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IBM 2400-Series Magnetic Tape Units

Original Equipment Manufacturers' Information

This manual will assist designers of accessory equipment for IBM 2401 and 2402 Models 1-6 Magnetic Tape Units, IBM 2403 Models 1-6 and 2404 Models 1-3 Magnetic Tape Units and Controls, and IBM 2803/2804 Models 1 and 2 Tape Control Units.

Additional information about the operation and use of these tape units in integrated data processing systems can be obtained from the *IBM 2400 Magnetic Tape Units and 2816 Switching Unit Component Description,* Form A22-6866, and from the local IBM Sales Office. Information concerning I/O operations is in *IBM System/360 Channel to Control Unit OEMI,* Form A22-6843.

Preface

The term "2400-series magnetic tape units" used in this manual refers to the 2401 and 2402 Models 1-6 Magnetic Tape Units, the 2403 Models 1-6 Magnetic Tape Unit and Control, the 2404 Models 1-3 Magnetic Tape Unit and Control, and the 2803/2804 Models 1 and 2 Tape Control Units. Information in this manual pertains to Models 1-6 of the 2400 series, unless otherwise specified.

The IBM 2415 Magnetic Tape Unit and Control contains two, four, or six tape drives and a control in a single unit. The drives and control are not marketed separately. Therefore, the 2415 control-to-drive interface is not described in in this manual. Tape timings for the 2415 are listed in the *IBM 2400 Magnetic Tape Units and 2816 Switching Unit Component Description,* Form A22-6866.

Fifth Edition
This edition, Form A22-6862-4, obsoletes Form A22-6862-3 and Technical Newsletter N22-0264. Significant changes have been made throughout the manual, and this new edition should be reviewed in its entirety.

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IBM 2400-Series Magnetic Tape Units 7
Recording Methods 8
Error Correction 8
Operator's Controls and Indicators 8
Operator's Panel 8

Input/Output Signal Lines 12
Input Lines 12
Select (TC77, 79, 86, 88, 97, 99, 106, and 108) 12
Go (TC9) 12
Backward (TC11) 12
Set Read Status (TC25) 12
Set Write Status (TC13) 12
Write Pulse (TC29) 12
Write LRCC Gate/Set NRZI (TC27) 13
Write Bus (TC3, 5, 17, 19, 21, 31, 33, 35, and 1) . . . 13
Rewind (TC39) 13
Rewind/Unload (TC41) 13
Metering Out (TC23) 13
Output Lines 13
Models 1/4, 2/5, 3/6 (TC180, 182, and 184) 13
Rewinding/Not Ready (TC142, 144, 156, 158, 172, 174, 186, and 188) 13
Seven Track/NRZI (TC178) 13
Select and Read Status (TC162) 13
Select and at Load Point (TC198) 14
Write Echo/Select and TI Off (TC196) 14
Select and TI Off/Inhibit Go (TC194) 14
Select and Not File-Protected (TC192) 14
Read Bus (TC84, 93, 95, 102, 104, 113, 115, 122, and 82) . 14
Backward Status (TC164) 14
2400-Series Models 1, 2, and 3 (TC37) 14

Specifications 16
Input/Output Line Specifications 16
Connector Pin Assignments 16
Mode Compatibility Feature 16
Simultaneous Read/Write Feature 16
Tape Unit Specifications 19
Read/Write Head 19
Tape Speed, Bit Density, and Byte Rate 19
2400-Series Tape Timings 19
Power Requirements 21
Machine Protection 21
File Protection 21
Tape Motion Start and Stop Times 21
Read Circuits 21
Noise 21
Tape Operating Environment 22
Recording Formats for Nine-Track, 800-bpi Tape . . . 22
Recording Formats for Nine-Track, 1,600-bpi Tape . . . 29
Recording Formats for Seven-Track Tape 30
Cabling 30
Connectors 33
Drivers and Terminators 34

Field Tester 43
Field Tester Controls and Signal Hubs 43
Switches 43
Variable Controls 44
Signal Hubs 44
Control Settings 44

Illustrations

Figure *Title* *Page*

IBM 2400-Series Magnetic Tape Units

1 IBM 2400-Series Magnetic Tape Unit Characteristics . 7
2 IBM 2400-Series Tape Unit Packaging 7
3 PE and NRZI Recording Compared 9
4 IBM 2401/2402 Operator's Panel 10

Input/Output Signal Lines

5 Rotation of Select (and Not Ready) Signal Lines . 12
6 PE and NRZI Bit Patterns on Tape 14

Specifications

7 Tape Unit Input Line Specifications 16
8 Tape Unit Output Line Specifications 16
9 Tape Unit/Control Unit Connector Pin Assignments 17
10 2402 Tail Gate Connectors 17
11 2403/2803 Signal and Power Connectors . . . 18
12 AC Power Connector Pin Numbering 19
13 Tape Unit/Control Unit Connector Pin Assignments with Simultaneous Feature 20
14 Start/Stop Timings 22
15 PE Read Bus Waveforms (Data Pattern 11001100) . 23
16 NRZI Read Bus Waveform (Nine Track) 24
17 Noise 24
18 Beginning-of-Tape and End-of-Tape Areas . . . 25
19 Track Spacing for Seven- and Nine-Track Tape . . 26
20 Data Block Format 27
21 Tape Mark Block Format 28
22 Organization of Blocks on Tape 28
23 Skew Gate and Character Gate Timings–Nine-Track NRZI (2803-2) 29
24 Read Backward Checking of Nine-Track NRZI Write Operation 29
25 2400 Cabling Schematic 31
26 2400 Cabling Schematic Data 32
27 2401/2/3/4 Connector and Component Part Numbers 33
28 Line Terminator, Models 1-6 34
29 Write Bus Terminator, Models 4-6 34
30 Tape Unit, Models 1-6, Metering-Out Line Termination 34
31 Tape Unit, Models 1-6, Line Driver 34
32 Control Unit, Models 1-6, Line Receiver 34
33 Control Unit, Models 1 and 2, Signal Line Driver; Control Unit, Model 1, Write Bus Driver 34
34 Tape Unit, Models 1-6, Line Receiver; Tape Unit, Models 1-3, Write Bus Receiver 34
35 Control Unit, Model 2, Write Bus Driver 35
36 Tape Unit, Models 4-6, Write Bus Receiver . . . 35
37 Tape Unit Read Preamplifier Number 2, Models 1-3 and 4-6 NRZI 36
38 Simultaneous Preamplifier, Models 4-6 NRZI . . 37
39 Simultaneous Preamplifier, Models 4-6 PE . . . 37
40 Control Unit Read Bus, Models 1 and 2, Receiver NRZI 38
41 Tape Unit Read Preamplifier, Model 4 PE . . . 39
42 Tape Unit Read Preamplifier, Model 5 PE . . . 40
43 Tape Unit Read Preamplifier, Model 6 PE . . . 41
44 Control Unit, Model 2, Read Bus Receiver PE . . 42

Field Tester

45 2400-Series Models 1-6 Field Tape Tester . . . 43
46 Field Tape Tester Control Settings 45

amp	ampere
asm	assembly
BCD	binary coded decimal
bkwd	backward
B/M	bill of material
bpi	bits per inch
CB	circuit breaker
CE	customer engineer
cm	centimeter
CRC	cyclic redundancy check
CU	control unit
EBCDIC	extended binary coded decimal interchange code
EOF	end of file
EOT	end of tape
EPO	emergency power off
F	fahrenheit
fwd	forward
HD	heavy duty
IBG	interblock gap
ips	inches per second
kb	thousands of eight-bit bytes
kd	thousands of four-bit decimal digits
LP	load point
LRC	longitudinal redundancy check
ma	milliampere
ms	millisecond
mv	millivolt
NFP	not file protect
NRZI	nonreturn to zero IBM
P	parity
PE	phase encoding
R/W	read/write
sec	second
SLT	solid logic technology
SU	switching unit
TC	tape connector
TCU	tape control unit
TI	tape indicate
TU	tape unit
usec	microsecond
v	volt
vac	volts alternating current
vdc	volts direct current
VRC	vertical redundancy check
$>$	greater than
$<$	less than
$\geqslant$	equal to or greater than
$\leqslant$	equal to or less than

IBM 2400-Series Magnetic Tape Units

Electronic computers require enormous amounts of input data that can be requested and received quickly. They also need a medium on which to record permanent output information and large quantities of intermediate data that must be recalled quickly and conveniently. The IBM 2400-Series Magnetic Tape Units, with their almost unlimited capacity for storing information, fulfill this need by functioning as both input and output devices, transporting magnetic tape and writing and reading it.

The 2400-series magnetic tape units are designed to operate with the System/360 configurations. The 2400 tape units use a two-gap, nine-track (eight data tracks and one check track), read/write head. The two-gap head allows error checking while the tape is being written. The first gap is used for writing and the second for reading. The recording density is 800 bpi. An optional seven-track head allows 2400-series Models 1-3 tape units to read or write seven-track tape at densities of 200, 556, or 800 bpi (bits per inch). Seven-track tapes written on IBM 2400-series and 729 tape units are compatible.

The 2400-series magnetic tape units and controls are available in six models and four types of packaging. Figure 1 is a listing of tape unit operating speeds and densities; Figure 2 describes packaging methods for each type of machine.

Machine Type	Packaging (Note 2)
2401 Models 1-6 Magnetic Tape Unit	One tape unit, single frame, self-contained dc power supply.
2402 Models 1-6 Magnetic Tape Unit	Two tape units, double frame, single self-contained dc power supply furnishes dc to both tape units.
2403 Models 1-6 Magnetic Tape Unit and Control (Note 1)	One tape unit plus one tape control, double frame, single self-contained dc power supply furnishes dc to tape unit and control.
2404 Model 1, 2, or 3 Magnetic Tape Unit and Control (Note 1)	One tape unit plus simultaneous read and write tape control, double frame, single self-contained dc power supply furnishes dc to tape unit and control.
2803 Model 1 or 2 Tape Control (Note 1)	One tape control, single frame, self-contained dc power supply.
2804 Model 1 or 2 Tape Control (Note 1)	One simultaneous read and write tape control, single frame, self-contained dc power supply.

Notes:

1. A standard 2403, 2404, 2803, or 2804 tape control communicates with and supplies ac power for as many as eight 2400-series tape units in any combination of machine types and models (a 2402 counts as two individual tape units).

2.

	Height	Width	Depth (inches)
Single Frame	60	30	29
Double Frame	60	60	29

Figure 2. IBM 2400-Series Tape Unit Packaging

Characteristics	2401 - 2404 Tape Units					
	Model 1 / Model 4	Model 1	Model 2 / Model 5	Model 2	Model 3 / Model 6	Model 3
Number of Tracks and Recording Method	Nine Track NRZI / Nine Track PE	Seven Track NRZI	Nine Track NRZI / Nine Track PE	Seven Track NRZI	Nine Track NRZI / Nine Track PE	Seven Track NRZI
Density in bpi (bytes per inch)	800 / 1,600	800 556 200	800 / 1,600	800 556 200	800 / 1,600	800 556 200
Data Rate (bytes per second)	30,000 / 60,000	30,000 20,850 7,500	60,000 / 120,000	60,000 41,700 15,000	90,000 / 180,000	90,000 62,500 22,500
Tape Speed (inches/second)	37.5 / 37.5	37.5	75.0 / 75.0	75.0	112.5 / 112.5	112.5
Interblock Gap (inches)	0.6 / 0.6	0.75	0.6 / 0.6	0.75	0.6 / 0.6	0.75

Figure 1. IBM 2400-Series Magnetic Tape Unit Characteristics

RECORDING METHODS

Before information is written on tape, tape coating is erased to a specified magnetic flux polarity. Erasure is accomplished by passing tape across a dc erase head before it is written. The erase head magnetizes the entire width of the tape so that the end of tape nearest the beginning-of-tape (BOT) marker is a north-seeking magnetic pole. Interblock gap areas have the same magnetic flux polarity that is produced by the erase head.

Both the nonreturn to zero IBM (NRZI) and the phase-encoded (PE) methods record information by producing magnetic flux reversals in the tape coating. The NRZI method uses a flux reversal in either direction to represent a 1-bit. When writing NRZI tape, flux reversals are written only for 1-bits. When reading NRZI tape, the absence of a flux reversal is interpreted as a 0-bit (Ⓐ, Figure 3).

When writing PE tape, flux reversals are written for both 1- and 0-bits. When tape is moving forward, a flux reversal to the magnetic polarity of "erased" tape at bit-shift time is defined as a 1-bit. A flux reversal to a polarity opposite that of erased tape at bit-shift time is defined as a 0-bit (Ⓑ, Figure 3). The comparison of the flux reversals needed to write a series of bits on tape in both NRZI and PE mode is shown on Ⓒ, Figure 3. The extra shifts that occur at bit-cell-boundary time (phase bits) are necessary to maintain the correct direction of shift for each type of bit, when writing two like PE bits (1 and 1 or 0 and 0) in succession.

Each PE data block is preceded and followed by a burst of all-zeros bytes and an all-ones marker (preamble and postamble). The preamble synchronizes the read detection circuits so that 1's and 0's are identified correctly when reading the data bytes which follow. The postamble indicates the end of the data in a tape block. When reading backward, the functions of the preamble and postamble are reversed.

When tape is read, the bits (flux reversals) are sensed by the read head to produce a waveform similar to the waveform which wrote the bits. The waveform is decoded in a 2803/2804 to 0- and 1-bits by comparing it to reference (clock) pulses. Because the sensing and decoding of a bit depend not only on the magnetic strength of the signal but also on the polarity and timing of the recorded signal, the possibility of an error because of weak or extraneous signals is considerably reduced.

The nine-track tape format used with the System/360 eight-bit code and the seven-track tape format used with the six-bit BCD code are shown in Figures 18-20. To increase nine-track reliability, the bit tracks are arranged to place the most-used bits in the center of the tape.

Error Correction

Nine-track NRZI tapes are written with a cyclic redundancy check (CRC) character at the end of each data block (Figure 18). This character, which is used to correct single-track read errors, is generated in the CRC register in the tape control. The contents of the nine positions of the CRC register are designated CP (parity) and C0 through C7.

The CRC character is formed in the following manner:

1. All data characters in the tape block are added to the CRC register without carry (each bit position n is exclusive ORed to Cn).
2. Between additions the CRC register is shifted one position (CP to C1, etc., and C7 to CP).
3. If shifting will cause CP to become a 1, the bits being shifted into positions C2, C3, C4, and C5 are inverted.
4. After the last data character has been added, the CRC register is shifted once more in accordance with steps 2 and 3.
5. To write the CRC character on tape, the contents of all positions except C2 and C4 are inverted. The parity of the CRC character is odd if the number of data characters within the block is even, and the parity is even if the number of data characters within the block is odd. The CRC character may contain all 0-bits only if the number of data characters is odd.

Additional information on nine-track NRZI error correction is in Field Engineering Theory of Operation, *IBM 2803/2804 Model 1 Tape Control and Tape Controls for 2403/2404 Models 1, 2, and 3,* Form Y22-2853.

