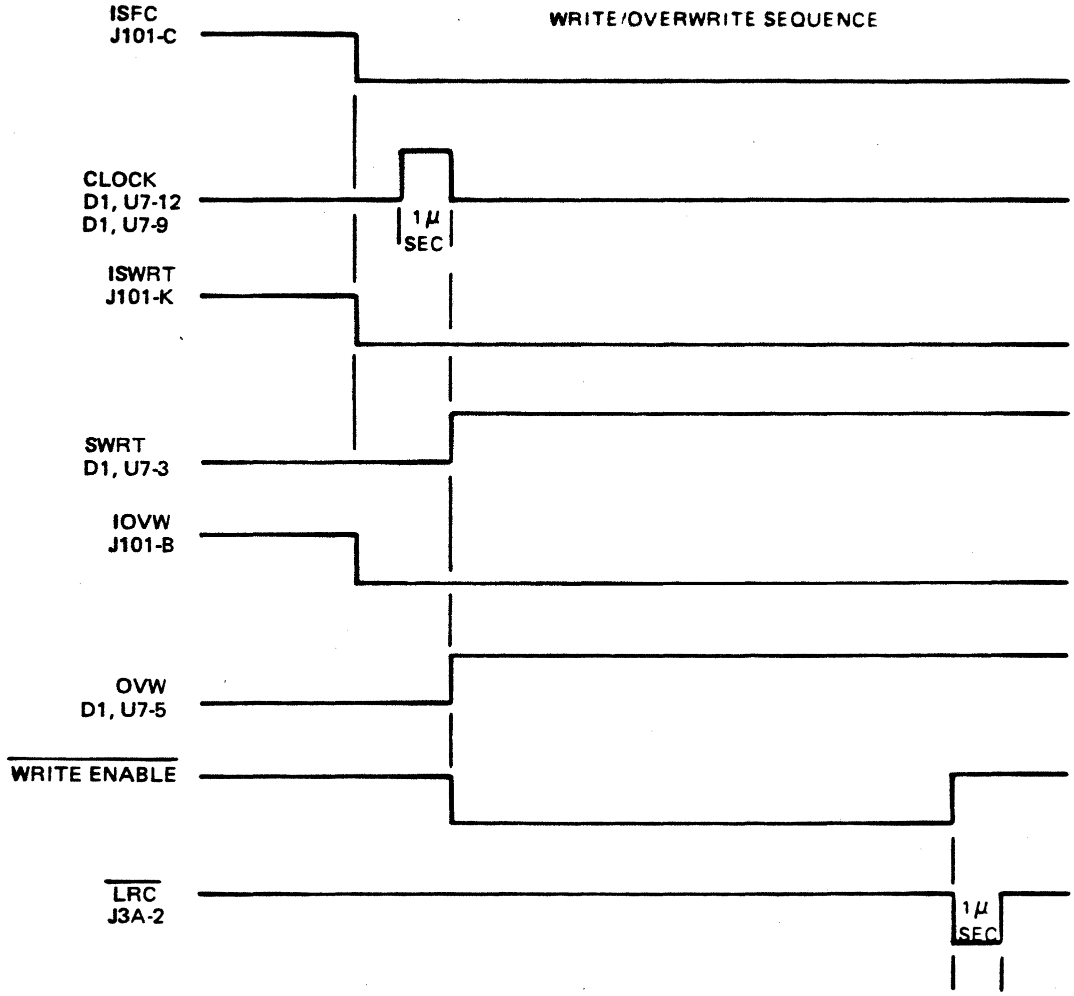


Figure 4-20. Write/Overwrite Timing Diagram

The BOTA signal goes high when the BOT marker is sensed. This causes RSTB to go low resetting the LDB flip-flop. With the reset of the LDB flip-flop, BOTDLY delay timing is terminated and LDBDLY is set low. RSTB going low causes RSTA to go low; RSTA going low sets RWDB low, RWDB high and RWDA low. RWDA going low sets RWDAD high and RWDAD going high sets RWDL low, terminating the rewind sequence.

4-27 Unload From BOT (OFF LINE)

To unload, the rewind switch is pressed and then released, producing a positive pulse output from the rewind latch. Refer to figures 4-21 and 4-23 for the schematic and timing diagram. A high RDYNOL signal, gated with the output of the rewind latch, causes a negative pulse to be applied to the UNL flip-flop, setting UNL low. UNL going low causes RSTC to go low, RSTB goes low, LDRST goes low, LUNLFET SW goes low, SET HOLD goes high and relay K3 is de-energized. K3 being de-energized shuts off the blower motor and drops vacuum. The tape unit performs a tape unload sequence.

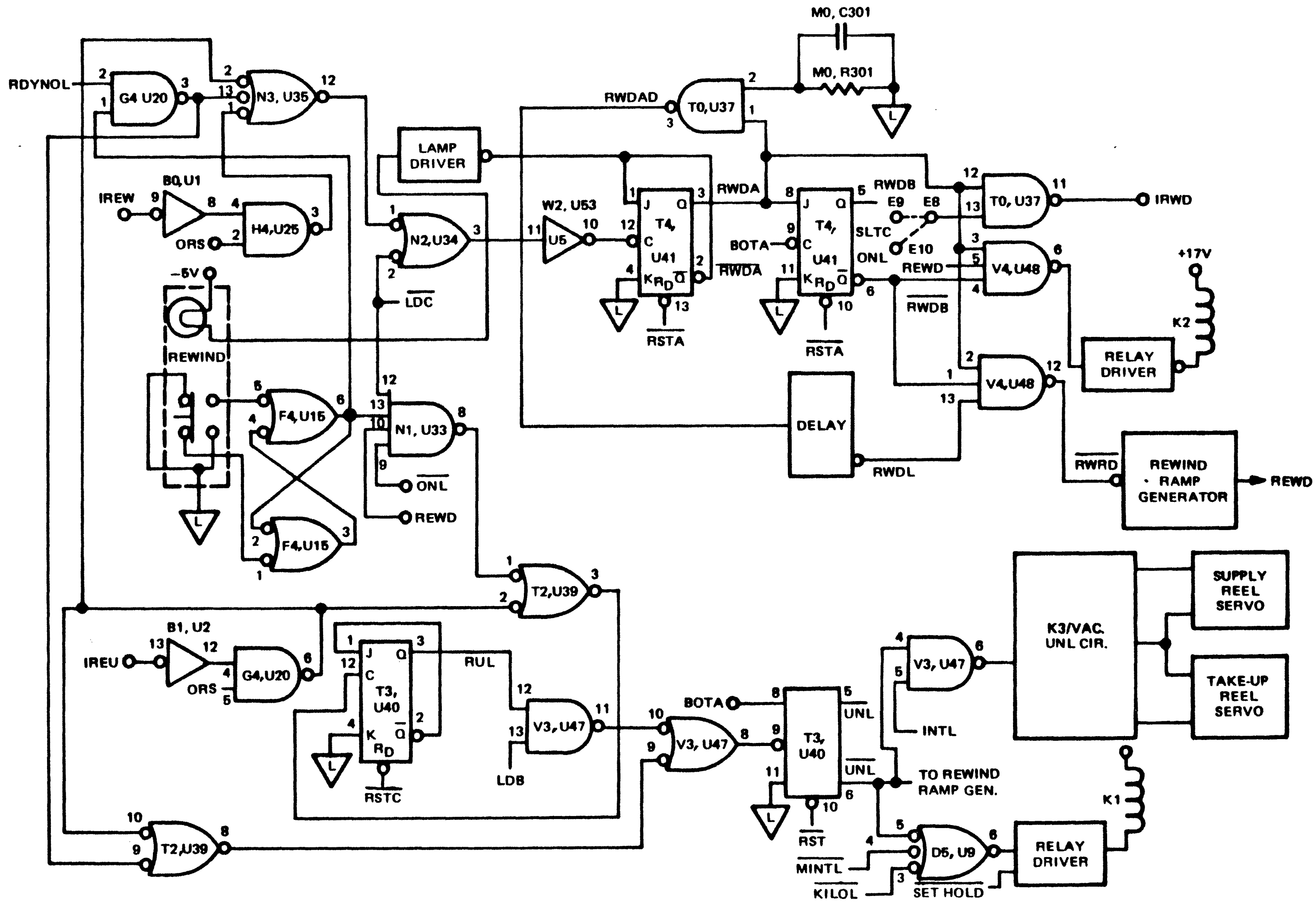


Figure 4-21. Rewind/Unload Control Circuits Simplified Diagram

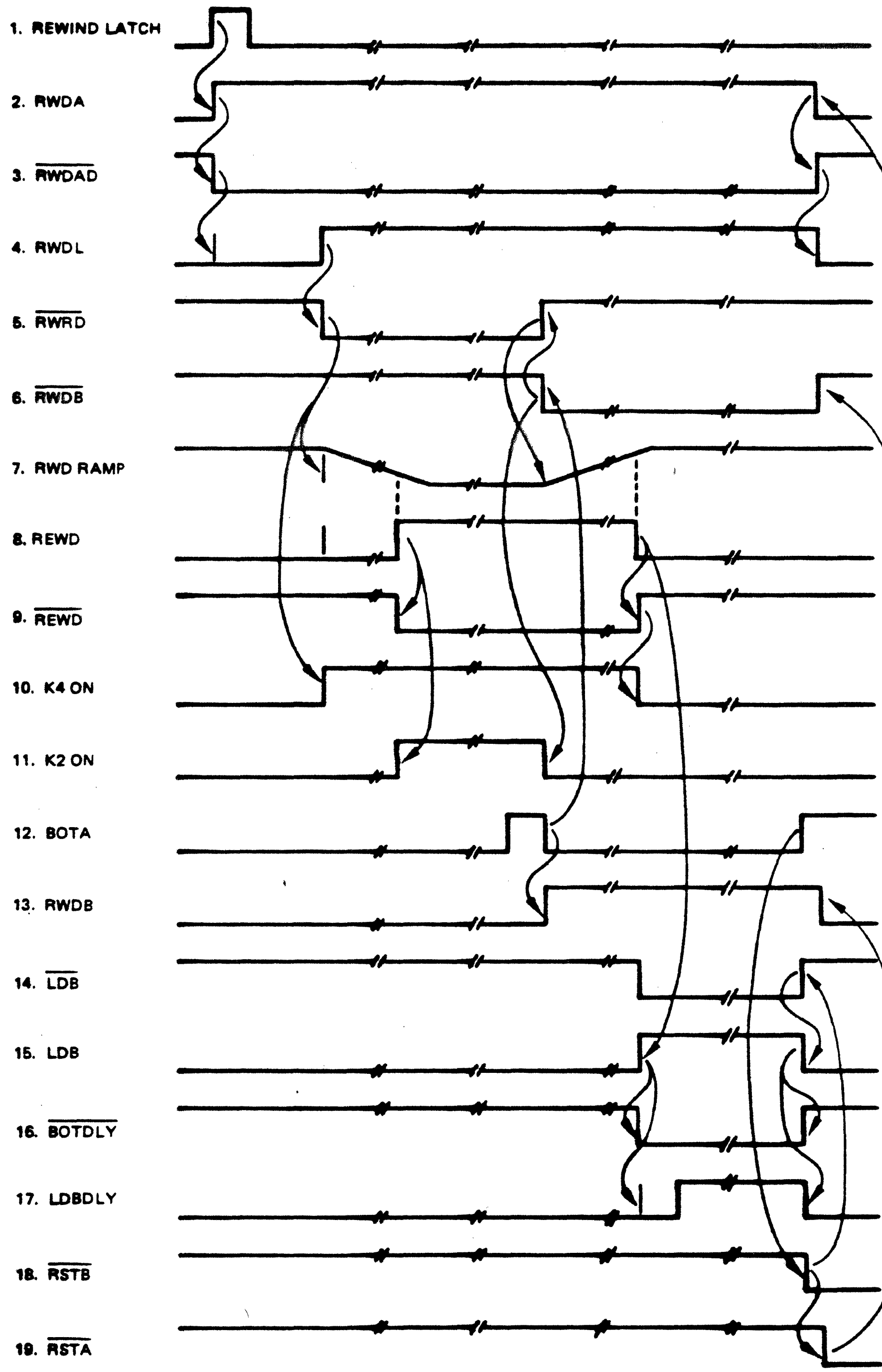


Figure 4-22. Rewind Off Line

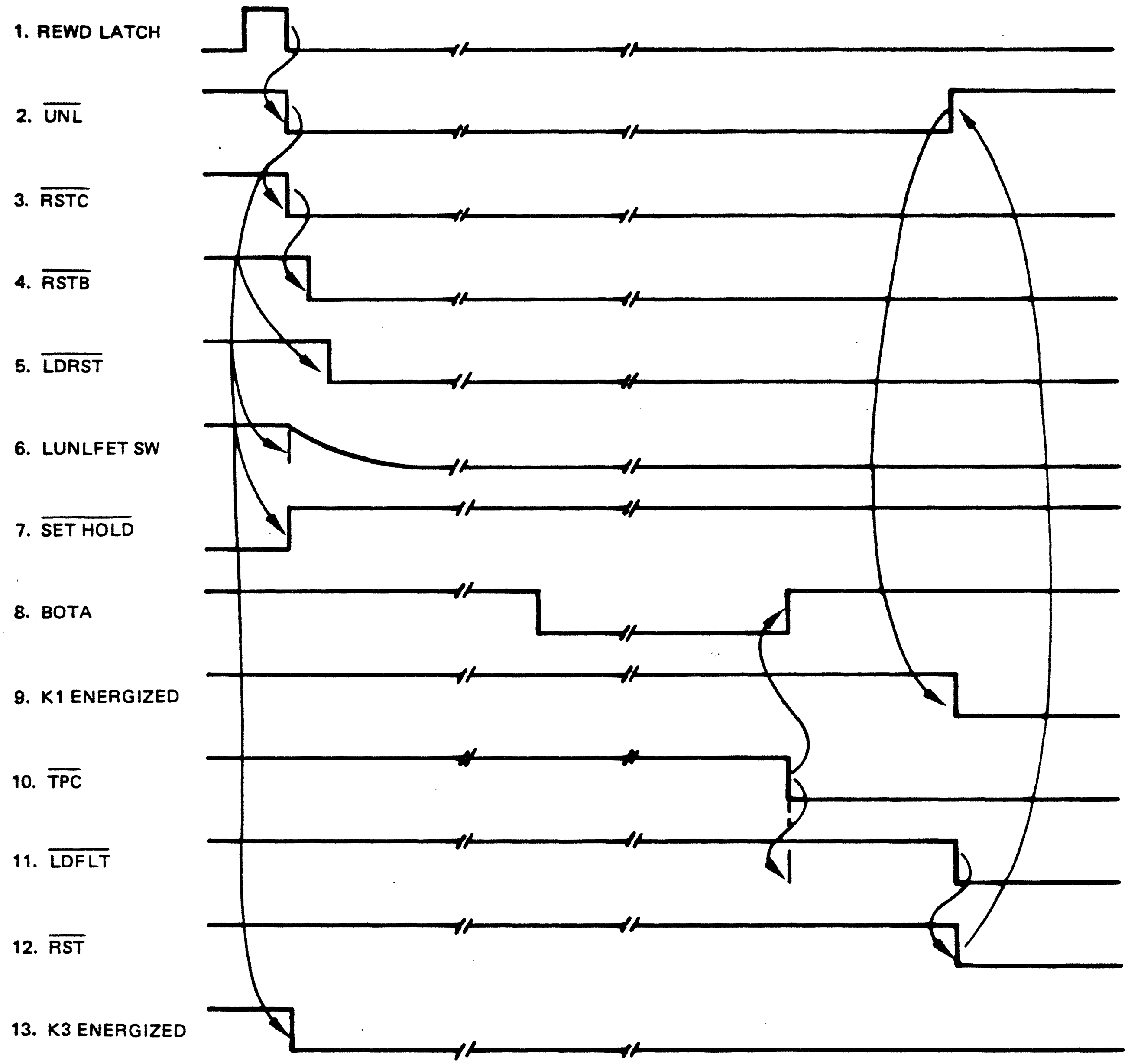


Figure 4-23. Unload From BOT Off Line

When the tape has cleared the BOT/EOT sensor, $\overline{\text{TPC}}$ goes low starting the $\overline{\text{LDFLT}}$ delay timing. When $\overline{\text{LDFLT}}$ delay times out and goes low, it sets $\overline{\text{RST}}$ low which resets the UNL flip-flop. $\overline{\text{UNL}}$ going high de-energizes relay K1 and completes the unload sequence.

4-28 Unload From Mid-Tape (OFF LINE)

The timing diagram (figure 4-24) shows the sequence for an unload from mid-tape operation. The first actuation of the rewind switch sets the tape unit into a normal rewind operation (figure 4-22 and paragraph 4-26). The second actuation of the rewind switch causes a negative pulse at T3, U40-12 which sets the RUL flip-flop.

The tape unit continues a normal rewind operation until the BOT marker is at the BOT/EOT sensor. At this point, the LDB flip-flop is reset, causing LDB to go low. LDB being gated with RUL causes the UNL flip-flop to be set. With $\overline{\text{UNL}}$ going low, the tape unit performs an unload sequence (figure 4-23 and paragraph 4-27): the RUL flip-flop is reset by $\overline{\text{RSTC}}$. After UNL is set and RUL reset, the unload sequence is the same as figure 4-23.

$\overline{\text{UNL}}$ through $\overline{\text{RSTC}}$ resets the RUL flip-flop. The UNL flip-flop is reset by the LDFLT timer (the timer is started after the tape end clears the EOT/BOT sensor). After UNL is set and RUL reset the unload sequence is the same as shown in figure 4-23.

4-29 Unload (ON LINE)

The unload sequence when the tape unit is on line is the same as unload from mid-tape, with the exceptions that IREU sets RWDA and the RUL flip-flop and at the end of the sequence the ONL flip-flop is reset taking the tape unit off line (refer to timing diagram 4-25).

4-30 ORS, ON LINE and IRDY (Shown During Load Sequence)

The timing diagram in figure 4-26 shows the timing for a load sequence with the generation of the ORS (ON LINE, RDY and SELECTED), ON LINE and IRDY signals. At the end of the load sequence, signal $\overline{\text{RSTB}}$ sets $\overline{\text{LDB}}$ high; $\overline{\text{LDC}}$ going high causes LOLSTR to go low which sets the ONL flip-flop. $\overline{\text{RSTB}}$ also resets the LDB flip-flop which sets $\overline{\text{LDB}}$ high which in turn sets RDY high. With RDY and ONL high and the tape unit selected, ORS goes high.

4-31 EOT/BOT Control Logic

Figure 4-27 shows a simplified schematic diagram of the EOT and BOT control logic. These circuits are used to provide an indication when the tape has passed or is positioned at the EOT or BOT marker. The outputs of the EOT/BOT circuits are passed through appropriate interface circuits to the external controller.

The output of both the EOT and BOT amplifiers is normally low, and goes high when active. Since both amplifier circuits are identical, only the EOT amplifier is described. The output of the EOT amplifier goes high when the EOT marker is in front of the EOT phototransistor.

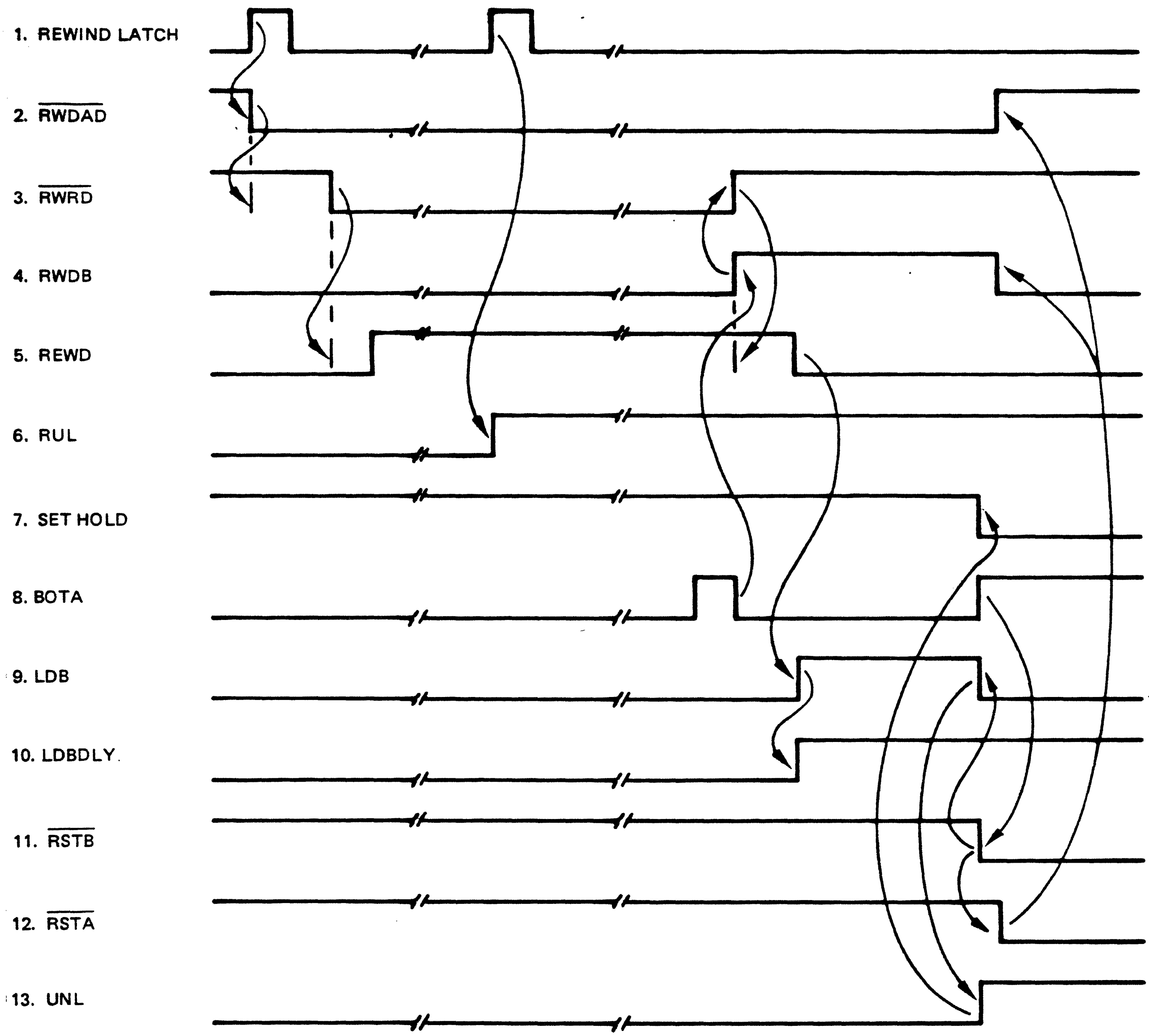


Figure 4-24. Unload From Mid Tape, Off Line

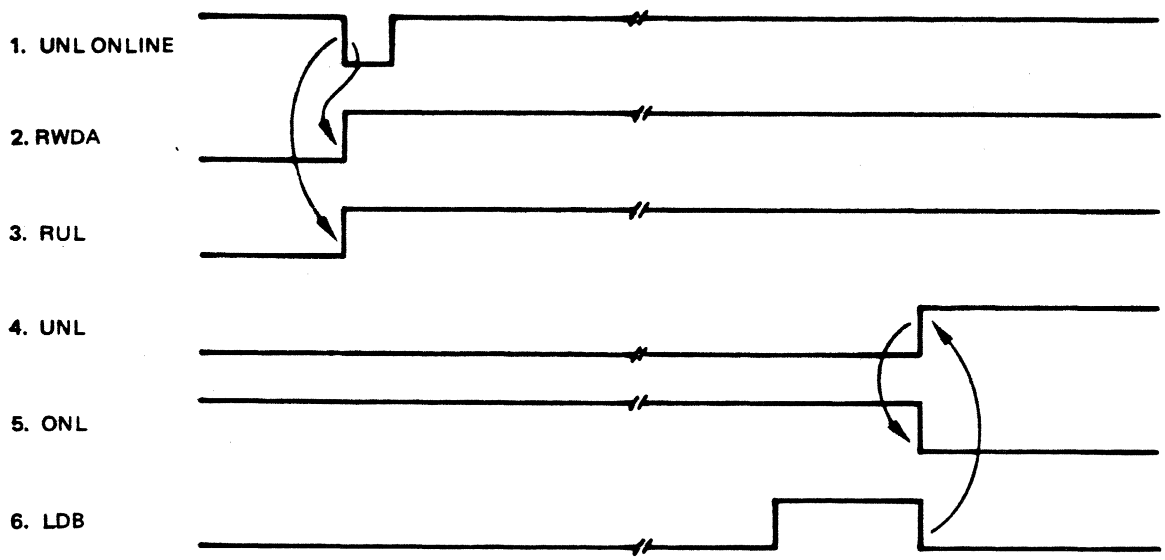


Figure 4-25. Unload On Line (Mid Tape)

Initially, the current through W6, R208 is set with blank tape in front of the EOT phototransistor so that the voltage at W6, U56-9 is negative. When W6, U56-9 is more negative than W6, U56-8, the amplifier output is negative. The phototransistor receives an increase of light from the EOT reflective marker, increasing current through W6, R219. The increase in current caused by the EOT marker creates an increase in voltage drop across W6, R208 so that W6, U56-9 goes positive. The output is switched to high, setting EOTA.

EOTA is applied to NAND gates W0, U51-1 and W1, U52-1. When the tape has been removed from in front of the EOT/BOT assembly, the reflector post in front of the assembly reflects the light, setting both BOT and EOT amplifiers high. Highs at W1, U52-1 and -2 set TPC at W1, U52-3 low, gating EOT high at W0, U51-12. If the tape unit is rewinding, RWDAD at W0, U51-13 is also low, preventing EOT from asserting IEOT through T1, U38-6. EOT through W1, U52-11 sets V1, U45-2 when FORWARD is asserted at W1, U52-13. If the jumper between pin E1 and E2 is connected, the output of V0, U44-2 is connected to T1, U38-4, asserting IEOT whenever the EOT marker has been passed in the forward direction. V1, U45-2 is reset when the marker has been passed in the reverse direction, a rewind operation is initiated, or the interlock is broken.

BOTA is gated with TPC, RWDA, LDB and LON from M1, U29-8 at W0, U51-10. IBOT is not asserted if the tape unit is loading, rewinding or the tape is not on the tape path.

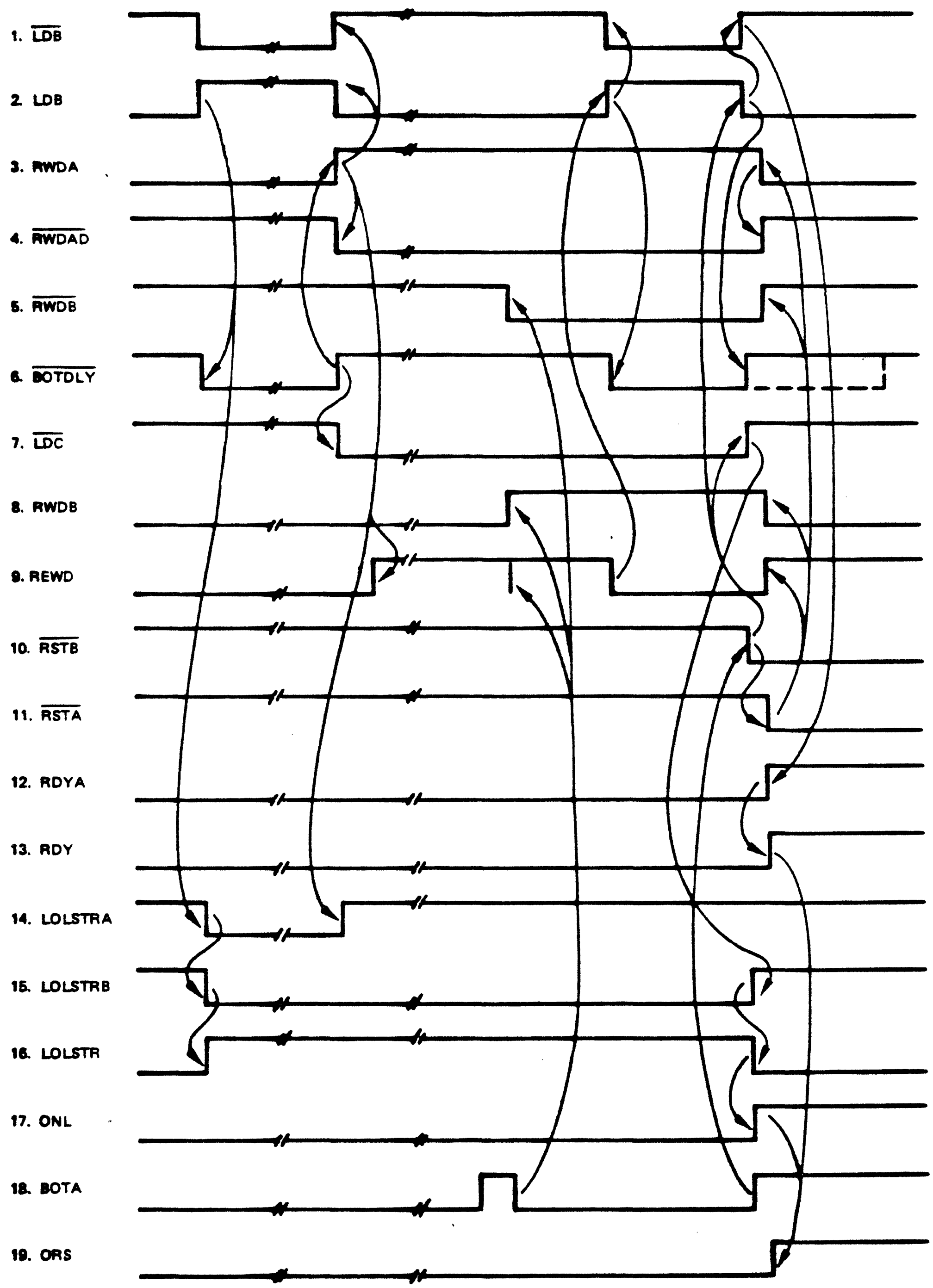


Figure 4-26. ORS, ON LINE & IRDY (Shown During Load Sequence)

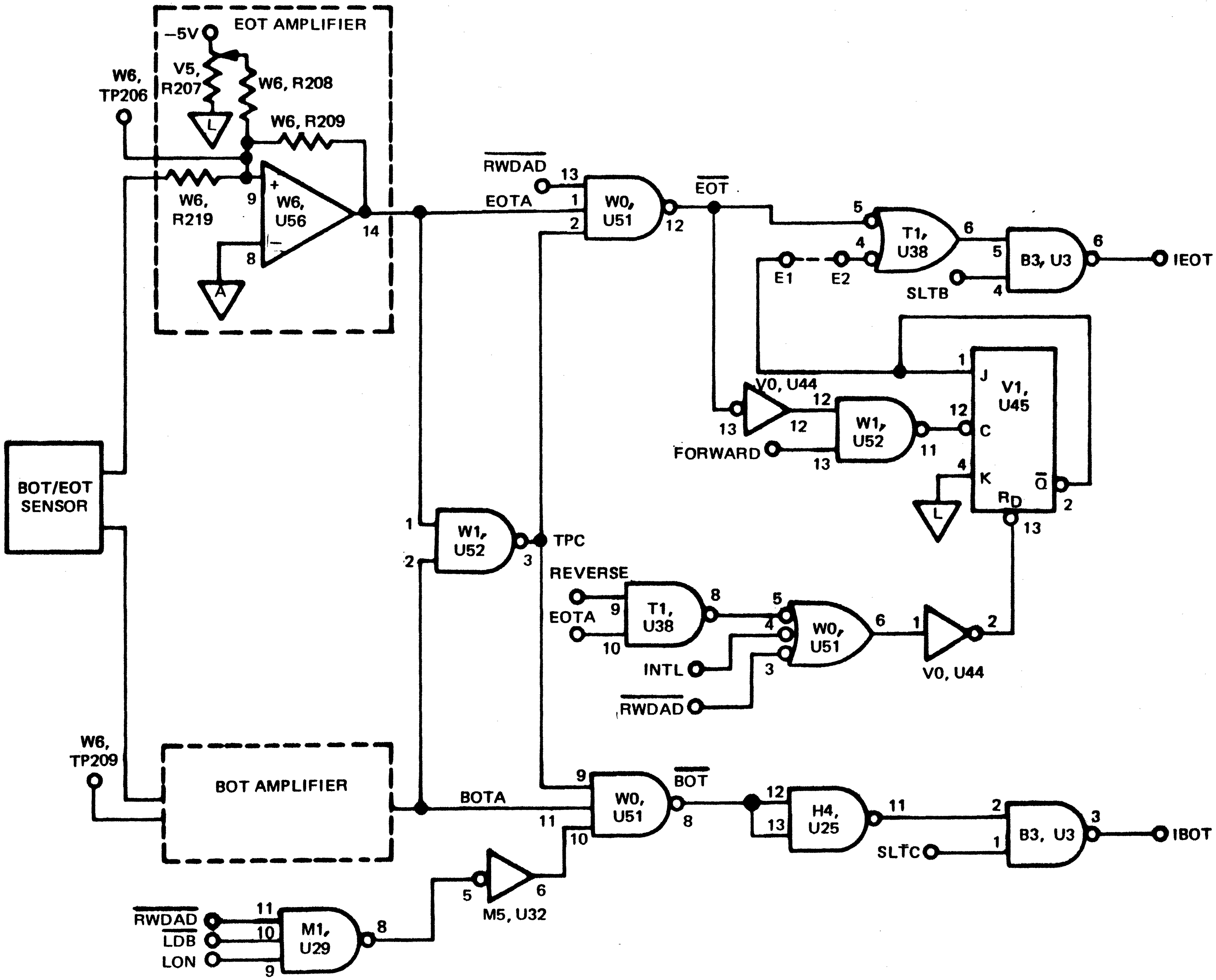


Figure 4-27. EOT/BOT Control Logic Simplified Diagram

4-32 Density Select Logic

Figure 4-28 shows a simplified diagram of the density select circuits. Density is selected from the front panel when a jumper is connected between E30 and E31. Front panel selection can select either high or low density. Density is selected by the external controller when a jumper is connected between E30 and E32. Controller selection can select either high or low density. When no jumpers are connected the tape unit operates in the high density mode only.