OPERATOR'S CONTROLS AND INDICATORS

Operator's Panel

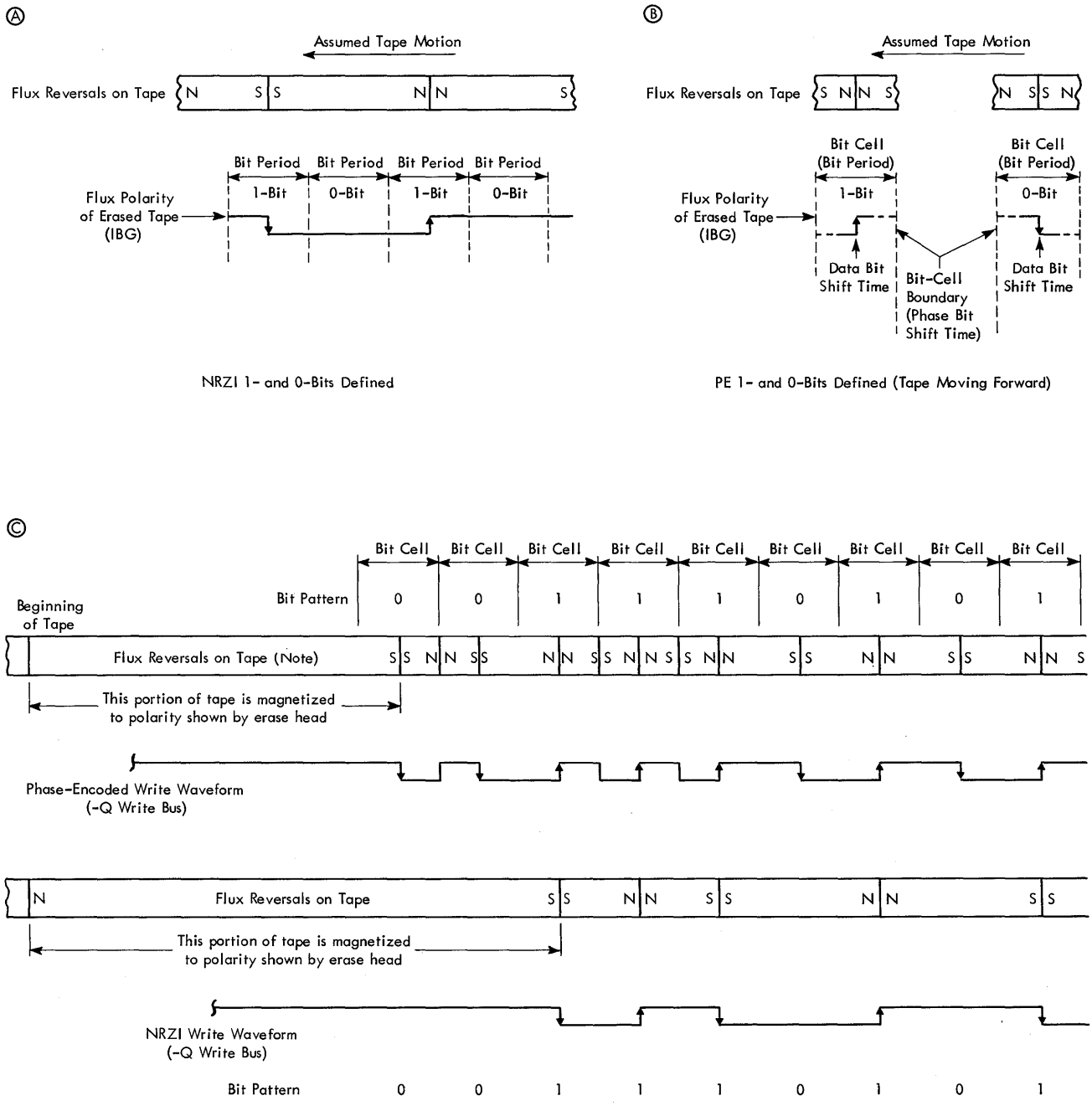
The operator's panel is shown in Figure 4. For convenience, the indicators are all in the upper row and the controls are in the lower row.

Select

The select indicator is turned on to show that the tape unit is the one selected to perform the next tape function. The tape unit must be in ready status.

Ready

When on, the ready indicator shows that the tape unit is in ready status; that is, the tape unit is loaded (tape in the vacuum columns and across read/write head), all interlocks are closed, and tape is not rewinding. This indicator is turned on by pressing the start pushbutton, but it will not turn on unless the two preceding conditions are satisfied. Pressing the start pushbutton while the tape is in motion, as in a load/rewind operation, will not turn on this indicator immediately; but the indicator will turn on when the load/rewind is completed.



Note: A flux reversal (NN or SS) is the area where the flux polarity of the magnetized tape is reversed. The particles of oxide coating on the tape are magnetized by the write head to act like tiny magnets whose combined effect is shown in this figure.

Figure 3. PE and NRZI Recording Compared

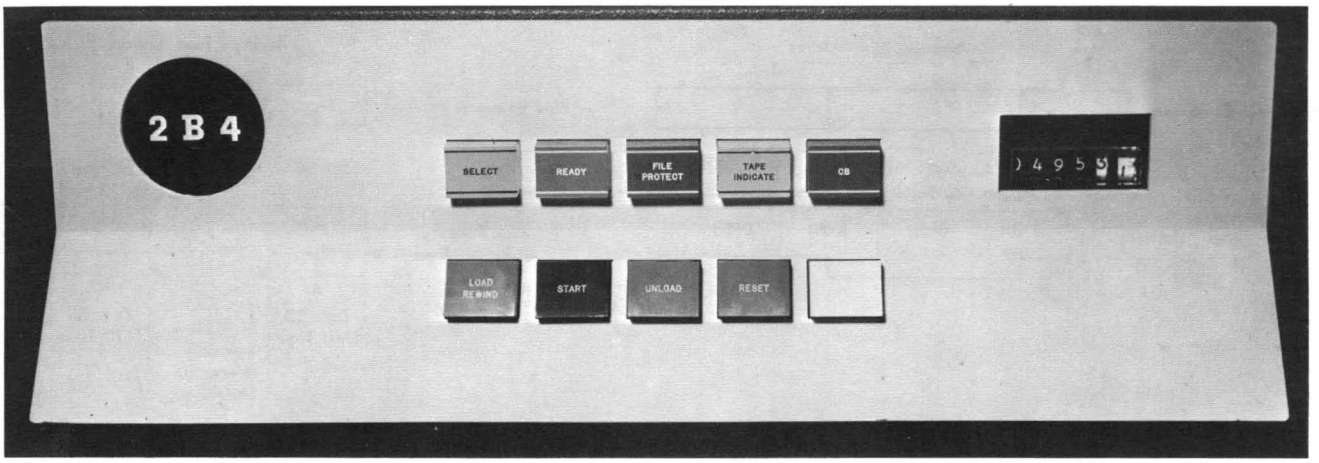


Figure 4. IBM 2401/2402 Operator's Panel

File Protect

When on, the file protect indicator shows that the loaded tape is file-protected; that is, neither writing nor erasing can take place on this unit because the file reel does not contain a file-protect ring.

Tape Indicate

Models 1-3: When on, the TI indicator signifies that an end-of-tape reflective marker has been photosensed during a forward tape operation. TI is reset when the tape unit receives a rewind, rewind/unload, or backward command, or when the tape unit is manually unloaded.

Models 4-6: During a backward command, TI is not reset unless the end-of-tape reflective marker is sensed again; otherwise, same as Models 1-3.

CB

When on, the CB indicator shows that a circuit breaker or circuit protector has been tripped. The tape unit cannot operate until the circuit breaker or protector has been reset.

Load/Rewind

Pressing the load/rewind pushbutton initiates a rewind to load point. If the tape unit is unloaded, pressing this pushbutton causes an auto-load operation before rewinding to load point. This pushbutton is inoperative if the tape unit is in ready status.

Pressing the load/rewind pushbutton (with power window) initiates a rewind to load point. If the tape unit is unloaded, pressing this pushbutton causes the power window to close first and then causes a tape auto-load operation before rewinding to load point.

If any object prevents closing of the power window, the safety bail at the top of the window will operate, causing the window to reverse direction and lower until fully open. After removing the obstruction, press the load/rewind pushbutton again to reinitiate the load/rewind operation. The load/rewind pushbutton is inoperative if the tape unit is in ready status.

Start

Pressing the start pushbutton places a loaded tape unit in ready status. Ready status is necessary before the tape unit can operate with the tape control. The start pushbutton is active after the load/rewind pushbutton has been pressed.

Unload

Pressing the unload pushbutton causes a tape unload operation. The unload pushbutton is inoperative if the tape unit is in ready status.

The unload pushbutton (with power window) is inoperative when the tape unit is in ready status. When not in ready status, pressing the unload pushbutton causes tape to be unloaded from the vacuum columns and the power window to be lowered.

Reset

Pressing the reset pushbutton returns the tape unit to manual control, removes the unit from ready status, and prevents operation through the tape control. This pushbutton can also stop a low-speed rewind operation, change a high-speed rewind to a low-speed rewind operation, or (with power window) close the power window (when the tape unit is unloaded and idle). The power window will not close if the reel door is open.

Note: The 2403/2404 operator's panel has an additional indicator (TCU CB/TH). It is next to the CB indicator

and shows a dc circuit overload or a thermal overload condition in the control unit. Under this indicator is an additional switch (meter). The meter switch is wired in parallel with the control unit's on-line/off-line switch. During the CPU halt or wait state, setting this switch to the off position renders the control unit and connected tape units inoperative; that is, not selectable by the program. The control and tape units are off-line and the meters are inoperative.

INPUT LINES

All input lines are SLT level with a minimum active (down) level of +1.2 volts and a minimum inactive (up) level of +2.5 volts.

Select (TC77, 79, 86, 88, 97, 99, 106, and 108)

This input line (one of eight select lines) selects a particular tape unit from the group connected in-line to the common control unit. The select signal lines are rotated in the cable so that the addressing select signal for any tape unit is always taken from TC77 (Figure 5). This signal gates the tape unit selected, allowing it to receive and transmit all subsequent signals from and to the control unit. The sixteen-address feature provides a ninth select line for operation with an IBM 2816 Switching Unit. The ninth line (high order) enables the 2816 to select an additional eight tape units.

Go (TC9)

Models 3/6 and Models 1/2 without Mode Compatibility Feature: This line controls tape motion; it is conditioned after the status lines have been set to establish the operation to be performed. The go line must be active for all operations that move tape forward or backward, except for rewind and rewind/unload. For these operations, tape motion is controlled internally.

Models 4/5 and Models 1/2 with Mode Compatibility Feature: In addition to the preceding conditions, tape motion is continued after the fall of the go line on read-type operations to advance the tape in preparation for reading the next block.

Backward (TC11)

This line sets the tape unit in backward status. If the go line is active with 'backward status' set, tape moves backward; if backward status is not set, tape moves forward. The tape unit remains in backward status, unless reset by 'set read status' or 'set write status.' Since tape can only be written forward, 'backward' sets 'read status' in the tape unit and may turn off TI. See "Tape Indicate."

Set Read Status (TC25)

This input line sets the tape unit in read status and conditions the write circuits. The tape unit remains in read status until 'set write status' becomes active. 'Set read status' presumes a forward read and therefore resets 'backward status.'

Set Write Status (TC13)

This input line sets the tape unit in write status and conditions the write circuits. The tape unit remains in write status until 'set read status' or 'backward' becomes active. 'Set write status' also resets 'backward status.'

Note: Because write checking is accomplished by reading, read circuits are conditioned during both read and write operations.

Write Pulse (TC29)

Models 1-3: These input pulses are sent into the tape unit on a line common to the write circuits of all nine tracks. This line is a sync pulse for the recording of data bytes and check characters. When active, this line signals

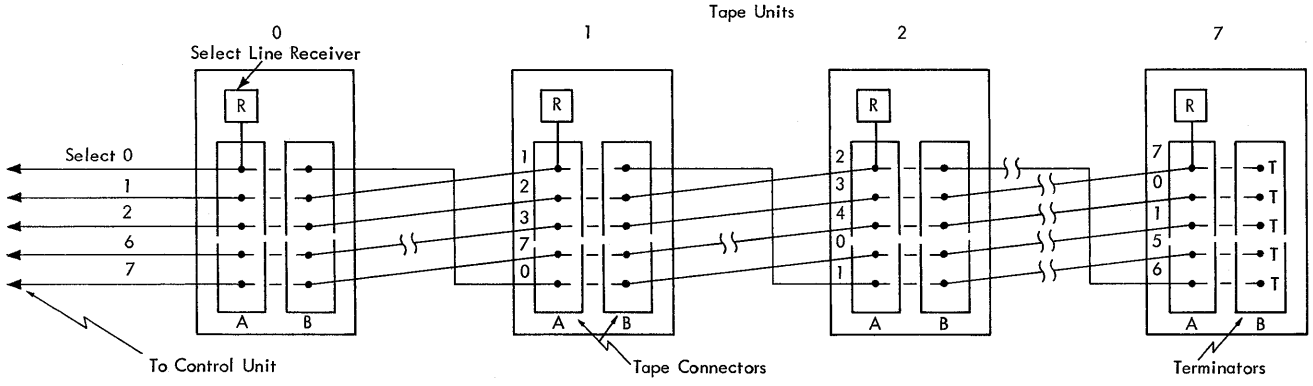


Figure 5. Rotation of Select (and Not Ready) Signal Lines

the tape unit to write a bit in each track whose corresponding write bus position is active. Is is also used with the write longitudinal redundancy check character (LRCC) gate line to write the LRC character.

Models 4-6: The write pulse is not used. TC29 of the A (in) connector is jumpered to TC29 of the B (out) connector to transmit a write pulse to Models 1-3 on the same cable.

Write LRCC Gate/Set NRZI (TC27)

Models 1-3: When this line is inactive, write pulse writes data. When this line is active, write pulse writes the LRC character.

Models 4-6: With the dual density 800/1,600 bpi feature and with tape at load point, this line sets the NRZI latch for a write operation.

Write Bus (TC3, 5, 17, 19, 21, 31, 33, 35, and 1)

Models 1-3: These nine input signal lines (0-7 and P) gate the write pulse to the write circuits of each track. When a write bus is active (down), a 1-bit is recorded; otherwise, a 0-bit is recorded in the associated track. The up or down level of these lines is determined by the coded data sent to the tape control unit.

Models 4-6: Essentially the same conditions as for Models 1-3; but because the write buses drive the write drivers directly, the write bus varies for both PE and NRZI recording. Zero bits in phase encoding are represented by a flux pattern different from that used in NRZI recording (Figure 6).

Rewind (TC39)

This input line causes the tape unit to perform a rewind operation (tape is rewound to the load point). Rewind also turns off TI. Rewind is at high speed if there is more than approximately 1/2 inch (3/16 inch for Models 1 and 4) of tape on the take-up reel; otherwise, it is a low-speed rewind.

Rewind/Unload (TC41)

Like rewind, this line causes a rewind of tape to load point but continues to unload tape (and lower the power window, if present) preparatory to changing reels. Rewind/unload also turns off TI.

Metering Out (TC23)

This input line is active when the systems conditions are met for running usage meters and the control unit is not off-line. The tape unit meter stops only if the metering-out line becomes inactive, if the tape unit is unloaded and not rewinding, or if the tape unit is at load point.

Metering out is terminated in each individual tape unit (Figure 30).

OUTPUT LINES

All output lines are SLT level with a minimum active (down) level of +0.3 volt and a minimum inactive (up) level of +2.5 volts. When output lines use the word ready, see "Ready" for full definition.

Models 1/4, 2/5, 3/6 (TC180, 182, and 184)

These output lines indicate the tape unit model and that the tape unit is selected and ready. Each tape unit activates only one of the three lines.

Rewinding/Not Ready (TC142, 144, 156, 158, 172, 174, 186, and 188)

This output line carries a unique tape unit address (0-7); it indicates that the tape unit is physically connected but not ready. A tape unit is not ready if it is unloaded, in reset status, or performing a rewind operation.

The 'not ready' line is rotated in the cable in the same manner as 'select' (Figure 5).

In a tape unit configuration that utilizes a 2816 Switching Unit, the active state of 'not ready' may also indicate that the tape unit is switched; that is, the tape unit is operating with another control unit.

On a rewind/unload command, the tape unit drops the model line (TC180, 182, and 184) before activating the rewinding/not ready line.

Seven Track/NRZI (TC178)

Models 1-3: This output line indicates that the seven-track feature is installed in the selected tape unit; suitable timing circuits in the control unit are conditioned. Seven track/NRZI may only be active concurrently with the 'Model 1/4, 2/5, 3/6' line.

Models 4-6: When active, this output line indicates that the Model 4, 5, or 6 is operating in 800 bpi NRZI mode. When inactive, this line indicates 1,600 bpi PE mode and gates the read bus terminations.

Select and Read Status (TC162)

The read/write status of a selected tape unit is indicated to the control unit through the 'select and read status' line. When active, this line indicates read status; when inactive, this line indicates write status. The 'select and read status' line is effective, however, only while a 'Model 1/4, 2/5, 3/6' line is active.

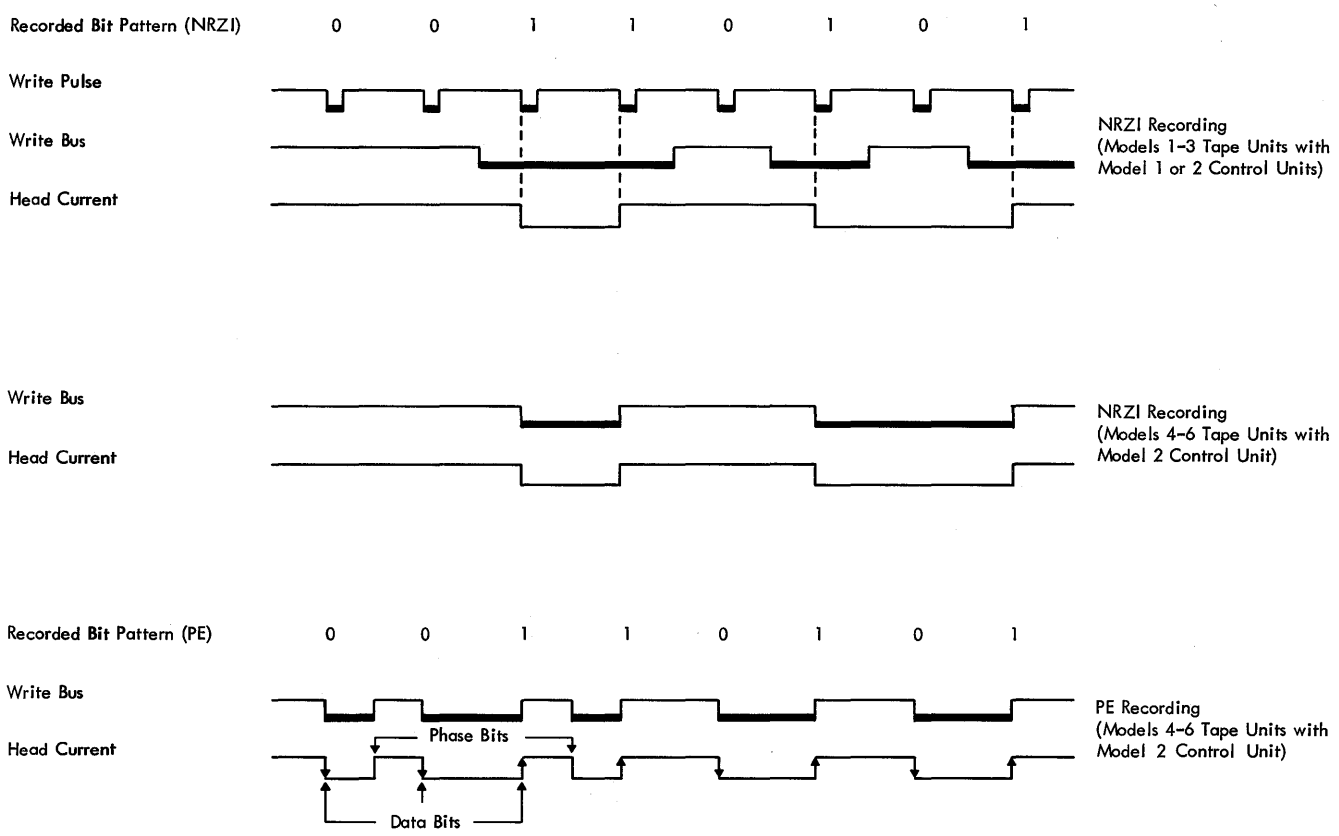


Figure 6. PE and NRZI Bit Patterns on Tape

Select and at Load Point (TC198)

This line indicates that the tape on the selected tape unit is positioned at load point. This line is reset if the tape is unloaded and not rewinding or if tape is moved forward.

Write Echo/Select and TI Off (TC196)

Models 1-3 without Mode Compatibility Feature: This line is activated or pulsed by the tape unit each time a bit is written on tape.

Models 4-6 or Models 1-3 with Mode Compatibility Feature: This line is active when the tape indicator of the selected tape unit is off; this indicates that the selected tape unit has not reached the useful end of tape. TI is set by sensing the end-of-tape reflective marker during a forward tape operation; it is reset by a backward, rewind, or unload operation.

Select and TI Off/Inhibit Go (TC194)

Models 1-3 without Mode Compatibility Feature: This line is active when the tape indicator of the selected tape unit is off; this indicates that the selected tape unit has not reached the useful end of tape. TI is set by sensing the end-of-tape reflective marker during a forward tape operation; it is reset by a backward, rewind, or unload operation.

Models 4 and 5 or Models 1 and 2 with Mode Compatibility Feature: 'Inhibit go' is active after the fall of go during a read operation. This indicates to the control unit that the tape is being positioned in preparation for reading the next block.

Select and Not File-Protected (TC192)

This line indicates that a selected and ready tape unit may perform a write operation because it is not file-protected. A tape unit is file-protected (writing or erasing of tape is prevented) when the file reel does not contain a write-enable ring.

Read Bus (TC84, 93, 95, 102, 104, 113, 115, 122, and 82)

These nine lines (0-7 and P) carry the read signals from the tape unit to the tape control unit for a read operation.

Backward Status (TC164)

This line is active when the tape unit is in backward status. Conditioning the go line causes backward motion of tape; as for example, in backspacing.

2400-Series Models 1, 2, and 3 (TC37)

Model 1, 2, or 3 Tape Unit with Mode Compatibility Feature: The active state of this line indicates to a Model 2 control unit that a Model 1, 2, or 3 tape unit has been selected.

Model 4, 5, or 6 Tape Unit: The inactive state of this line gates the proper write data and also selects the proper read bus termination.

INPUT/OUTPUT LINE SPECIFICATIONS

Figures 7 and 8 are listings of the specifications for the input and output lines to the 2400-series tape units. See "Input/Output Signal Lines."

CONNECTOR PIN ASSIGNMENTS

Figure 9 is a listing of the input and output signals with their respective connector pin assignments. Figure 10 shows the physical location of the connector pins on the tape unit. Figure 11 shows the pin locations on the control unit. Figure 12 shows the power plug pin locations and assignments. See Figure 27 for connector part numbers.

MODE COMPATIBILITY FEATURE

The mode compatibility feature allows 2400-series Models 1-3 tape units (seven and nine track) to operate with a Model 2 tape control in NRZI mode. Since the feature modifies the stopping characteristics of the tape unit and the assignment of tape unit signal lines, a tape unit that has the mode compatibility feature installed can operate only with Model 2 control units.

SIMULTANEOUS READ/WRITE FEATURE

The simultaneous feature allows the control unit to call simultaneously for a write operation on one tape unit and a read operation on another tape unit. The control unit must be a 2804 Model 1, 2404 Model 1, 2, or 3, or a 2804 Model 2 and the tape unit must have the simultaneous feature installed. Input/output line definitions and functions remain the same, except for the addition of one input line (simultaneous control). This line is active whenever a 2804 or 2404 control is connected to the tape unit interface. All input/output line specifications also remain the same; however, additional pin assignments for the write interface are necessary (Figure 13).

Input Lines		
Line Name	Rise or Fall Time (Maximum)	Pulse Width (Minimum)
Select	0.25 usec	NS*
Backward	0.25 usec	9.5 usec
Go	0.25 usec	NS
Set Read Status	0.25 usec	10.5 usec
Set Write Status	0.25 usec	7.9 usec
Write Pulse (M1-3 only)	NS*	3.0 usec

Note: The write bus must be active no later than 0.25 usec after the write pulse becomes active and held active for 6 usec after the rise of the write pulse in Mod 3. (9 usec, Mod 2; 12.6 usec, Mod 1).

Each of the following lines should be held active until one of its respective responses are generated.

Command	Response
Rewind	Not Ready or Select & at LP
Rewind/Unload	Not Ready
Backward	Backward Status
Set Read Status	Select and Read Status
Set Write Status	(Not) Select and Read Status
Set NRZI **	NRZI

*NS - not specified
** - Models 4-6 with dual density, 800/1,600 bpi feature.

Figure 7. Tape Unit Input Line Specifications

Output Lines		
Line Name	Rise or Fall Time (Maximum)	Maximum Response Time (from Select)
Model 1,4--2,5--3,6	1 usec	2.0 usec
2400 Model 1, 2, 3	1 usec	2.0 usec
Select & TI Off	1 usec	6.8 usec
Select & at LP	1 usec	6.2 usec
Select & Read Status	1 usec	6.2 usec
Not File Protect	NS*	6.2 usec
Backward	NS*	6.2 usec
Inhibit Go	Adjustable	See Notes

Note: Model 1, 2, 3 line must be up no later than 5 usec after Select is received at the tape unit.
Write Echo min. pulse width = 0.3 usec

Inhibit go is adjustable to hold up go 4.0 ms to give a read stop time of 7.6 ms in Model 4, or Model 1 with mode compatibility; inhibit go is adjustable to hold up go 1.2 ms to give a read/write stop time of 3.4 ms in Model 5, or Model 2 with mode compatibility; not applicable to Models 6 and 3.

*NS- not specified

Figure 8. Tape Unit Output Line Specifications

Connector	Control Unit Connector Pin No.		Signal Name	Tape Unit Connector Pin No.	
	Signal	Shield		Signal	Shield
A	B03	B02	Select TU 0	77	76
	B05	B04	Select TU 1	79	78
	B08	B07	Select TU 2	86	87
	B10	B09	Select TU 3	88	89
	B12	B13	Select TU 4	97	96
	D04	D05	Select TU 5	99	98
	D06	D07	Select TU 6	106	107
	D09	D08	Select TU 7	108	109
	D11	D10	Spare	117	116
	D13	D12	Spare	119	118
	G03	G02	Spare	176	175
	G05	G04	Spare	190	191
	G08	G07	TU 0 Rwd-NR	142	141
	G10	G09	TU 1 Rwd-NR	144	143
	G12	G13	TU 2 Rwd-NR	156	157
	J04	J05	TU 3 Rwd-NR	158	159
	J06	J07	TU 4 Rwd-NR	172	171
	J09	J08	TU 5 Rwd-NR	174	173
	J11	J10	TU 6 Rwd-NR	186	187
	J13	J12	TU 7 Rwd-NR	188	189
B	B03	B02	Go	9	10
	B05	B04	Backward	11	12
	B08	B07	Set Write Status	13	14
	B10	B09	Set Read Status	25	24
	B12	B13	Wr LRCC Gt/Set NRZI	27	26
	D04	D05	Spare	7	8
	D06	D07	Rewind	39	40
	D09	D08	Rewind/Unload	41	42
	D11	D10	Metering Out	23	22
	D13	D12	2400 Model 1,2,3	37	38
	G03	G02	Write Bus P	1	2
	G05	G04	Write Bus 0	3	4
	G08	G07	Write Bus 1	5	6
	G10	G09	Write Bus 2	17	16
	G12	G13	Write Bus 3	19	18

Connector	Control Unit Connector Pin No.		Signal Name	Tape Unit Connector Pin No.	
	Signal	Shield		Signal	Shield
B	J04	J05	Write Bus 4	21	20
	J06	J07	Write Bus 5	31	32
	J09	J08	Write Bus 6	33	34
	J11	J10	Write Bus 7	35	36
	J13	J12	Write Pulse	29	28
C	B03	B02	Mod 3, 6	184	183
	B05	B04	Mod 2, 5	182	181
	B08	B07	Mod 1, 4	180	179
	B10	B09	Seven Track/NRZI	178	177
	B12	B13	Sel & Read Status	162	163
	D04	D05	Sel & At Load Point	198	199
	D06	D07	Backward Status	164	165
	D09	D08	Sel & TI (Tape Ind) Off/Inhibit Go	194	195
	D11	D10	Sel & Not File Protect	192	193
	D13	D12	Spare	124	125
	G03	G02	Read Bus P	82	83
	G05	G04	Read Bus 0	84	85
	G08	G07	Read Bus 1	93	92
	G10	G09	Read Bus 2	95	94
	G12	G13	Read Bus 3	102	103
	J04	J05	Read Bus 4	104	105
	J06	J07	Read Bus 5	113	112
	J09	J08	Read Bus 6	115	114
	J11	J10	Read Bus 7	122	123
	J13	J12	Wr Echo/Sel & TI Off	196	197
D	G03	G02	TU 8 Rwd-NR		
	G05	G04	TU 9 Rwd-NR		
	G08	G07	TU 10 Rwd-NR		
	G10	G09	TU 11 Rwd-NR		
	G12	G13	TU 12 Rwd-NR		
	J04	J05	TU 13 Rwd-NR		
	J06	J07	TU 14 Rwd-NR		
	J09	J08	TU 15 Rwd-NR		
	J11	J10	Spare		
	J13	J12	High Order		

Note: These lines used only in conjunction with 2816 Switching Unit.