When HI DEN is high, the $\overline{\text{HI DEN}}$ lamp is illuminated and the $\overline{\text{HI DEN}}$ output to the data electronics is set low. In addition, the SLTB signal gates line driver M0, U28-9, setting the IDDI output low. The IDDI output indicates high density operation to the external controller. In the dual-speed option, when high density is asserted at H1, U24-2, $\overline{\text{SPD}}$ goes low at H1, U24-3 and the tape unit operates at the lower speed.

When the quad density option is used and PE operation is selected, the tape unit operates at the lower of the two tape speeds. The $\overline{\text{SPD}}$ signal for this mode goes low when the IDD signal from the controller goes low.

4-33 Nine-Track Circuit

Figure 4-29 shows a simplified diagram of the 9-track circuit. The 9-TRACK switch is used with the quad density option and combination 7- and 9-track, single speed, NRZI tape units. When the 9-TRACK switch is used with the quad density option, pins E28 and E29, E20 and E23, and E24 and E25 are connected. When the 9-TRACK switch is pressed, H0, U23-8 goes low at the lamp driver and at inverter T0, U37-9. This causes the 9-TRACK switch lamp to illuminate and the 9-TRACK signal to go high. The high 9-TRACK signal is applied to the data electronics, indicating 9-track operation. The $\overline{\text{SPD}}$ signal at H1, U24-3 is held low by HID being low. This causes the tape unit to operate at the lower speed.

When 7-track operation is used in the quad density option, the 9-TRACK switch is released to place the switch in the 7-track position. This applies a high input to the lamp driver and T0, U37-9 causing the 9-TRACK switch lamp to extinguish and the 9-TRACK signal to go low, indicating 7-track operation. In the 7-track position of the 9-TRACK switch, a low is applied to H1, U24-1. This holds the $\overline{\text{SPD}}$ signal low during 7-track operation and causes the tape unit to operate at the higher speed.

4-34 File Protect Circuit

The file protect circuit (figure 4-30), can be connected as either a file protect circuit or a write enable circuit. When connected as a file protect circuit, the FILE PROTECT lamp is illuminated when a file reel without a write ring is mounted on the tape unit. This indicates that writing or erasing on the tape is not possible. When connected as a write enable circuit, the WRITE ENABLE lamp is illuminated when a file reel with a write ring is mounted on the tape unit. This indicates that writing or erasing on the tape can be performed.

When a write ring is installed in the file reel, the high INTLA signal is applied to inverter G0, U19-11 and to the data electronics as the WRITE POWER signal. The low output from G0, U19-10 is applied to G0, U19-5 and M0, U28-4.

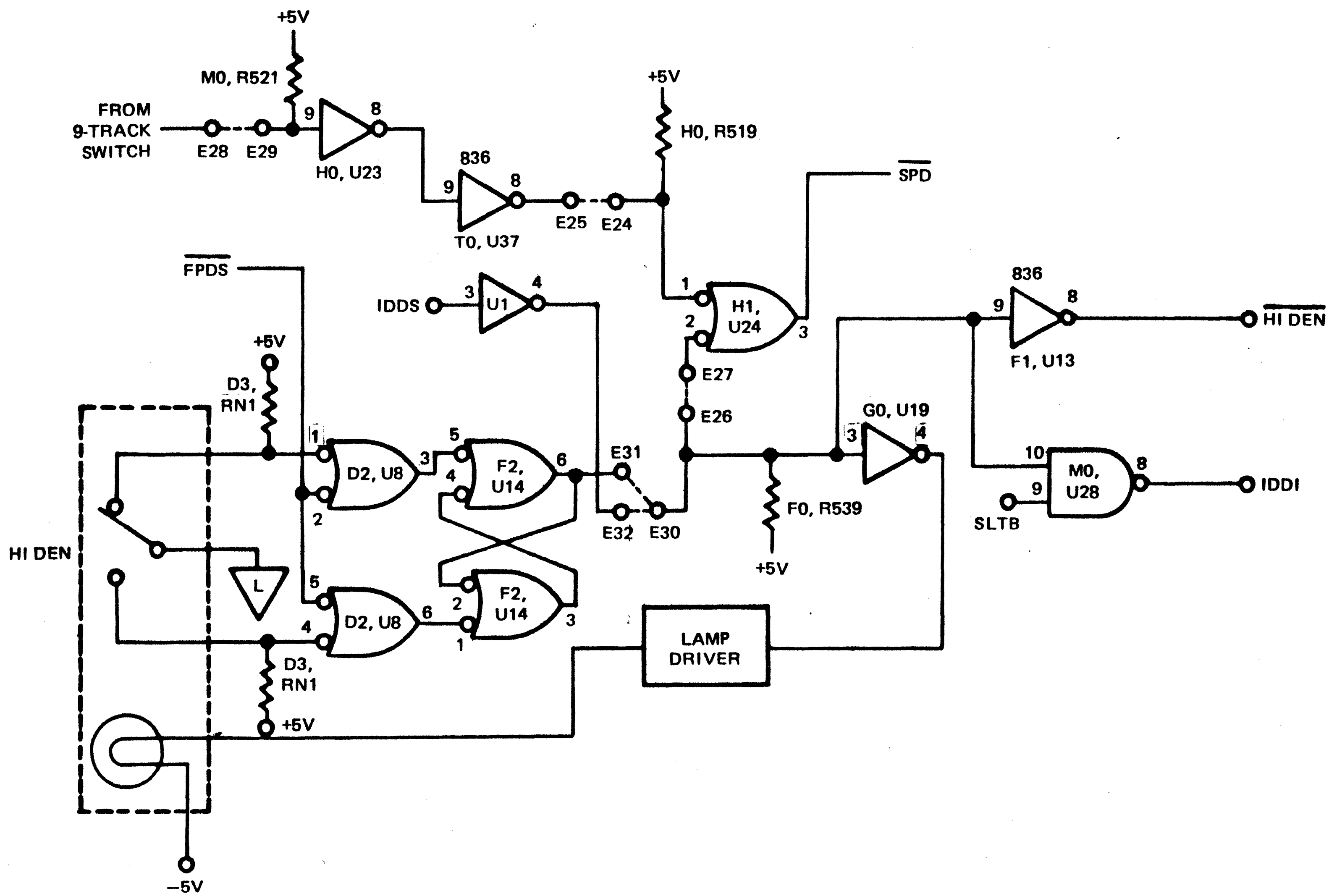


Figure 4-28. Density Select Circuits Simplified Diagram

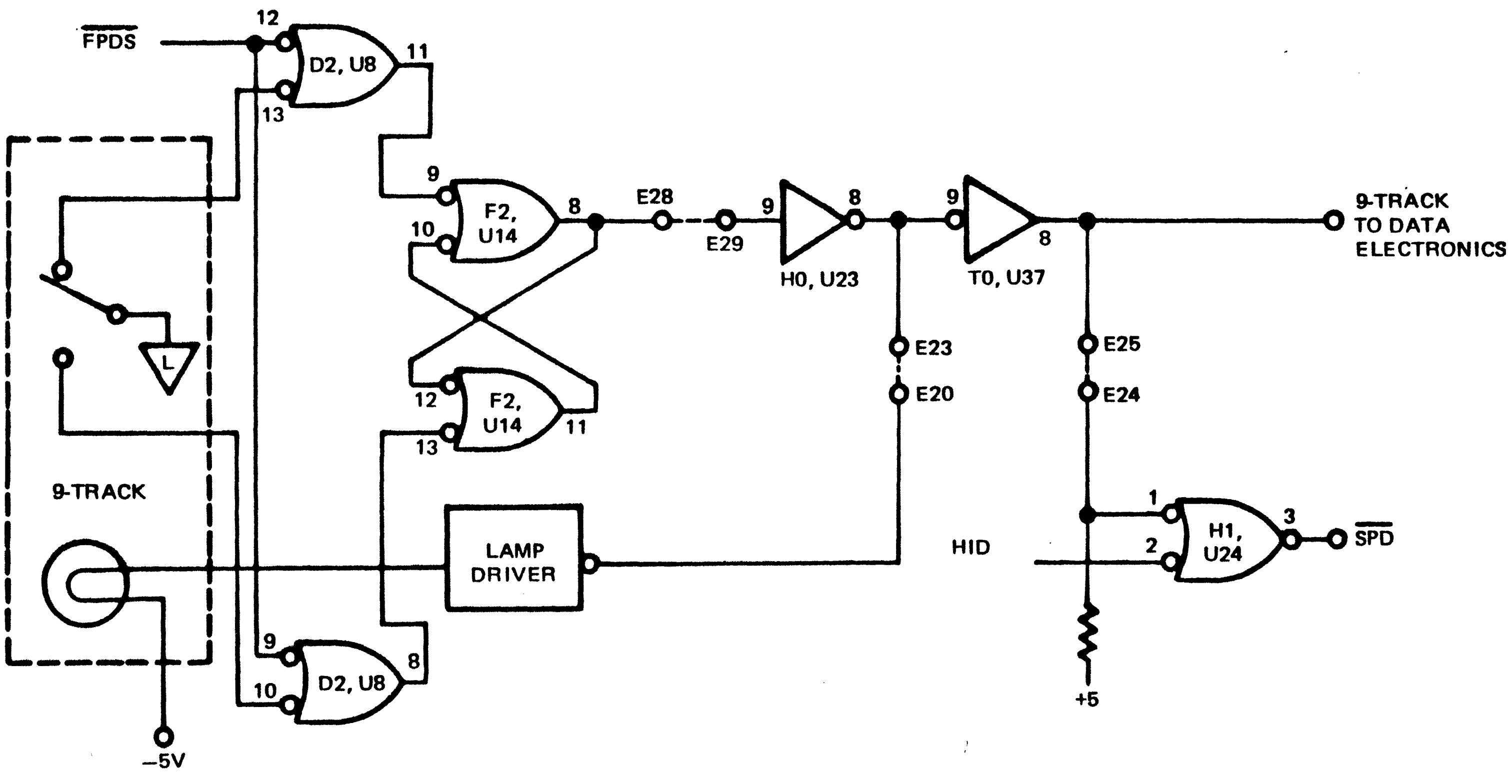


Figure 4-29. Nine-Track Circuit Simplified Diagram

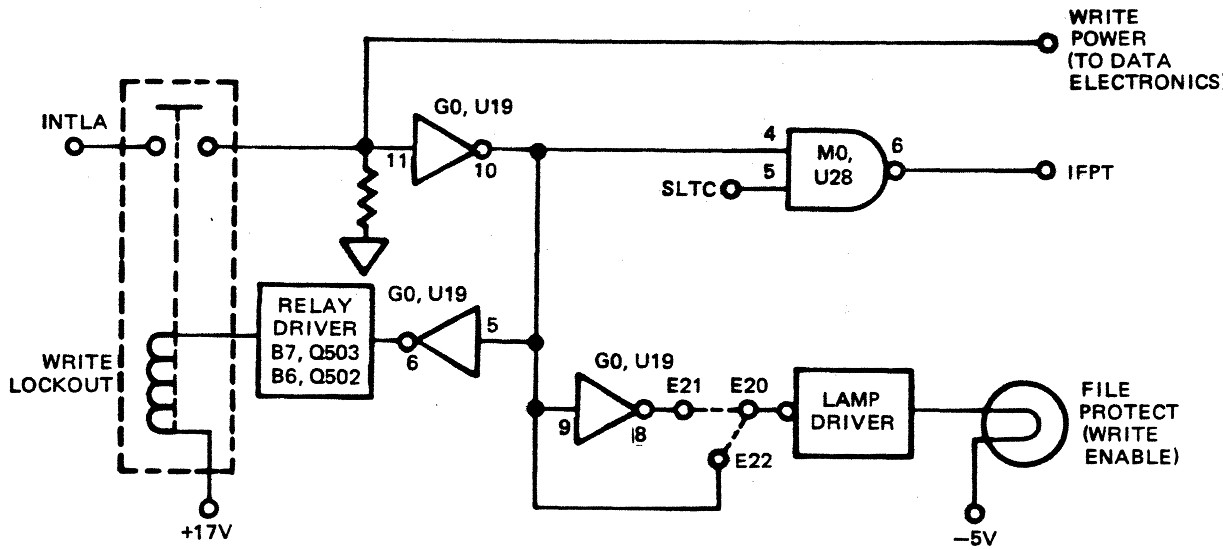


Figure 4-30. File Protect Circuit Simplified Diagram

The low input at M0, U28-4 causes the IFPT signal to the controller to go high. This indicates that the tape is not file protected (a write ring is installed in the file reel). The low input to G0, U19-5 is inverted and turns on relay driver B7, Q503/B6, Q502. This energizes the write lockout solenoid which secures the write lockout assembly. If the circuit is connected as a file protect circuit, the jumper between E20 and E21 is connected and the jumper between E20 and E22 is not connected. Since the input to lamp driver is then high, the FILE PROTECT lamp remains extinguished. This indicates that writing or erasing on the tape can be performed. If a write ring is not installed in the file reel, the input to lamp driver is low, causing the FILE PROTECT lamp to illuminate. This indicates that writing or erasing on the tape is not possible.

When the circuit is connected as write enable circuit, the jumper between E20 and E22 is connected; the jumper between E20 and E21 is not connected. Since input to lamp driver is then low, the WRITE ENABLE lamp illuminates. This indicates that writing or erasing on the tape can be performed. If a write ring is not installed in the file reel, the input to lamp driver is high causing the WRITE ENABLE lamp to remain extinguished. This indicates that writing or erasing on the tape is not possible.

4-35 DATA BOARD ELECTRONICS

The following paragraphs describe the operation of the NRZI and PE data boards. The data boards perform the functions of reading and writing data on magnetic tape. Complete schematic diagrams for the NRZI and PE data board circuits are contained in Chapter 6.

4-36 NRZI Data Board Operation

The NRZI data board contains nine circuits, one for each of the data tracks. For a seven-track head, tracks 0 and 1 are not used. The circuits are divided into two parts; the write and the read circuits. Both the write and the read operation are described in the following paragraphs. Since the circuits for the different tracks are identical, only one will be described.

4-37 NRZI Write Circuits

The WRT DATA PARITY input (IWDP) is inverted at U29-4 and is gated with DATA READY (I DATA READY) setting U32-10 low if a logic one is present on the interface. Refer to figures 4-31 and 4-32. The low transition through C101 turns off Q101 setting U29-10 low and keeping U32-10 low through jumper 101 to 102. Capacitor C101 is charged through R103 and potentiometer R102 until Q101 is again conducting at saturation, setting flip-flop U33-3 through 103 to 104. For a single gap head, U32-10 is connected directly to U33-12 through jumper 102 and 104. Another DATA READY and logic one will reset U33-3. If U33-3 is set when the LRC strobe occurs, U32-4 will reset U33-3 through Q101.

The outputs at pins 3 and 2 of flip-flop U33 alternately drive Q102 and Q103 so that every time flip-flop U33 sets or resets a flux change occurs on the tape.

The write current is supplied by the WRITE POWER and WRITE ENABLE signals. If WRT ENABLE is low, Q1 will conduct at saturation, which will cause Q2 and Q3 to conduct at saturation as long as WRITE POWER supplies +5 volts to Q2 emitter. A jumper is installed between 13 and 14 when the high density (HI DEN) signal controls the operation of the NRZI data board when it is used with a PE data board. A jumper is installed between E17 and E15 for 9-track operation, or between E16 and E15 for 7-track operation, when the 9-TRACK signal controls the operation of the NRZI data board when it is used on a quad-density (three data card) tape unit. Transistor Q2 supplies current through CR1 for the erase head and for the differential head drivers Q102 and Q103 transistor Q3 supplies the head current.

4-38 NRZI Read Circuits

Read head signals ranging from 5 to 35 millivolts are amplified by U103. Refer to figures 4-33 and 4-34. The gain of U103 is determined by the series connection of R115, R118 and potentiometer R117. For a single gap head, a jumper from J3 to J4 is included as well as diodes CR101, CR102, CR103 and CR104. Refer to NRZI data board in the attached drawing package.

The output of U103 at TP101 is connected to diode CR105 and to the unity gain inverted Q104. The output of Q106 is connected to CR106. These output signals are compared to a read threshold voltage at diode CR107.

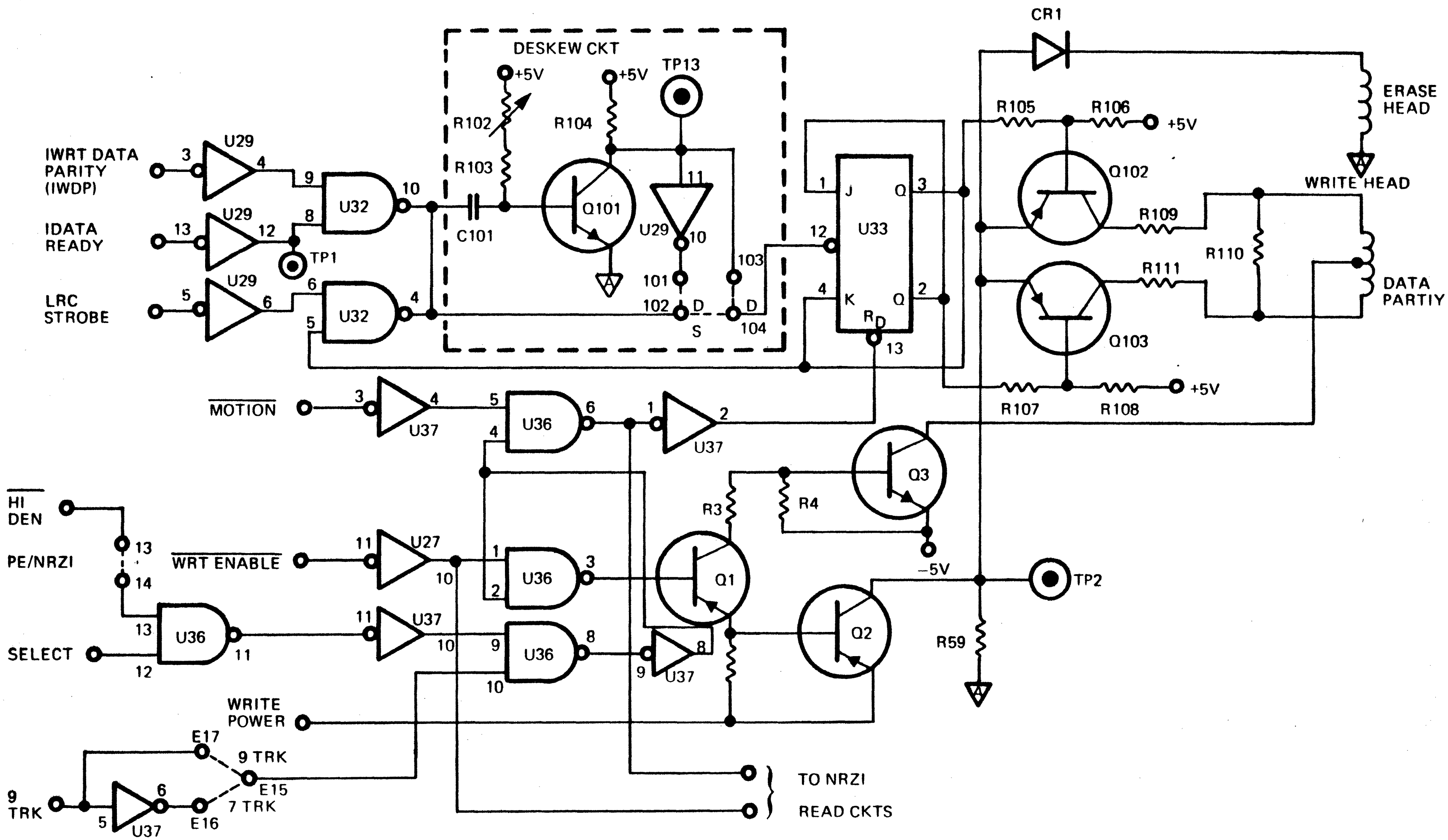


Figure 4-31. NRZI Data Board Write Circuits Simplified Diagram

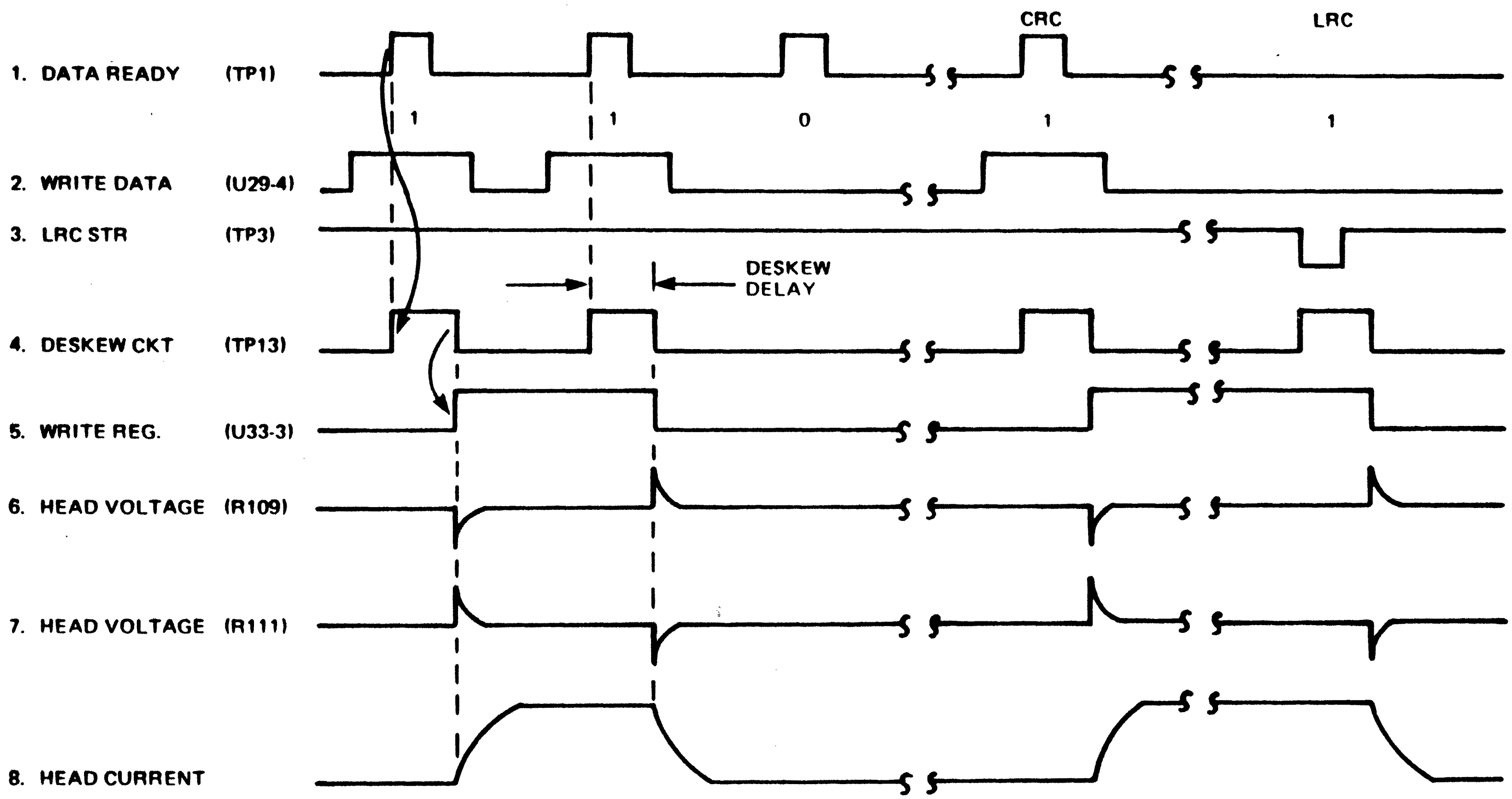


Figure 4-32. NRZI Write Data Timing Diagram

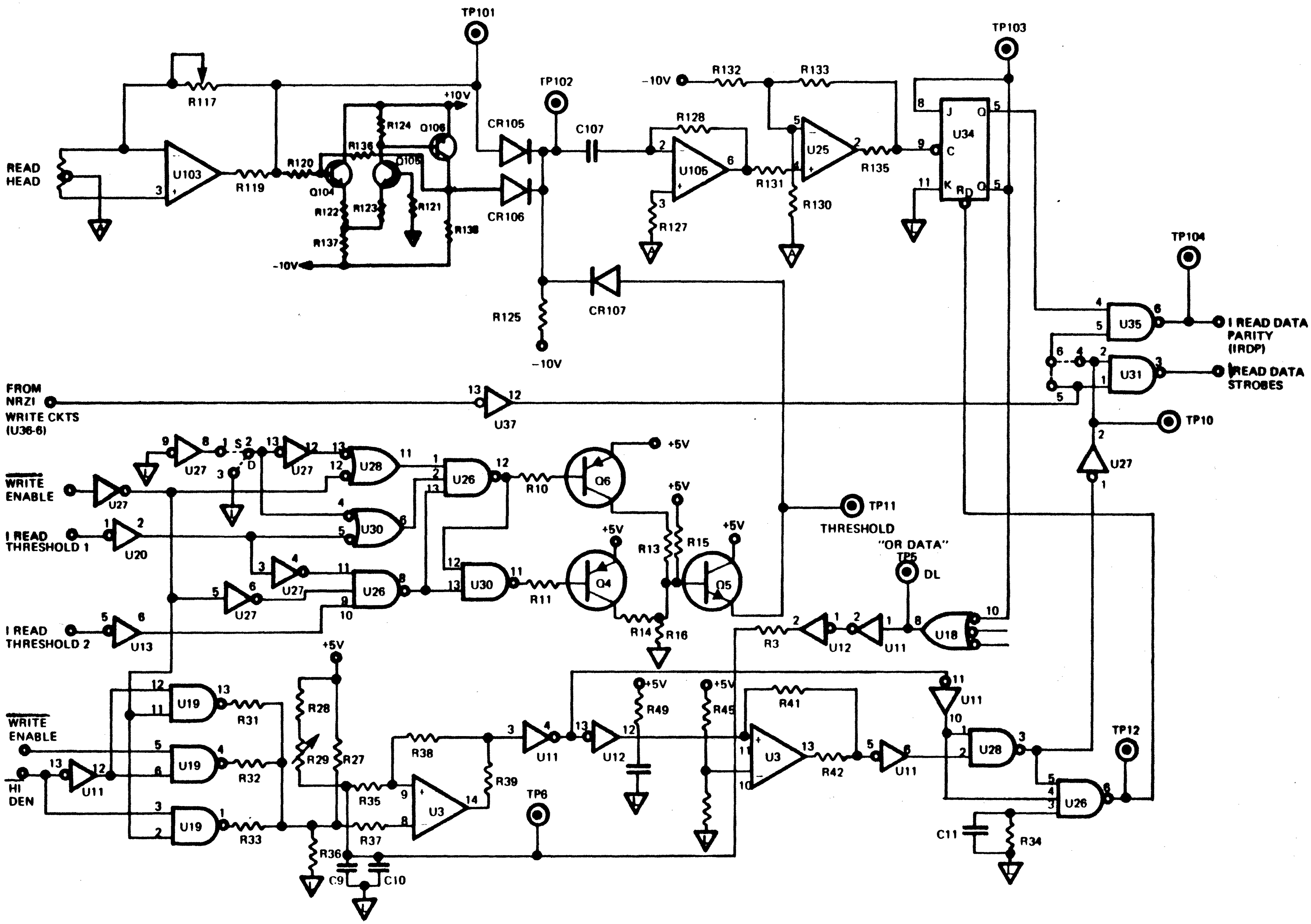


Figure 4-33. NRZI Data Board Read Circuits Simplified Diagram

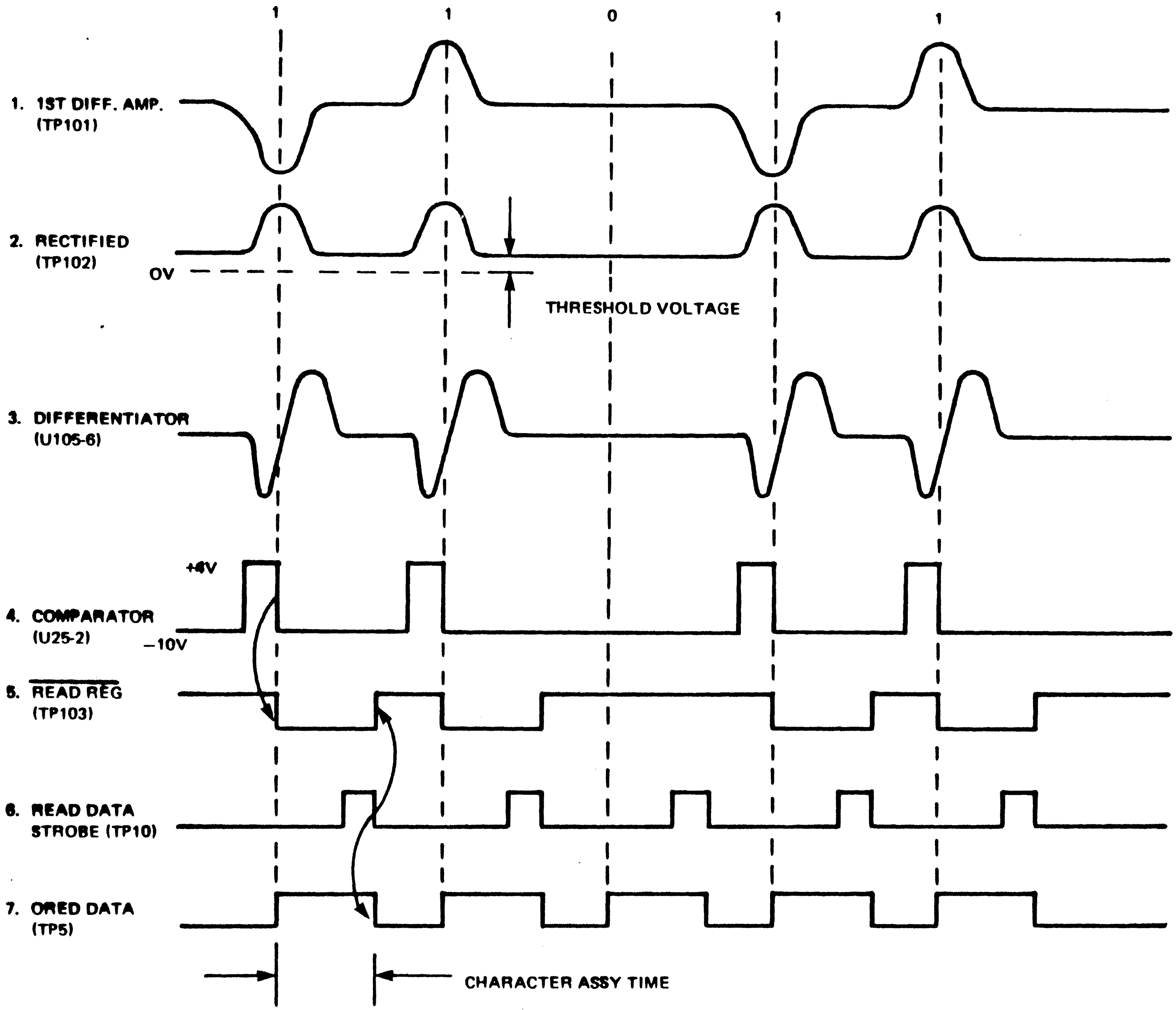


Figure 4-34. NRZI Read Data Timing Diagram

For normal threshold, about 25% of maximum voltage, Q5 is saturated and Q4 is turned off setting the voltage at the base of Q6 by voltage divider R13, R15, and R16, goes low setting U30-11 and U16-12 high and turning off Q4 and Q5. Since R15 has a higher resistance than the parallel combination of R13 and R15, the read threshold is set lower, at about 12% of the maximum voltage.