Note: All shield pins connect to machine ground
Rwd-NR= Rewinding-Not Ready

Figure 9. Tape Unit/Control Unit Connector Pin Assignments

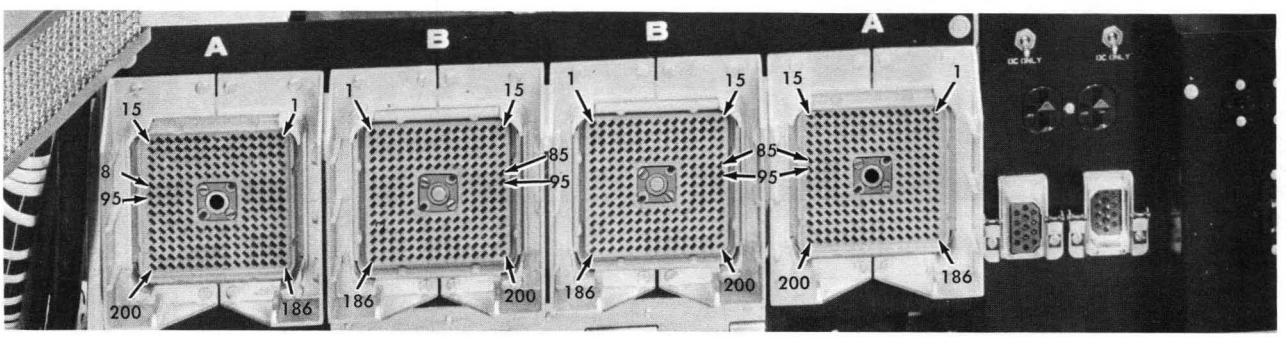
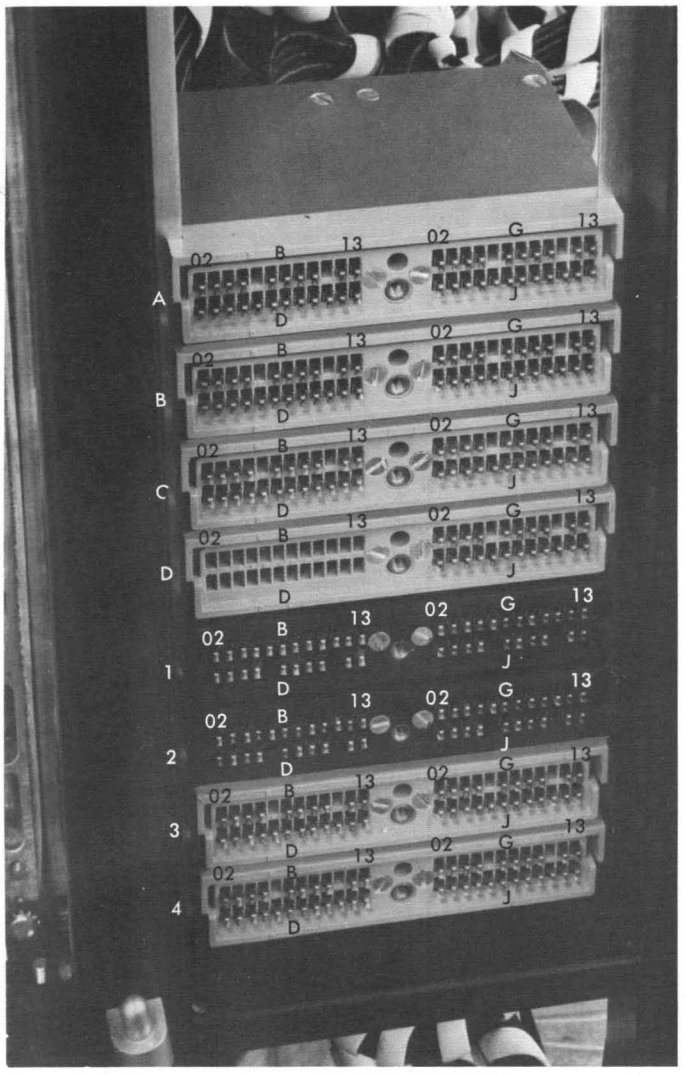


Figure 10. 2402 Tail Gate Connectors



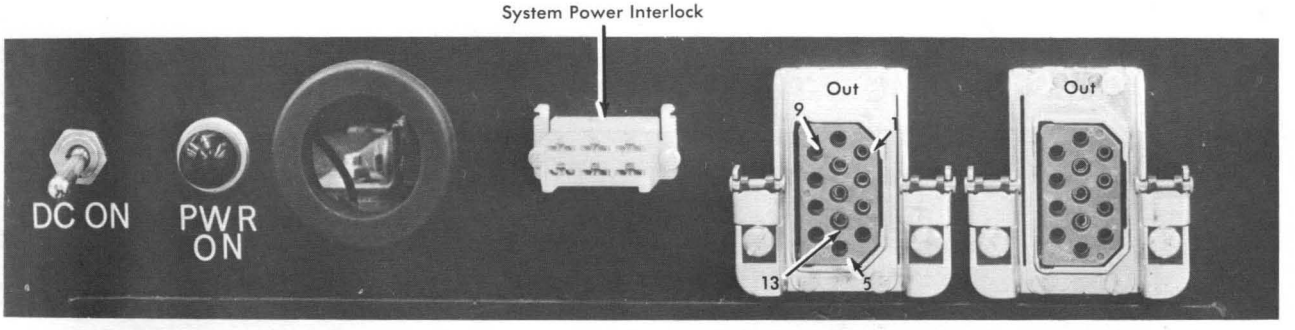
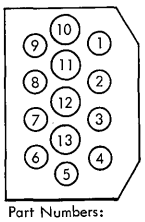


Figure 11. 2403/2803 Signal and Power Connectors



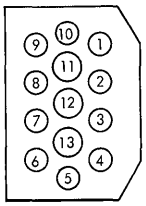
Part Numbers:
In--526517 (Male) Out--526516 (Female)

60-Hertz Tape Units

Pin	Function
1	Convenience Outlet
2	Convenience Outlet
3	Frame Ground
11	One Phase } Unregulated ac
12	One Phase } Unregulated ac
13	One Phase } Unregulated ac

50-Hertz Tape Units

Pin	Function
1	Neutral
2	Frame Ground
3	Frame Ground
6	Convenience Outlet
7	Convenience Outlet
11	One Phase } Unregulated ac
12	One Phase } Unregulated ac
13	One Phase } Unregulated ac



Part Number:
Out--526516 (Female)
(Two Used per Tape Control)

60-Hertz Tape Controls

Pin	Function
1	Convenience Outlet
2	Convenience Outlet
3	Frame Ground
11	One Phase } Unregulated ac
12	One Phase } Unregulated ac
13	One Phase } Unregulated ac

50-Hertz Tape Controls

Pin	Function
1	Neutral
2	Frame Ground
3	Frame Ground
4	Frame Ground (2803A Machines Only)
5	Frame Ground (2803A Machines Only)
6	Convenience Outlet
7	Convenience Outlet
11	One Phase } Unregulated ac
12	One Phase } Unregulated ac
13	One Phase } Unregulated ac

Figure 12. AC Power Connector Pin Numbering

TAPE UNIT SPECIFICATIONS

Most specifications are the same for the 2401, 2402, and 2403 Models 1-6 and 2404 Models 1-3 tape units. When differences exist, specifications are indicated for each machine. Information concerning external power, air conditioning, weights, and dimensions is available from IBM Regional Sales Engineering through the IBM Branch Office.

Read/Write Head

The two-gap construction of the read/write head provides for read checking while writing.

	Models 1-3		*Models 4-6*
Specification	*Nine Track*	*Seven Track*	*Nine Track*
Distance between gaps (in.)	0.150	0.300	0.150
Write track width (in.)	0.044	0.048	0.044
Read track width (in.)	0.040	0.030	0.040
Write current (ma)	53^{+20}_{-0}	53^{+20}_{-0}	40 ± 5 (NRZI) (Model 4) 17.5 ± 2.5 (PE) (Models 5 and 6) 22.5 ± 2.5 (PE)

Tape Speed, Bit Density, and Byte Rate

Tape Speed

	Mod 1/4	*Mod 2/5*	*Mod 3/6*
Forward, backward, and low-speed rewind (ips)	37.5	75.0	112.5
Maximum rewind time for 2,400-ft reels (minutes):			
Rewind	3.0	1.4	1.0
Rewind/Unload	2.2	1.5	1.0

Bit Density

800 bpi only, nine track, Models 1-3
200, 556, and 800 bpi, seven track, Models 1-3
1,600/800 bpi, nine track, Models 4-6

Byte Rate

Model	*Rate*
1	30 kb/60 kd
2	60 kb/120 kd
3	90 kb/180 kd
4	60 kb or 120 kd/30 kb or 60 kd*
5	120 kb or 240 kd/60 kb or 120 kd*
6	180 kb or 360 kd/90 kb or 180 kd*

* With dual density feature.

kb = thousands of eight-bit bytes per second.
kd = thousands of four-bit decimal digits per second.

2400-Series Tape Timings

Time to perform read, read backward, and write commands is equal to: number of bytes, multiplied by time per byte, plus interblock time.

Nominal Interblock Gap (ms)

	*2401-2404**	
Model	*Nine Track*	*Seven Track*
1	16.0	20.0
2	8.0	10.0
3	5.3	6.6
4	16.0	NA
5	8.0	NA
6	5.3	NA

* The 2404 is available only in Models 1-3.
NA = Not applicable.

Time/Byte (usec)

	*2401-2404**				
	Nine Track		*Seven Track*		
Model	*1,600 bpi*	*800 bpi*	*800 bpi*	*556 bpi*	*200 bpi*
1	NA	33.3	33.3	48.0	133.0
2	NA	16.7	16.6	24.0	67.0
3	NA	11.1	11.1	16.0	44.0
4	16.7	33.3	NA	NA	NA
5	8.3	16.7	NA	NA	NA
6	5.6	11.1	NA	NA	NA

* The 2404 is available only in Models 1-3.

Nine and Seven Track	*Model 1 (ms)*	*Model 2 (ms)*	*Model 3 (ms)*
	(With Model 1 Control Unit)		
When writing or reading from load point, add:	350	75	48
Forward/backward status change time* (to be added if appropriate)	264	32	16
Write tape mark order time from initiation to disconnect:			
Nine track, 800 bpi	99	49	33.5
Seven track	103	51	35.0

* The tape unit maintains the status (forward/backward) of the operation it has performed. Forward/backward status change time must be added for every forward following a backward operation, every backward following a forward operation, and for every forward operation initiated at load point.

Connector	Control Unit Connector Pin No.		Signal Name	Tape Unit Connector Pin No.	
	Signal	Shield		Signal	Shield
A	D02	D03	Select TU 0 Write	190	191
	D04	D05	Select TU 2 Write	160	161
	D06	D07	Select TU 4 Write	148	147
	D09	D08	Select TU 6 Write	152	151
	D11	D10	Model 3/6 Write	47	46
	D13	D12	Model 1/4 Write	51	50
	B03	B02	Select TU 1 Write	176	175
	B05	B04	Select TU 3 Write	146	145
	B08	B07	Select TU 5 Write	150	149
	B10	B09	Select TU 7 Write	154	153
	B12	B13	Model 2/5 Write	49	48
	J02	J03	Select TU 0 Read	77	76
	J04	J05	Select TU 2 Read	86	87
	J06	J07	Select TU 4 Read	97	96
	J09	J08	Select TU 6 Read	106	107
	J11	J10	Model 1/4 Read	180	179
	J13	J12	Model 3/6 Read	184	183
	G03	G02	Select TU 1 Read	79	78
	G05	G04	Select TU 3 Read	88	89
	G08	G07	Select TU 5 Read	99	98
	G10	G09	Select TU 7 Read	108	109
	G12	G13	Model 2/5 Read	182	181
B	D02	D03	Go Write	7	8
	D04	D05	Set Write	13	14
	D06	D07	Wr Echo/Sel & TI Off (Write)	196	197
	D09	D08	Select & Read Status (Write)	128	129
	D11	D10	Sel & Not File Protect (Write)	130	131
	D13	D12	Sel & TI Off/Inhibit Go (Write)	194	195
	B03	B02	Wr LRCC Gate/Set NRZI (Write)	27	26
	B05	B04	Write Pulse	29	28
	B08	B07	Seven Track/NRZI (Write)	61	62
	B10	B09	Select & At Load Point (Write)	168	169
	B12	B13	Backward Memory (Write)	166	167
	J02	J03	Go Read	9	10
	J04	J05	Set Read	25	24
	J06	J07	Rewind Unload	41	42
	J09	J08	Select & Read Status (Read)	162	163
	J11	J10	Select & Not File Protect (Read)	192	193
	J13	J12	Metering Out	23	22
	G03	G02	Backward Read	11	12
	G05	G04	Rewind	39	40
	G08	G07	Seven Track/NRZI (Read)	178	177
	G10	G09	Select & At Load Point (Read)	198	199
	G12	G13	Backward Memory (Read)	164	165

Connector	Control Unit Connector Pin No.		Signal Name	Tape Unit Connector Pin No.	
	Signal	Shield		Signal	Shield
C	D02	D03	Write Bus P	1	2
	D04	D05	Write Bus 1	5	6
	D06	D07	Write Bus 3	19	18
	D09	D08	Write Bus 5	31	32
	D11	D10	Write Bus 7	35	36
	D13	D12	Spare	119	118
	B03	B02	Write Bus 0	3	4
	B05	B04	Write Bus 2	17	16
	B08	B07	Write Bus 4	21	20
	B10	B09	Write Bus 6	33	34
	B12	B13	Spare	110	120
	J02	J03	TU 0 Rwd-NR	142	141
	J04	J05	TU 2 Rwd-NR	156	157
	J06	J07	TU 4 Rwd-NR	172	171
	J09	J08	TU 6 Rwd-NR	186	187
	J11	J10	Simultaneous Control	63	64
	J13	J12	Spare	126	127
	G03	G02	TU 1 Rwd-NR	144	143
	G05	G04	TU 3 Rwd-NR	158	159
	G08	G07	TU 5 Rwd-NR	174	173
	G10	G09	TU 7 Rwd-NR	188	189
	G12	G13	Spare	117	116
D	D02	D03	Read Bus P Read	82	83
	D04	D05	Read Bus 1 Read	93	92
	D06	D07	Read Bus 3 Read	102	103
	D09	D08	Read Bus 5 Read	113	112
	D11	D10	Read Bus 7 Read	122	123
	D13	D12	Spare/Set NRZI (Read)	138	139
	B03	B02	Read Bus 0 Read	84	85
	B05	B04	Read Bus 2 Read	95	94
	B08	B07	Read Bus 4 Read	104	105
	B10	B09	Read Bus 6 Read	115	114
	B12	B13	2400 Model 1,2,3 (Read)	124	125
	J02	J03	Read Bus P Write	59	60
	J04	J05	Read Bus 0 Write	55	56
	J06	J07	Read Bus 3 Write	75	74
	J09	J08	Read Bus 5 Write	71	70
	J11	J10	Read Bus 7 Write	67	66
	J13	J12	Spare	43	44
	G03	G02	Read Bus 0 Write	57	58
	G04	G05	Read Bus 2 Write	53	54
	G08	G07	Read Bus 4 Write	73	72
	G10	G09	Read Bus 6 Write	69	68
	G12	G13	2400 Model 1,2,3 (Write)	37	38

*Note: All shield pins connect to machine ground.
Rwd-NR = Rewinding-Not Ready

Figure 13. Tape Unit/Control Unit Connector Pin Assignments with Simultaneous Feature

Nine and Seven Track	*Model 1/4 (ms) (With Model 2 Control Unit)*	*Model 2/5 (ms)*	*Model 3/6 (ms)*
When writing or reading from load point, add:	320.0	64.0	48.0
Forward/backward status change time* (to be added if appropriate)	224.0	16.0	16.0
Write tape mark order time from initiation to disconnect:			
Nine track, 800 bpi	100.6	50.5	33.5
Seven track	104.4‡	52.2‡	34.8‡
Nine track, 1,600 bpi	101.2†	50.6†	33.7†

Nine and Seven Track	*Model 1/4 (ms) (With Model 1 or 2 Control Unit)*	*Model 2/5 (ms)*	*Model 3/6 (ms)*
Rewind order disconnect time§	30.0	30.0	30.0
Rewind/unload order disconnect time	45.0	45.0	45.0
Tape rewind, full reel (minutes)	3.0	1.4	1.0
Rewind/unload, full reel (minutes)	2.2**	1.5	1.1

* The tape unit maintains the status (forward/backward) of the operation it has performed. Forward/backward status change time must be added for every forward following a backward operation, every backward following a forward operation, and for every forward operation initated at load point.

** Rewind/unload takes less time than rewind in the Model 1 or 4 because tape is rewound to load point at high speed. Rewind requires reloading tape. In both Models 2 or 5 and 3 or 6, tape is reloaded during a rewind/unload at the end of high-speed rewind and rewound to load point at low speed; it is then unloaded again (rewind does not require final unloading).

‡ The seven-track feature is not installed on Models 4-6.

† Models 1-3 cannot process 1,600-bpi tape.

§ With tape at load point, rewind-disconnect time is immediate.

Power Requirements

1. Power-on circuit breaker on back side of unit turns off power to unit without disconnecting the power cable.
2. Input power:

208/230 vac ± 10%, 3-phase, 60 (± 1/2) hertz
195/220/235 vac (△), 3-phase, 50 (± 1/2) hertz
380/480 vac (Y), 3-phase, 50 (± 1/2) hertz

Unit	*kva*	*BTU/hr*	*Cubic Ft/Minute*
2401	1.6	3,500	500
2402	3.2	7,000	1,000
2403	2.1	5,500	1,000
2404	2.4	6,300	1,200

Note: Convenience outlets are for Field Engineering use only. See Figure 12 for power connector pin assignments.

Machine Protection

Model 1/4: The overloading of any circuit protector (except CP11, power window) causes the ready relay (R101) and the capstan motor relay (DP4) to be de-energized. The CB indicator shows an overload in all models.

Models 2/5, 3/6: The overloading of any circuit protector (except CP11, power window) causes the run relays (R1, DP5, and DP6) and the not-file-protect relay (NFP1) to be de-energized.

File Protection

Recorded files of tape reels are protected from erasure when a write enable ring is not inserted into the groove on the back of the file reel. When inserted, this ring actuates the not-file-protect mechanism and allows current to flow in the write heads when the tape unit is placed in write status.

Tape Motion Start and Stop Times

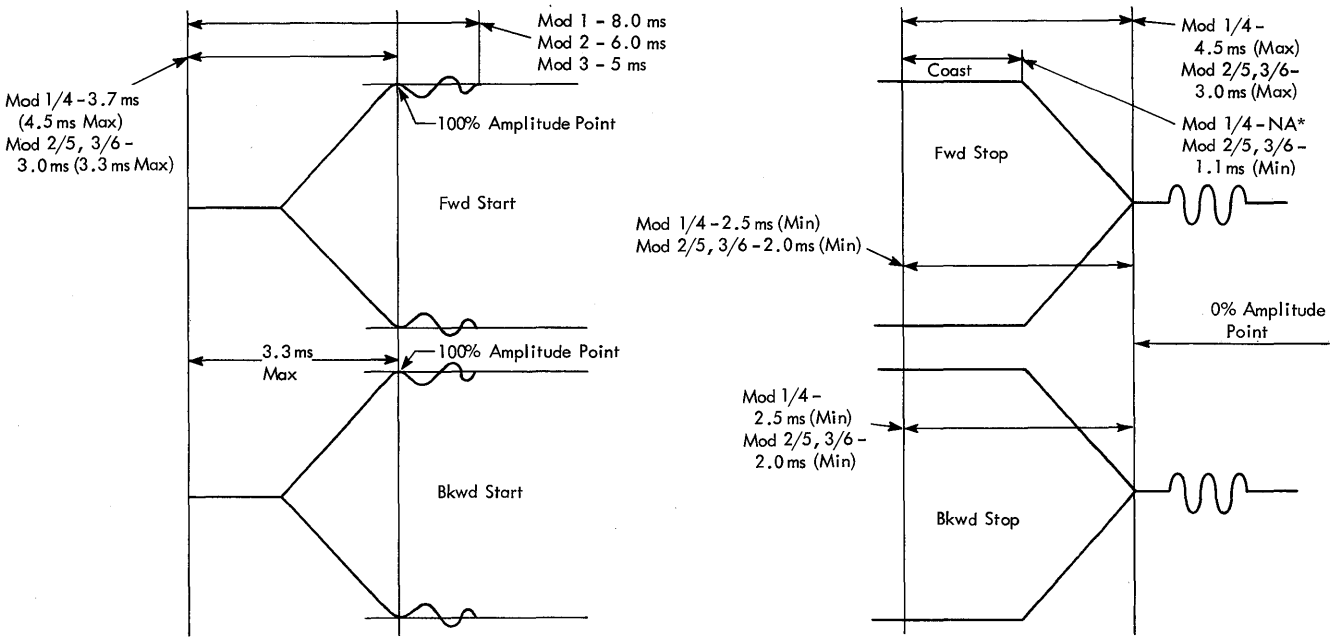
1. Full-speed coast (within 5 percent of nominal speed) after fall of go (Figure 14).
   1.1 ms (minimum) for Models 2/5, 3/6
   Not applicable for Model 1/4
2. Start time (forward and backward). Time from rise of go to the initial 100-percent amplitude point (Figure 14).
   3.7 ms (4.5 maximum) for Model 1/4
   3.0 ms (3.3 maximum) for Models 2/5, 3/6
3. Stop time (forward and backward). Time from fall of go until signal reaches zero-amplitude point.
   2.5 ms (minimum) for Model 1/4
   2.0 ms (minimum) for Models 2/5, 3/6
4. "Go-up" time is 20.0 ms minimum under all conditions while measuring timings 1, 2, and 3.
5. When "go-down" time is greater than 25 ms, start time is not to exceed 4.5 ms for Model 1 or 3.3 ms for Models 2/5, 3/6.

Read Circuits

For Models 1-3 tape units, the minimum peak-to-peak preamplifier signal output, measured with preamplifiers set for maximum output, is 11 volts. Measure at pin H of preamplifier while writing all ones at 800 bpi (1,600 bpi in Models 4-6 PE), using a calibrated output tape (part 461108). Preamplifier gain should be adjusted to an average of 7.8v, peak-to-peak, for NRZI recording in Model 1/4; for Model 2/5, 8.8v; for Model 3/6, 9.8v. For Models 4-6, PE recording, the preamplifier gain should be adjusted to an average of 0.5v peak-to-peak (Figures 15 and 16).

Noise

Write circuit feedthrough is less than 0.4v, peak-to-peak, at the read bus while writing ones in-phase on all tracks for



* Not Applicable

Figure 14. Start/Stop Timings

Models 1-3 NRZI; 0.05v, peak-to-peak, for Models 4-6 PE (Figure 17).

Read crosstalk is less than 0.5v, peak-to-peak, at the read bus on unwritten track, with all ones written in-phase on all other tracks for Models 1-3 NRZI; 0.025v, peak-to-peak, for Models 4-6 PE (Figure 17).

Base-line shift, while in read status is $\leq$ 0.6v (forward), 1.2v, peak-to-peak (backward), at the read bus while running at 200 bpi or less in Models 1-3 (Figure 17).

With write head disconnected, a 10v peak-to-peak signal is erased to 400 mv (or less) by the erase head in Models 1-3. A 500-mv signal is erased to 20 mv (or less) in Models 4-6.

Tape Operating Environment

The following conditions for use of IBM magnetic tape are recommended:

Relative Humidity	20-80%
Temperature	60-90°F
Max Wet Bulb Temperature	78°F

Tape exposed to other conditions should be reconditioned to the operating environment for a time period equal to the storage time (maximum reconditioning period is 24 hours). When not in use, reels of tape should always be stored vertically in their plastic containers.

When shipping tape-loaded reels, place them in containers and seal each reel in a plastic bag. Additional protection should be provided by packing in stiff cardboard shipping cartons. Plastic bags and cartons can be obtained from IBM.

Recording Formats for Nine-Track, 800-bpi Tape

Recording Method (NRZI): One-bits produced by each reversal of flux polarity. Tape is fully saturated in each direction.

Erasure:

1. Tape is fully saturated in the erased direction in the initial gap and interblock gap areas. Any erased section of tape has its north magnetic pole in the direction of the beginning-of-tape (load point) marker and its south magnetic pole in the direction of the end-of-tape marker.
2. The erased area of the initial gap must begin at least 1.7 inches before the trailing end of the beginning-of-tape marker (Figure 18).

Track Spacing: See Figure 19.

Parity: A vertical parity bit is written in track P for each data byte that contains an even number of data bits.

Cyclic Redundancy Checking: A CRC character is written four bit spaces beyond end of each data block (Figure 20). Parity of the CRC character is related to the odd/even count of the data bytes in the block. (Odd number of data bytes–even CRC parity; even number of data bytes–odd CRC parity.) See "Error Correction" for description of CRC character generation.

Longitudinal Redundancy Check Character: A LRC character makes each track's bit count even for that block, and the LRC character is written eight bit spaces from the end of each data block (Figure 20). The LRC character always has odd parity. The LRC character is deskewed in the same manner as data bytes.

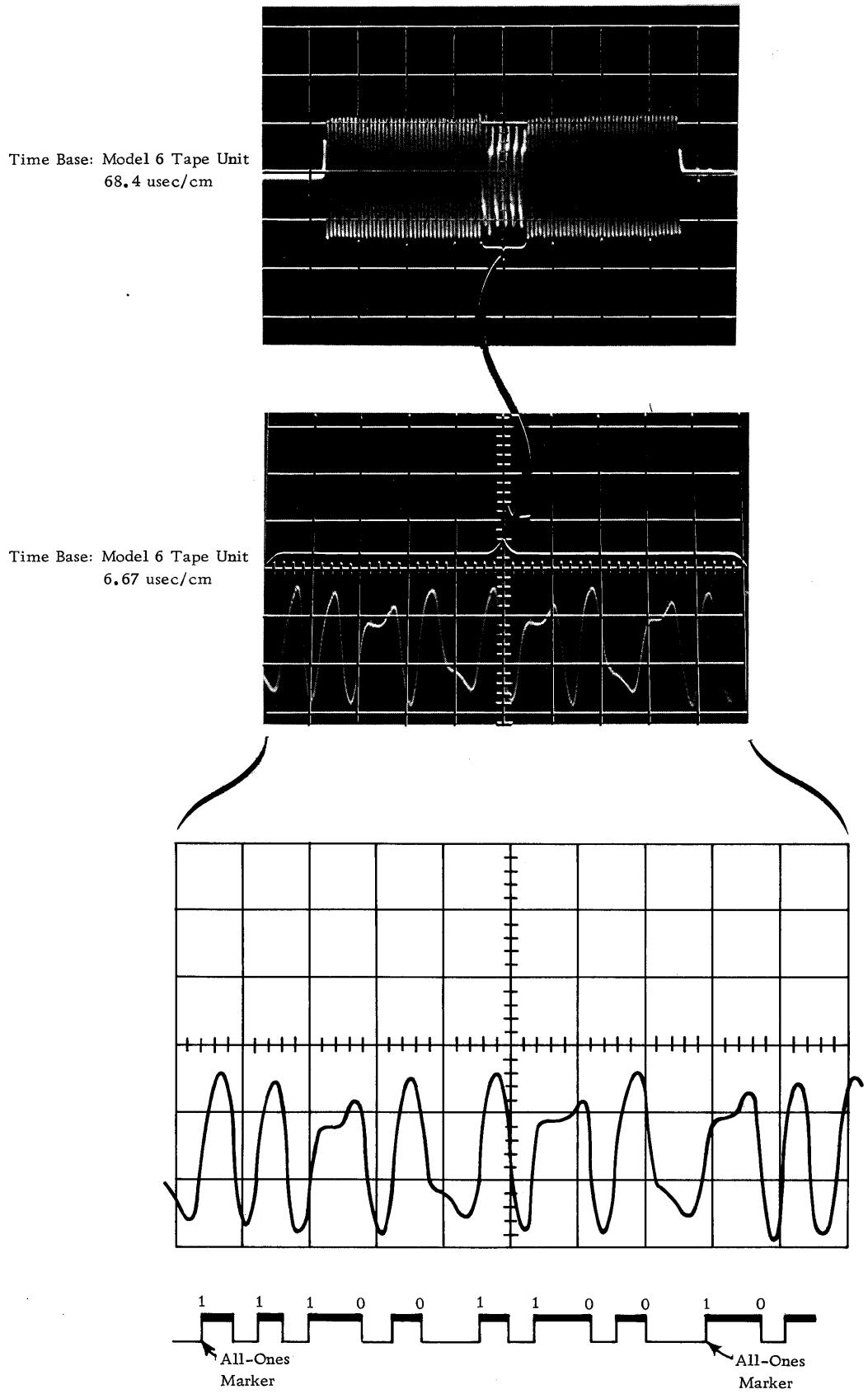


Figure 15. PE Read Bus Waveforms (Data Pattern 11001100)

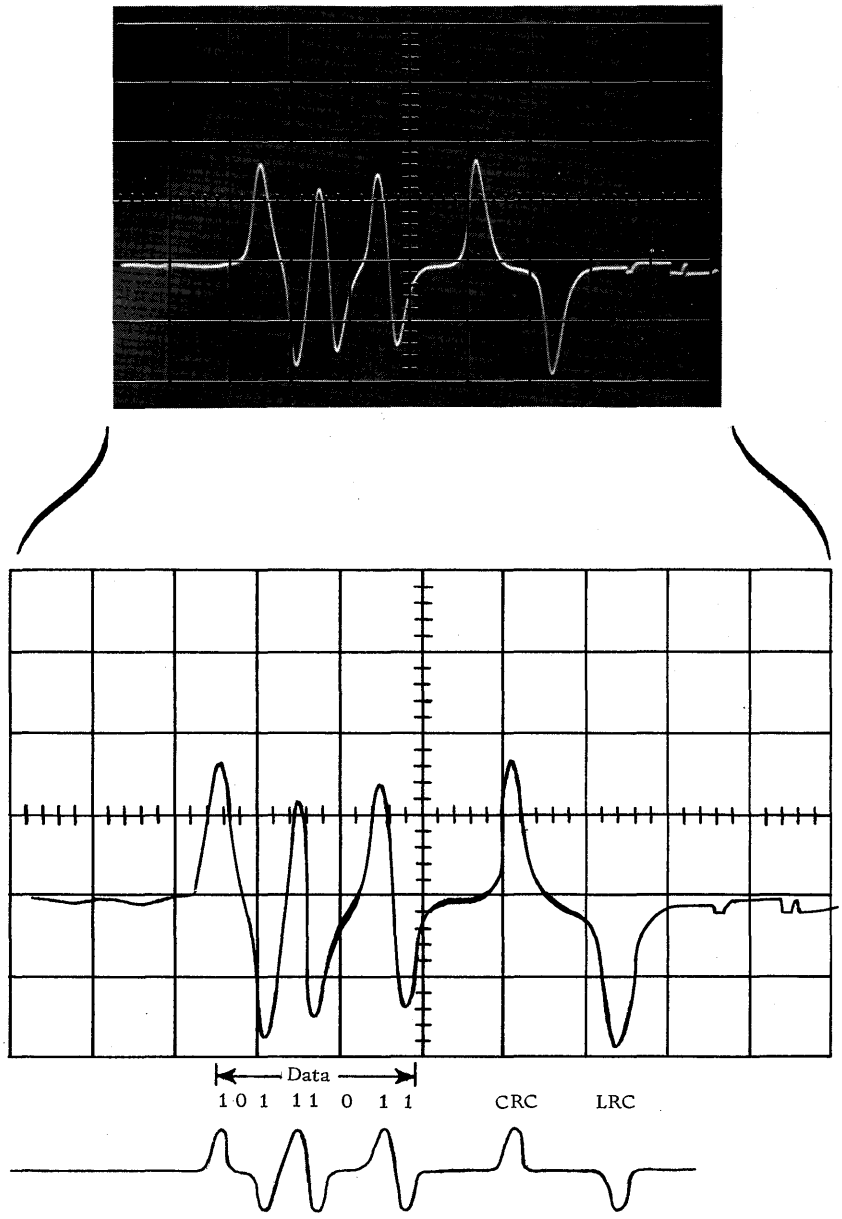


Figure 16. NRZI Read Bus Waveform (Nine Track)