For single gap heads, a jumper is connected from 1 to 2 setting U28-11 high. If, for example, READ THRESHOLD 1 is set high, U26-8 goes high and U30-6 goes low and U26-12 goes high, turning off Q5 and saturating Q4. This sets the threshold high. If, for example, READ THRESHOLD 2 is set, U26-12 and U30-11 are set high turning off Q5 and Q4, setting the threshold low.

Therefore, if the output voltage is higher than the threshold, CR107 is reverse-biased and the signal is not impeded, applying the positive peaks from the amplifier and inverter to differentiator U105.

The gain of U105 is determined by the reactance of C107 and R128, so the gain of U105 increases at 20 dB per decade until U105 is cut off by R128 and C108. Therefore, the peaks of the signals are changed to zero crossings and the amplitude is less dependent upon the data pattern since the output is related to the rate of change of input which is constant. When the output of U105 crosses zero and goes negative, comparator U25-2 switches high. As U25-2 goes low, it sets U34-5. Flip-flop U34 is gated with MOTION or READ DATA STROBE at U35-5 to drive the READ DATA PARITY line.

Any low input to U18 sets +DL high. This sets U12-2 high allowing C9 and C10 to charge through R28 and potentiometer R29. When the voltage at TP6 and U3-9 reaches the voltage at U3-8, U3-14 switches high. The voltage at U3-8 is set by the voltage divider formed by R27 and R36 creating a delay that is set equal to 1/2 the data rate. R31, R32, and R33 parallel R36; this lowers the voltage at U3-8 and decreases the delay of the circuit during read-after-write and high density read operations.

U12-12 goes high when U3 switches high allowing C13 to charge through R49. When the voltage at U3-11 reaches the voltage at U3-10, U3-13 switches high, creating a delay of about 1 second. When U3-14 switches high U28-3 goes low until U3-13 goes high. This 1 second pulse is gated at U31-1 with MOTION to create the READ DATA STROBE.

When U28-3 goes high, all the inputs to U26-6 are high which sets U26-6 low resetting flip-flop U34.

Jumpers on the board determine if seven track, single gap, and speed are asserted. NRZI is always asserted. All of the read flip-flops are connected to a resistive ladder at TP9 that is useful in determining skew problems.

4-39 PE Data Board Operation

The PE data board contains nine circuits, one circuit for each of the data tracks. The circuits are divided into write and read circuits. Both the write operation and read operation are described in the following paragraphs. Since the circuits for different tracks are identical, only one data track will be described.

4-40 PE Write Circuits

The write current amplitude is set to the NRZI write current level when switching to the write mode.

When $\overline{\text{WRT ENA}}$ is true, U16-3 will be low, turning on Q10, Q11 and Q12. Refer to figures 4-35 and 4-36. Q12 conducts at saturation, supplying the current for the write heads (-WRT PWR). Q11 supplies the current for the differential head drivers (+WRT PRW SW). Flip-flop U1-3 is set high (HI CURRENT) by U16-3, applying a low to U15-6 causing conduction of U15. With U15 on, R101 and R105 are in parallel and establish an increased-driving power through the differential head drivers. $\overline{\text{WRT ENA}}$ going low causes a high at the base of Qxx turning the device on. Qxx going on turns on Qxx and Qxx causing current to flow through the erase head. An erase is always performed prior to a write. When $\overline{\text{MOTION}}$ is true, U17-12 is set low turning on Q7 and establishing envelope power (ENV PWR) for the read circuits.

The WRT DATA PARITY input is inverted at U6 and clocked into flip-flop U7-5 by $\overline{\text{DATA RDY}}$. The outputs of flip-flop U7-6 and 7 alternatly drive the differential head drivers creating a flux change on the tape.

When the first data ready signal is received, U1-3 is set low causing a high on U15-6. This stops conduction of U15 and removes R101 from the differential head driver circuit thereby reducing the driving power through the differential head drives. The write current is reduced to the normal PE write current level.

4-41 PE Threshold Circuits

A jumper from E10 to E9 is connected for a dual gap configuration setting the gate at U18-6 high (figure 4-37). When $\overline{\text{WRT ENA}}$ is low, U17-8 goes high and U18-3 goes low causing U17-6 to go high turning Q5 off and Q6 on. This condition establishes a threshold level of 25%.

When $\overline{\text{WRT ENA}}$ goes high, U18-3 goes high, U18-6 is high and U17-8 is held high by RTTH 1 being low. These conditions cause U17-6 to go low turning Q5 on and Q6 off, establishing a threshold level of 15%.

The assertion of RTTH 1 causes U17-8 to go low setting U17-6 high and U18-11 high turning Q5 and Q6 off. This condition establishes a threshold level of 5%.

4-42 PE Read Circuits

The read head signals are amplified by the differential amplifier U101. Refer to figures 4-38 and 4-39.

U101 is connected to differentiator U102. The gain of U102 is determined by the reactance of C104 and R114, so the gain of U102 increases at 30 dB per decade until cut off by R114 and C105. Therefore, the peaks of the signals are changed to zero crossings and the amplitude is less dependent upon data pattern since the output signal is related to the rate of change of the input, which is constant. The output of U102 is applied to the zero crossing detector at U103-8

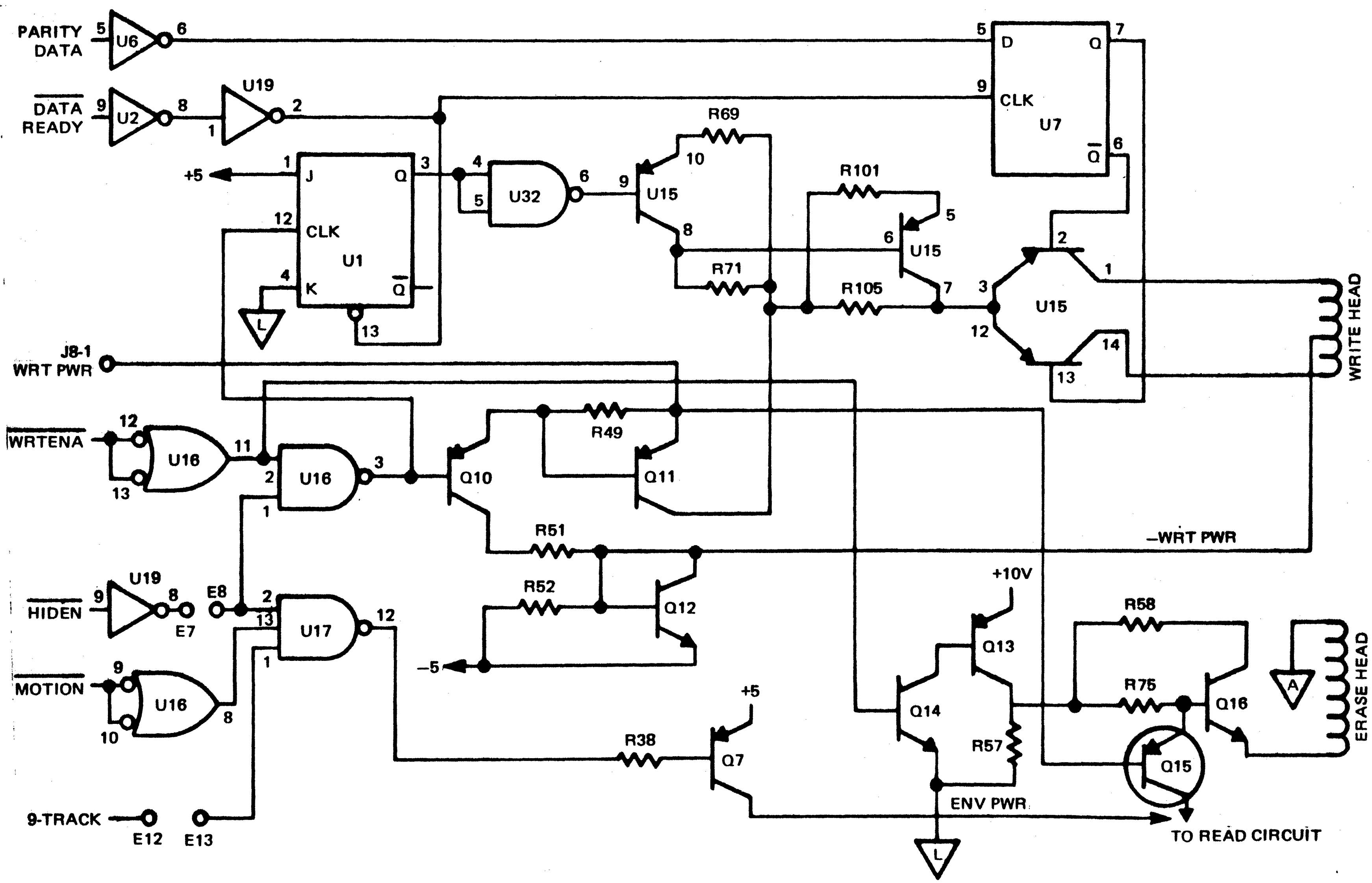
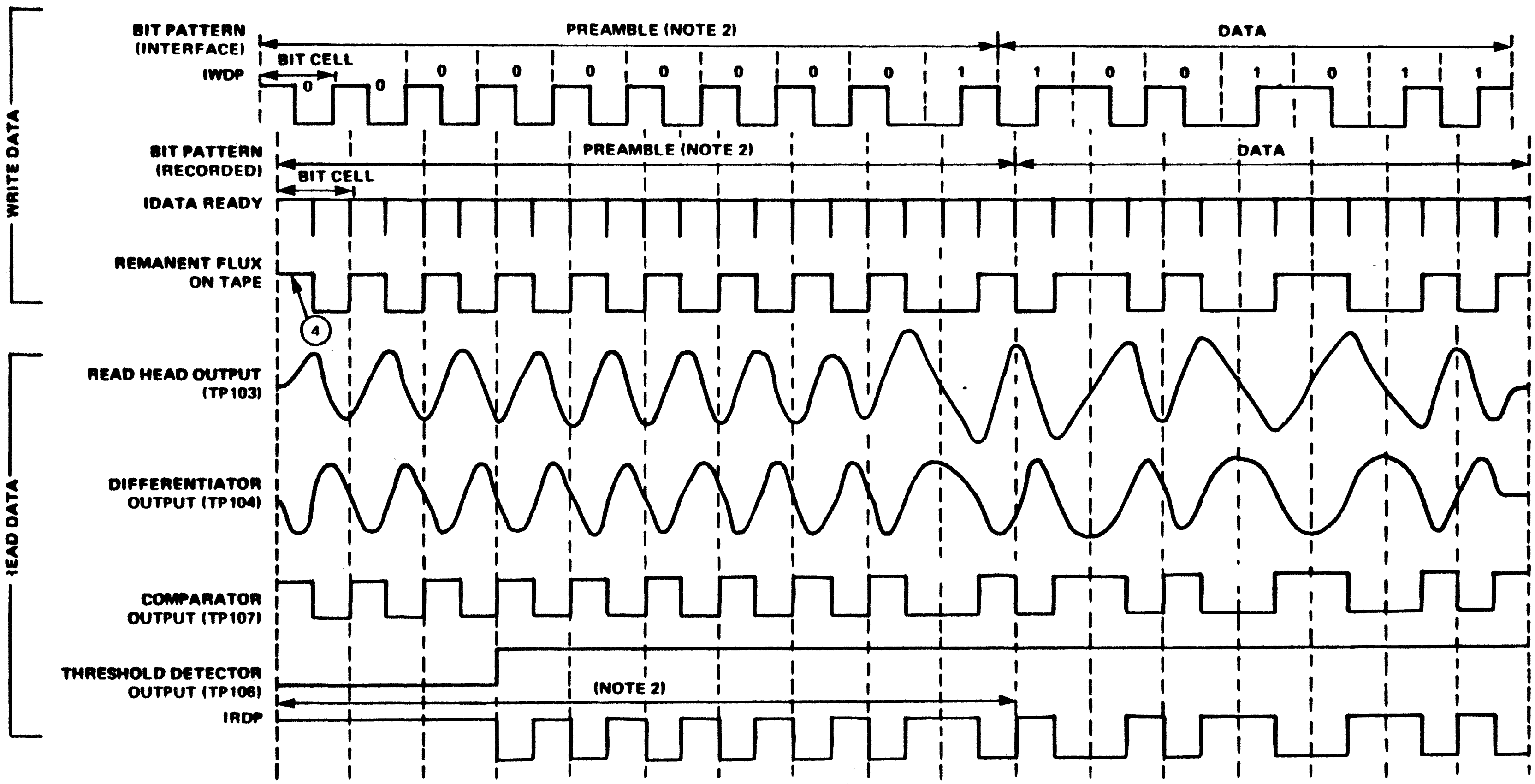


Figure 4-35. PE Write Circuits Simplified Diagram



NOTES:

1. TAPE UNIT MUST BE SELECTED, READY, AND ON-LINE.
2. PREAMBLE IS SHOWN SHORTENED TO SIMPLIFY DRAWING. PREAMBLE CONSISTS OF 40 ZEROS FOLLOWED BY ONE 1.
3. POSTAMBLE NOT SHOWN. POSTAMBLE CONSISTS OF ONE 1 FOLLOWED BY 40 ZEROS.
4. FLUX POLARITY OF INTERLOCK GAP.

Figure 4-36. PE Data Write/Read Timing Diagram

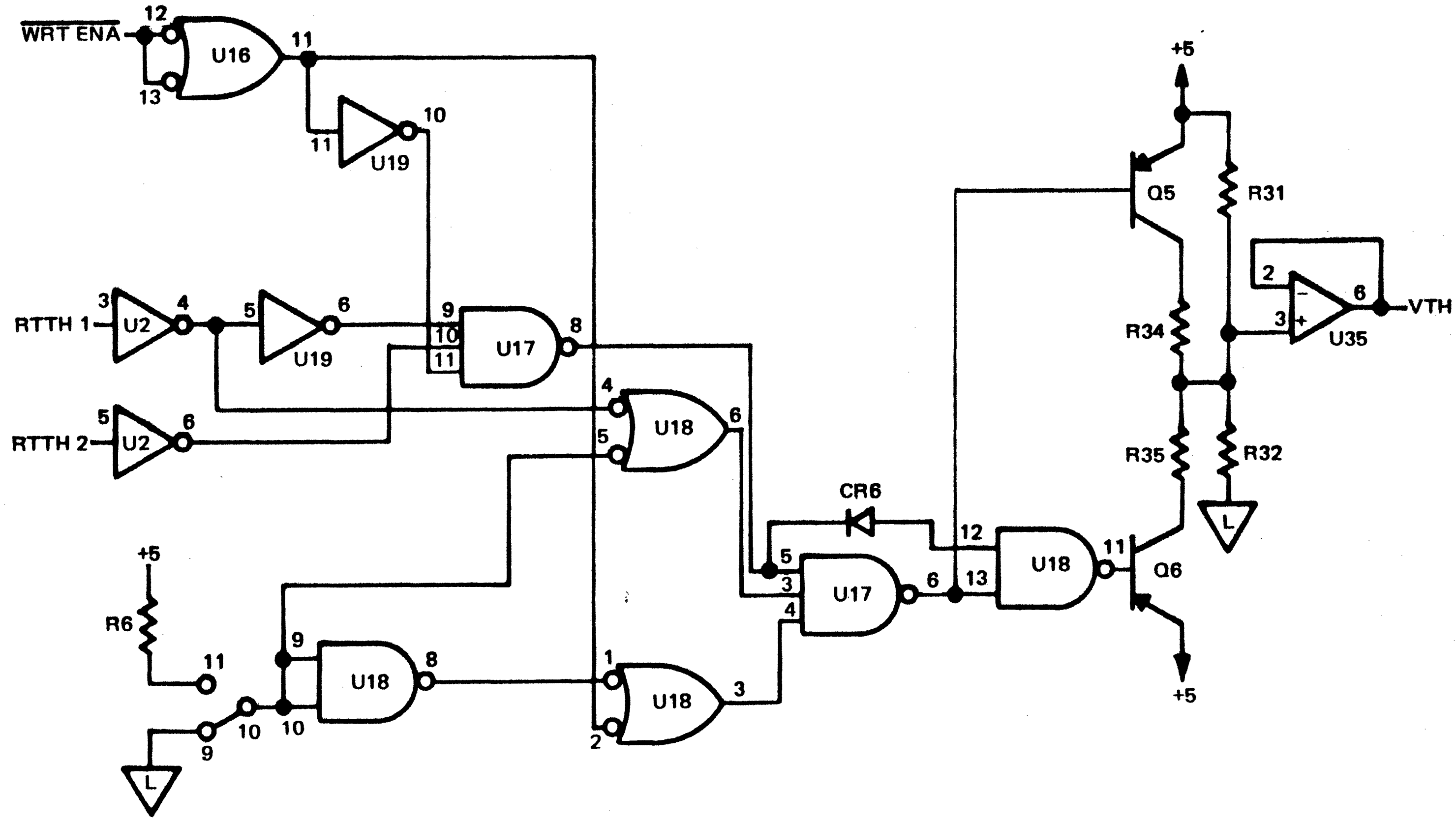


Figure 4-37. PE Threshold Dynamic Switching Circuits Simplified Diagram

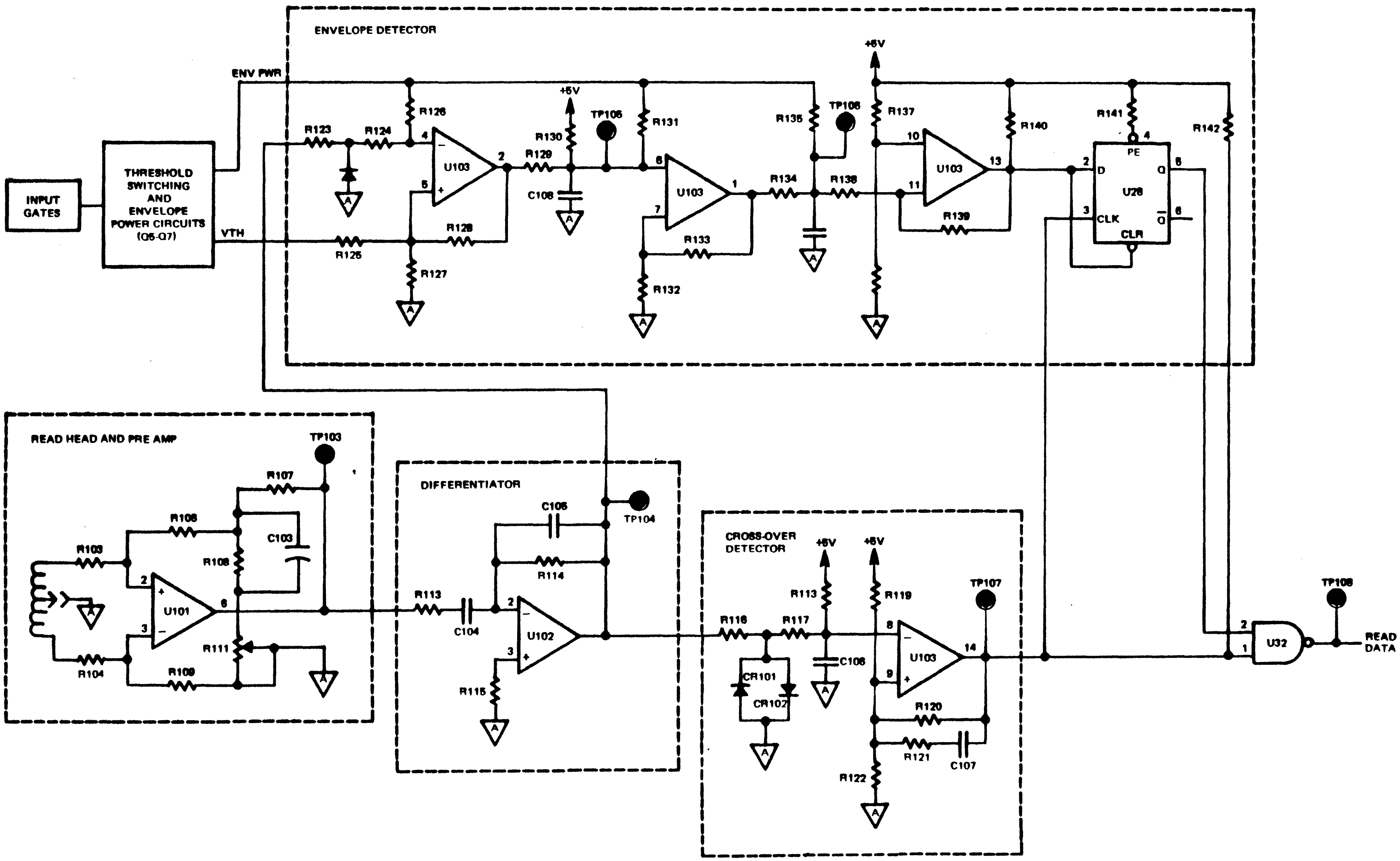


Figure 4-38. PE Data Board Read Circuits Simplified Diagram

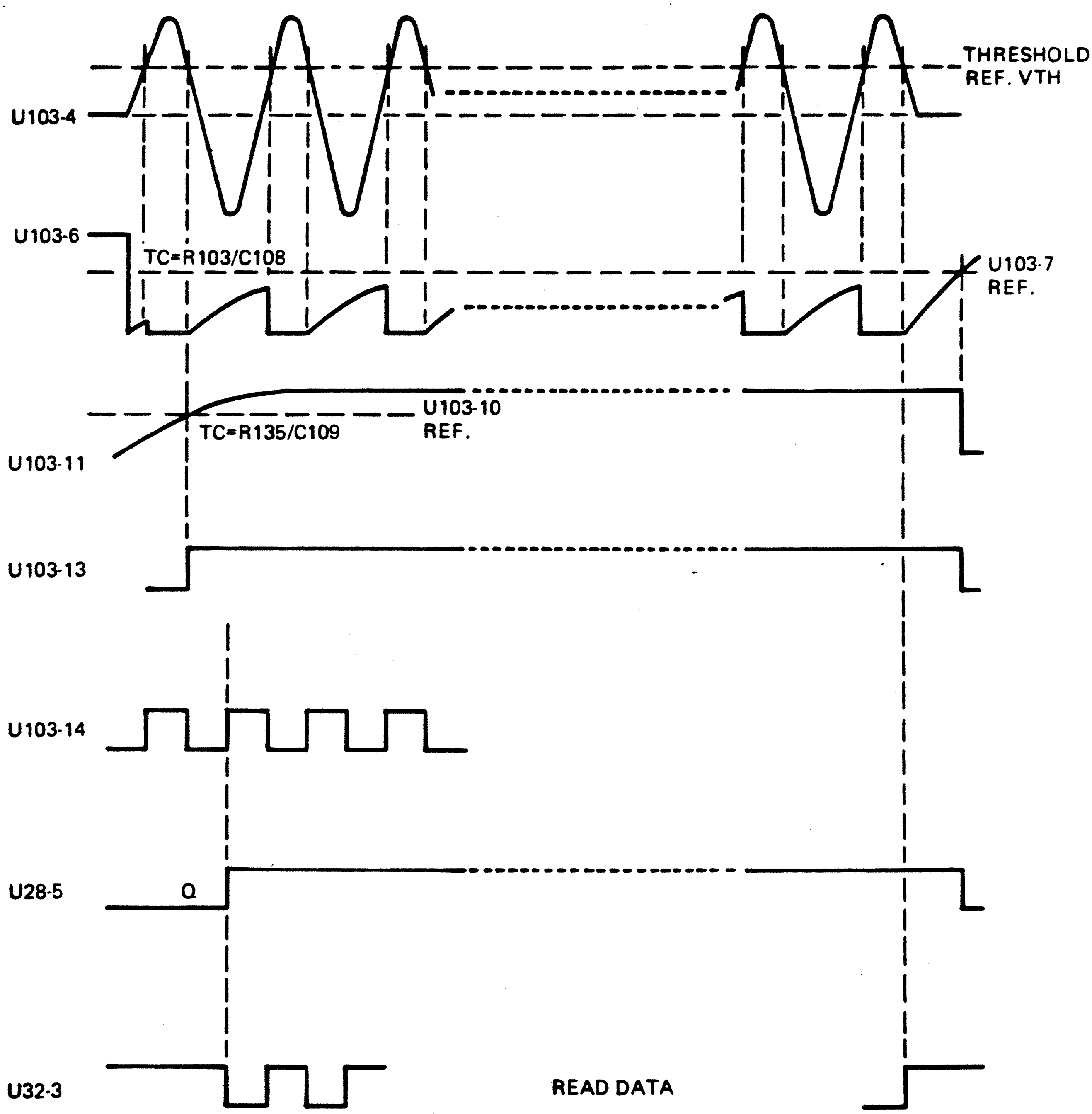


Figure 4-39. PE Read Timing Diagram

and to the envelope detector at U103-4. The zero crossing detector detects whenever the differentiators negative going output crosses zero, creating a positive output signal at U103-14. The signal is applied to the line driver at U32-1 and gated with the output of the envelope detector.

The envelope detector includes three circuits of U103 and flip-flop U28. U103 compares the output of the differentiator with the read threshold reduced by 1/2 by R125 and R127. The thresholds are 26%, 22% and 8%. If the signal is more negative than the threshold, U103-2 switches high allowing C108 to charge through R130. The R130/C108 time constant is such that U103-1 is switched high allowing C109 to charge through R135. When U103-11 rises to a sufficient level U103-13 is switched high and applied to flip-flop U28-2. U28-2 is clocked by U103-14 setting U28-5 high conditioning U32 to allow read data to appear at U32-3.

When there are no negative pulses applied to U103-4, C108 will charge to a level causing U103-1 to go low. U103-1 going low causes U103-13 to go low applying a low to U28-2 which clocked into the flip-flop setting U28-5 to a low. U28-5 going low disables read data at U32-3.

4-43 PE Delayed +5 Volts

The +5 volts to line drivers U29, U31 and U32 is delayed to eliminate false data at the outputs of the line drivers. Refer to figure 4-40.

When +5 comes up Q4 is turned on causing Q3 to be turned off. With Q3 going off, C5 is allowed to charge through R15 to a sufficient level to turn on Q2. Q2 turning on causes Q1 to turn on and applies +5 DEL to U29, U31 and U32. The R15/C5 time constant establishes the desired time delay for +5 DEL.

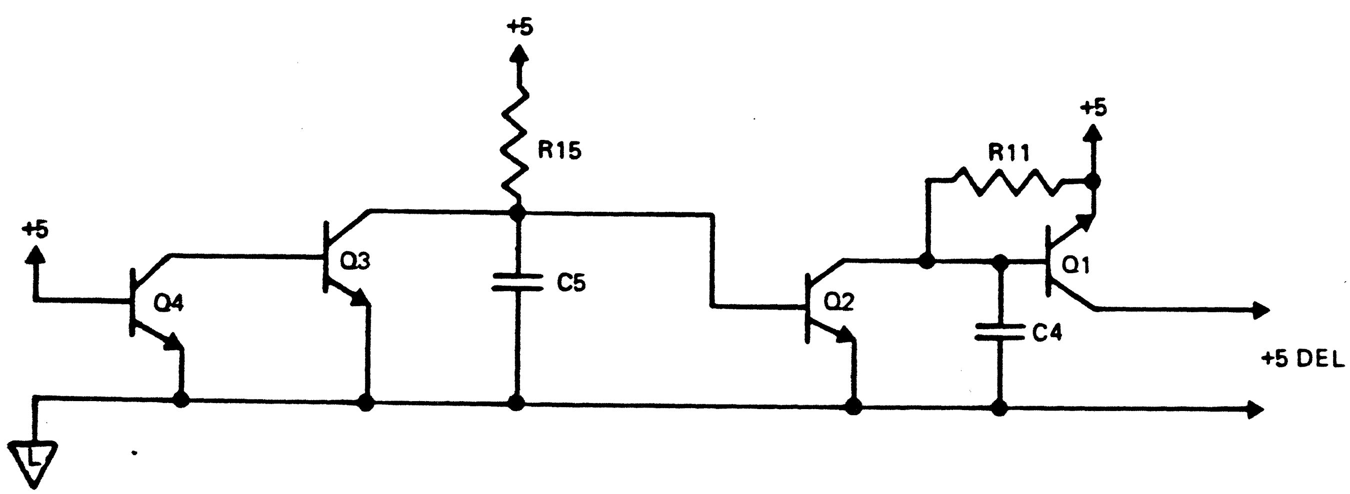


Figure 4-40. PE +5 Volt Delayed Circuit Simplified Diagram

4-44 PRIMARY POWER CIRCUITS

The primary power circuits consist of two parts: 1) a power supply module (see figure 4-41); and 2) the power supply regulator circuits located on the tape control board. The power supply module (see figure 4-41) contains the service power switch, line filter, a power transformer, full wave rectifiers, capacitors, fuses and resistors. The power supply regulator circuits consist of the four regulator circuits and a power reset circuit. Figure 4-41 shows a simplified diagram of the primary power circuit. The following paragraphs describe both the power supply module and the power supply regulator circuits.

4-45 POWER SUPPLY MODULE

The power supply module supplies unregulated ±20 volts to the power supply regulator circuits, and unregulated ±36 volts to the reel servo and capstan servo circuits located on the Heatsink PWBA. The power supply module also supplies 12 volts ac to the relay K1 through K4 circuits located on the heatsink PWBA (refer to figure 4-41).

During normal operation, service power switch S1 is closed and primary power is supplied through fuse F1 and line filter FL1 to the input of the triac circuit. When the ON/OFF switch is placed in the on position, high side of the line is connected through resistor R2 to the gate of triac Q1. This turns on Q1 and allows primary power to be applied through Q1 to stepdown transformer T1. Resistor R3 and capacitor C1 prevents Q1 from being turned on by commuting currents. Capacitors C2, C3, C4 and C7 are used to filter the unregulated +20 and -20 volt outputs from the full wave rectifiers.

4-46 POWER SUPPLY REGULATOR CIRCUITS

The power supply regulator circuits consist of four separate regulator circuits which supply +10 volt, +5 volt, -10 volt and -5 volt outputs. In addition, the power supply regulator circuits also provide a reset ($\overline{PSET}$) signal to the tape unit control circuits. The $\overline{PSET}$ signal initializes various logic circuits when power is first turned on, or disables the servo motors and disconnects the write power from the data boards when the ±20 or ±10 volt power supplies malfunction.

4-47 +10 Volt Regulator

The +10 volt regulator consists of series regulator transistor Q3 and reference diodes CR1, CR2 and CR9 (see figure 4-42). Unregulated +20 volts is applied to the collector of series regulator transistor Q3 and +10 volts is output from the emitter through R10.

Diodes CR1, CR2 and CR3 provide over-current protection. If the base to emitter voltage of Q3 and the voltage drop across R10 ever become more than three diode drops below the base voltage, the diodes will become forward biased and conduct. This causes the Q3 base voltage to drop, lowering the output.