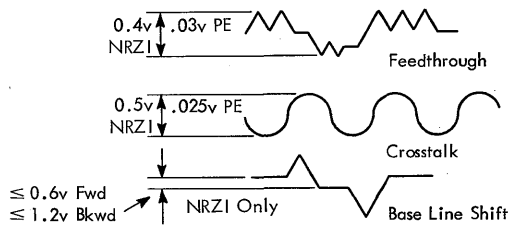


Figure 17. Noise

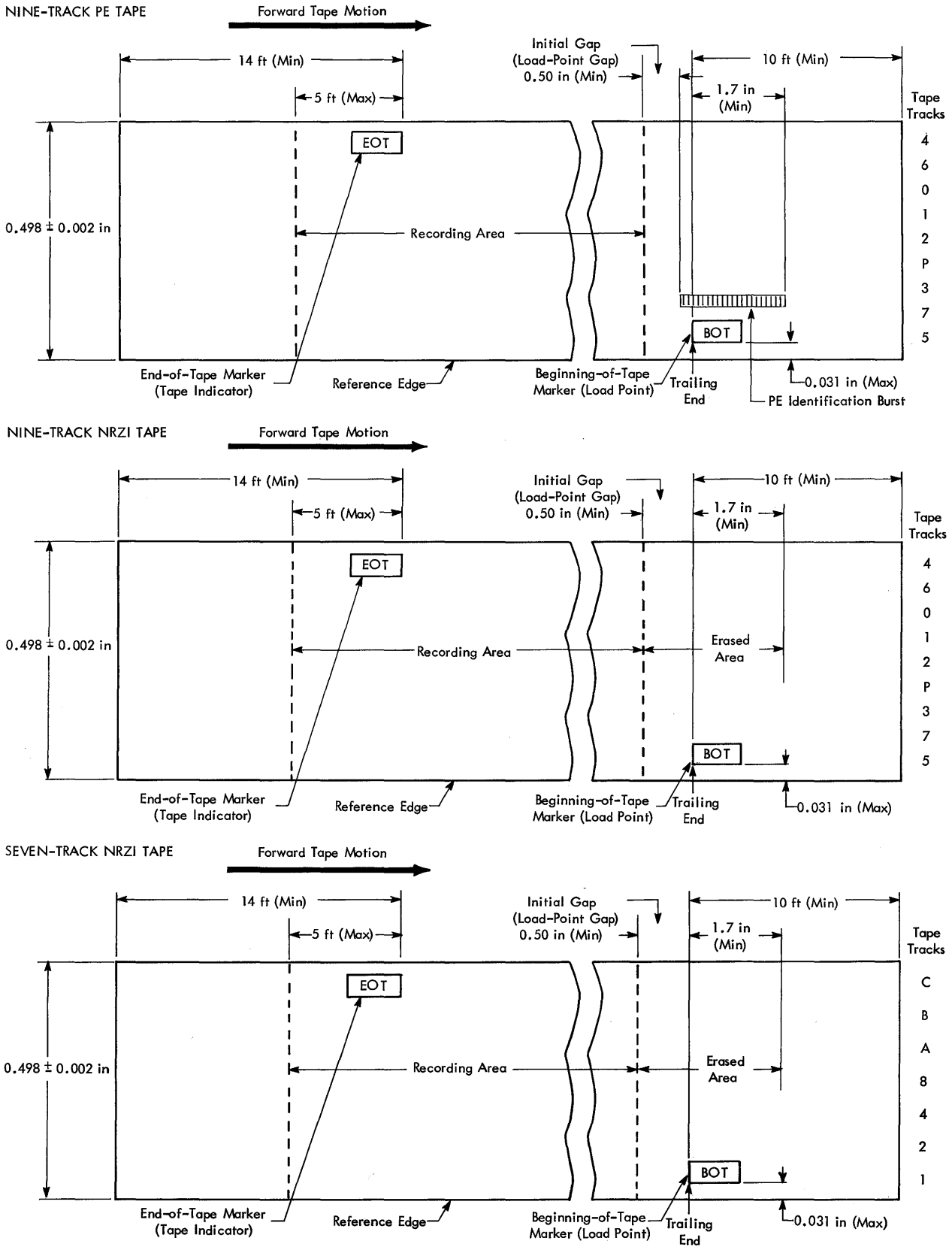
Interblock Gap (IBG): The size of the IBG is 0.50 inch minimum, 0.60 inch nominal, measured from the LRC character to the first data byte of the next block (Figure 22).

Tape Mark: See Figure 21.

Organization of Blocks on Tape: See Figure 22.

Skew Alignment Procedure (Figure 23):

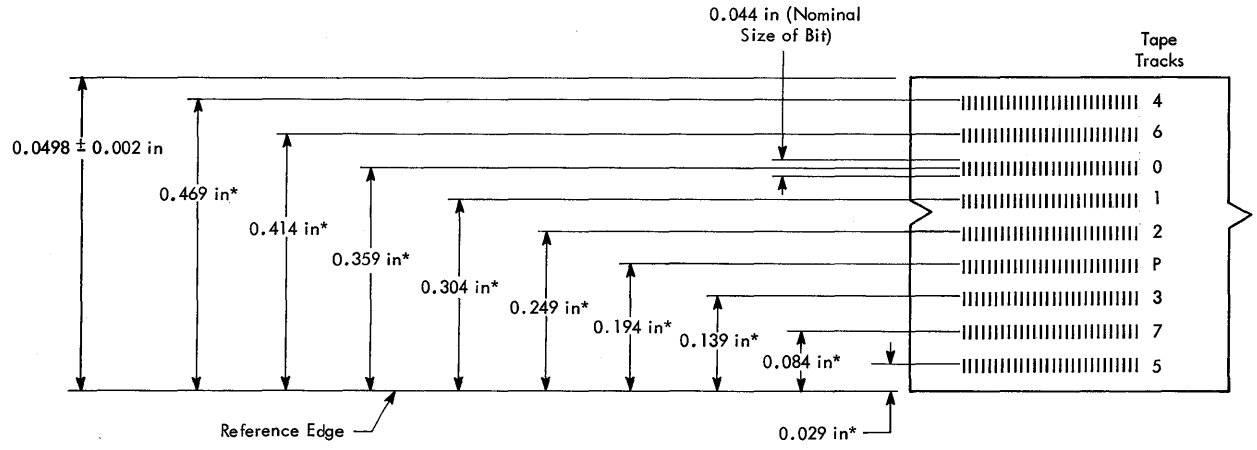
1. Adjust mechanical skew by scoping the outside tracks (4 and 5) while reading master skew tape, IBM part 432362.
2. Set read skew on all data tracks to less than 0.25 usec (Model 3 or 6 tape units), 0.40 usec (Model 2 or 5 tape units), or 0.75 usec (Model 1 or 4 tape units).



Note: Tape viewed from top while standing at front of tape unit. Markers are on top; recording is done on underside (oxide side) of magnetic tape.

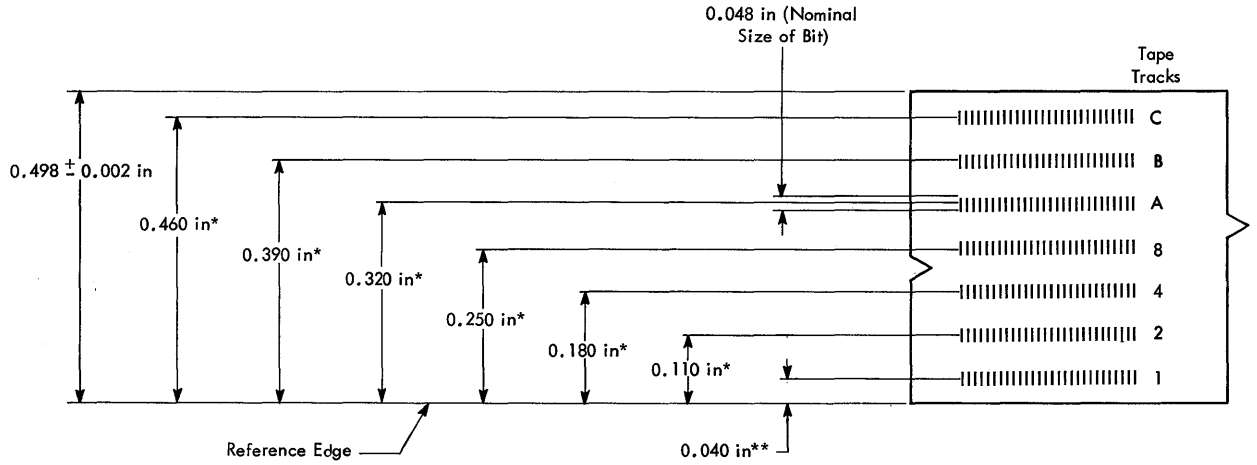
Figure 18. Beginning-of-Tape and End-of-Tape Areas

NINE-TRACK TAPE



*All track locations ± 0.003 in.

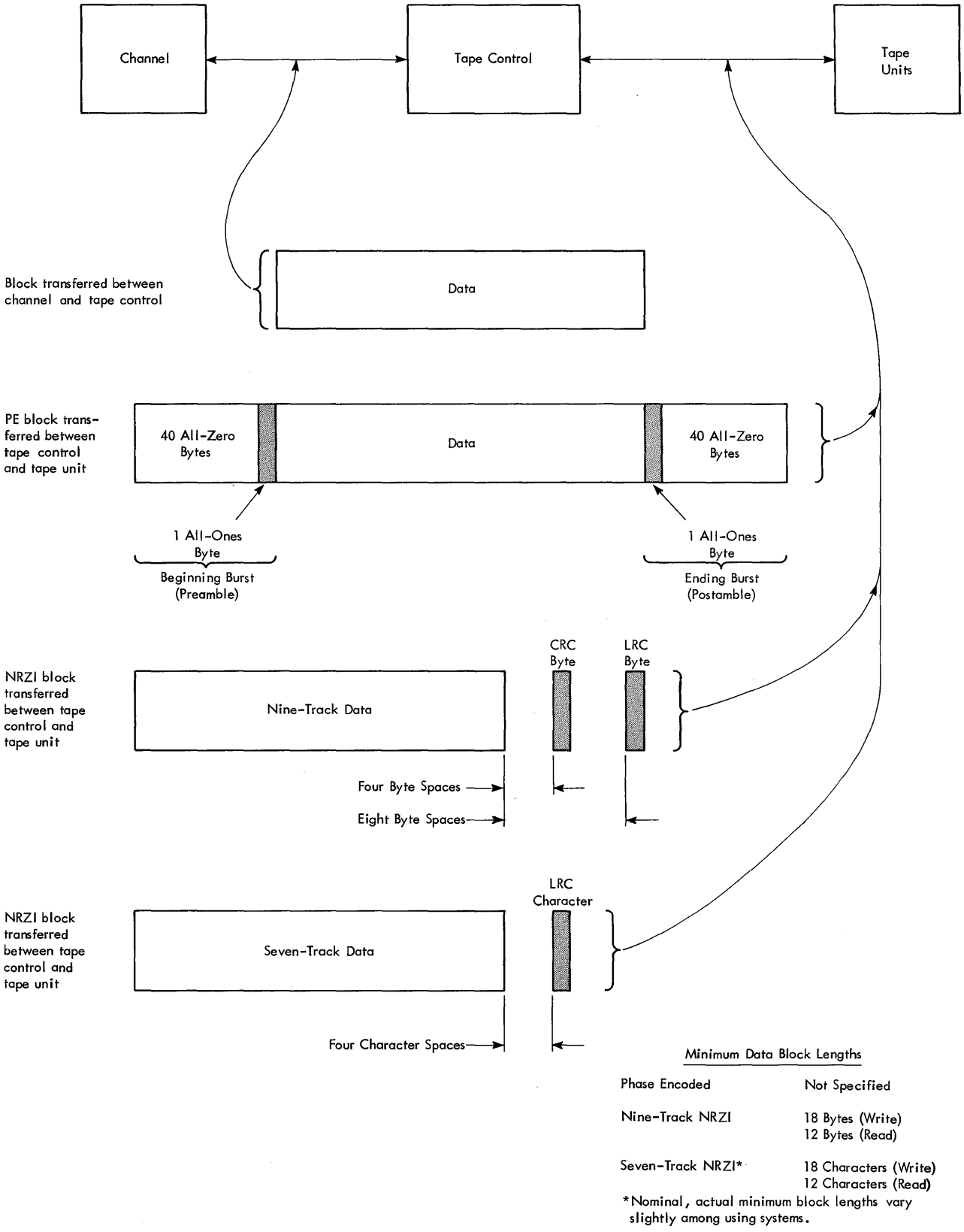
SEVEN-TRACK TAPE



*Track locations 2-C: +0.0040 in.
-0.0035 in.

**Track location 1: ± 0.0025 in.

Figure 19. Track Spacing for Seven- and Nine-Track Tape



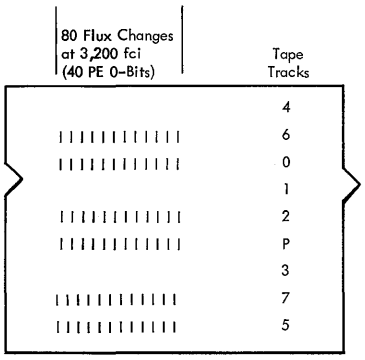
Minimum Data Block Lengths

Phase Encoded	Not Specified
Nine-Track NRZI	18 Bytes (Write) 12 Bytes (Read)
Seven-Track NRZI*	18 Characters (Write) 12 Characters (Read)

*Nominal, actual minimum block lengths vary slightly among using systems.

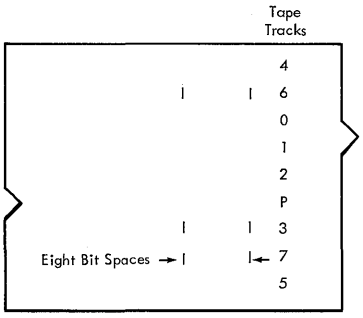
Figure 20. Data Block Format

Nine-Track PE Tape Mark



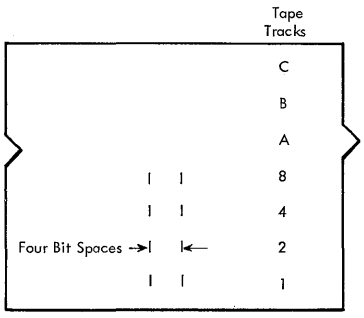
A PE tape mark is a special control block that consists of at least 80 flux reversals at 3,200 fci in data tracks P, 0, 2, 5, 6, and 7. Tracks 1, 3, and 4 are dc-erased. For recognition, the tape mark must contain at least 64 flux reversals in data tracks P, 0, and 5 (zone 1) or tracks 2, 6, and 7 (zone 2), with tracks 1, 3, and 4 (zone 3) dc-erased. Although the tape mark is preceded by approximately 3.75* inches of erased tape, this gap is not a requirement.

Nine-Track NRZI Tape Mark



A nine-track NRZI tape mark is a special control block that consists of a character with 1-bits in data tracks 3, 6, and 7, and an identical LRC character eight bit spaces from it. No CRC character is written. Although the tape mark is preceded by approximately 3.75* inches of erased tape, this gap is not a requirement.

Seven-Track NRZI Tape Mark



A seven-track NRZI tape mark is a special control block that consists of a character with 1-bits in data tracks 8, 4, 2, and 1, and an identical LRC character four bit spaces from it. Although the tape mark is preceded by approximately 3.90* inches of erased tape, this gap is not a requirement.

* Varies with tape unit speed and mechanical adjustment.

Figure 21. Tape Mark Block Format

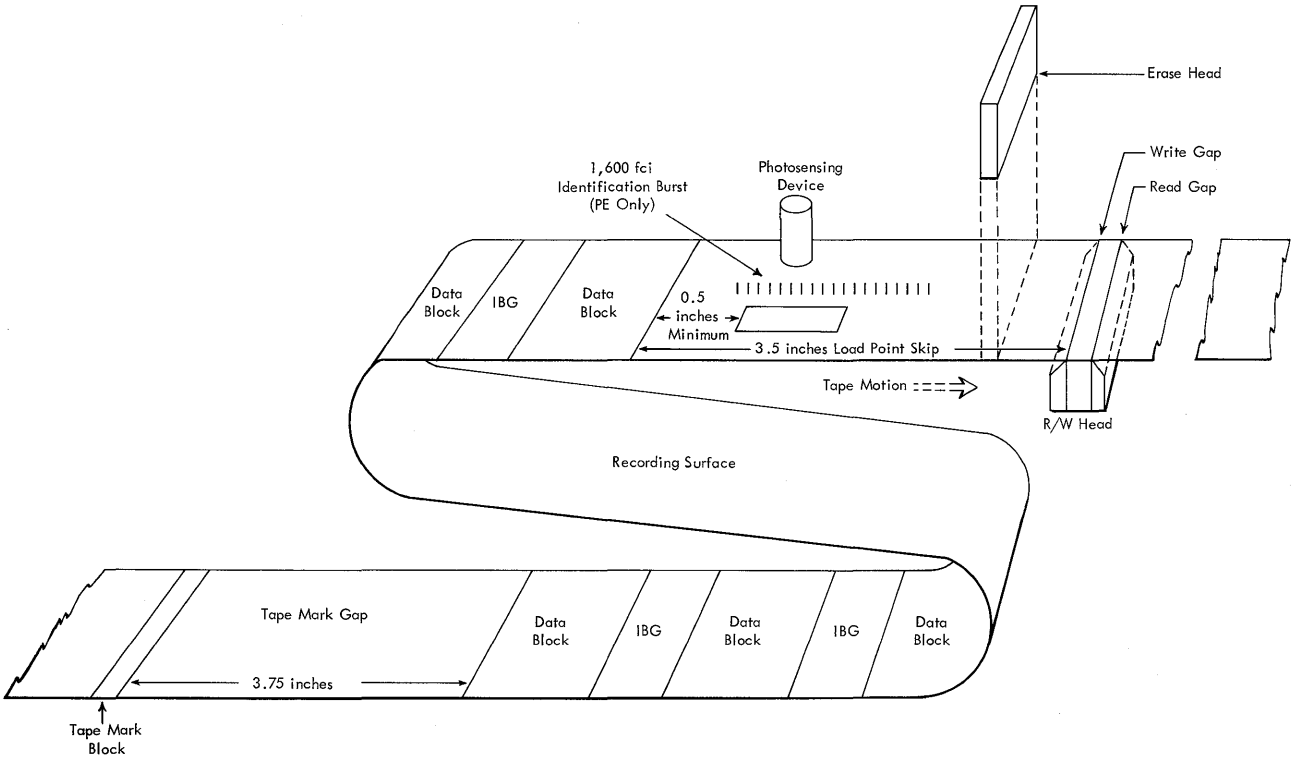
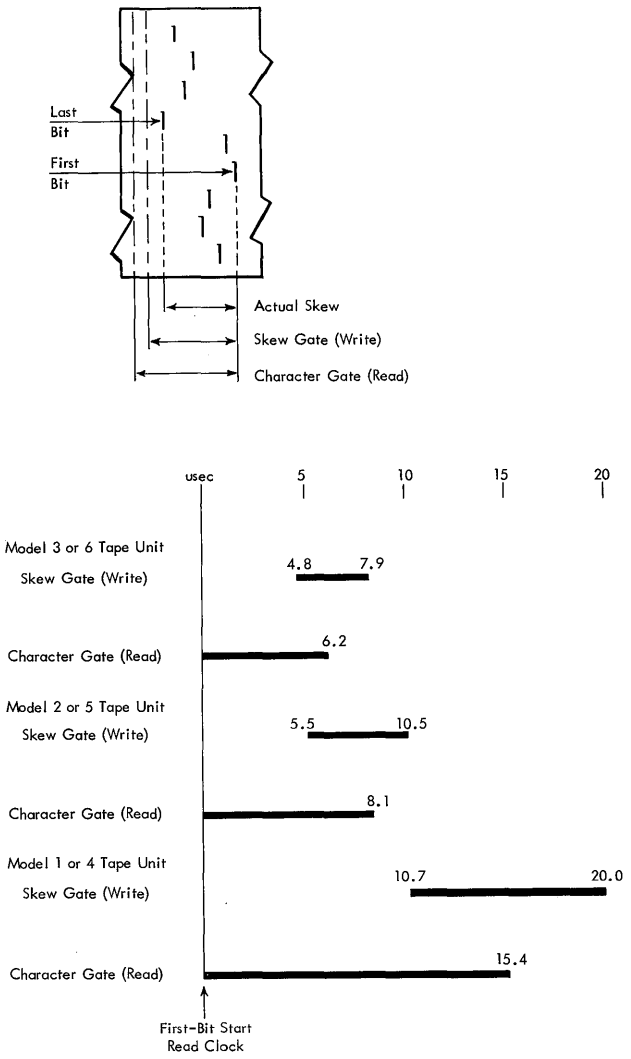


Figure 22. Organization of Blocks on Tape



Note: All timings +8 percent, -10 percent.

Figure 23. Skew Gate and Character Gate Timing--Nine-Track NRZI (2803-2)

3. Set write skew to less than 0.18 usec (Model 3 or 6 tape units), 0.27 usec (Model 2 or 5 tape units), or 0.54 usec (Model 1 or 4 tape units) at the read bus of the tape unit when reading while writing continuous 1-bits.

Time Asymmetry: For read pulses, time asymmetry shall not exceed 0.5 usec (Model 6 tape units), 0.75 usec (Model 5 tape units), or 1.0 usec (Model 4 tape units).

Interchangeability: To ensure complete interchangeability, maximum variations within a character (assuming proper skew and asymmetry alignment as in preceding text) for any reel of tape, read by any tape unit connected to any tape control, must be equal to or less than the read character gate for the tape speed at which the tape is being read.

This requirement can usually be met by applying the following rules to the control unit timings (Figure 23) for the 2400-series tape units:

1. When writing, the time between bytes should not be less than the fall of the skew gate plus 1 usec, including variations because of tape speed, skew, and bit configuration.

2. When reading, the time between bytes should not be less than the end of the read character gate plus 1 usec, including variations because of tape speed, skew, and bit configuration.

Write Clipping Level: See Figure 24.

Tape: IBM part 432349 or equivalent.

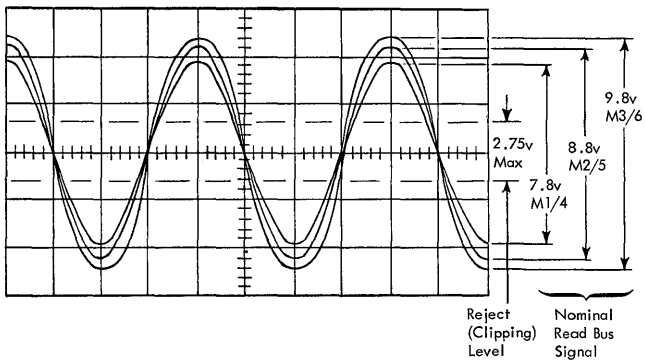


Figure 24. Read Backward Checking of Nine-Track NRZI Write Operation

Recording Formats for Nine-Track, 1,600-bpi Tape

Recording Method (PE): Tape is saturated in each direction. Flux reversals are written for both 1- and 0-bits. When tape is moving forward, a flux reversal to the magnetic polarity of erased tape at bit-shift time is a 1-bit, and a flux reversal to the polarity opposite that of erased tape at bit-shift time is a 0-bit.

Erasure: Tape is fully saturated in the erased direction in the initial gap and interblock gap areas. Any erased section of tape has its north magnetic pole in the direction of the beginning-of-tape (load point) marker and its south magnetic pole in the direction of the end-of-tape marker.

PE Identification Burst: A 1,600 bpi PE tape is written with an identification burst at load point. This burst consists of 1,600 flux reversals per inch in track P; all other tracks are erased. The PE burst must begin at least 1.7 inches before the trailing end of the beginning-of-tape marker and continue past the trailing end of the beginning-of-tape marker (Figure 18).

Track Spacing: See Figure 19.

Parity: A vertical parity bit is written in track P for each data byte that contains an even number of data bits.

Data Block Format: Data bytes in each block are preceded by a 41-character preamble and followed by a 41-character postamble. The preamble contains 40 characters with 0-bits in all tracks, followed by one character with 1-bits in all tracks. Data bytes immediately follow the preamble. The postamble contains one character with 1-bits in all tracks, followed by 40 characters with 0-bits in all tracks. The postamble immediately follows the last data byte (Figure 20).

Interblock Gap (IBG): The size of the IBG is 0.50 inch minimum, 0.60 inch nominal, measured from the end of the postamble to the start of the preamble of the next block. The preamble of the first block must begin not less than 0.50 inch from the end of the PE identification burst and 0.50 inch from the trailing end of the load-point marker (Figure 18).

Tape Mark: See Figure 21.

Organization of Blocks on Tape: See Figure 22.

Skew Alignment: For complete interchangeability, adjust mechanical skew by scoping the outside tracks (4 and 5) while reading a master skew tape, IBM part 432362. Tape must then be written with less than 560 microinches of skew (all sources) at 1,600 bytes per inch (5.0 usec at 112.5 ips–Model 6 tape unit). Maximum skew for any reel of tape, read by any tape unit connected to any tape control, must be equal to or less than 1.8-bit times for the tape speed at which the tape is being read.

Write Check Level: Level is 15 percent of the nominal read bus amplitude.

Tape: IBM part 457893 or equivalent.

Recording Formats for Seven-Track Tape

Recording Method (NRZI): One-bits produced by each reversal of flux polarity. Tape is fully saturated in each direction.

Erasure:

1. Tape is fully saturated in the erased direction in the initial gap and interblock gap areas. Any erased section of tape has its north magnetic pole in the direction of the beginning-of-tape (load point) marker and its south magnetic pole in the direction of the end-of-tape marker.
2. The erased area of the initial gap must begin at least 1.7 inches before the trailing end of the beginning-of-tape marker (Figure 18).

Track Spacing: See Figure 19.

Parity: Seven-track tape can be written in either odd or even parity. A parity bit is written in track C for each data character that does not have the desired parity (odd or even).

Longitudinal Redundancy Check Character: A LRC character makes each track's bit count even for that block, and the LRC character is written four bit spaces from the end of each data block or tape mark character (Figure 20). The LRC character is deskewed in the same manner as data characters.

Tape Mark: See Figure 21.

Interblock Gap (IBG): The size of the IBG is 0.680 inch minimum, 0.750 inch nominal, measured from the LRC character to the first data character of the next block (Figure 22).

Organization of Blocks on Tape: See Figure 22.

Tape: Tape format must conform to all 729 specifications. Tape should also meet IBM tape specifications at a density not less than the recorded density.

CABLING

IBM will supply the necessary cables as mentioned in this manual. The cables will be supplied up to the maximum lengths specified. All cables must be ordered through the IBM Sales Representative and by the appropriate cable group number only. The IBM part numbers relating to the cables are listed for design information only. Figures 25 and 26 give signal and power cabling information for the 2400-series tape units.

In the interest of safety, all IBM machines shipped to the customer have been equipped with grounded cord plugs. No other type of plug will be supplied by IBM. If any machine in a group is grounded, all other machines in the group must be grounded. Grounded machines must be placed so that it is impossible to touch simultaneously a grounded machine and an ungrounded machine, electrical equipment, metal cabinet, etc.