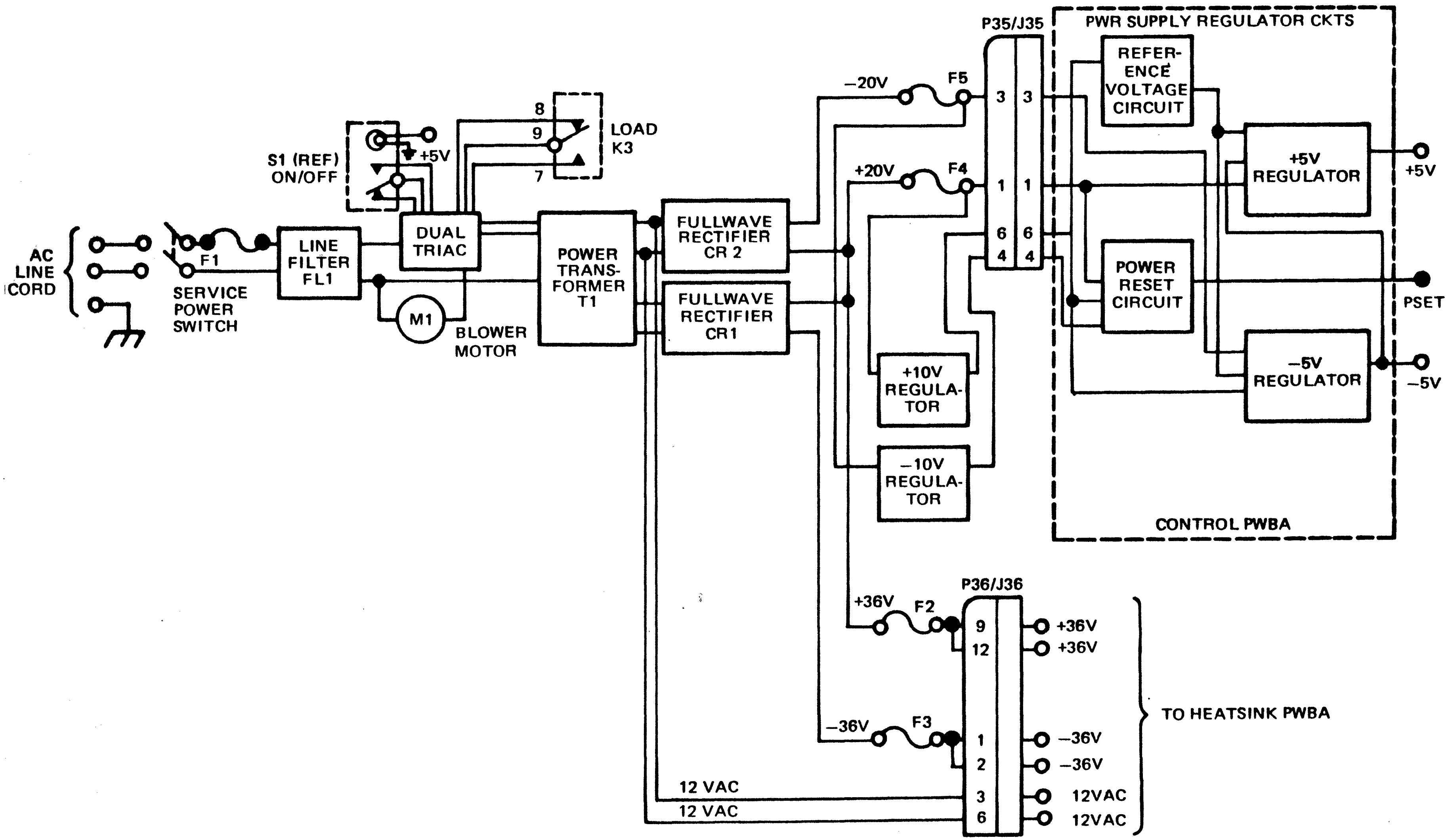


Figure 4-41. Primary Power Circuits Simplified Diagram

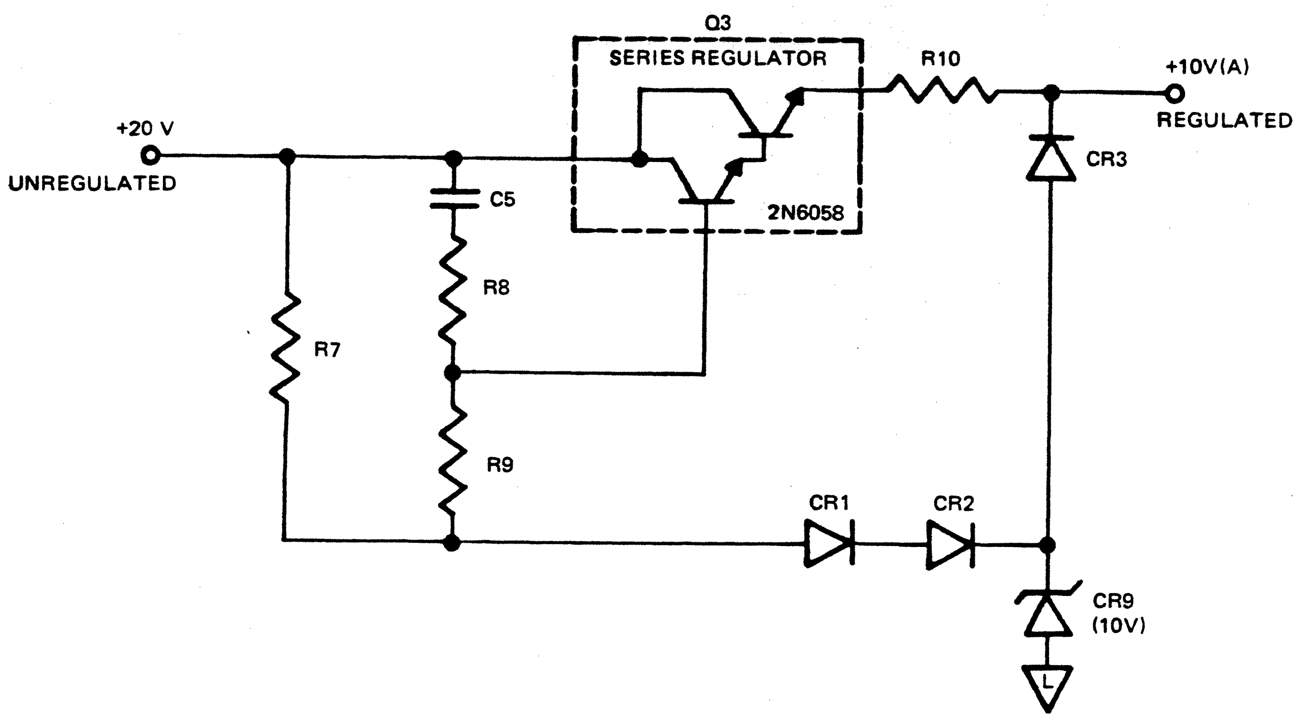


Figure 4-42. +10 Volt Regulator Circuit Simplified Diagram

4-48 -10 Volt Regulator

The -10 volt regulator consists of series regulator transistor Q4 and reference diodes CR6, CR7 and CR8 (see figure 4-43). Diode CR6 is a 10 volt Zener diode. The three diodes set the base voltage of the Q4 to regulate the voltage at the emitter of the series regulator. Diode CR5 provides over-current protection by always maintaining the -10 volt regulated output more negative than -9.4 volts. If the output voltage rises above -9.4 because of an increase in current flow through R13, CR5 will conduct, lowering the base voltage of Q4 and the output.

4-49 +5 Volt Regulator

The +5 volt regulator circuit consists of series regulator transistor Q17 and operational amplifier U64, with associated components. Refer to figure 4-44.

To maintain +5 volts, operational amplifier U64 is used to control the base voltage of Q17. The -5 volt supply provides the reference voltage input to U64 such that the output of U69 provides the correct base voltage to Q17, needed to maintain the +5 volts. Diodes CR36, CR57, CR58 and CR59 provide over-current protection by serving as a current path if the regulated output falls more than 4-diode drops below the output of U64 (base of Q17) because of an increase in voltage drop across R392. This causes the +5 volts output voltage to be decreased. Diode CR60 is for protection against transients during power turn on and keeps the regulated output from going below - 0.6 volts.

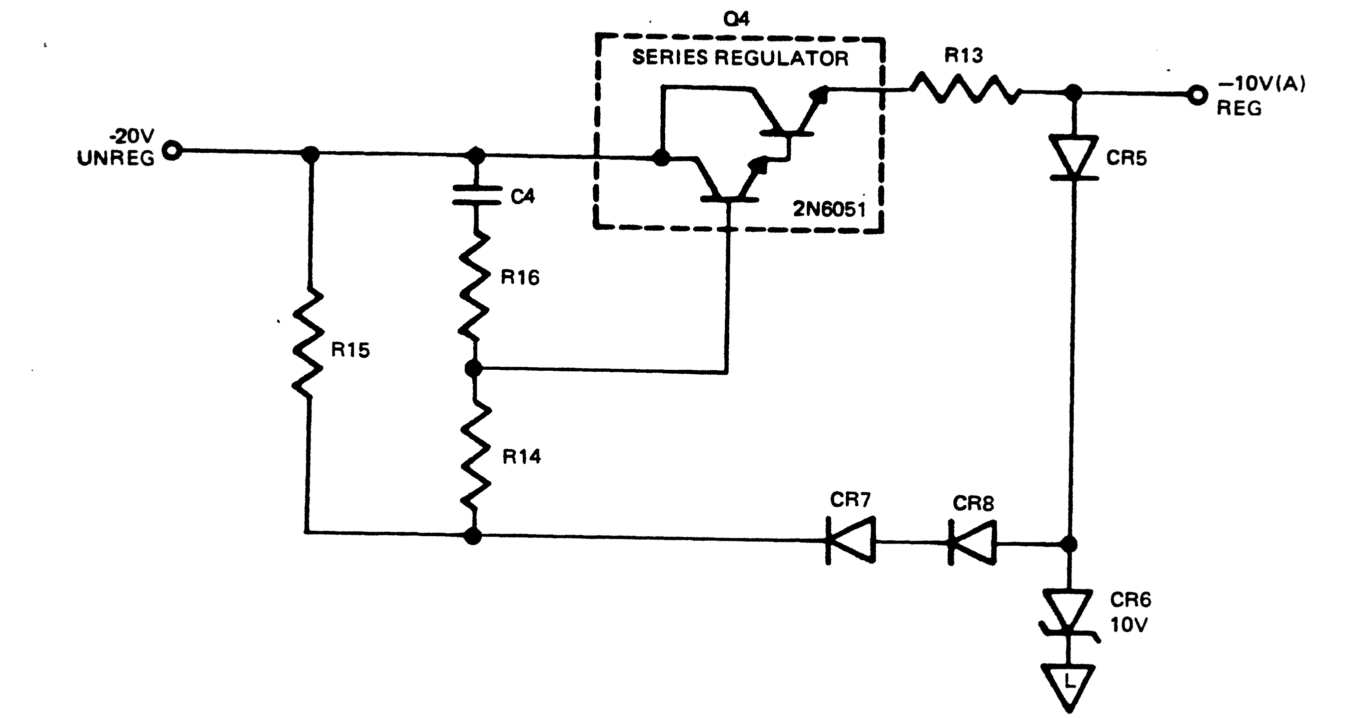


Figure 4-43. -10 Volt Regulator Circuit Simplified Diagram

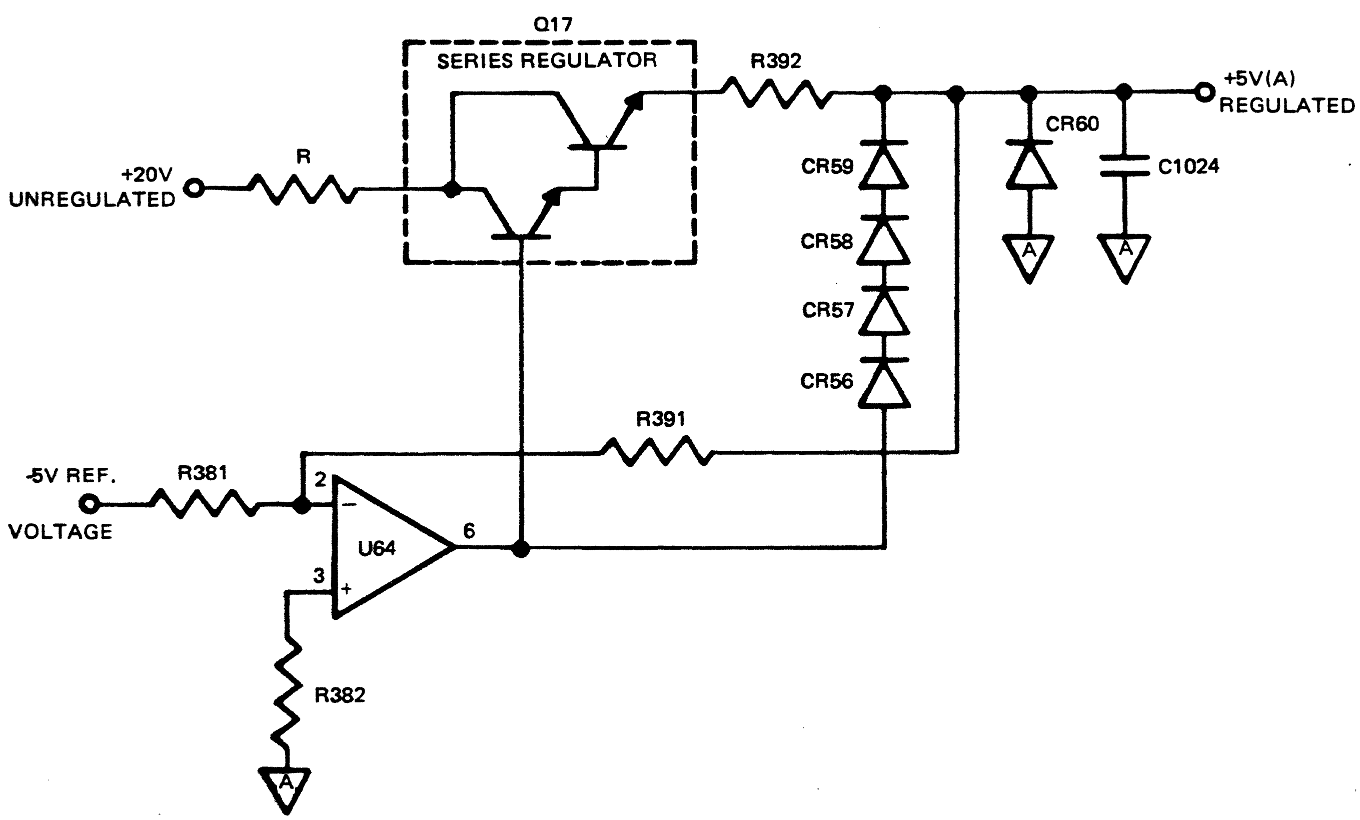


Figure 4-44. +5 Volt Regulator Circuit Simplified Diagram

The +5 volt regulator also incorporates an SCR crowbar protection circuit, consisting of Zener diode CR52 and SCR2. If the regulated voltage output rises above 6.2 volts, CR52 breaks down and conducts, turning on SCR2. This, in turn, provides a shorted path to ground for the unregulated input of +20 volts, causing fuse F2 on the power supply module to burn out.

4-50 -5 Volt Regulator

The -5 volt regulator functions very similar to the +5 volt regulator, see figure 4-45. The operational amplifier U63 is controlled by the voltage reference circuit.

Potentiometer R398 is adjusted so that the output of amplifier U63 maintains the base voltage of Q18 needed to maintain the -5 volts.

Diodes CR65, CR66, CR67 and CR68 provide over-current protection and diode CR69 serves as protection against turn-on transients. These diodes function essentially the same as those described for the +5 volt circuit in the preceding paragraph.

4-51 POWER RESET CIRCUIT

Figure 4-46 shows a simplified diagram of the power reset circuits. The circuit consists of Q56 and Q59 and associated components. When power is first turned on, $\overline{\text{PSET}}$ is always at a logic low. As the power supply voltages reach their nominal levels, $\overline{\text{PSET}}$ remains low for a time period determined by R360, R361 and C101. This temporary logic low signal is used to initialize logic circuits on the tape control board.

When the power supply voltages reach the nominal voltage, Q56 will be off and Q59 will be on. Q56 being off will supply a logic high at $\overline{\text{PSET}}$.

The loss of the +5 volt supply will cause Q59 to be turned off, this applies a positive voltage to the base of Q56 causing Q56 to turn on. Q56 turning on causes $\overline{\text{PSET}}$ to go low, generating a machine reset. The loss of +10 or -10 volt supply will have the same effect.

4-52 TAPE TRACK LAYOUT AND DATA FORMATS

4-53 TAPE TRACK LAYOUT

The magnetic tape unit reads and writes standard 9-track or 7-track tapes depending on the exact equipment configuration. Figure 4-47 shows the orientation and layout dimensions of tape tracks for both formats. Note that 9-track tape is used both for PE or NRZI recording, whereas 7-track tape is used only for NRZI.

4-54 Beginning and End of Tape Formats

In order to assure reliability and tape compatibility in the storage of data, an erased area is recorded in the vicinity of the beginning-of-tape (BOT) marker that is affixed near the reference edge at the start of every tape and an unrecorded area is left in the vicinity of the end-of-tape (EOT) marker affixed at the trailing end of a tape reel. These unrecorded areas are specified in figure 4-48.

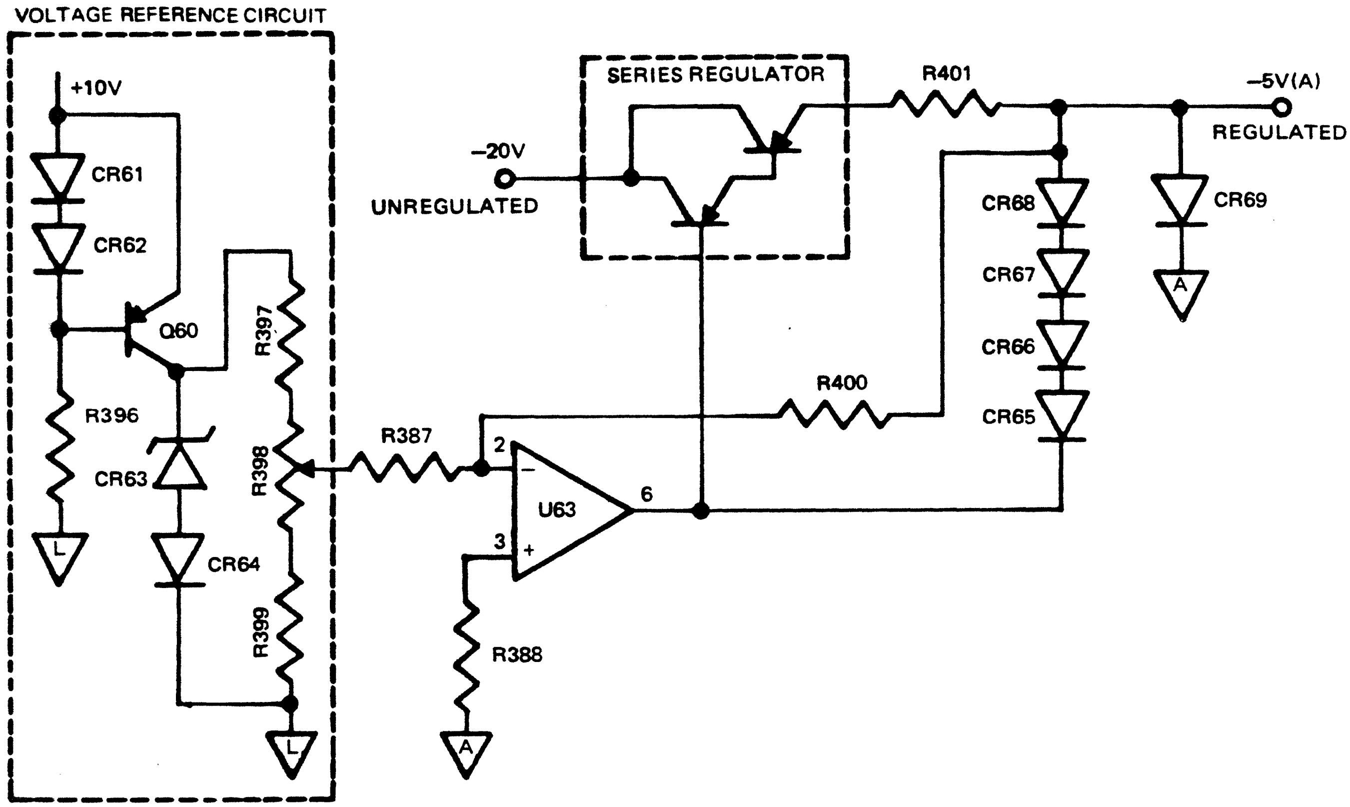


Figure 4-45. -5 Volt Regulator Circuit Simplified Diagram

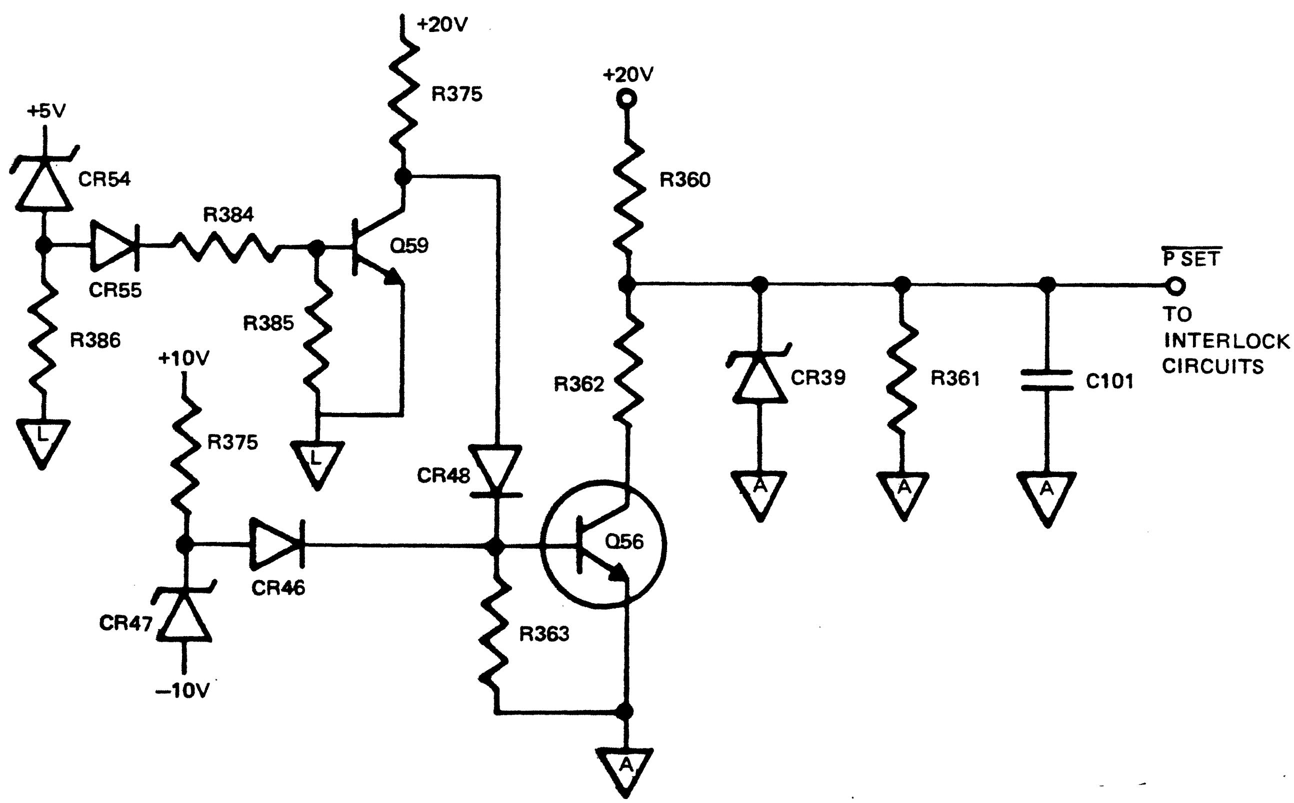


Figure 4-46. Power Reset Circuit Simplified Diagram

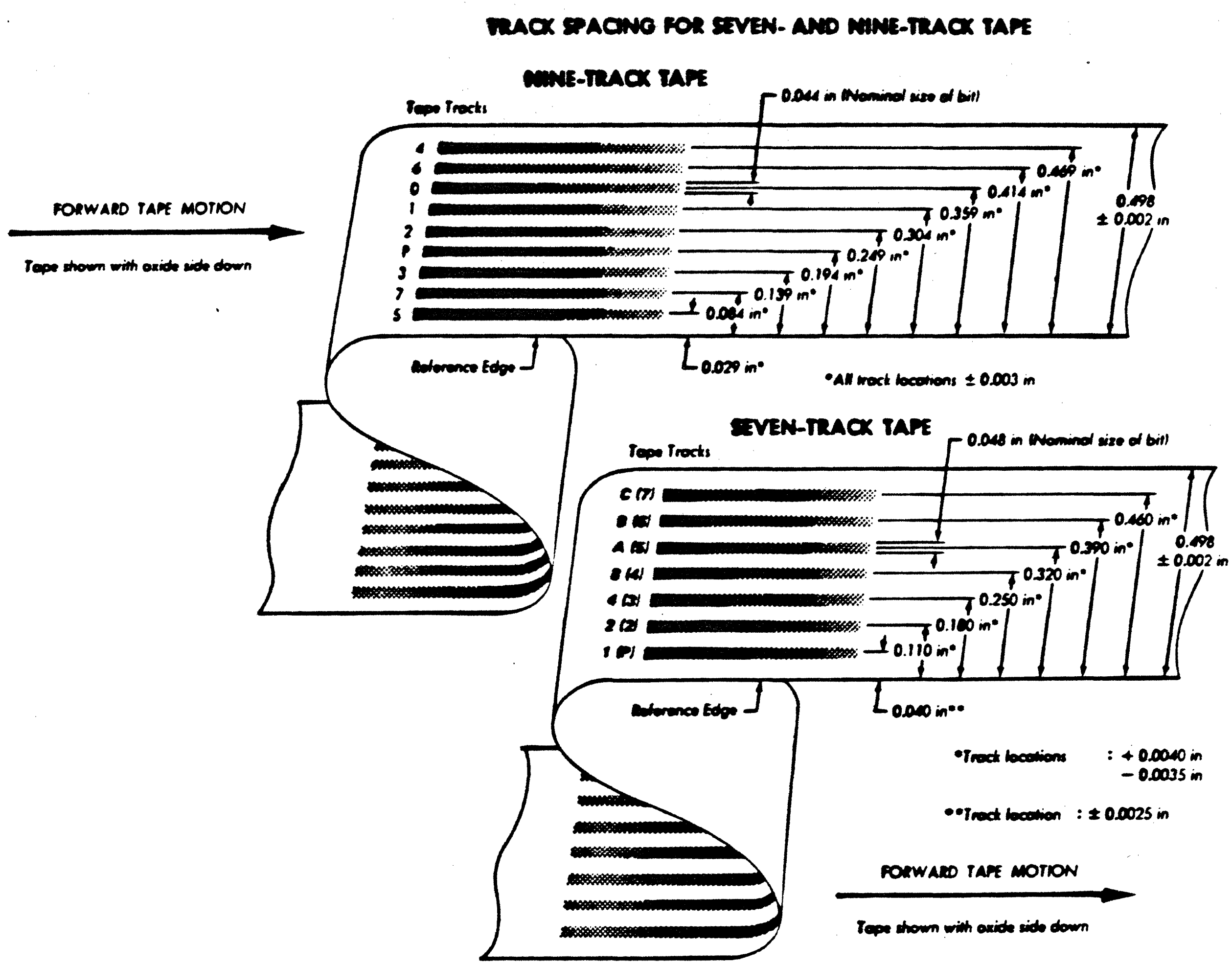


Figure 4-47. Tape Track Layouts

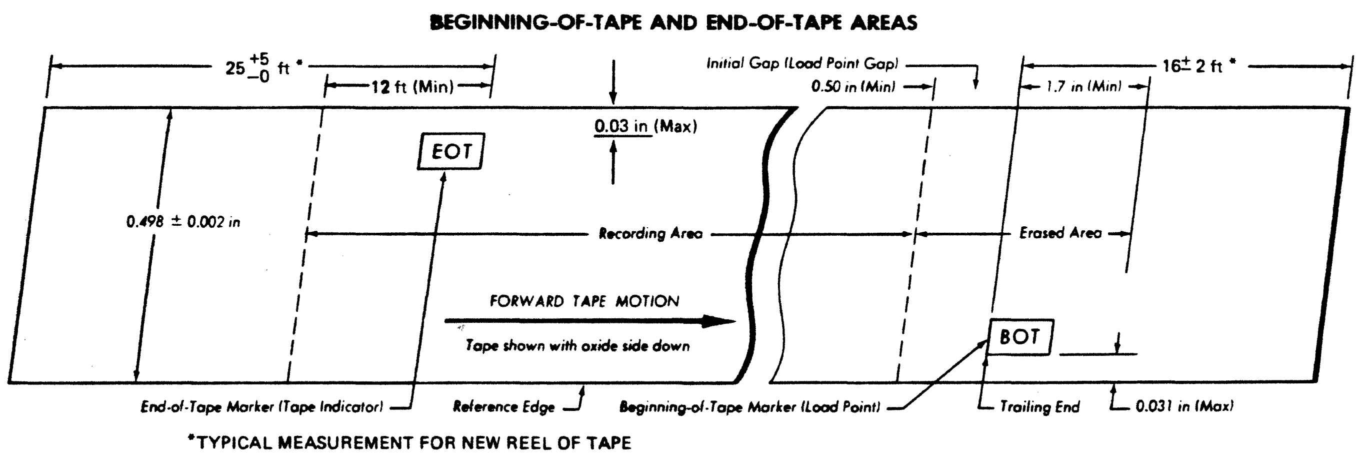


Figure 4-48. BOT and EOT Erase Formats

The manner of recording the first data after a BOT marker depends on whether the data is NRZI or PE format. On NRZI recorded tapes, the first data record begins after a delay of approximately 6 inches. On PE recorded tapes, there is first a PE identifying burst, consisting of alternate "1's" and "0's" on channel P, all other channels being erased. Then there is a space, after which the first data record starts. Minimum spacing between data records is 0.6 inch.

4-55 NRZI Data Recording Format

When using NRZI coding, a logical 1 bit appears on the interface lines as a low voltage level and a logical 0 as a high voltage level. However, on the tape a logical 1 bit is recorded as a flux change and a logical 0 bit as no change. The direction of the change is immaterial. Refer to figure 4-49.

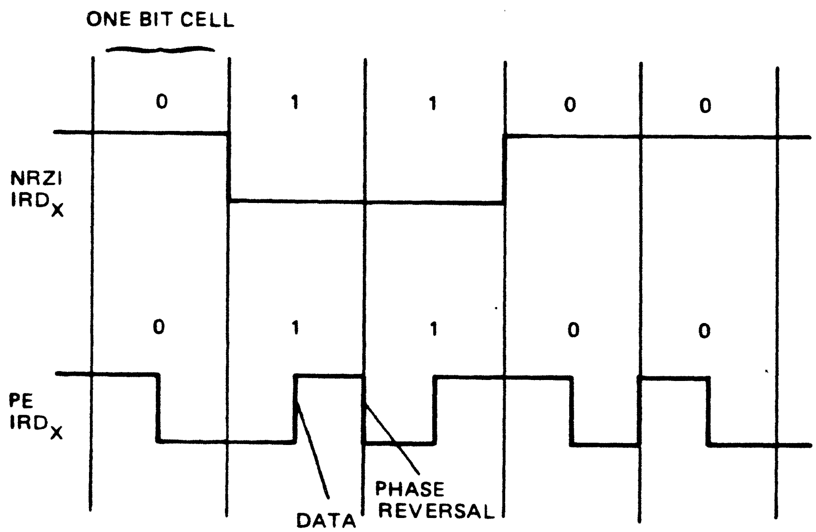


Figure 4-49. NRZI and PE Data Formats

The data is formatted and recorded on the tape in blocks referred to as records. The exact configuration of a record depends on whether the tape is in 7- or 9-track format. On 9-track tape, each record consists of the data, a cyclic redundancy check (CRC) character, and a longitudinal redundancy (LRC) character. The CRC character must occur four character times after the final data character, and the LRC character must occur four character times after the CRC. A minimum spacing of 0.5 inch is required between records. The end of a record is shown in figure 4-50.

On 7-track tape, each record consists of data, followed by an LRC character only, as shown in figure 4-50. Minimum spacing between data records is 0.6 inch.

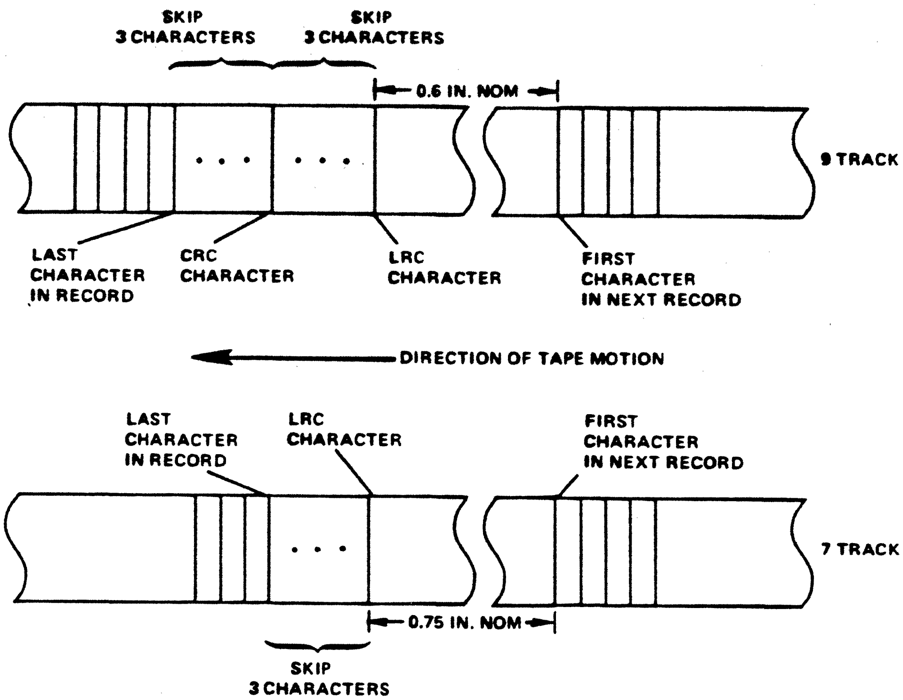


Figure 4-50. End-of-Record Mark Formats for 7- and 9-Track NRZI Tapes

4-56 PE DATA RECORDING FORMAT

On the interface a low-to-high transition in the middle of the bit cell time is defined as a logical 1 and a high-to-low transition as a logical 0. Refer to figure 4-51. A phase reversal occurs between successive zero bits to establish proper transition relationships for the data. Consequently, two data strobes (data ready) are used by each PE data bit. On the tape a logical 1 bit is recorded as a flux change in one direction and a logical 0 as a flux change in the opposite direction. On the output lines the data is self-clocked and does not require an output clock (read strobe).

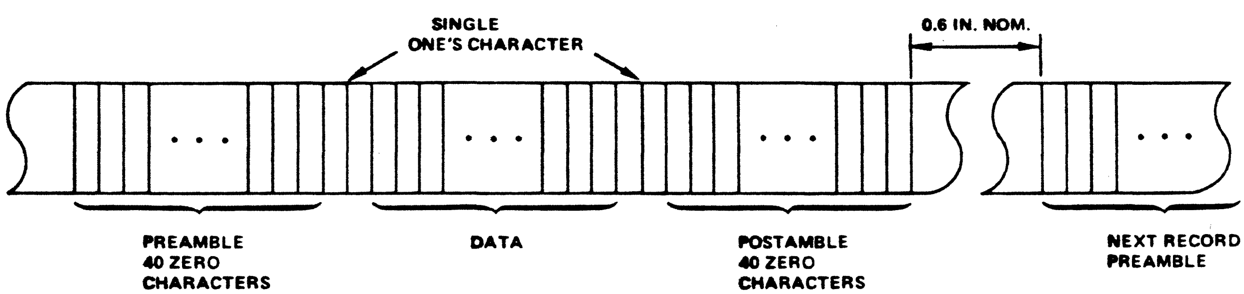


Figure 4-51. PE Record Data Format

The data is formatted on the tape in records with each record consisting of a preamble, the data, and a postamble (see figure 4-50). The preamble consists of 40 characters of logical 0's and one character of logical 1's. The postamble is a mirror image of the preamble, and consists of one character of logical 1's and 40 characters of logical 0's. A minimum spacing of 0.5 inch is required between records. PE data is always recorded on 9-track tape.

4-57 RECORD AND FILE MARKS

Standard end-of-record and end-of-file mark formats for NRZI recordings are shown in figures 4-49 and 4-52 respectively. The corresponding preamble and postamble for PE recording is described in paragraph 4-55. The end-of-file mark for PE recording is shown in figure 4-53.

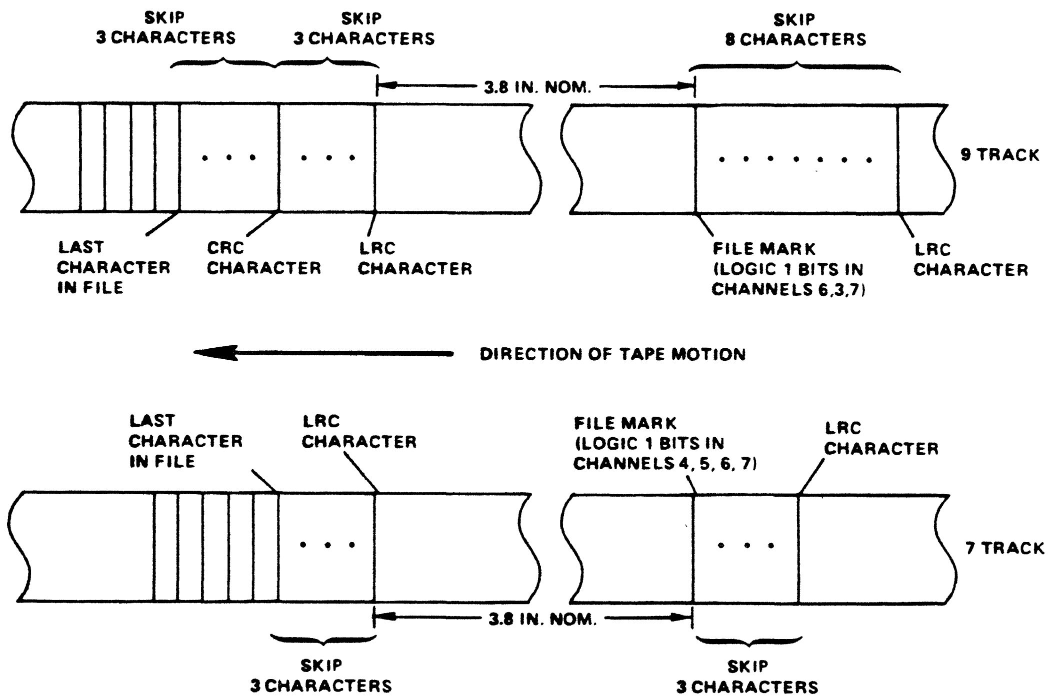


Figure 4-52. End-of-File Mark Formats for 7- and 9-Track NRZI Tapes

4-58 PROGRAM SEQUENCE

The data formats described in paragraphs 4-54 through 4-57 have various gaps preceding or following the records, end-of-file marks, etc. These gaps serve the purposes of the protecting previously recorded data during a write operation and assuring the accuracy of data read from the tape during any possible combined sequence of reading, writing, and editing. The gaps also allow ample time for the tape motion to start and stop.

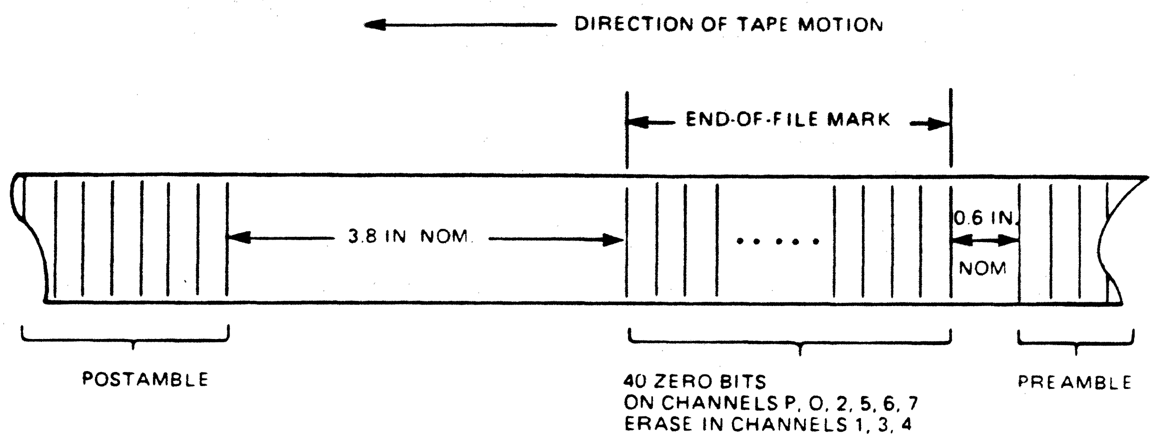


Figure 4-53. End-of-File Mark for PE Tapes

The implementation of these gaps is the function of the formatter. In the formatter these gaps translate into time delays between two signal pulses, prior to starting an operation (pre-delays) and delays after completing an operation (post-delays). Because the length of the gaps, as measured on tape, is to be maintained constant regardless of tape speed, the pre-delays and post-delays vary in time depending on the tape speed. Table 4-2 contains a listing of the essential pre-delays and post-delays for various NRZI and PE tapes. The information in table 4-2 is expressed in terms of distances on tape as well as time.

4-59 START UNIT, WRITE RECORD

Figure 4-54 shows control inputs and output timing for the sequence of starting the tape unit, writing and then rewinding the tape to the load point. The sequence is as follows:

a. Assert ILELECT address line (0, 1, 2, or 3).

b. Check the presence of IRDY, IONL, and IBOT signals from the tape unit.

c. Assert ISFC and ISWRT. ISWRT can be cleared after 10 sec.

d. The tape unit will accelerate to synchronous speed. After a pre-delay programmed by the formatter, data present at the formatter inputs will be gated to the WRITE DATA lines and clocked into the tape unit synchronous with the DATA READY clock.

e. After the last character in the record is written, the formatter will gate the proper CRC, LRC, as they are shown in figures 4-50, 4-52 and 4-53.

TABLE 4-2. PRE-DELAYS AND POST-DELAYS

OPERATION	PRE-DELAYS	
	TYPICAL DELAY (in msec)	TOTAL DELAY (in ns)
Write from BOT	91.00	6.640
Write - Dual Gap Head		
7-channel	7.30	0.365
9-channel	5.65	0.240
Write - Single Gap Head		
7-channel	7.30	0.515
9-channel	7.65	0.390
Write File Mark	50.00	3.565
Read from BOT	18.90	1.607
Read Forward	4.00	0.120
Read Reverse	4.00	0.120
Read Reverse/Edit	4.00	0.120
	POST-DELAYS	
Write	1.00	0.265
Write File Mark	1.00	0.265
Read Forward	0.00	0.190
Read Reverse/Edit		
7-channel	4.30	0.515
9-channel	2.65	0.390
Read Reverse		
7-channel	2.65	0.390
9-channel	1.00	0.265

NOTES:
1. NRZI tapes can be either 7- or 9-tracks; PE tapes are always 9-tracks
2. Write head to read head distance on dual gap heads = 0.150 inch.
3. Write head to erase head distance = 0.340 inch on all heads.

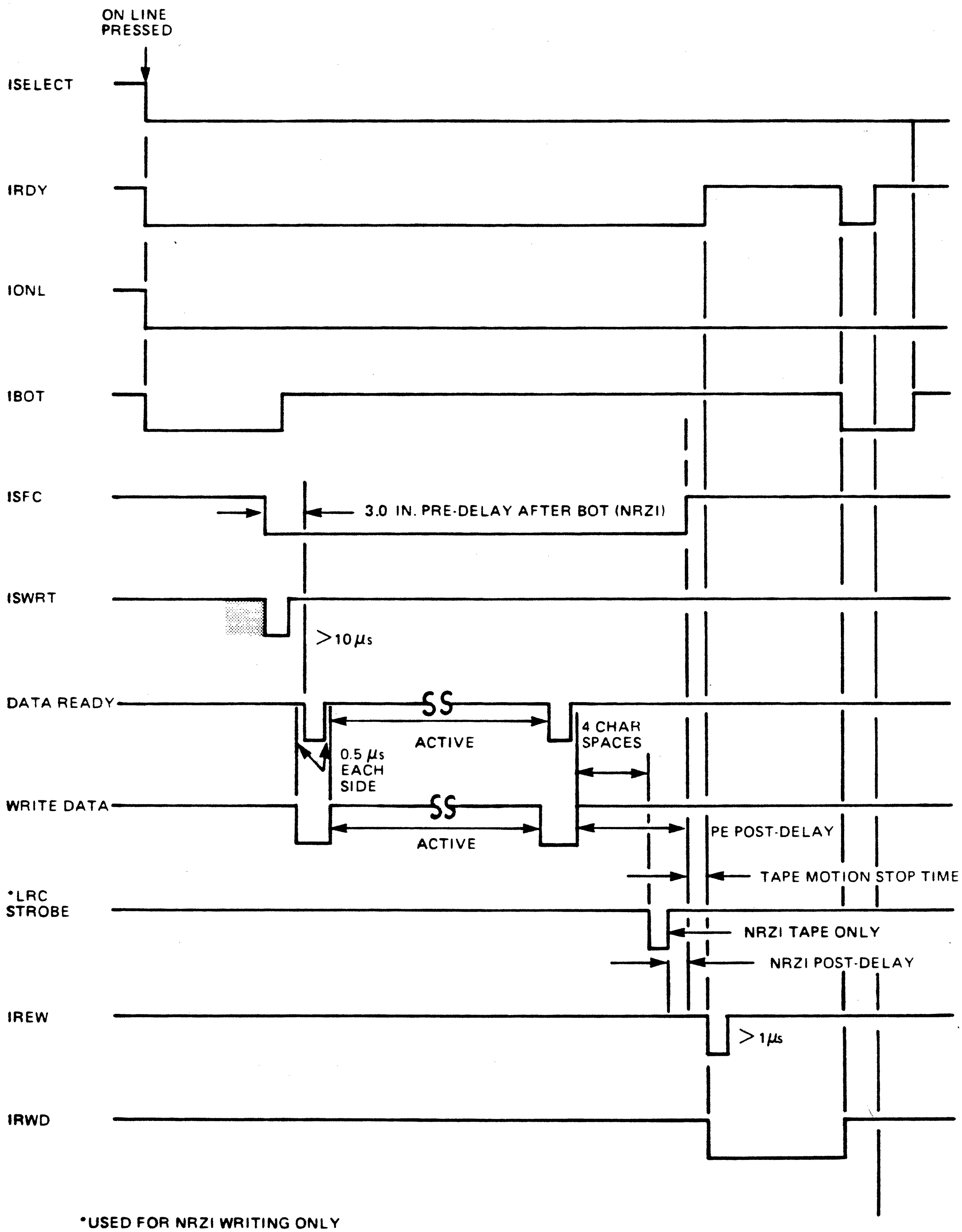


Figure 4-54. Timing Diagram for a Typical Start-Write-Stop Sequence

f. The formatter will wait for the post-delay and then disable the ISFC signal. The tape unit will stop after the stop distance of 0.190 inch.

g. Assert IREW for at least 1 sec.

h. Verify that IRWD is asserted until the tape has rewound and is repositioned at BOT (IBOT asserted).

4-60 START UNIT, READ RECORD

The process for reading data is the same as that for writing data, except ISWRT is not asserted. Data is sampled on the READ DATA lines at the trailing edge of the READ DATA strobe.

4-61 EDIT/OVERWRITE SEQUENCE

An individual record within a file can be edited by writing over the same number of characters of existing data. The sequence is as follows: first, the record is read in the forward direction and tape is stopped at the end of the record; next, the record to be edited is read in reverse edit mode (ISRC) and a post-delay, as shown in table 4-2, is inserted by the formatter as the beginning of the record is reached. This post-delay assures that the head is stopped in the proper place in the interrecord gap to start the edit overwrite operation. Then ISWRT, ISFC and IOVW are asserted to perform editing of the next record in the forward direction. The timing is the same as for a normal write operation.

Chapter 5

MAINTENANCE

5-1 INTRODUCTION

This chapter contains the information required to perform maintenance on the Model 2790 Magnetic Tape Unit. The chapter contains preventive maintenance information, checkout and alignment procedures, component replacement instructions, and troubleshooting procedures to isolate malfunctions. Before using the information in this chapter, the maintenance technician must have a thorough knowledge of the material contained in Chapter 4. One or more of the simplified schematics, logic diagrams and timing diagrams in Chapter 4 may also prove helpful during checkout and alignment, and when troubleshooting the tape unit.

The tape unit is designed to operate at maximum capability with a minimum of maintenance and adjustments. Repair of the tape unit and replacement of parts is planned to be as simple as possible. The use of test equipment is kept to a minimum, and only common tools are required in most cases.

5-2 PREVENTIVE MAINTENANCE

Preventive maintenance on the Model 2790 Magnetic Tape Unit consists of periodic cleaning, checking for alignment and wear of the tape handling components and replacement of worn parts as necessary. Component replacement instructions are presented in paragraph 5-50. To ensure reliable operation of the tape unit at optimum design potential, and to assure high mean time between failures, a scheduled preventive maintenance program is recommended. For ease of use this program has been divided into operator preventive maintenance and service engineer preventive maintenance. Table 5-1 lists preventive maintenance which should be performed periodically by the equipment operator and table 5-2 lists preventive maintenance procedures which should only be performed by a qualified engineer or maintenance technician.

5-3 CLEANING THE UNIT

The tape unit requires clearing in the following major areas: Head and associated quides, roller guides, tape cleaner, and capstan. The following paragraphs present instructions on the tape components.

To clean the head, head guides, and tape cleaner, use a lint-free cloth or cotton swab moistened in 90% isopropyl alcohol. Wipe the head and tape cleaner carefully to remove all accumulated oxide and dirt.

TABLE 5-1. OPERATOR PREVENTIVE MAINTENANCE SCHEDULE

MAINTENANCE PROCEDURE	HOURS BETWEEN MAINTENANCE	MAINTENANCE TIME (HOURS)
Clear head, tape guides, tape cleaner face, and capstan surface	8	.13
Clear vacuum chamber	16	.1
Check tape guides and capstan	16	.1
Clear tape cleaner	80	.1
Clean tape unit surface	3000	.5

TABLE 5-2. SERVICE ENGINEER PREVENTIVE MAINTENANCE

MAINTENANCE PROCEDURE	HOURS BETWEEN MAINTENANCE	MAINTENANCE TIME (HOURS)
Check skew, tape tracking, head wear, tape speed, EOT/BOT, and Data Electronics	2000	.75
Replace reel motor brushes and check tape tension	5000	.15
Replace capstan motor, blower motor, and blower motor belt	10,000	1.0
Replace reel motors	15,000	.25
Replace control switches and lamps	15,000	.25

CAUTION

Rough or abrasive cloths should not be used to clean the head and head quides. Use only 90% isopropyl alcohol. Other solvents, such as carbon tetrachloride, may result in damage to the head lamination adhesive.

To clean the capstan, use only a cotton swab moistened with 90% isopropyl alcohol to remove accumulated oxide and dirt.

To clean the roller guides, use a lint-free cloth or cotton swab moistened in 90% isopropyl alcohol. Wipe the guide surfaces carefully to remove all accumulated oxide and dirt.

CAUTION

> Do not soak the guides with excessive solvent. Excessive solvent may seep into the precision guide bearings, causing contamination and a breakdown of the bearing lubricant.

To clean the inside of the vacuum column glass, use a lint-free cloth and any commercial glass cleaner (preferably liquid, not spray). Remove any matter which covers the vacuum holes. Wipe the bottom and sides of the vacuum column with a lint-free cloth, moistened with 90% isopropyl alcohol, to remove oxide dirt.

5-4 CHECKOUT AND ALIGNMENT

The checkout and alignment procedures can be used to verify that the equipment is operating within specifications, or to check a particular suspected circuit. Test equipment required to perform the maintenance procedures contained in the following paragraphs is listed in table 5-3. Test equipment with equivalent characteristics may be substituted for the equipment listed in table 5-3. If abnormal indications are obtained during performance of the following procedures, refer to the troubleshooting procedures in paragraph 5-46. For component location on the circuit boards, refer to the PWBA drawings listed in Chapter 6.

5-5 TAPE CONTROL BOARD ELECTRICAL ADJUSTMENTS

Acceptable limits are defined in each adjustment procedure, taking into consideration the assumed accuracy of the test equipment specified in table 5-3. When the measured value of any parameter is within the specified acceptable range, NO ADJUSTMENTS should be made. If the measured value falls outside the specified acceptable limits, adjustments should be made in accordance with the revelant procedure.

When any adjustment is made, the value set should be the exact value specified (to the best of the operator's ability) in the procedure. Refer to Chapter 6 for component location on the control board.

CAUTION

> Primary power should be removed from the unit when rear access is required except in cases of electrical testing and adjustments. This is done by disconnecting the power cord, or by turning the service power switch to the OFF position.

TABLE 5-3. TOOLS AND TEST EQUIPMENT

COMMON NAME	MANUFACTURER MODEL OR TYPE NUMBER
Vacuum Column Alignment Tool	9810017-01
Micrometer	
IBM Master Skew Tape	432640
Dual Channel Oscilloscope	Tektronix 453
Drive Belt Tension Tool, Pneumatic Assembly	T0023-01A
Miscellaneous Shims	Refer to Spare Parts Lists in Chapter 6
TX-1200 Tape Transport Exerciser	Wilson Labs
Digital Multimeter	Weston 4440

5-6 Adjustment of Regulated Supplies

The ±5 volt regulated supplies are located on the control board. Adjustments made on one regulator affect the other, so both regulators must be adjusted until the outputs of both are correct. Limits for the ±5 volt supply are listed below. Any adjustment of the voltage regulator must be followed by a check of the capstan speed, ramps, and reel servos (paragraph 5-11 through 5-16). Apply primary power to the tape unit and proceed with the alignment listed in the following paragraphs. Power supply information is shown in the following list.

POWER SUPPLY INFORMATION			
POWER SUPPLY	NOMINAL VALUE	ACCEPTABLE RANGE	ADJUST TO:
+5 volt supply	+5.0 volts	+5.10 to +4.90V	+5.0 ± .10V
-5 volt supply	-5.0 volts	-5.125 to -4.875V	-5.0 ± .125V

5-7 ±5 Volt Supply Regulator Adjustment

Check the ±5 volt regulators to verify that they are within tolerances using a digital voltmeter.

Upper Limit	Lower Limit	Between Test Points
+5.10 VDC	+4.90 VDC	TPD2 (Analog Ground)
-5.125 VDC	-4.875 VDC	TPF2

a. If the readings are within these limits, it is NOT necessary to readjust the regulators.

b. If an adjustment is necessary;

Adjust Pot	Nominal Reading	Test Points
	+5.00 ± .10 VDC	TP703
R723	-5.00 ± .125 VDC	TP705

Since there is interaction between the two power supplies, only one adjustment is necessary. Adjust the pot while monitoring the +5 volt supply, check the -5 volt supply to verify that it is within the specified limits.

5-8 ADJUSTMENT OF EOT/BOT AMPLIFIERS

The EOT/BOT amplifier circuit is located on the control board. Perform the following steps to prepare the tape unit and then continue to the amplifier adjustments.

NOTE

The ±5V regulators must be checked and adjusted, if necessary, prior to checking the EOT/BOT amplifier system.

a. Apply power to the tape unit.

b. Load a reel of tape on the tape unit.

c. Press and release the LOAD control twice (once on units equipped to automatically position the tape at the BOT marker) to tension the tape, and advance the tape to the BOT marker.

5-9 BOT Amplifier Adjustment

a. Remove the head covers. Check and, if necessary, adjust the position of the EOT/BOT tape sensor until it is parallel to the tape path. Refer to figure 5-1.

b. Connect multimeter between TP209 and ground. Replace the head covers.

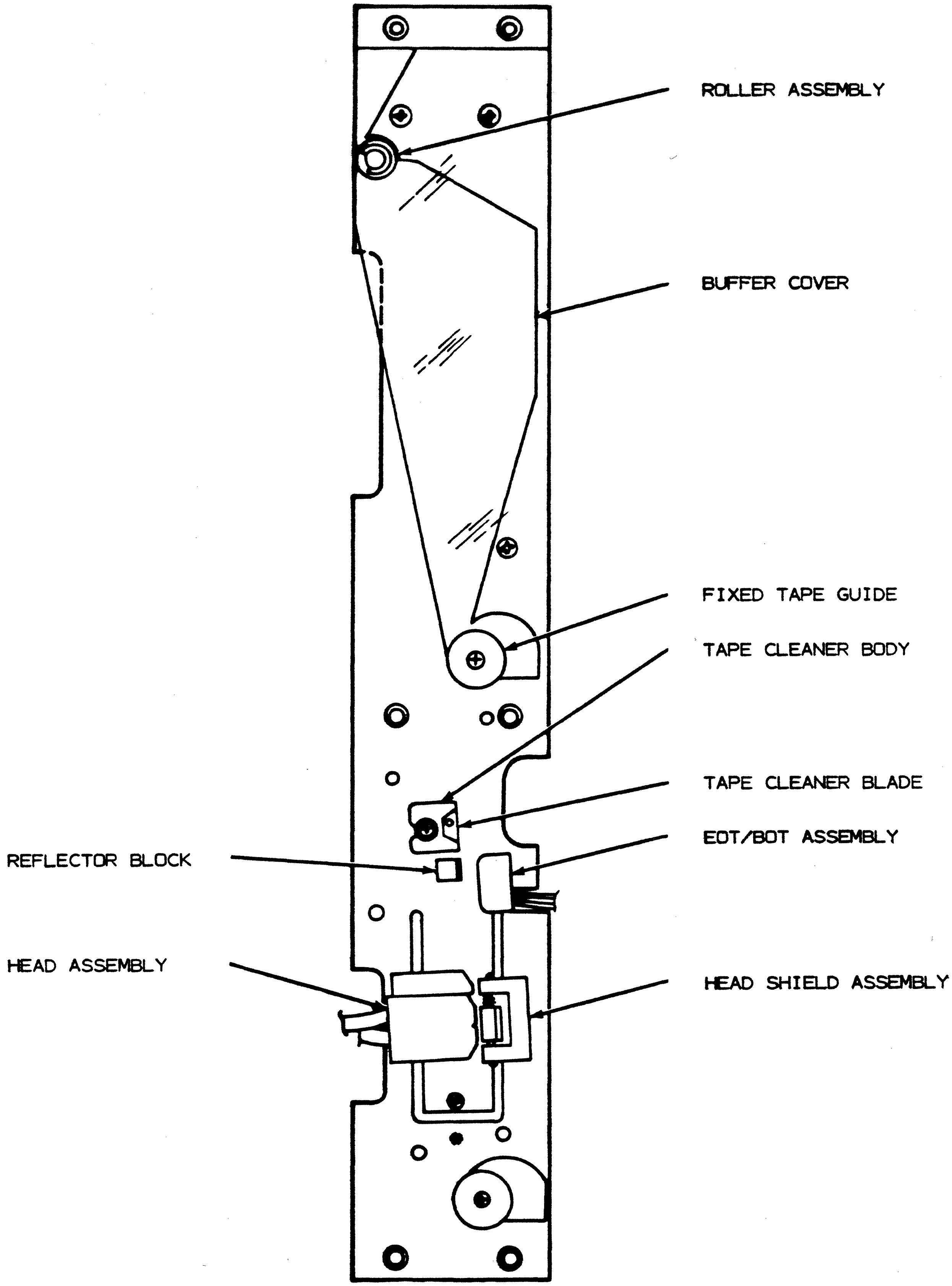


Figure 5-1. Head Assembly

c. Alternately position the tape on and off the BOT marker and adjust potentiometer R211 so that the on BOT marker voltage is +1.5 volts above ground and has a swing of at least 3 volts between the on and off-marker positions. Off-marker voltage should be -1.5 volts, minimum.

5-10 EOT Amplifier Adjustment

a. Remove the head covers. Check the position of the EOT/BOT tape sensor and, if necessary, adjust the tape sensor until it is parallel to the tape path. Refer to figure 5-1.

b. Position the tape to the EOT marker.

c. Connect a multimeter between TP206 and ground. Replace the head covers.

d. Alternately position the tape on and off the EOT marker and adjust potentiometer R207 so that the on EOT marker voltage is +1.5 volts above ground and has a swing of at least 3 volts between the on and off-marker positions. Off-marker voltage should be -1.5 volts, minimum.

5-11 ADJUSTMENT OF CAPSTAN SPEED

The following procedures include the capstan amplifier offset adjustment, a preliminary speed adjustment and a final speed adjustment.

5-12 Capstan Zero Adjustment

a. Load tape and advance it to BOT.

b. Connect the leads of the digital multimeter between TP612 (+) and ground.

c. Adjust offset potentiometer R682 until the voltage displayed on the digital multimeter is between 0.0V $\pm$.05V.

5-13 Ramp Timing Adjustment

The two tape acceleration and deceleration ramps are controlled by two potentiometer adjustments located on the control board. For dual speed tape units, set the unit to the higher of the two speeds and follow the adjustments given. After ramp timing has been completed, the lower speed ramp adjustments can be performed. Load a reel of tape on the unit and proceed with the following adjustments.

a. Connect an oscilloscope to TP609 and sync the oscilloscope on the negative going leading edge. Ground the oscilloscope at analog ground.

b. Initiate a forward-start/stop tape motion using either TP201 or TP202. Observe the oscilloscope display (see figure 5-2).

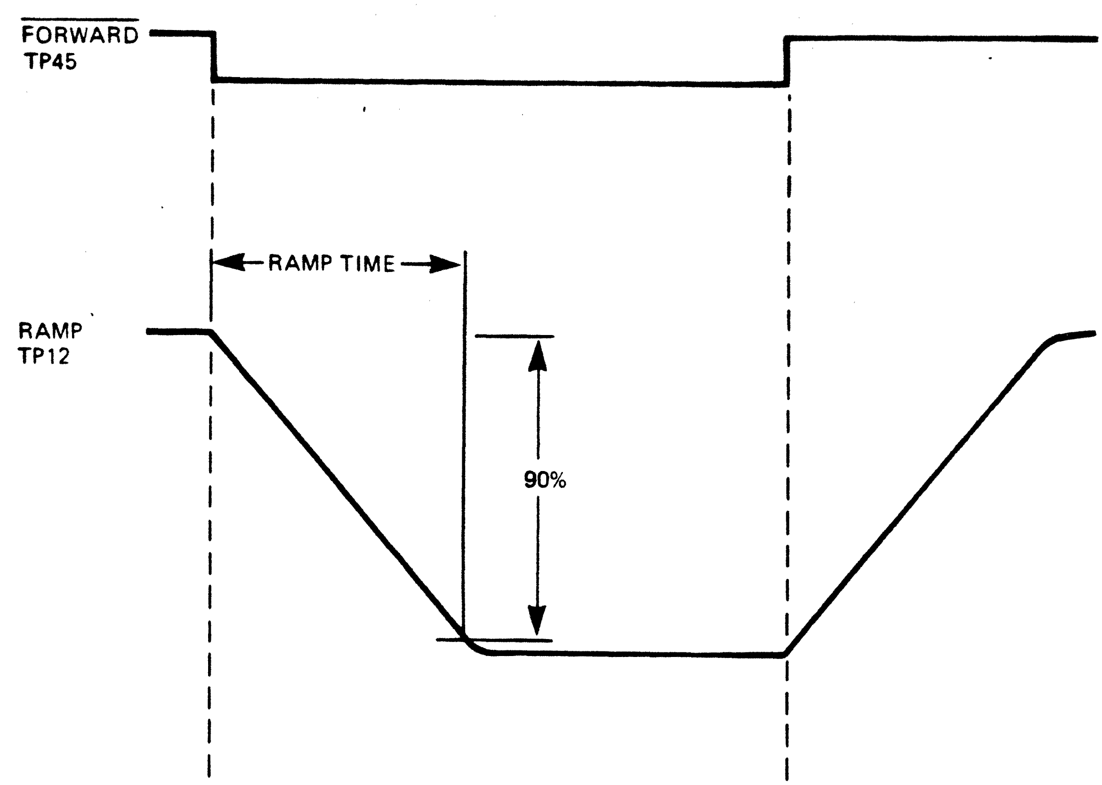


Figure 5-2. Forward Ramp Waveform

c. On dual speed tape units, set to the higher speed. Adjust pot R693 until the ramp is 90% of the final amplitude, equal to the appropriate ramp time for the tape speed.

d. Set the tape unit to the lower speed (or single speed unit) and adjust pot R688 for the proper ramp width at the higher tape speed. See table 5-4.

TABLE 5-4. RAMP WIDTH TIMING

SPEED (ips)	RAMP TIMING (msec)
75	5.0
125	3.0

5-14 Capstan Speed Adjustment

The capstan mounted strobe disc is used to perform tape speed adjustments of the synchronous speed. Tape speed adjustments made using the strobe disc are accomplished by illuminating the capstan hub from a flourescent light source and adjusting potentiometer until the disc image, created by the pulsating light source, becomes stationary. The accuracy of the adjustment if determined by the length of time in which the disc image completes one revolution. If the image takes longer to make one revolution than the specified time indicated in the following chart, the tape unit is still within specifications if it is within the tolerance limits.

$$\text{Time for one revolution} = \frac{X}{\text{(tape speed)}} \quad \frac{628}{\text{(accuracy percent)}}$$

TAPE SPEED (IPS)	1% TOLERANCE (ROTATION TIME)
75	>8.4 sec.
125	>5.0 sec.

The strobe disks have two sets of rings and should be used with the following rules:

a. Part No. 9210378-02 (75 ips). The outer ring is used when the light source is 50 Hz, and the inner ring is used when the light source is 60 Hz.

b. Part No. 9260138-01 (125 ips). The outer ring is used when the light source is 60 Hz, and the inner ring is used when the light source is 50 Hz.

Perform the adjustments as follows:

a. Rethread tape around capstan.

b. Set maintenance switch SW1 to forward position.

c. On dual-speed units set transport to high speed. Adjust potentiometer R603 until image becomes stationary (within 1%) in the forward direction.

d. Set to reverse direction, and adjust potentiometer R637 until disc image becomes stationary (within 1%) in the reverse direction.

e. On dual-speed tape units, set transport to low speed (or single speed units). Adjust potentiometer R695 until disc image becomes stationary (within 1%) in forward direction.

5-15 Adjustment of Capstan Rewind Speed

Before adjusting the capstan rewind speed, verify that the capstan synchronous speed is correct (refer to preceding procedures). Perform the following steps for the tape unit rewind adjustment.

NOTE

The +5V regulators must be checked and adjusted, if necessary, prior to checking the capstan rewind speed.

a. Apply power to the tape unit.

b. Load a reel of tape.

c. Press and release the LOAD control twice (once on units equipped to automatically position the tape at the BOT marker) to tension the tape, and to advance the tape to the BOT marker.

d. Connect the leads of the digital multimeter between TP608 (+) and tack output (Gnd).

e. Run the tape forward. Record on the voltage indicated on the digital multimeter's display.

f. The correct rewind voltage is calculated by using the following formula:

$$\frac{\text{measured voltage}}{\text{tape speed}} \times 375 = \text{rewind voltage}$$

g. After calculating the rewind voltage, initiate a rewind operation. Adjust potentiometer R745 until that voltage calculated in step f (+0, -3%) is displayed on the digital multimeter.

5-16 VACUUM COLUMN ELECTRICAL ADJUSTMENT

The electrical adjustments for vacuum column machine supply and take-up reel servos are identical. Consequently, the procedure is presented with the take-up reel servo test points and potentiometers indicated in parenthesis. Test points and potentiometers not in parenthesis are those required for the supply reel servo adjustment. Perform the following steps to prepare the tape unit for the adjustment procedure.

NOTE

The ±5V regulators must be checked and adjusted, if necessary, prior to checking the electrical vacuum column adjustment.

a. Apply power to the tape unit.

b. Load a loop of tape in the vacuum column as shown in figure 5-3, and mark the vacuum column window as shown.

c. On dual speed units, set to higher of two tape speeds.

d. Momentarily engage the LOAD control.

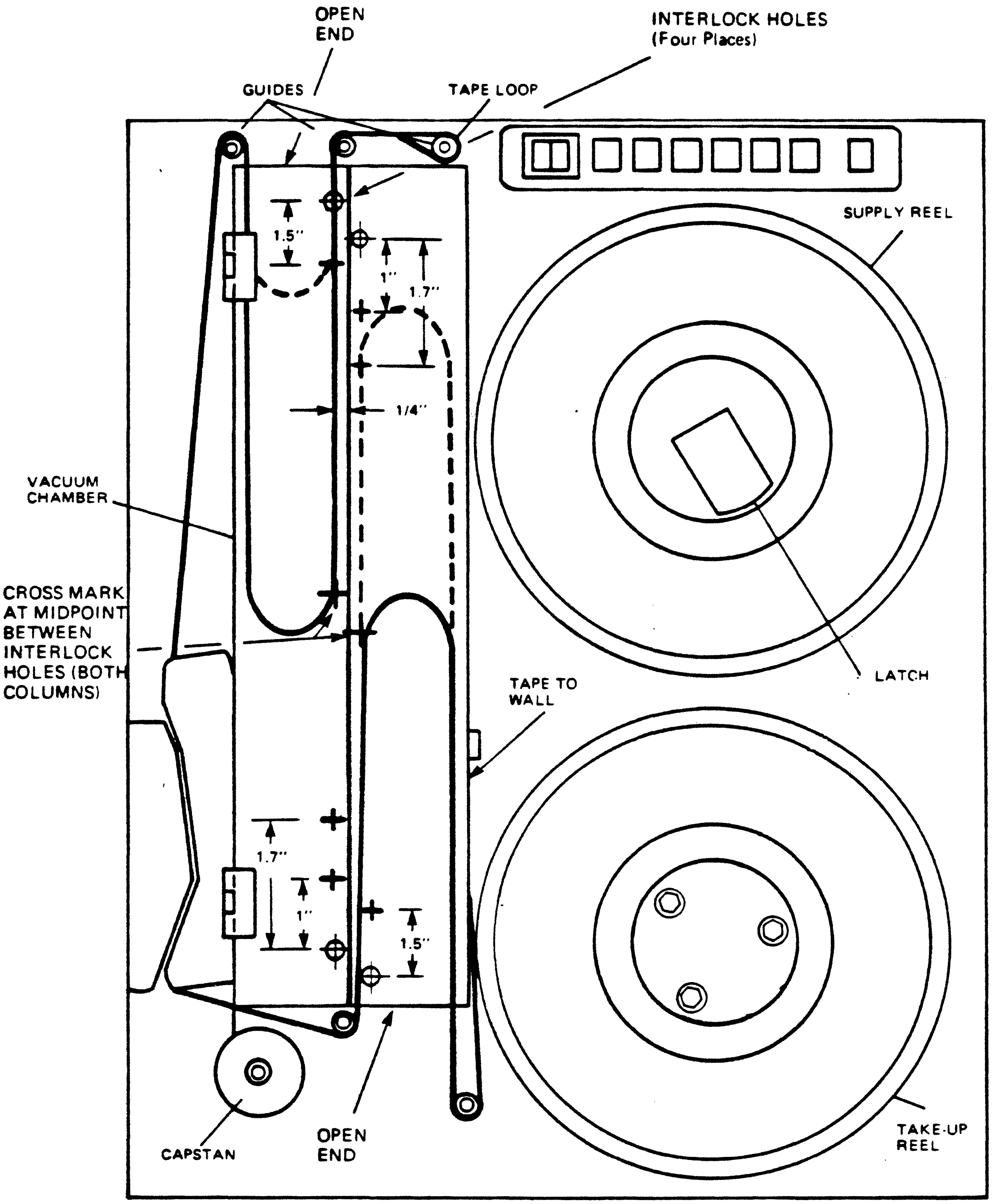


Figure 5-3. Tape Loop for Vacuum Column Servo Adjustment

5-17 Vacuum Column Adjustment

a. Adjust potentiometer R639 (R608) to middle gain of range.

b. Connect the leads of the digital multimeter between TP601 (TP606) and analog ground TP.

c. Position the tape loop such that the tape intersects a point one quarter inch from the vacuum column wall and half the distance between the interlock holes. Adjust potentiometer R119 (R114) for and indication of zero volts (±0.01 vdc) on the digital multimeter.

d. Locate the tape loop such that the tape intersects a point one-quarter inch from the vacuum column wall and 1.5 inches from the supply (take-up) column's open end interlock hole. Adjust R608 (R639) until 1.8 volts (±0.03 vdc) is measured.

e. Locate the tape loop in the center of the column, as in step c. Adjust R119 (R114) for an indication of zero volts (+0.01 vdc) on the digital multimeter.

f. Connect the multimeter's leads to TP603 (TP608) and analog ground, and adjust R606 (R637) until +1.5 volts (+0.1 vdc) is measured on the digital multimeter.

g. Load an empty reel on the supply or take-up hub.

h. Using the front panel LOAD switch, alternately run the tape in the forward and reverse directions.

i. Adjust the potentiometer R608 (R639) for proper tape travel. The tape should intersect a point one quarter inch from the vacuum column wall and 1.5 inches (+0.1, -0.2) from the open end interlock hole. The loop position at the closed end of the chamber should operate between 1 and 1.7 inches from the interlock hole.

NOTE

> If the operating points do not fall within the above regions, complete steps J, K, and i, then repeat steps h and i.

j. Load a full reel on the supply or take-up hub.

k. Using the front panel switch, alternately run the tape in the forward and reverse directions.

1. Adjust potentiometer R606 (R637) such that the tape travel is symmetrical between the two interlock holes (±0.5 inches).

5-18 NRZI DATA BOARD ELECTRICAL ADJUSTMENTS

The following paragraphs describe the adjustments required for proper operation of the NRZI data board. Refer to the drawings in Chapter 6 for component location. Acceptable limits are defined in each of the following adjustments procedures for both the dual gap and single gap head assemblies. The following list of adjustment procedures indicate which adjustment procedures are applicable to single gap head assemblies and which are applicable to the dual gap assembly and the order in which the adjustment procedures should be performed.

a. Read amplifier gain adjustment procedure: Dual and single gap heads.

b. Read head skew measurement and adjustment procedure: Dual and single gap heads.

c. Write head deskew: Dual gap heads only.

d. Head shield adjustment: Dual gap heads only.

e. Read strobe: Dual and single gap heads.

f. Character assembly time.

5-19 Read Amplifier Gain Adjustment

The gain of each of the read amplifiers located on the NRZI data board is independently adjustable. Perform the following steps to prepare the tape unit for the adjustment procedure.

a. Clean the head assembly and tape path as described in paragraph 5-3.

b. Apply power to the tape unit.

c. Load a master output tape* on the tape unit. Press and release the LOAD control twice (once on unit equipped to automatically position the tape at the BOT marker) to tension the tape, and to advance the tape to the BOT marker.

d. Use the TX-1200 Tape Transport Exerciser to write 800 bpi all ones on all channels. Refer to the Tape Transport Exerciser manual (Part No. 9580062) for equipment interconnect and set up instruction.

e. After recording all ones on all channels, rewind tape to the BOT marker (for single gap).

f. Connect oscilloscope to TP101.

g. Read with MAINTENANCE switch in Forward and adjust the amplifier gains. Refer to table 5-5 and figure 5-4 for NRZI/PE TEST POINTS and OUTPUT SIGNALS.

*A prerecorded master output tape should not be used for setting amplifier gains. Signal decay resulting from reading the tape over and over with different heads will result in false gain adjustments.

TABLE 5-5. NRZI/PE TEST POINTS AND OUTPUT SIGNALS

POTENTIOMETERS	TEST POINTS	ANALOG VOLTAGE AVERAGE ALL ONES SIGNAL
NRZI R117 through R917	TP101 through TP901	10.0 volts P-P
PE R111 through R911	TP104 through TP904	6.0 volts P-P

5-20 Read Head Skew Measurement and Adjustment

The read head skew measurement and adjustment procedures should only be required when the read head has been replaced. The adjustment of read skew is accomplished mechanically by shimming one of the head guides. The shims are 0.0005 inches thick and correct for 37.5 microinches of skew. The maximum allowed shims, under any one guide, is four. Both guides should not be shimmed on the same head place assembly. The shims can be mounted by removing the guide and placing the shim on the screw that mounts the guide and reassembling the guide on the head plate assembly. Load IBM master skew tape on the tape unit and perform the following adjustments.

5-21 Skew Measurement and Adjustment

a. Using a dual trace oscilloscope, connect channel A to TP603 and channel B to TP703 for nine channel units. For seven channel units, connect channel A to TP903 and channel B to TP103.

b. Using the front panel LOAD maintenance switch, run the tape forward. Observe the time displacement between the two signals displayed on the oscilloscope (figure 5-5). Calculate the amount of displacement (refer to table 5-6).

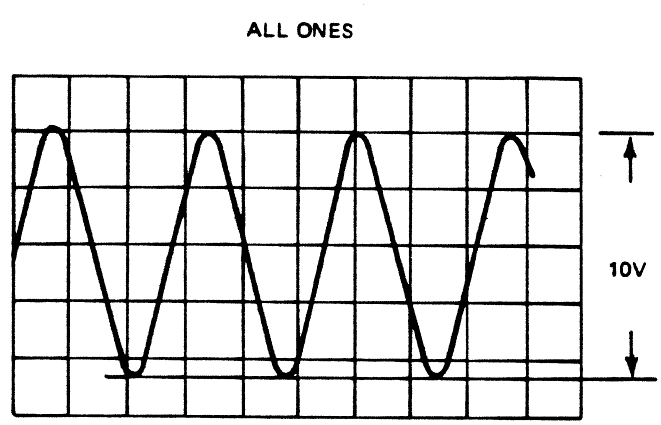


Figure 5-4. Amplifier Waveforms (TP101)

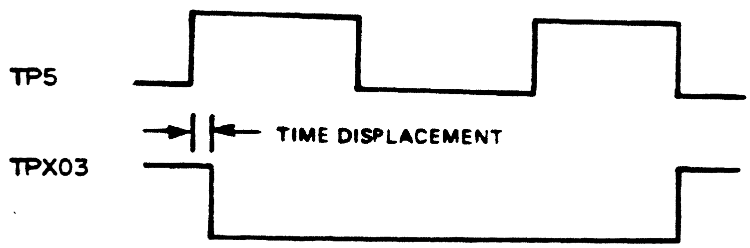


Figure 5-5. Output Waveforms (TP103, TP203, TP603, TP703)

TABLE 5-6. EQUIVALENT DISPLACEMENT TIMES FOR 100 AND 175 MICROINCHES OF SKEW AT VARIOUS TAPE SPEEDS

SPEED (IPS)	100 MICROINCHES (microseconds)	175 MICROINCHES (microseconds)
75	1.3	2.3
125	0.8	1.4

5-22 Write Head Deskew Adjustment

To ensure proper write head deskewing the read head gap scatter must first be plotted using the IBM master skew tape. This plot is then duplicated while writing on a tape by adjusting the write deskew single-shot potentiometers. Load the IBM master skew tape on the tape unit and perform the following adjustments.

5-23 Read Head Gap Scatter Plot

a. Using a dual trace oscilloscope, connect channel A to TP5.

b. Use the LOAD switch to run the tape forward and monitor TP103 through TP903 with channel B of the oscilloscope. Record the time displacement between channels A and B of the oscilloscope (figure 5-5).

5-24 Write Deskew Adjustment

a. Unload the IBM master skew tape from the tape unit and load a scratch reel of tape on the unit.

b. Press and release the LOAD control twice (once for units equipped to automatically position the tape at the BOT marker) to tension the tape, and to advance the tape to the BOT marker.

c. Use the TX-1200 Tape Transport Exerciser to write all ones in all channels. Refer to the tape transport exerciser manual (Part No. 9580062) for equipment interconnection and set up instructions.

d. Adjust potentiometer R102 through R902 to center of range.

e. Connect oscilloscope channel A to first-track-in (zero time displacement) from read head gap scatter. Connect channel B of oscilloscope to TP103 through TP903 while monitoring the signals at these test points, adjust the write deskew potentiometers (R102 through R902) so that the READ HEAD GAP SCATTER PLOT is duplicated.

5-25 Staircase Skew Measurement

A quick check of all read/write adjustments can be made by observing the waveform at TP9 (figure 5-6). The TX-1200 Tape Transport Exerciser (Part No. 00295) should be set up to write all ones on all channels. The length of time from the first step to the last is the total amount of skew displacement. If the skew is greater than 175 microinches (table 5-6) the tape path adjustment (paragraph 5-38) should be performed.

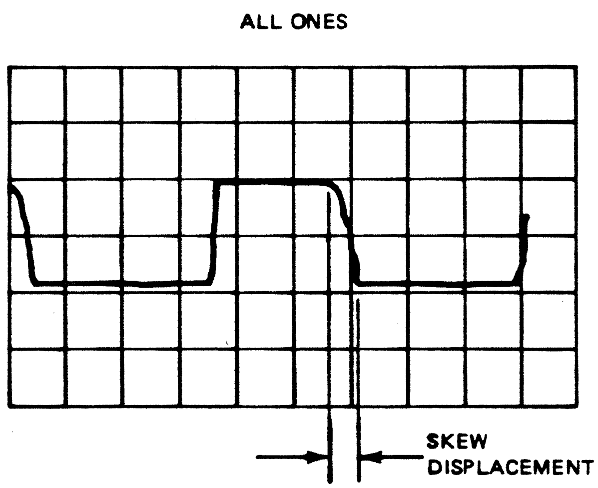


Figure 5-6. Staircase Waveform (TP9)

5-26 Head Shield Adjustment

The flux gate adjustment is necessary to minimize the crosstalk between the read and write heads. Perform the following steps to prepare the tape for the adjustment procedure.

a. Unplug P19 from control board to disable capstan power.

b. Apply power to the tape unit.

c. Load a reel of tape on the unit. Press and release the RESET switch, then the ON LINE switch.

d. Use the TX-1200 Tape Transport Exerciser to write all ones on all channels. Refer to the tape transport exerciser manual (Part No. 9580062) for equipment interconnect and set up instructions.

5-27 Adjustment of Head Shield

a. Connect oscilloscope channel A to TP601 and channel B to TP701 (nine channel) or channel A to TP901 and channel B to TP101 (seven channel).

b. The amplitude of the signal displayed on the oscilloscope should be less than 0.5 volts.

c. If the signal amplitude is greater than the allowed limit, remove the head cover. Loosen the two screws securing the flux gate (figure 5-1) and adjust the flux gate until the voltage is within limits. Be careful that the flux gate does not touch the tape.

d. Check the rest of the tracks and verify the amplitude is less than .5 volts.

5-28 Read Strobe Adjustment

Load a scratch tape on the tape unit, then use the TX-1200 Tape Transport Exercisor to write 800 bpi, all ones on all channels. Refer to the tape transport exerciser manual (Part No. 9580062) for equipment interconnect and set up instructions. After recording all ones on all channels, rewind the tape to the BOT marker and proceed to the following adjustment procedures.

a. Connect oscilloscope channel A to TP5.

b. Run the tape forward in the read mode.

c. Adjust potentiometer R29 such that the positive pulse observed on the oscilloscope is equal to one half of a bit time. (Refer to table 5-7).

TABLE 5-7. ONE-HALF BIT TIME FOR VARIOUS TAPE SPEEDS AND DENSITIES

ONE-HALF BIT TIME (Microseconds)			
SPEED (IPS)	800 BPI	556 BPI	200 BPI
75	8.5	12.0	34
125	5.0	7.2	20

5-29 Threshold Measurement

The correct threshold voltages are necessary to correctly read data from tape. Perform the following steps to measure the threshold voltages.

a. Apply power to the tape unit.

b. Load a reel of tape on the tape unit. Press and release the LOAD control twice (once on unit equipped to automatically position the tape at the BOT marker) to tension the tape and to advance the tape to the BOT marker.

c. Verify that Read Threshold 1 and Read Threshold 2 are not asserted.

d. Set the tape unit off line. Connect the oscilloscope to test point TP11. The voltage should be 1.3 volts.

e. Set the tape unit on line. Assert Read Threshold 2. The voltage should be 0.7 volts.

f. For dual gap version data boards, use the TX-1200 to write data. Single gap version assert Read Threshold 1. The voltage should be 2.1 volts.

5-30 PHASE ENCODED DATA BOARD ELECTRICAL ADJUSTMENTS

The adjustments contained in this section should be performed whenever a tape head is removed and replaced. The following list indicates the order in which the adjustment procedures should be performed.

a. Read amplifier gain adjustment.

b. Read head skew measurement and adjustment.

c. Flux gate adjustment.

Refer to drawing number 9040134 in Chapter 6 for component location on the PE data board.

5-31 Read Amplifier Gain Adjustment

The gain of each of the read amplifiers located on the Phase Encoded (PE) data board is independently adjustable. Perform the following steps to adjust the PE data board read amplifiers.

a. Clean the head assembly and tape path as described in paragraph 5-3.

b. Apply power to the tape unit.

c. Load a standard level output tape on the tape unit. Press and release the LOAD control twice (once on units equipped to automatically position the tape at the BOT marker) to tension the tape, and to advance the tape to the BOT marker.

d. Use the TX-1200 Tape Transport Exerciser to write all ones on all channels. Refer to the tape transport exerciser manual (Part No. 9580062) for equipment interconnect and set up instructions.

e. After recording all ones on all channels, rewind the tape to the BOT marker.

f. Connect the oscilloscope to TP104.

g. Run the tape forward in the read mode.

h. Adjust potentiometer R111 until the analog signal displayed on the oscilloscope is 6 volts peak-to-peak. (Refer to figure 5-7).

i. Repeat step h for all channels usint TPX04 and potentiometers RX11, where X is 2 through 9.

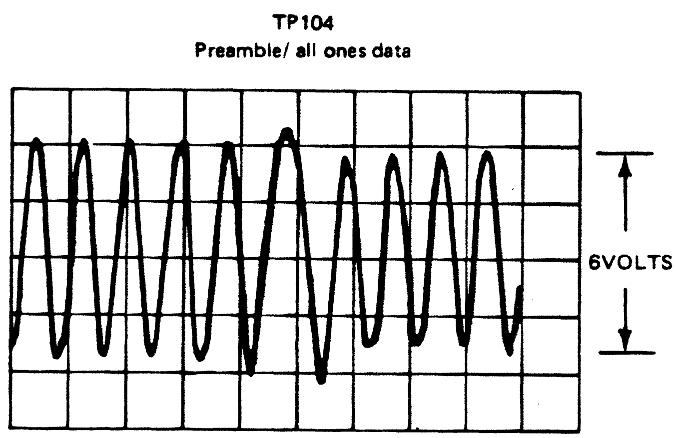


Figure 5-7. Amplifier Waveform (TP104)

5-32 Read Head Skew Measurement and Adjustment

The read head skew measurement and adjustment procedures should only be required when the read head has been replaced. The adjustment of read skew is accomplished mechanically by shimming one of the head guides. The shims are 0.0005 inches thick and correct for 37.5 micorinches of skew. The maximum allowed shims, under any one guide, is four. Both guides should not be shimmed on the same head plate assembly. The shims can be mounted by removing the guide and placing the shim on the screw that mounts the guide, then reassembling the guide on the head plate assembly. Perform the following measurement and adjustment steps.

a. Apply power to the tape unit.

b. Load the IBM master skew tape on the tape unit. Press and release the LOAD control twice (once on units equipped to automatically position the tape at the BOT marker) to tension the tape, and to advance the tape to the BOT marker.

c. Using a dual trace oscilloscope, connect channel A to TP607 and channel B to TP707.

d. Using the maintenance switch SW1, run the tape forward. Observe the time displacement between the two signals displayed on the oscilloscope (see figure 5-5). Calculate the amount of displacement (refer to table 5-6).

If the displacement is less than 100 microinches, no shimming is required. If the displacement is greater than 100 microinches and TP707 is the leading signal, the guide on the capstan side of the head assembly should be shimmed. Otherwise shim the other guide. The number of shims required can be calculated as follows:

$$\text{Number of Shims} = \frac{(\text{Tape Speed}) \times (\text{Time Displacement})}{37.5 \times 10^{-6}}$$

e. After the guide has been shimmed, verify that the displacement is less than 100 microinches.

5-33 Flux Gate Adjustment

The flux gate adjustment is necessary to minimize the crosstalk between the read and write heads. Perform the following steps to accomplish the flux gate adjustments:

a. Apply power to the tape unit.

b. Load a reel of tape on the unit. Press and release the LOAD control twice (once on units equipped to automatically position the tape at the BOT marker) to tension the tape, and to advance the tape to the BOT marker.

c. Remove the tape from the capstan so that the only signal present at the output of the read amplifier is crosstalk from the write head.

d. Use the TX-1200 Tape Transport Exerciser to write all ones on all channels. Refer to the tape transport exerciser manual (Part No. 9580062) for equipment interconnect and set up instructions.

e. Connect oscilloscope channel A to TP604 and channel B to TP704.

f. The amplitude of the signal displayed on the oscilloscope should be less than 0.5 volts.

g. If the signal amplitude is greater than the allowed limit, remove the head covers. Loosen the two screws securing the flux gate (figure 5-1) and adjust the flux gate until the voltage is within limits. Be careful that the flux gate does not touch the tape.

h. Check the other tracks and verify the amplitude is less than 0.5 volts.

5-34 Staircase Skew Measurement

A quick check of all read/write adjustments can be made by observing the waveform at TP5 (figure 5-8). Set up the TX-1200 Tape Transport Exerciser (Part No. 00295) to write all ones on all channels. The length of time from the first step to the last is the total amount of skew displacement. If the skew is greater than 175 microinches (see table 5-4). Tape path adjustment (paragraph 5-38) should be performed.

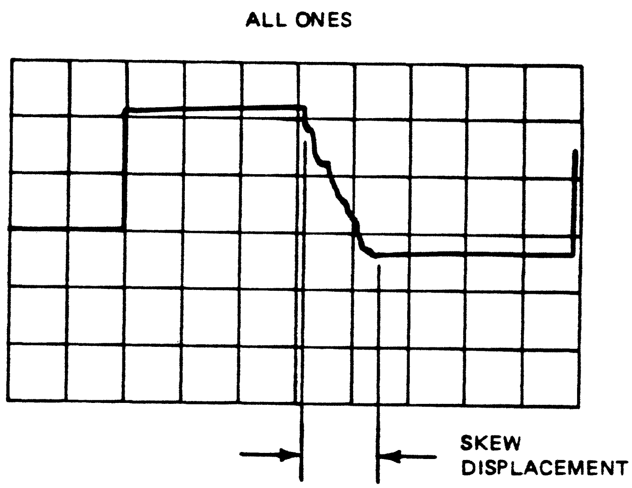


Figure 5-8. Staircase Waveform (TP5)

5-35 Threshold Measurement

The correct threshold voltages are necessary to correctly read data from tape. To measure the threshold voltages, perform the following steps.

a. Apply power to the tape unit.

b. Load a reel of tape on the tape unit. Press and release the LOAD control twice (once on units equipped to automatically position the tape at the BOT marker) to tension the tape and to advance the tape to the BOT marker.

c. Verify that Read Threshold 1 and Read Threshold 2 are not asserted.

d. Set the tape unit off line. Connect oscilloscope to test point TP4. The voltage should be 0.9 volts.

e. Set the tape unit on line. Assert Read Threshold 2. The voltage should be 0.3 volts.

f. For dual gap version data boards, use the TX-1200 to wirte data. Single gap version assert Read Threshold 1. The voltage should be 1.6 volts.

5-36 MECHANICAL CHECKOUT AND ALIGNMENT

The following paragraphs present checkout and alignment procedures for the mechanical components of the 2790 Series Magnetic Tape Unit. Any mechanical alignment procedure not included in the following paragraphs is a factory procedure and should not be attempted in the field. Refer to figures 4-2 and 5-1 for various mechanical views of the tape units.

5-37 Tape Path Alignment Measurement

Load a tape on the tape unit and perform the following steps:

a. Using the maintenance switch SW1, run the tape forward and reverse.

b. Check at all of the guides if the tape is being curled or warped at the edges while tape is moving. If it is, perform the tape path adjustment (paragraph 5-38).

c. Check that the tape stays in the center of the capstan as the tape is run forward and reverse. If it doesn't, perform the tape path adjustment (paragraph 5-38).

d. Remove the tape guide caps from the fixed tape guides on the head-plate assembly.

e. Press the spring loaded tape guides washers to the headplate. Secure to this position.

f. Using the maintenance switch SW1, run the tape forward and reverse.

g. Verify that the tape movement across the fixed tape guides is less than 0.10 inches. If the tape movement is greater than 10 mils, perform the tape path adjustment (paragraph 5-38).

h. Replace tape guide caps on the guides. Release the spring loaded washer.

i. Perform the staircase skew measurement (paragraph 5-25 or 5-34).

5-38 Tape Path Adjustment

Alignment of the tape path components is accomplished by using alignment tool 9810017. The tape path components consist of the head plate, the tape guide rollers (supply and take-up), the supply and take-up hub, and the capstan.

CAUTION

The alignment tool is precision made and must be handled with care to avoid damage.

5-39 Head Plate Adjustment

NOTE

This procedure is required only when fixed tape guide is replaced. Otherwise, do not adjust the head plate.

a. Remove power from the tape unit.

b. Remove the two head covers, the reels and the tape unit overlay. Be careful of components on the head plate assembly. The overlay is secured with hook and loop fabric.

c. Remove the ceramic caps from the two guides.

d. Remove the vacuum chamber door by unfastening the hinges from the chamber. Leave the hinges on the door.

e. Check each guide as shown in figure 5-9, which indicates the two positions of the alignment tool. The flat edge of the tool is used. Place the flat edge across the vacuum chamber so that the tool is over the guide and then measure the gap with a feeler gauge. The gap should be .003 $\pm$ .005 inches.

f. If either guide position is out of tolerance, adjust head plate by changing shims of screw nearest to guide requiring adjustment, as follows:

CAUTION

Adjustment requires removing the head plate. The three plate-mounting screws each have spacers and, possibly, shims. The gold-colored spacers might be different sizes, silver-colored spacers are matched in size. Follow the procedure carefully to avoid spilling spacers and shims. If spacers are removed, keep track of their original positions for re-assembly. Also keep track and reinstall shims of screws not requiring adjustment.

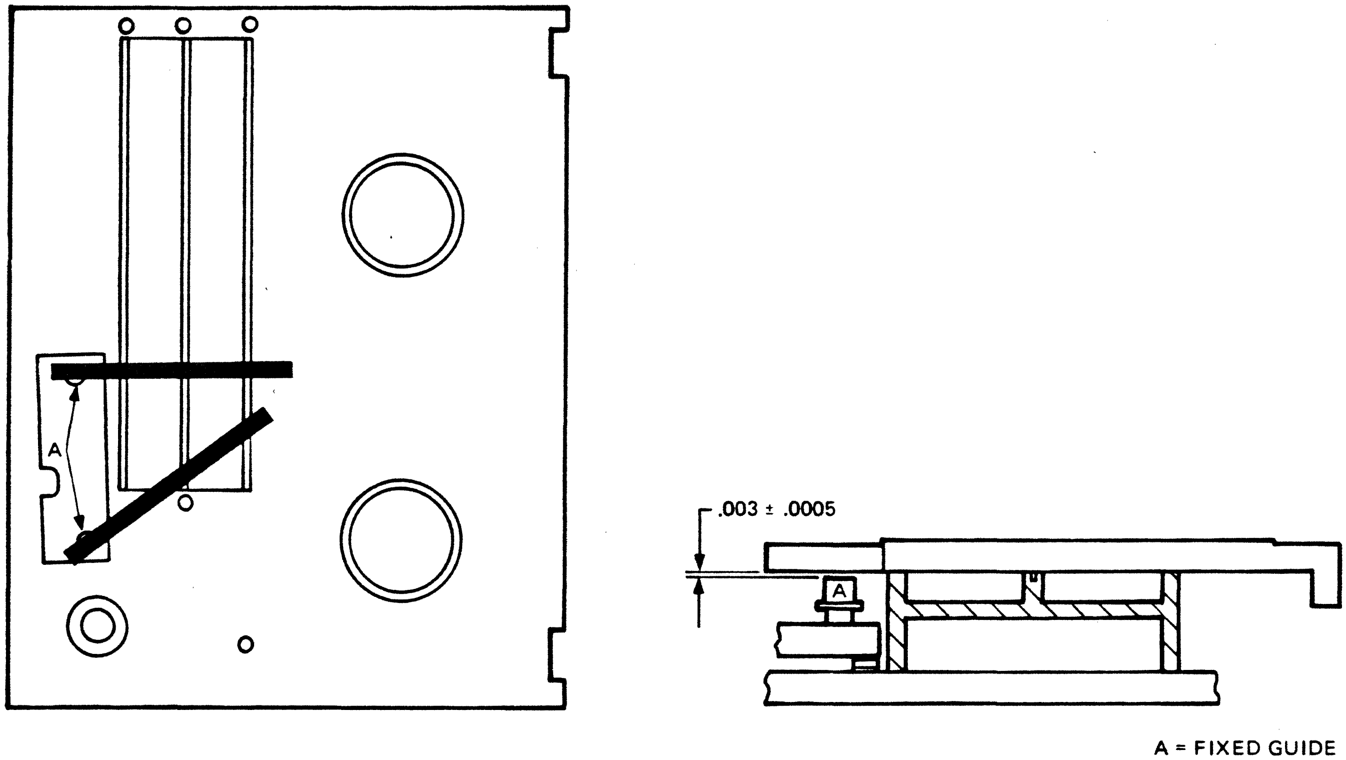


Figure 5-9. Head Plate Alignment Tool Positioning

g. Unplug head cable connectors and EOT/BOT cable connector.

h. Slowly loosen the three mounting screws but only until they are disengaged from the deck plate. Then, hold the screw, spacers and shims in place. Tilt the plate so that the spacers do not fall and carefully remove the plate.

i. Add or remove shims to whichever screw is nearest to the guide requiring adjustment. Shim both, if necessary. To avoid causing tilt of head plate, add shims to center mounting screw by an amount equal to the average change of the other two.

j. Reinstall plate and re-check guide heights. Repeat procedure until proper height is achieved.

k. When adjustment is correct, reinstall guide caps and vacuum chamber door and reconnect head cable connectors and EOT/BOT connector.

5-40 Tape Guide Roller Adjustment

NOTE

This procedure is required only when tape guide roller is replaced or reversed. Adjustment is not required after bearing replacement unless roller was reversed. Except under these conditions, don't adjust tape guide rollers.

In figure 5-10, the top view of the door shows the five positions of the alignment tool for adjusting each rooler, identified by number. The close-up view shows the two positions of the tool for aligning rollers 2 (left) and 1, looking into the end of the vacuum columns. The alignment tool illustrations show the different tool cuts used for the roller offset measurements.

a. Remove power from the tape unit.

b. Remove entry guide. (Required only when rollers 3 or 5 are to be cleaned).

c. Remove reels, head covers, and the tape unit overlay. Be careful of components on the head plate assembly. The overlay is secured with hook and loop fabric.

d. Remove vacuum cover by unfastening hinges from the chamber. Leave the hinges on the door.

e. Position alignment tool for roller 1. Make sure proper cut is selected for checking offset, as shown in figure 5-10. If offset is incorrect, adjust as follows:

CAUTION

There might be shims between roller blocks and deck. Try to keep shims in place when block is loosened or, if they slip out, reinstall in original position.

f. Adjust offset by carefully loosening block mounting screw and positioning roller against alignment tool. Retighten block mounting screw.

g. With tool in same position, check roller height. As shown in close view (figure 5-10), bottom flange of roller should meet undercut of tool, which corresponds to .0015-inch height from chamber surface. To adjust height, loosen set screw in the side of the block.

h. Check rollers 2, 3, and 5 for offset and height, using alignment tool as indicated. Note that .0725 offset is used for roller 5. If any offset adjustment is required, observe some caution regarding shims.

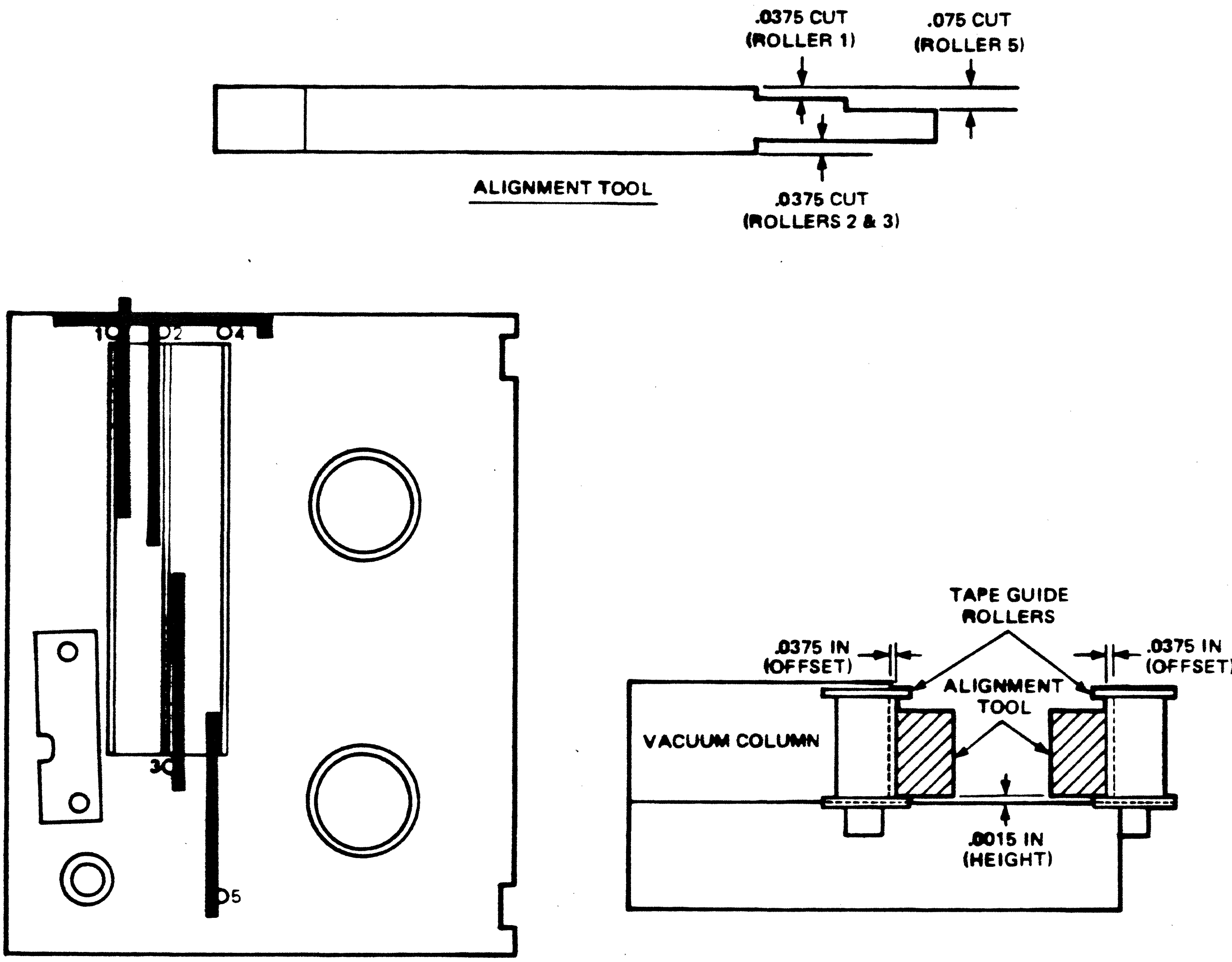


Figure 5-10. Tape Roller Height and Offset Adjustment

i. Rollers 1 and 2 must be in proper adjustment before roller 4 is checked. Check roller 4 by positioning straight edge of the alignment tool against rollers 1 and 2, as shown. Do not press against the springs of rollers 1 and 2. Adjust roller 4, if necessary, by moving rear flange against alignment tool.

j. Reinstall vacuum cover and reels and, using the forward/reverse switch, run a scratch tape on forward and reverse to check tape alignment. If tape bites into edges of a roller, push on the roller shaft to determine azimuth correction then add shims as required.

k. Remove power from tape unit. Remove tape and reels and reinstall overlay, reels and entry guide.

5-41 Reel Hub Height Adjustment

NOTE

This procedure is required only when a tape hub is replaced. Otherwise do not adjust the reel hub height.

a. Remove power from tape unit.

b. Remove reels, head covers and the tape unit overlay. Be careful of components on the head plate assembly. The overlay is secured with hook and loop fabric.

c. Remove the vacuum chamber door by unfastening the hinges from the chamber. Leave the hinges on the door.

d. Check each hub as shown in figure 5-11, which indicates the two positions of the alignment tools. The L-shaped edge of the alignment tool and the edges of the reel hub should just touch as the hub is rotated.

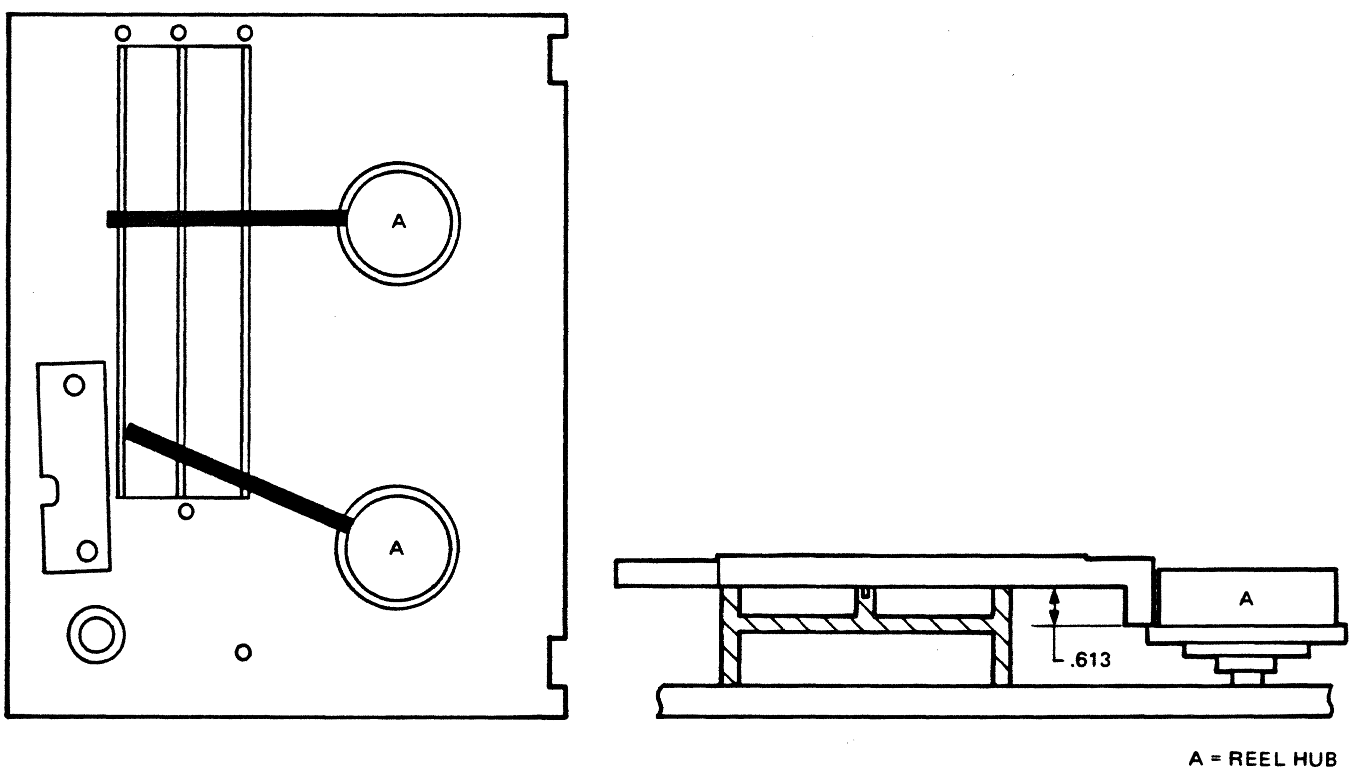


Figure 5-11. Reel Hub Height Alignment Tool Positioning

e. If necessary loosen hub set screws and adjust hub height.

NOTE

Hub is secured by a cover set screw, under which is a set screw that is tightened against a key, which fits into a slot in the shaft. Use Loctite 242 on cover screw when retightening.

f. Reinstall overlay and vacuum chamber door.

5-42 Capstan Height Adjustment

NOTE

The following procedure is required only when a capstan or capstan motor is replaced. Otherwise, do not adjust the capstan height.

a. Remove power from the tape unit.

b. Remove reels, head covers and the tape entry guide.

c. Remove vacuum chamber door. Remove the door by unfastening the hinges from the chamber. Leave the hinges on the door.

d. Position the alignment tool on the chamber and capstan as shown in figure 5-12. The capstan should be flush against the .025-inch step of the alignment tool. Measure to the metal edge of capstan itself and not to the plastic speed disk.

e. If necessary, adjust capstan height by removing allen-head set screw on vacuum supply manifold and loosening shaft set screw located underneath. Retighten set screw and reinstall cap screw with Loctite 242. (Cover screw has nothing to torque against.)

NOTE

The following steps check capstan perpendicular alignment by permitting the tape to run without being guided by the ceramic flanges at the fixed-roller guides.

f. Remove overlay, which is held on with hook and loop fabric or double-sided tape. Remove fixed guide caps and push lower ceramic rings of guides out of tape contact position. This can be done by tilting the rings and jamming them into a fixed position clear of the tape path or holding them back with masking tape.

g. Install reels, with scratch tape, and run tape forward and reverse while watching capstan. There should be no lateral motion of the tape. If there appears to be lateral motion, adjust capstan position as follows.

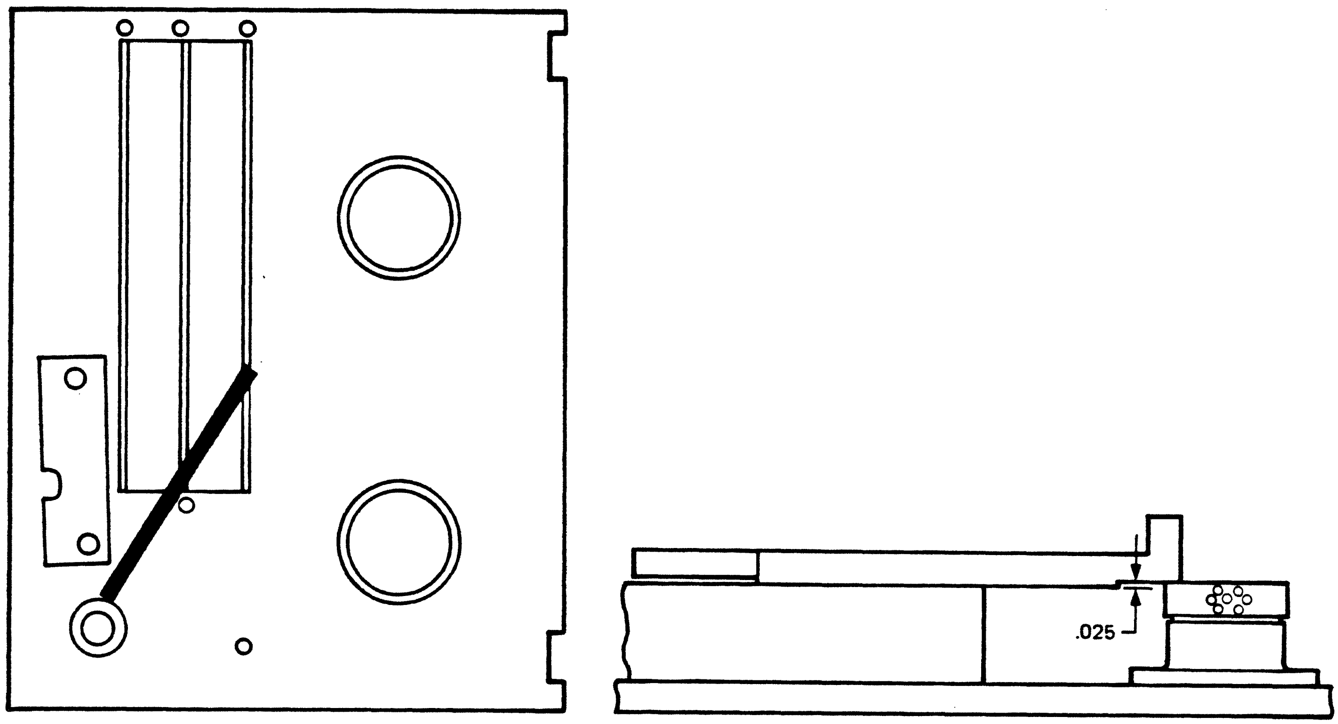


Figure 5-12. Capstan Height Alignment Tool Positioning

h. Loosen the three capstan assembly mounting screws, located on the deck, outside of the capstan assembly mounting hole.

i. Adjust set screws, located next to mounting screws. As each set screw is turned clockwise it causes the capstan to tilt toward that set screw. Capstan position is also altered slightly by the retightening of the mounting screws. Repeat procedure as required. One method of finding correct position is to loosen mounting screws, grasp the capstan motor assembly, and manually move it into position that provides proper tape alignment. Then adjust set screws to achieve that position.

j. When tape is correctly aligned, with mounting screws tightened, torque each mounting screw to 12 inch pounds.

k. Return fixed guide rings and caps to normal position, remove reels, reinstall overlay, vacuum chamber door and entry guide and reinstall reels.

5-43 Vacuum Motor Belt Tension Adjustment

Adjust the vacuum motor belt tension as follows:

a. Remove power from tape unit.

b. Loosen the three screws which secure the vacuum blower to the vacuum motor plate assembly.

c. Attach drive belt tension tool T0023-01A to the drive belt and position the vacuum blower assembly so that the tension tool indicates 13-15 pounds.

d. Secure the vacuum blower to the plate assembly by tightening the three screws.

e. Let the tension tool hang freely from the belt and observe that the reading is 13-15 pounds.

5-44 Write Lockout Assembly Adjustment

Remove power from tape unit and perform the following steps to adjust the write lockout assembly.

a. Install a reel without a write protect ring on the supply reel hub. Check that the write lockout plunger (figure 4-2) is centered in the write protect right groove and doesn't rub on the bottom of the groove.

b. If the plunger is not centered in the groove, loosen the two write lockout mounting screws and reposition the assembly. Tighten the mounting screws.

c. If the plunger rubs on the bottom of the groove, loosen the solenoid mounting screws and position the solenoid until the plunger just clears the bottom of the groove. Tighten the mounting screws.

d. Install a reel with a write protect ring on the supply reel hub and check to see if the write lockout microswitch closes.

e. If the microswitch does not close, loosen the solenoid mounting screws and position the solenoid until the microswitch just closes. Tighten the mounting screws.

f. Apply power to the tape unit. The plunger should be pulled away from the reel and not rub against the reel, when the LOAD control is pressed and released and the tape is tensioned.

5-45 TROUBLESHOOTING

Troubleshooting of the 2790 Series Magnetic Tape Unit requires a thorough knowledge of the contents of Chapter 4. Before performing any detailed troubleshooting, the preliminary checks contained in the following paragraph should be performed. If the problem is not corrected by performing the preliminary checks, refer to paragraphs on system level troubleshooting and to the troubleshooting charts. Note that the troubleshooting procedures do not include checking individual components such as switches, capacitors, resistors, etc. Checking of such components is to be done by conventional voltage and resistance tests, with the aid of the schematic and assembly diagrams in the attached drawing package.

5-46 PRELIMINARY CHECKS

Preliminary checks are performed to ascertain that the equipment is connected properly and that the proper operating voltages are present.

a. Verify that all cables and connectors are in good condition and that connections are made correctly.

b. Verify that the five fuses on the rear panel are not burned out, and that they are of the specified rating (figure 2-8).

c. Inspect for evidence of broken wires, and overheated components.

5-47 SYSTEM LEVEL TROUBLESHOOTING

An initial check should always be made of the power supply circuits. Specifically, the ±5V regulator supplies should be checked to ensure correct output voltage. Check external equipment to eliminate the possibility of this equipment causing the malfunction. If the malfunction is a control function, or if all channels of data are affected, ensure that all inputs to the tape unit (control and data) are correct.

If a fault is associated with all channels, check the control circuits that provide control signals to the data processing operation. Check for the presence of the control signals at the data board and verify correct logic levels and timing. If a specific signal is missing, conventional signal tracing techniques may be used to lead to the defective circuit. This method should be used to locate problems associated with either read or write data functions. If the problem is associated with only one channel, compare a signal level and waveforms of a good channel to those of a defective one (all data channels are identical).

If a control problem exists, determine what control function is defective and troubleshoot the appropriate control circuit. Check the suspected circuit for defective logic levels. Also, verify that timing relationships of the signals developed in the suspected circuits are correct when compared to signals developed independent of the suspected circuit.

5-48 TROUBLESHOOTING CHARTS

The system troubleshooting charts in table 5-8 are provided to aid the maintenance technician in isolating malfunctions in the tape unit. The troubleshooting charts provide typical symptoms of malfunctions along with probable causes, possible remedies and references to procedures within the manual which may aid the maintenance technician in isolating a fault circuit. This table should be used in conjunction with the assembly and schematic diagrams in the attached drawing package.

TABLE 5-8. TROUBLESHOOTING CHART

SYMPTOM	PROBABLE CAUSE	REMEDY	REFERENCE
Does not start to load	EOT and BOT not working properly.	Check operation and adjust the BOT and EOT amplifiers.	Paragraph 4-31, 5-8
	LOAD or RESET switch defective.	Check operation of switches. Replace as necessary.	Paragraph 4-8, 4-22
	Logic problem, LDA flip-flop is not set.	Repair tape control board.	Paragraph 4-9
Load operation does not move tape into column.	K3 relay or driver defective.	Check to see if K3 contacts close. Replace.	Paragraph 4-9
	Load reel motor driver defective.	Check to see if 17 volts is at J7-3 when Q4 turns on and the reel motors turn.	Paragraph 4-9
	Interlock switches defective	Check operation of switches. Adjust or replace.	Paragraph 4-9
Load operation moves tape into vacuum column, but tension is not made.	Interlock switches do not close.	Check operation of switches. Adjust or replace.	Paragraph 4-9
	K1 relay or driver defective.	Check to see if K1 contacts close. Replace	Paragraph 4-9
	Osc and Sync Det malfunction.	Loop a length of tape in the columns (figure 5-3). Press the load switch to turn on the vacuum motor. Check operation of the OSC and sync detectors. Replace.	Paragraph 4-14, 5-17

TABLE 5-8. TROUBLESHOOTING CHART (Continued)

SYMPTOM	PROBABLE CAUSE	REMEDY	REFERENCE
Load operation moves tape into vacuum column, but tension is not made. (Continued)	Reel servo amplifiers malfunction.	Check operation of servo amplifiers. Adjust.	Paragraph 4-16, 5-16
When the capstan moves tape, the interlock switches open.	Osc and Sync. Det malfunction.	Loop a length of tape in the columns (figure 5-3). Press the LOAD switch to turn on the vacuum motor. Check the operation of the OSC and sync detectors. Replace	Paragraphs 4-14, 5-17
	Capstan speed or ramp not correct.	Remove tape from around capstan. Check capstan speed and ramp at TP12.	Paragraphs 4-17, 5-13, 5-14
	Reel servo is out of adjustment.	Adjust reel servo.	Paragraphs 4-9, 5-16
Tape moves past BOT marker during LOAD or REWIND.	Dull BOT tab.	Replace BOT tab.	
	BOT amplifier malfunction.	Check operation and adjust the BOT amplifier.	Paragraphs 4-31, 5-8
Tape unit does not respond to For/Rev commands but to manual switch.	Tape unit not on line or selected.	Check that the correct select line is asserted. Check on line switch and flip-flop. Repair if necessary.	Paragraphs 4-21, 4-22
Does not respond to manual For/Rev.	Defective BOT and EOT sensor or amplifier.	Check operation and adjust amplifier.	Paragraphs 4-31, 5-8

TABLE 5-8. TROUBLESHOOTING CHART (Continued)

SYMPTOM	PROBABLE CAUSE	REMEDY	REFERENCE
Does not respond to manual For/Rev. (Continued)	Tape unit is not ready.	Check inputs to gate U36-8 to determine which one is not high.	Paragraph 4-16
	Tape unit is on line.	Check and replace on line flip-flop.	Paragraph 4-9
	K1 relay contacts 10/9 do not make.	Check if TP14 and J1-1 are at the same voltage. Replace.	Paragraph 4-9
	Component failure in For/Rev ramp gen. or capstan amp.	Check the operation of the components in the ramp gen. and amplifier.	Paragraphs 4-18, 4-20
	Manual switch defective.	Check MFWD and MREV signals.	Paragraph 4-23
Interlock switches are opened during rewind.	K2 relay or driver not working properly.	Check that the contacts of K2 close. Replace.	Paragraphs 4-9, 4-31
	The high gain is not switched on in the reel servos.	During a rewind operation, check that each pair of voltages: TP26 and cathode of CR6004, and TP29 and cathode of CR7004 are at the same voltage. Replace defective component if necessary.	Paragraph 4-16
	Reel servos are not adjusted or working properly.	Check and adjust the reel servos.	Paragraph 4-16, 5-16
	Rewind speed or ramp are not correct.	Adjust the rewind speed and check the ramp times.	Paragraphs 4-19, 5-15

TABLE 5-8. TROUBLESHOOTING CHART (Continued)

SYMPTON	PROBABLE CAUSE	REMEDY	REFERENCE
Interlock switches are opened during rewind. (Continued)	Logic problem asserting a forward command during rewind operation.	Check that TPB is zero during rewind. Repair.	Paragraphs 4-18, 4-23
	Fuses F2 or F3 open.	Replace bad fuse.	
Responds to forward command but doesn't write. Reads a good tape correctly.	No write power to data or write currant is not enabled.	Check write lockout microswitch is closed and TP3 for PE or TP2 for NRZI data boards is a +5 volts and collector of Q3 -5 volts. Repair.	Paragraphs 5-44, 4-34, 4-37, 4-40
	Interface cable or receiver malfunction.	Check write data, data ready, LRC strobe and SWRT receiver outputs for proper levels.	Paragraphs 4-38, 4-40
	Write head connector not properly plugged into J1.	Check that head connector is securely into J1.	
Data is incorrectly written but a good tape can be read.	The tape is bad.	Replace the tape.	
	Intermittant connection with write power.	Check that the write lockout solenoid is energized and microswitch is solidly closed. Adjust or replace	Paragraphs 4-34, 4-44
	Incorrect data format.	Check pre-delays, post-delays, and data format.	Table 4-2
	Write deskew needs adjustment.	Adjust the write deskew.	Paragraphs 4-37, 5-22

TABLE 5-8. TROUBLESHOOTING CHART (Continued)

SYMPTOM	PROBABLE CAUSE	REMEDY	REFERENCE
Data is incorectly written but a good tape can be read. (Continued)	Component in write electronics defective.	Check operation of write channels and repair if necessary.	Paragraphs 4-37, 4-40, 5-25, 5-28, 5-31
A correctly written tape can not be read while being written.	Head shield improperly adjusted.	Adjust flux gate.	Paragraphs 5-26, 5-34
A good tape cannot be correctly read.	Tape path needs cleaning	Clean the head, guides, and tape cleaner.	Paragraph 5-3.
	Read electronics need adjustment.	Adjust the read amplifiers and read strobe.	Paragraph 4-38, 4-42, 5-19, 5-28, 5-31
	Read head connector not properly plugged into J2.	Check that head connector is securely into J2.	
	Interface cable or receiver malfunction.	Check the outputs of the read data cable drivers for proper levels.	
	PE data board component failure in envelop detector circuit.	Check the envelop detector relays. Replace.	Paragraph 4-42
	Component failure in threshold circuit	Check threshold voltage (PE; TP4, NRZI; TP11).	Paragraphs 4-38, 4-42, 5-29, 5-36
	For single gap head, faulty write head driver.	Check if any head driver is causing current to flow in the head. Repair.	

5-49 REMOVAL AND REPLACEMENT PROCEDURES

The following paragraphs provide procedures for replacing various components within the tape unit. These procedures should be read and understood before attempting component removal and replacement. When performing these procedures, the maintenance technician should refer to the mechanical assembly illustrations and drawings in Chapter 6.

5-50 TAPE GUIDE ROLLER REPLACEMENT

Replace tape guide roller as follows:

a. Remove the C-clamp securing the tape guide flange to the tape guide shaft.

b. Remove the tape guide flange and bearing assembly.

c. Install the new tape guide flange and bearing assembly.

d. Secure the new tape flange to the tape guide shaft with the C-clamp removed in step a.

e. Check the tape guide height by mounting the alignment tool as shown in figure 5-10. Position the alignment tool against the tape guide roller.

f. If the alignment tool is not centered between the flanges of the guide roller, perform the tape guide roller adjustment procedure (paragraph 5-40).

5-51 REEL SERVO MOTOR REPLACEMENT

Replace reel servo motor as follows:

a. Remove the head covers.

b. Remove fixed reel by removing the three screws attaching the reel to the hub.

c. Gently remove the tape unit overlay, taking care not to damage any components mounted on the head plate assembly.

d. Disconnect the servo motor plug from the main harness (figure 1-2), and the air hose.

e. Loosen the setscrew that secures the reel hub to the motor shaft.

CAUTION

There are two set screws used.

f. Remove the four screws attaching the motor to the baseplate and remove the motor. Use these screws to attach the new motor to the baseplate.

g. Mount the reel hub on the shaft of the new motor.

h. Perform the reel hub height adjustment procedure (paragraph 5-41).

i. Plug the reel servo motor into the harness, and connect air hose.

5-52 CAPSTAN MOTOR REPLACEMENT

Replace capstan motor as follows:

a. Remove the head covers.

b. Gently remove the tape unit overlay, ensuring that components mounted on the head plate assembly are not damaged.

c. Loosen the setscrews securing the capstan to the capstan motor shaft and remove the capstan.

d. Disconnect the power leads from the capstan motor (figure 1-2).

e. Remove the screws attaching the capstan motor to the tape unit baseplate. Note location of shims so that the new motor can be shimmed the same way. Re-install screws and shims in same manner when installing the new capstan motor to the tape unit baseplate.

f. Secure the capstan to the capstan motor shaft. Perform capstan height adjustment procedure (paragraph 5-42).

g. Install tape unit overlay.

h. Install the head covers.

i. Connect power leads to the capstan motor.

5-53 VACUUM MOTOR BELT REPLACEMENT

Replace vacuum motor belt (rear accessability) as follows:

a. Loosen the three screws that secure the vacuum blower to the vacuum motor plate assembly.

b. Remove the old vacuum motor belt.

NOTE

The vacuum blower pulley has two positions for mounting the vacuum motor belt: The smaller diameter is for operation from sea level to 2,000 feet, and the larger diameter for operation from 2,000 to 4,000 feet. A high altitude pulley (separate) is used from 4,000 to 8,000 feet.

c. Install the new vacuum motor belt.

d. Perform the vacuum motor belt tension adjustment procedure paragraph 5-43.

e. Replace vacuum motor belt (front accessability) as follows:

f. Perform paragraph 5-64 steps a through c.

g. Perform paragraph 5-54 steps a through d.

h. Perform paragraph 5-64 steps d and e.

5-54 HEAD REPLACEMENT

Replace head as follows:

NOTE

> The head may require replacement for one of two reasons: internal fault in the head of cable, or wear. The first reason can be established by reading a master tape: the second can be verified by measuring the depth of the wear on the head crown.

a. Remove the head covers.

b. Disconnect the tape head connectors.

c. Remove the two screws which attach the head to the head plate assembly.

d. Ease the head cable through the hole in the deck.

e. Route the new head cable through the deck hole.

f. Using the two screws removed in step c, attach the new head to the head plate assembly.

g. Connect the tape head connector.

h. Perform the NRZI or PE data electronics adjustment procedure, paragraph 5-26 or 5-39, respectively.

i. Replace the head covers.

5-55 VACUUM CHAMBER REPLACEMENT

(Recommended only as factory procedure, because of difficulty in resetting tape path.)

Replace vacuum chamber as follows:

a. Remove power from the tape unit.

b. Remove the head covers and fixed reel.

c. Gently remove the tape unit overlay, ensuring that components mounted on the head plate assembly are not damaged.

d. Remove the screws attaching chamber entry block and remove the block.

e. Remove the six screws attaching the vacuum chamber assembly to the tape unit baseplate.

f. Carefully lift the vacuum chamber assembly from the tape unit baseplate and disconnect the vacuum hoses and signal plug.

g. Connect the vacuum hoses and signal plug to the new vacuum chamber assembly.

h. Using the four screws removed in step 3, attach the new vacuum chamber assembly to the tape unit baseplate. Using the screws removed in step d, attach the vacuum entry block.

i. Perform the tape path alignment measurement procedure (paragraph 5-37).

j. Perform the vacuum chamber adjustment procedure (paragraph 5-17).

k. Replace the tape unit overlay.

l. Replace the head covers, and fixed reel.

5-56 TRANSDUCER REPLACEMENT

a. Remove the vacuum chamber assembly (paragraph 5-55, steps a through f).

b. Remove the ten screws attaching the transducer to the vacuum chamber assembly.

c. Gently lift the transducer from the vacuum chamber assembly.

d. Disconnect signal leads from the transducer, noting the terminal connection of the wires.

e. Disconnect the vacuum hoses from transducer. Remove the transducer.

f. Solder the signal leads and connect the hoses to the new transducer.

CAUTION

When connecting signal leads to the transducer, precautions must be taken to prevent heat or mechanical damage to the plastic insulation washers on the solder posts.

g. Using the screws removed in step b, attach the new transducer to the vacuum chamber assembly. Do not tighten screws.

h. Connect a 24-inch H_2O vacuum source to transducers through a V/2 tube, and then tighten screws at terminal end of transducer that is being replaced. Tighten remaining screws in order, working opposite end of transducer.

i. Disconnect vacuum source from transducers.

j. Replace the vacuum assembly (paragraph 5-55, steps g thru 1).

5-57 VACUUM CHAMBER WINDOW REPLACEMENT PROCEDURE

a. Remove four screws that attach vacuum chamber window hinges to column.

b. Remove vacuum chamber window.

c. Hold new window down firmly in place against vacuum chamber while installing and tightening hinge screws.

CAUTION

To prevent vacuum leaks, ensure that window is held flush against vacuum chamber while tightening hinge screws.

5-58 TAKE-UP REEL REPLACEMENT

Remove and replace take-up reel as follows:

a. Remove three screws attaching plate to hub.

b. Remove plate.

c. Remove old reel flange and replace with new.

d. Replace plate, align holes, insert screws and tighten.

5-59 GUIDE ROLLER BEARING REPLACEMENT

NOTE

When bearings are replaced, the roller must be reinstalled in its original position. Otherwise, alignment might change. If roller is reversed or replaced, realign per paragraph 5-40.

a. Move outside end of roller so that it can be reinstalled in the same position.

b. Remove retaining ring and flat washer located between retaining ring and outside bearing.

c. Remove roller, with bearings, from shaft. Do not lose flat washer located between bearing and spring.

d. Remove and replace bearings fitted into each end of roller.

e. Reassemble, making sure that roller is installed in original position.

5-60 SERVO AMPLIFIER ASSEMBLY REPLACEMENT PROCEDURE

a. Disconnect all Molex plugs from the servo amplifier board (all plugs are identified).

b. Remove harness from the re-usable cable clamp.

c. Remove the ground wire (GRN) from the servo amplifier assembly.

d. Remove the pivot mounting screws from the assembly.

e. Remove the servo amplifier assembly from the front of the tape unit.

f. Install the new assembly using the screws removed in (d).

g. Connect the ground wire (GRN) to the servo amplifier assembly.

h. Connect all Molex plugs to their respective jacks. Example: P10A mates with J10A.

i. Place harness in re-usable cable clamp and secure.

5-61 PNEUMATIC ASSEMBLY REPLACEMENT PROCEDURE

Paragraphs 5-62 and 5-63 explain the methods of removal and replacement of the pneumatic assembly.

5-62 Rear-Access Pneumatic Assembly Removal and Replacement

a. From the front of the tape unit, remove the hose clamps from the vacuum blower using the snapper removal tool. The hose clamps are to be re-used for installation of the new pneumatic assembly.

b. Remove hoses from the vacuum blower.

c. Disconnect the blower motor power leads from TB1-9 and TB1-10.

d. Remove the ground strap from the pneumatic assembly mounting plate.

e. Remove the three mounting screws that secure the pneumatic assembly mounting plate to the main frame.

f. Lift the pneumatic assembly and remove from the tape unit taking care not to damage the relay interconnect assembly.

g. Install the new pneumatic assembly using the three mounting screws that were removed in step 3.

h. Connect the blower motor power leads to TB1-9 (white) and TB1-10 (orange).

i. Connect the ground strap to the pneumatic assembly mounting plate.

j. Connect the blower hoses to the vacuum blower using the clamps removed in step a. Secure clamps using the snapper installion tool or a pair of pliers. The hose from the vacuum blower output is connected to the muffler.

5-63 Front-Access Pneumatic Assembly Removal and Replacement

a. Remove the muffler and muffler mounting bracket. Mounting hardware to be re-used for re-installation of muffler assembly.

b. Perform steps a through e of paragraph 5-62.

c. Lift the pneumatic assembly, rotate from left to right (counterclockwise) in the horizontal plane and remove from the tape unit taking care not to damage the relay interconnect assembly or the servo amplifier assembly.

d. Perform steps g through j of paragraph 5-62.

e. Install the muffler and muffler mounting bracket.

5-64 RELAY INTERCONNECT ASSEMBLY REPLACEMENT PROCEDURE

a. Disconnect all Molex plugs from the interconnect assembly (all plugs are identified).

b. Remove the green, yellow and blue wires from relay socket and pins. Note wire color and pin location for use when installing the new relay interconnect assembly.

c. Remove assembly mounting screws. There are three located in the front and one in the rear of the assembly securing it to the mounting bracket. The mounting hardware is to be re-used for installation of the new relay interconnect assembly.

d. Remove the interconnect assembly from the front or rear of the tape unit, which ever is accessable.

e. Install the new interconnect assembly using the mounting hardware removed in step c.

f. Connect all Molex plugs to their respective jacks. Example: P36 mates with J36.

Chapter 6

DRAWINGS AND PARTS LISTS

6-1 INTRODUCTION

This chapter contains parts location illustrations, replaceable parts lists, and the assembly drawings, schematics, and wiring diagrams applicable to the 2790 Series Magnetic Tape Unit.

6-2 REPLACEABLE PARTS LISTS

The replaceable parts lists are keyed by figure reference to the parts location illustrations and contain brief descriptive nomenclature and part number for each replaceable part. A spare parts list of miscellaneous spares is also included, but not illustrated.

6-3 DRAWINGS

The following list includes all the diagrams needed to maintain the 2790 Series Magnetic Tape Unit.

NOTE

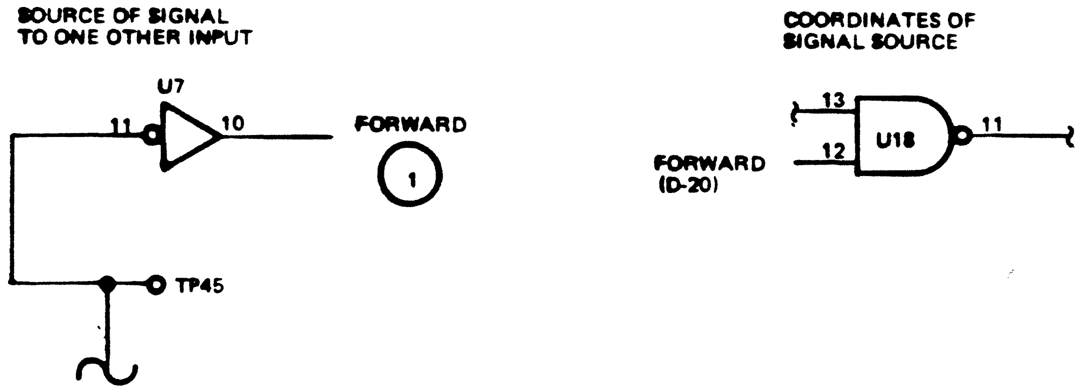
Some of the diagrams listed may not be applicable to the customer's particular tape unit.

DRAWING TITLE	DRAWING NO.
Control PWBA Assembly	9040149
Control PWBA Schematic	9940149
NRZI PWBA Assembly	9040135
NRZI PWBA Schematic	9940135
P.E. Data PWBA Assembly	9040170
P.E. Data PWBA Schematic	9940170
Power Supply Assembly	9020210
Power Supply Schematic	9910042
Power Supply Wiring Diagram	
Vacuum Chamber Wiring Diagram	9930016
Pneumatic Assembly Wiring Diagram	

DRAWING TITLE (Continued)	DRAWING NO.
Dual Triac PWA Assembly	9040151
Dual Triac Schematic	9940151
Servo Amp. PWBA Assembly	9040147
Servo Amp. PWBA Schematic Diagram	9940147
System Interconnect Diagram	

Generally, all logic symbols appearing in the logic diagrams in these drawings are drawn in accordance with MIL-STD-806C. All logic elements are identified by a reference designator, such as U2, indicating the integrated circuit package where the element is located. The pin number of the integrated circuit package follows its reference designator, i.e., U2-8 (refer to figure 6-1).

The method used to indicate signal flow and logic component interconnection on the schematics and logic diagrams is shown below. A circled number at the output of a logic component indicates that the output is the signal source at other inputs. For example, the circle "1" shown below at the output of inverter U7-10 indicates that FORWARD is the signal source at one other input. An alphanumeric number in parenthesis at the input to a logic element indicates the vertical-horizontal coordinates (example: D-20) of the input signal source component on the drawing. For example, the notation (D-20) FORWARD shown at the input to NAND gate U18-12 indicates that the signal source for FORWARD is located at drawing coordinates D-20 (vertical-horizontal).



SYMBOL	TABLE	SYMBOL	TABLE
INVERTER A → X $X = \overline{A}$	A X 0 1 1 0	NOR A, B → X $X = \overline{A+B}$	A B X 0 0 1 0 1 0 1 0 0 1 1 0
AND A, B → X $X = AB$	A B X 0 0 0 0 1 0 1 0 0 1 1 1	EXCLUSIVE OR A, B → X $X = A\overline{B}+\overline{A}B$ OR $X = A \oplus B$	A B X 0 0 0 0 1 1 1 0 1 1 1 0
NAND A, B → X $X = \overline{AB}$	A B X 0 0 1 0 1 1 1 0 1 1 1 0	D-TYPE FLIP-FLOP PR, D, Q, C, $\overline{Q}$, CLR	see D-type table below
OR A, B → X $X = A+B$	A B X 0 0 0 0 1 1 1 0 1 1 1 1	74LS109 DUAL J-$\overline{K}$ EDGE-TRIGGERED FLIP-FLOPS. SET, J, Q, CK, $\overline{K}$, CLEAR	see 74LS109 table below

D-TYPE FLIP-FLOP

PR	CLR	D	Q	$\overline{Q}$
L	H		H	L
H	L		L	H
H	H	H	H	L
H	H	L	L	H

74LS109 DUAL J-$\overline{K}$ EDGE-TRIGGERED FLIP-FLOPS.

INPUT					OUTPUT	
PR	CLR	CLOCK	J	$\overline{K}$	Q	$\overline{Q}$
L	H	–	–	–	H	L
H	L	–	–	–	L	H
H	H	↑	L	L	L	H
H	H	↑	H	H	H	L
H	H	↑	L	H	Q_0	$\overline{Q}_0$
H	H	↑	H	L	$\overline{Q}_0$	Q_0

Note: Boolean equations are positive logic convention.

Figure 6-1. Signal Flow and Logic Symbols

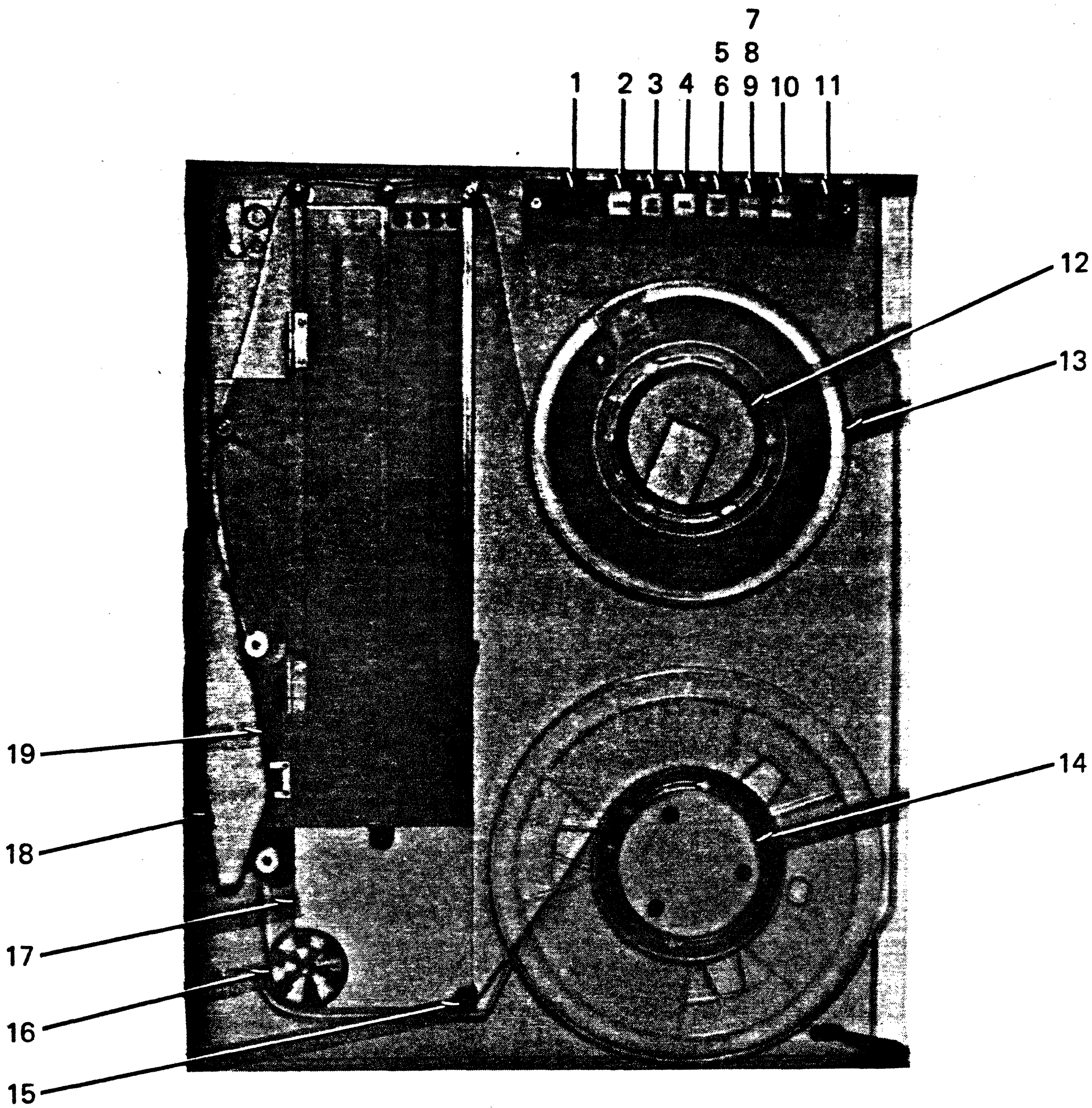


Figure 6-2. 2790 Series Parts Location, Front View

TABLE 6-1. REPLACEABLE PARTS LIST (FRONT)

FIGURE REF.	DESCRIPTION	PART NUMBER
6-2		
1	Address Switch (Option)	08200004-01
	Momentary Switches	
2	Load	08300016-04
3	On Line	08300016-02
4	Rewind	08300016-03
5	File Protect Indicator	11520001-01
6	Write Enable Indicator (Option)	11520001-02
	Alternate Action Switch	

TABLE 6-1. REPLACEABLE PARTS LIST (FRONT) (Continued)

FIGURE REF.	DESCRIPTION	PART NUMBER
7	HI DEN	08300018-01
8	1600 BPI (Option)	08300018-02
9	9 Track (Option)	08300018-03
10	Reset	08300016-05
11	Power Switch	9260049-01
	Bulb	11130001-01
12	Reel Retainer Assembly	9020035-01
	Cover	9210356-01
	Hub	9210357-01
	Handle	9210358-01
	Spring	9210706-01
	Rubber Ring	9260070-01
	Push Rod	9260075-01
	Actuator	9260076-01
	Pad	9260101-01
	Groove Pin	48230002-01
	Plastic Ball	50000003-01
	Compression Spring	21000103-01
13	Reel (Take-up)	9260154-01
14	Reel Retainer Assembly (fixed)	9020218-01
	Cover	9210804-01
	Hub	9210805-01
15	Tape Roller Assembly	9020123-01
	Shaft, tape guide	9210427-02
	Guide, Roller	9210683-01
	Spring	9210592-01
	Bearing	20111002-01
	Spacer, Shaft	35191201-10
	Ring, Retaining	54010002-01
16	Disc, Tape Velocity (125 ips)	9260138
17	Vacuum Chamber Assembly	9020230-01
	Cover	9260203-01
	Tape Position Sensor Assembly (Supply)	9020060-01
	Tape Position Sensor Assembly (Take-up)	9020060-02
	Vacuum Block Assembly	9060055-02
	Gasket, Vacuum Block	9260119-01
	Harness Assembly	9080038-01
18	Head Cover Assembly (Short)	9060223
	Head Cover (Short)	9260175-01
	Banana Plug (2)	47000101-01
	Nut, Hex, 6-32 (2)	45400601-01
19	Head Cover Assembly (Long) (Not Shown)	9020228-01
	Head Cover (Long)	9260198-01
	Banana Plug (2)	47000101-01
	Nut, Hex, 6-32 UNC-2B (2)	45400601-01

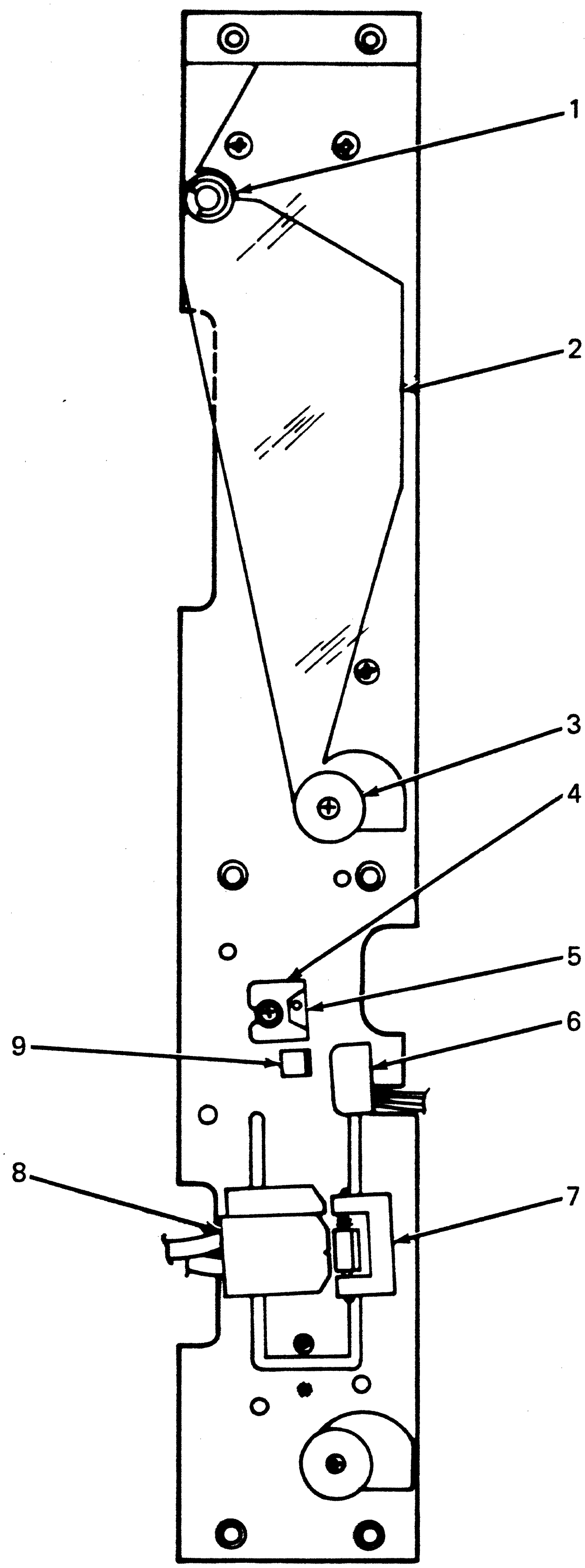


Figure 6-3. Head Plate Assembly Parts Location

TABLE 6-2. REPLACEABLE PARTS LIST HEAD PLATE ASSEMBLY (9020225)

FIGURE REF.	DESCRIPTION	PART NUMBER
6-3		
1	Roller Assembly	9020099-01
2	Buffer Cover	9260202-01
3	Fixed Tape Guide (2 places)	9210641-01
	Cap, tape guide	9260030-01
	Washer tape guide	9210068-01
	Spring, fixed guide	9210069-01
	Shim .0005	9210250-01
4	Tape Cleaner Body	9210277-01
5	Tape Cleaner Blade	9210279-01
6	EOT/BOT Assembly	9060063-01
7	Head Shield Assembly	9020032-01
8	Head Assembly	
	Nine track, chrome	9510048-01
	Seven track, chrome	9510049-01
9	Reflecter Block	9210325-01
NOTE: Indicate machine model number and tape speed when ordering.		

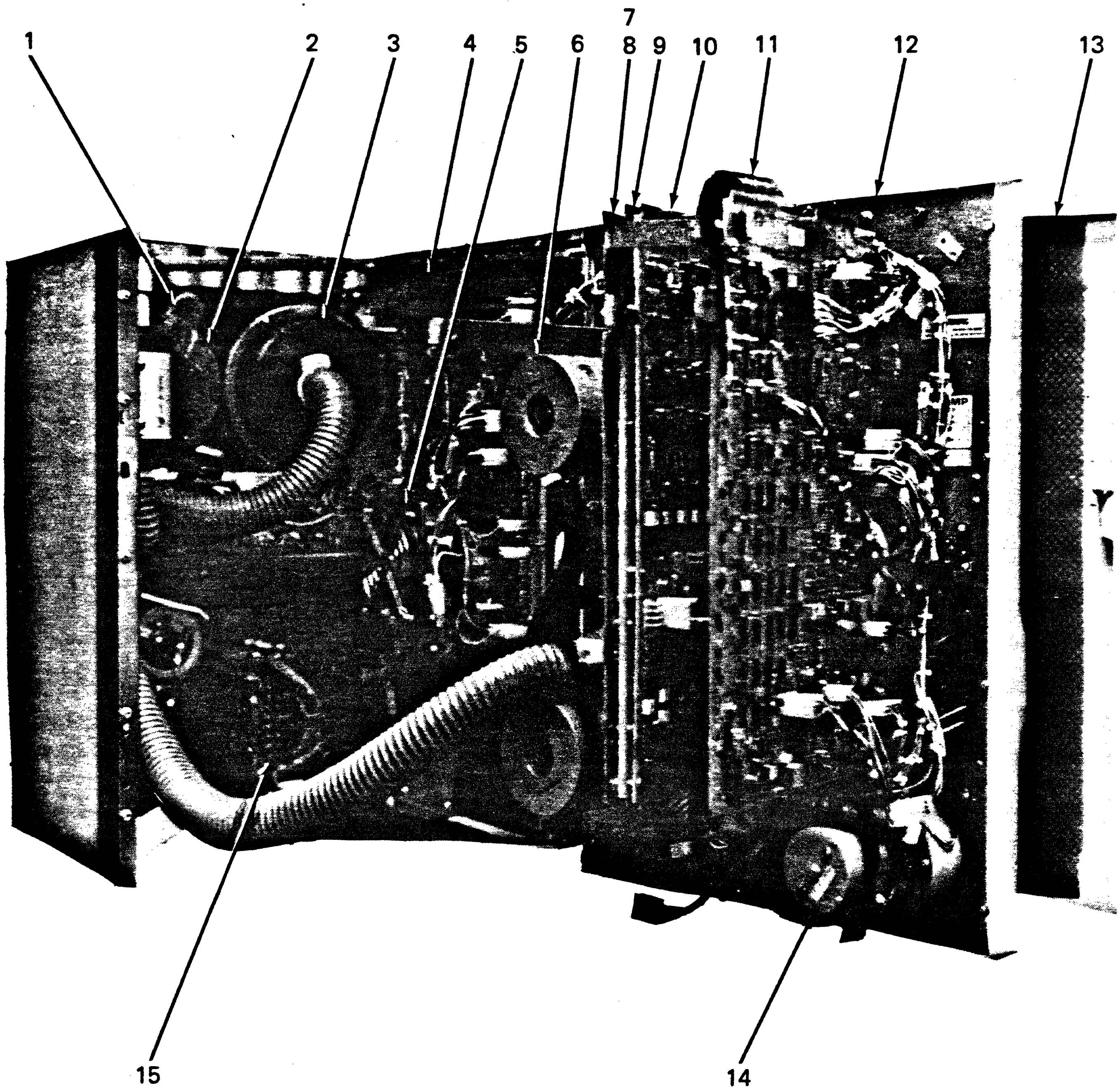


Figure 6-4. 2790 Series Parts Location, Interior View

TABLE 6-3. REPLACEABLE PARTS LIST (INTERIOR)

FIGURE REF.	DESCRIPTION	PART NUMBER
6-4		
1	Pneumatic Assembly	9020211
2	Blower Motor Assembly	9060200-01
	Motor	15100103
3	Blower Assembly	9020236
	Blower	49100103
4	Servo Amplifier Assembly	9020198
5	Fan Assembly (50/60 Hz)	9060252
	Servo Amplifier Heatsink Assembly	9020203
	Servo Amplifier PWBA	9040147
	Servo Amplifier Heatsink	9210803
	Transistor, 2N6059 (mounted on heatsink)	05706059-01
	Transistor, 2N6058 (mounted on heatsink)	05706057-01
	Transistor, 2N6051 (mounted on heatsink)	05706051-01
6	Reel Motor Assembly	9060178
	Reel Motor (supply or take up)	9510032-01
7	Write Lockout Assembly (hidden)	9020241
8	Pressure Switch Assembly (hidden)	9020204
9	PE Data PWBA	9040170
10	NRZI Data PWBA	9040133
11	Control PWBA	9040149
12	Transport Plate Assembly	9020214
13	Door Assembly	9060062
14	Capstan Motor Assembly	9020221
	Capstan	9210725-01
15	Power Supply Assembly (see table 6- , also)	9020210
	Cap, Mylar, 0.47µf, ±10%, 200V (C6-C9)	01144474-01
	Cap, Mylar, 3800µf, 25V (C4, C5)	01518389-01
	Cap, Elect., 61000µf, 50V (C2, C3)	01538619-01
	Diode, Silicon Rectifier (CR1, CR2)	02500400-01
	Resistor Jumper Assembly, 1.2K ohm (R1, R2)	9060182-04
	Resistor Jumper Assembly, 270 ohm (R3, R4)	9060182-03
	Switch, Toggle (S1)	08600004-01
	Fuse Holder	12800003-01
	Fuse, 15 amp, FNM (F1) 90-125 Vac	09250001-01
	Fuse, 7 amp, FNM (F1) 190-250 Vac	09230003-01
	Fuse, 10 amp, 3 AG (F2, F3)	09200103-38
	Fuse, 5 amp, 3 AG (F4, F5)	09230001-01
	Fuse, 2 amp, 3 AG (F6, F7)	09220003-01
	Triac Assembly, 10V power supply	9020240-01
	Traic PWB	9040151-02
	Transistor, 2N6165 (Q1, Q2)	05500103-01
	Transistor, 2N6058 (Q3)	05706058-01
	Transistor, 2N6051 (Q4)	05706051-01

TABLE 6-3. REPLACEABLE PARTS LIST (INTERIOR) (Continued)

FIGURE REF.	DESCRIPTION	PART NUMBER
15 Cont.	Power Transformer T1	9510058-01
	Transistors (mounted on heatsink):	
	2N6030	05700106-01
	2N6052	05706052-01
	2N5630	05700105-01
	2N5686	05705686-01
	MJ11015	05700110-01
	MJ11016	05700109-01

*Indicate machine model number and tape speed when ordering.

TABLE 6-4. 2790 PARTS LIST (REAR VIEW)

FIGURE REF.	DESCRIPTION	PART NUMBER
6-5		
1	Pneumatic Assembly (see table 6-3)	
2	Blower Assembly (see table 6-3)	
3	Blower Motor Assembly (see also table 6-3)	
	Blower Motor Belt (see table 2-5 for correct part number)	
	Blower Motor Pulley (see table 2-5 for correct part number)	
4	Power Supply Assembly (base shown - see also table 6-3)	9020210
5	Power Cord	13500005-01
6	EMI Filter FL1	05000004-01
7	Fuse Posts (F2-F7)	1280001-02
8	I/O Panel Assembly	9020235
	I/O Panel	9210612-01
	Relay Socket Assembly	9020231-01
	Interconnect PWBA	9040148-01
	Relay (K1, K3)	41426042-01
	Relay (K2)	06500101-01
	Relay (K4)	41426022-01
	Harness	9260177-01
		9080085-000

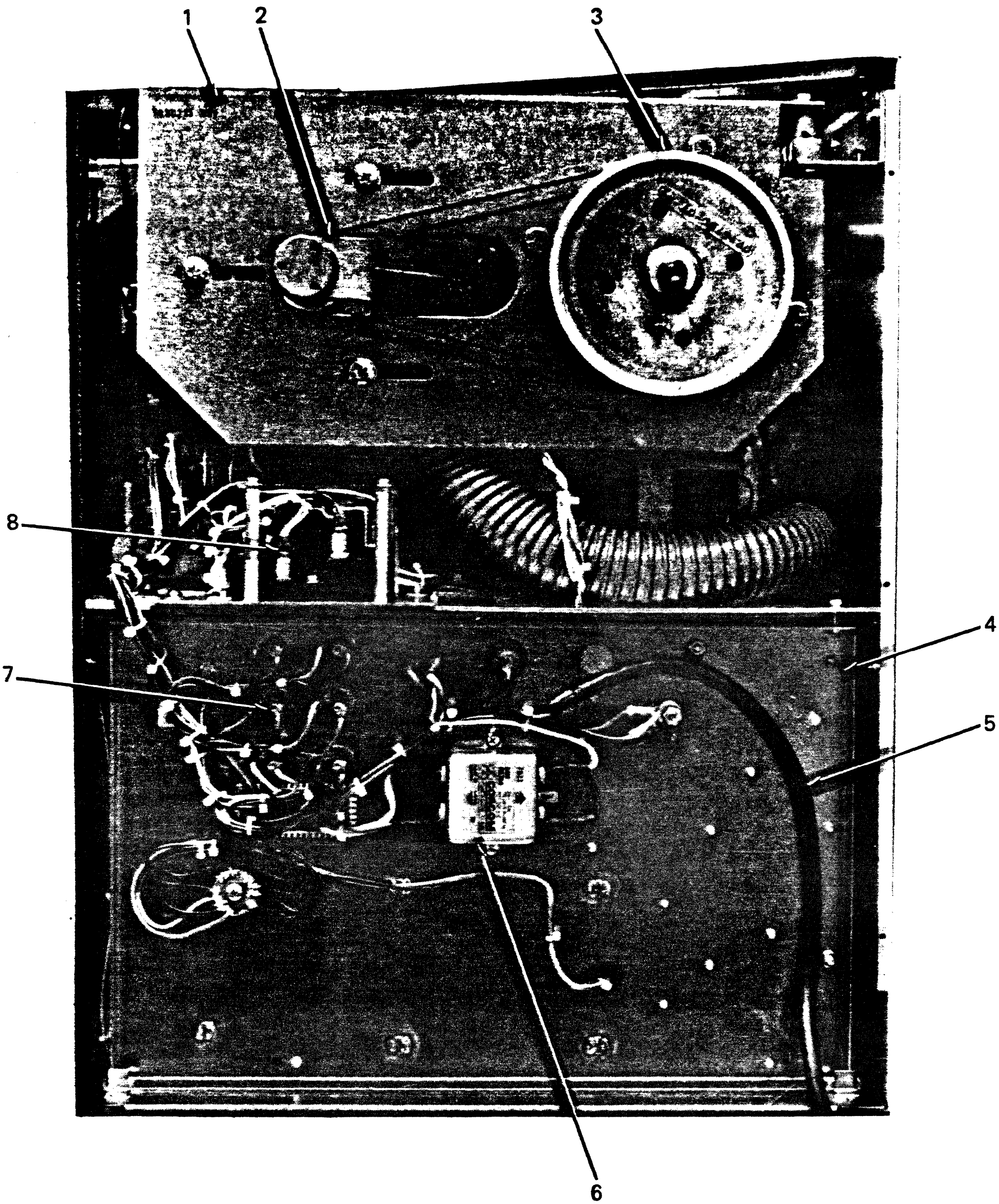


Figure 6-5. 2790 Tape Unit Rear View

TABLE 6-5. MISCELLANEOUS REPLACEABLE PARTS LIST

DESCRIPTION	UTILIZATION			PART NUMBER
	CONTROL BOARD	NRZI BOARD	PE BOARD	
COMPONENTS				
TRANSISTORS				
2N3053	X			05703053-01
2N3904	X	X	X	05103904-01
2N3906	X	X	X	05203906-01
2N5321	X	X	X	05705321-01
2N5323	X	X	X	05705323-01
2N4858	X			05300105-01
2N3638			X	05200103-01
MPQ2907			X	05200109-01
DIODES				
IN914B		X		02100914-03
IN3592	X		X	02100101-01
IN4003	X			02104003-01
IN4735	X			02204735-01
IN4740	X			02204740-01
IN754				02200108-15
IN4454	X		X	02100102-01
IN4370	X		X	02200108-01
IN4734	X			02204734-01
IN4733	X			02204733-01
IN4742	X			02204742-01
INTEGRATED CIRCUITS TTL				
SN 7400		X	X	03207400-01
SN 7401		X		03207401-01
SN 7404		X	X	03207404-01
SN 7405		X		03207405-01
SN 7410		X	X	03207410-01
SN 7438	X	X	X	03207438-01
SN 74107		X	X	03204107-01
SN 75451	X			03155451-01
SN 4714	X			03200302-01
SN 7474N			X	03207474-01
74LS00	X			03200255-01
74LS04	X			03200257-01
74LS08	X			03200254-01
74LS107	X			03200259-01
74LS10	X			03200260-01
74LS20	X			03200261-01
74LS11	X			03200310-01
SN74LS175M			X	03200300-01

TABLE 6-5. MISCELLANEOUS REPLACEABLE PARTS LIST (Continued)

DESCRIPTION	UTILIZATION			PART NUMBER
	CONTROL BOARD	NRZI BOARD	PE BOARD	
COMPONENTS				
Linear				
LM339	X	X	X	03000339-01
SN 72709		X		03052709-01
SN 72709*		X		9260143
SN 72741	X			03052741-01
LM318			X	03000130-01
NE5534			X	03000136-01
DLT				
SN 15836	X	X	X	03100836-01
SN 151805		X		03101805-01
POWER SUPPLY				
Power Supply Assembly				9020210
Resistor Assemblies, R1 and R2				9060182-04
Resistor Assemblies, R3 and R4				9060182-03
Switch S1				08600004-01
Diode Rectifier, CR1 and CR2				02500400-01
WRITE LOCKOUT ASSEMBLY				
Solenoid, L1				9510029-01
Miniature Switch, S1				08500003-01
Resistor, WW, 20 Ohms, 5W, R1				04670200-01
CONTROL SWITCHES/LAMPS/ RELAYS/ETC.				
Power Switch Bulb (SW8FE)				08500004-99
Lamp				1113000-01
Lamp (Control Panel)				11520001-01
Relay K1				41426042-01
Relay K2				06500101-01
SCR40654				05500654-01
Connector (26 pins)				07120007-01
SHIM MATERIAL				
Shim .001 inch thickness				9210250-01
.0005 inch thickness				9210250-02
.003 inch thickness				9210248-01
.005 inch thickness				9210249-01
.010 inch thickness				9210246-01

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