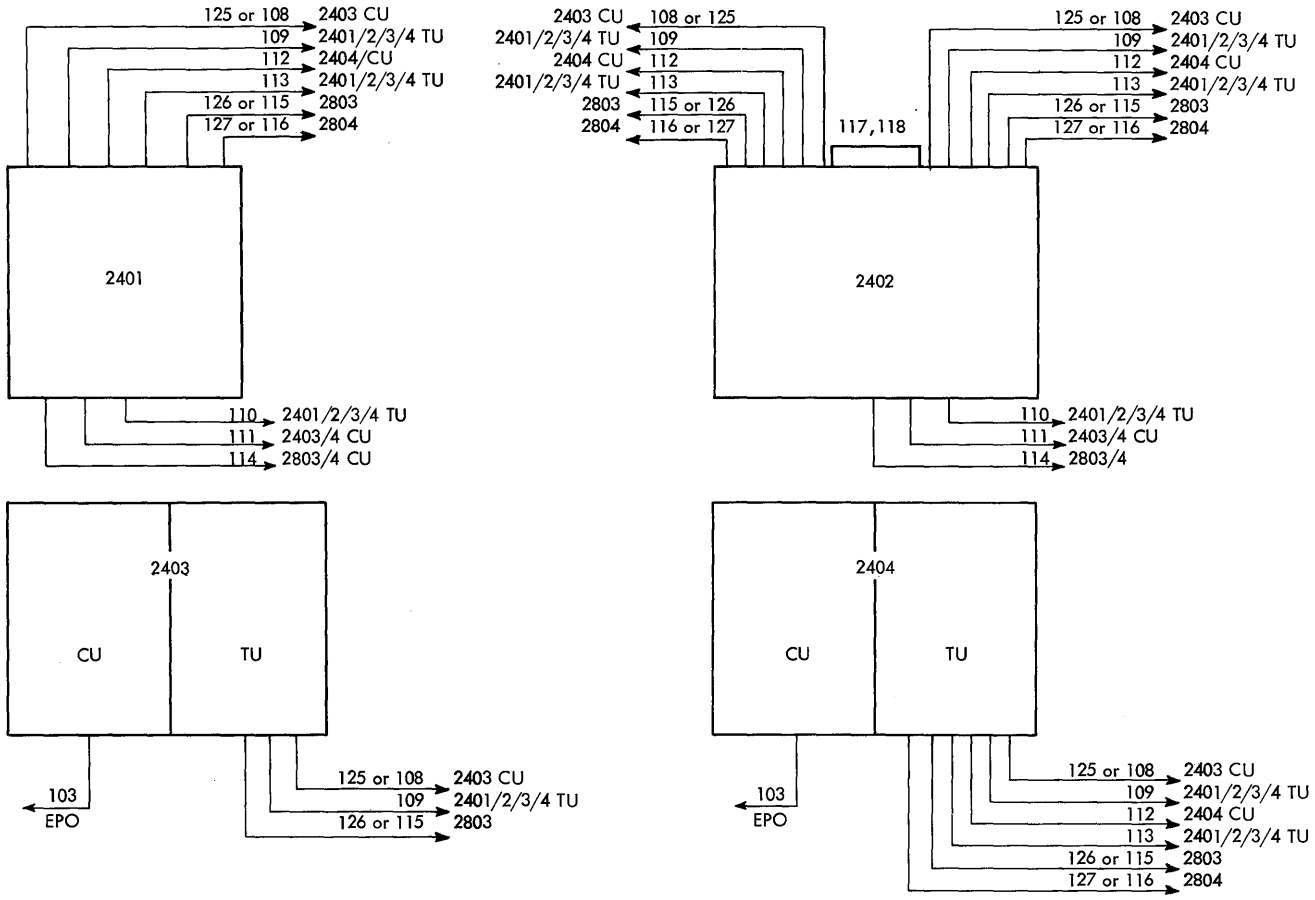


Figure 25. 2400 Cabling Schematic

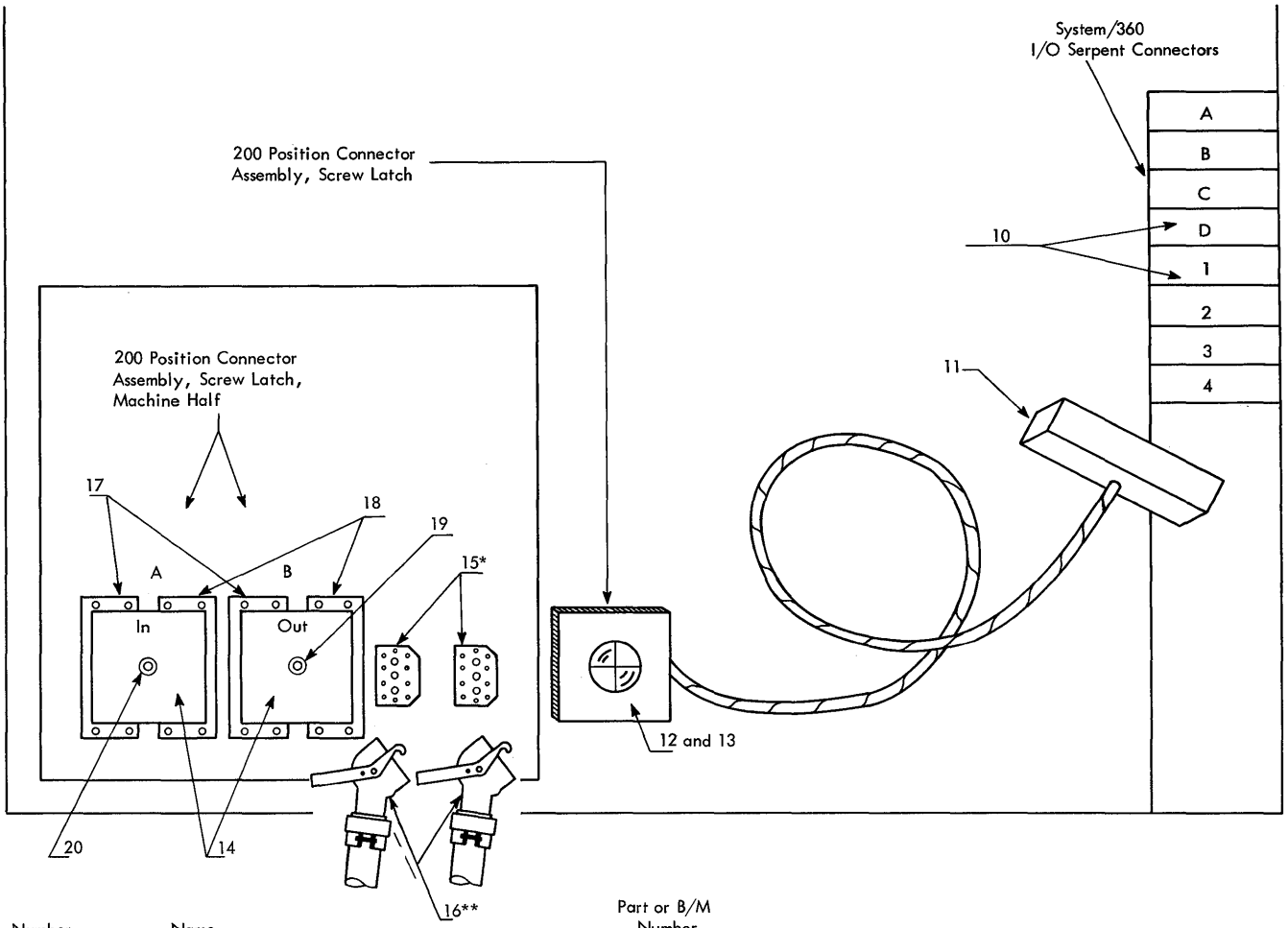
Cable Group Number	Key Number	Part Number	From	To	Purpose	Notes
	108A	5318935	2401/2/3/4 (TU) M1-3	2403 (CU) M1-3	Signal	1 and 3
108	108B	5356195			Terminator	
109	109	5356175	2401/2/3/4 (TU) M1-6	2401/2/3/4 (TU)M1-6	Signal	1
110	110	535098	2401/2	2401/2/3/4 (TU)	Power	2
111	111	535098	2401/2	2403/4 (CU)	Power	2
	112A	5373619	2401/2/3/4 (TU) M1-3	2404 (CU) M1-3	Signal	1
112*	112B	5373693			Terminator	
113*	113	5362289	2401/2/3/4 (TU) M1-6	2401/2/3/4 (TU) M1-6	Signal	1
114	114	535098	2401/2	2803/4	Power	2
	115A	5318935	2401/2/3/4 (TU) M1-3	2803 Model 2	Signal	1 and 3
115	115B	5356195			Terminator	
	116A	5373619	2401/2/3/4 (TU) M1-3	2804 Model 1	Signal	1
116*	116B	5373693			Terminator	
117	117	5356178	2402	2402	Signal	
118*	118	5363290	2402	2402	Signal	
125	125A	5318935	2401/2/3/4 (TU) M1-6	2403 (CU) M4-6	Signal	1 and 3
	125B	5417910			Terminator	
126	126A	5318935	2401/2/3/4 (TU) M1-6	2803 Model 2	Signal	1 and 3
	126B	5417910			Terminator	
127	127A	5373619	2401/2/3/4 (TU) M1-6	2804 Model 2	Signal	1
	127B	5417978			Terminator	

* Simultaneous Feature

Notes:
1. The total length of signal cables on any one tape channel, for a maximum of eight tape units, must not exceed 120 feet measured from control unit connector to tape connector on the last tape unit in line.
2. The maximum length cable provided for a single tape unit or between tape units in line is 25 feet (X dimension), measured from bottom of unit to bottom of unit.
3. No more than four tape units may be connected in line on each of the control unit power outlets.
4. Part numbers of the 48 position control unit connector and 200 position tape unit connector and mounting components are given in Figure 27.

Figure 26. 2400 Cabling Schematic Data

CONNECTORS



Number	Name	Part or B/M Number
10	S/360 I/O Serpent Connector	B/M 5362321
11	S/360 I/O Serpent Connector	B/M 5362313
12	Connector Asm, 200 Pos, Screw Latch (A)	Part 591752
13	Connector Asm, 200 Pos, Screw Latch (B)	Part 591751
14	Board	Part 598688
15	Power Receptacle (To Tape Units)	Part 526516
15*	Power Receptacle (From CU or Preceding TU)	Part 526517
16	Power Plug Housing	Part 535077
16**	Power Plug Insert (To Tape Units)	Part 526517
16**	Power Plug Insert (From CU or Preceding Tape Unit)	Part 526516
17	Guide	Part 598251
18	Guide	Part 598247
19	Retainer Assembly	Part 591759
20	Retainer Assembly	Part 591758

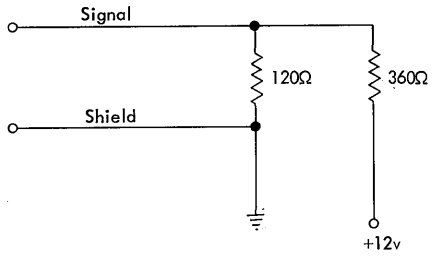
Parts Not Shown:

Contacts (200-Position)	
For #20 - 24 wire	Part 598041
For #16 - 18 wire	Part 596224
For #26 - 29 wire	Part 596224 (Use with stuffer Part 596230)
Screw, Guide Mounting	Part 28413

Figure 27. 2401/2/3/4 Connector and Component Part Numbers

DRIVERS AND TERMINATORS

Figures 28-44 show transistor circuits used to drive, receive, and terminate the lines between the control unit and tape units.



This is a representative circuit of those used in the terminator connector (part 5356195) which must be inserted in the connector B position of the last tape unit in a line. (Terminator part 5373693 would be used for tape units with simultaneous feature.)

Figure 28. Line Terminator, Models 1-6

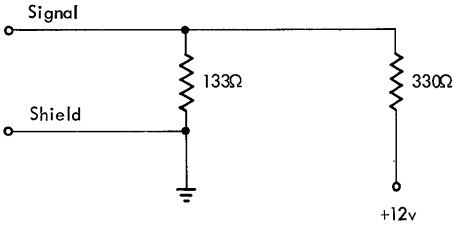


Figure 29. Write Bus Terminator, Models 4-6

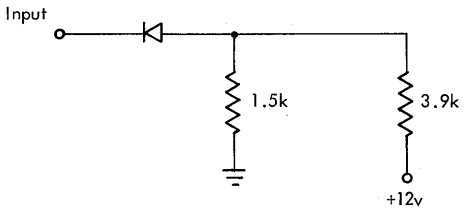


Figure 30. Tape Unit, Models 1-6, Metering-Out Line Termination

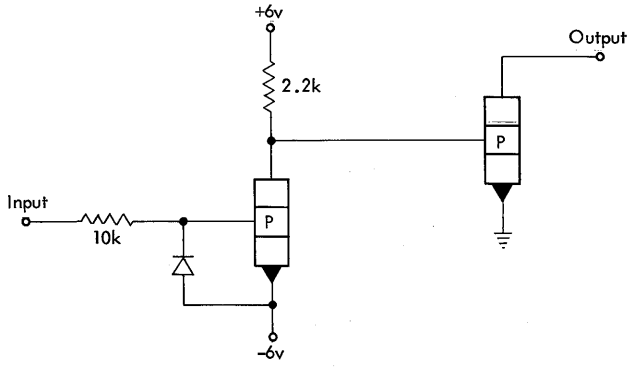


Figure 31. Tape Unit, Models 1-6, Line Driver

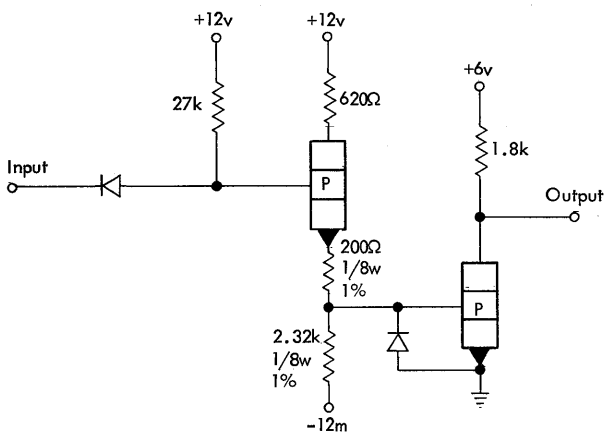


Figure 32. Control Unit, Models 1-6, Line Receiver

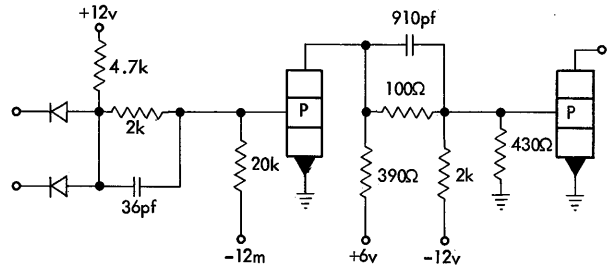


Figure 33. Control Unit, Models 1 and 2, Signal Line Driver; Control Unit, Model 1, Write Bus Driver

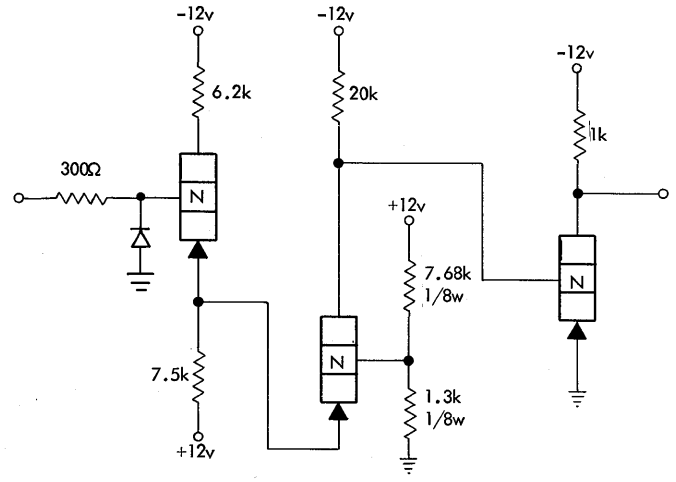


Figure 34. Tape Unit, Models 1-6, Line Receiver; Tape Unit, Models 1-3, Write Bus Receiver

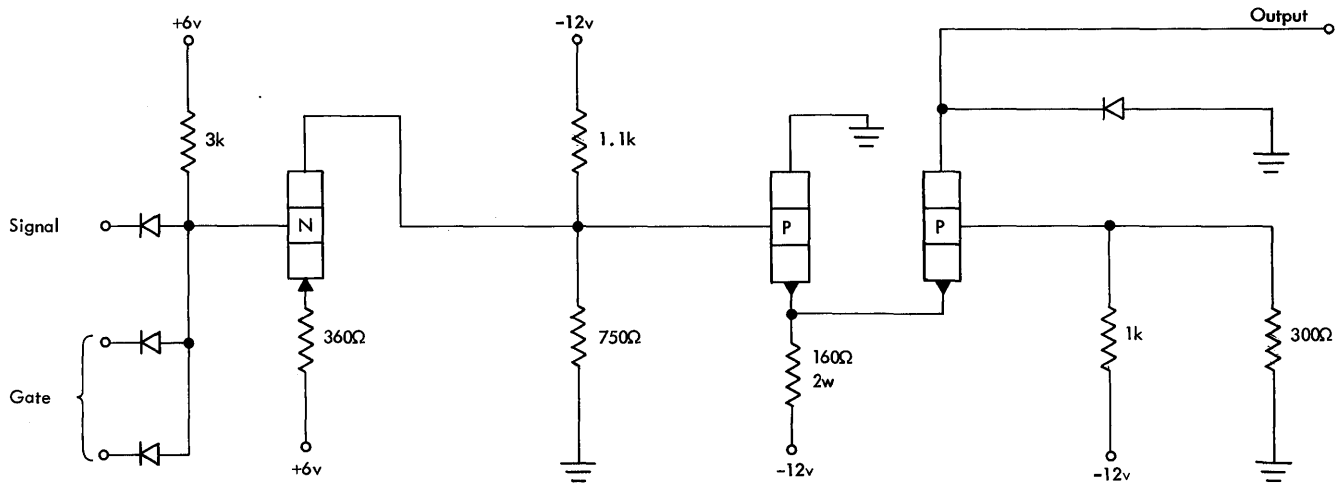


Figure 35. Control Unit, Model 2, Write Bus Driver

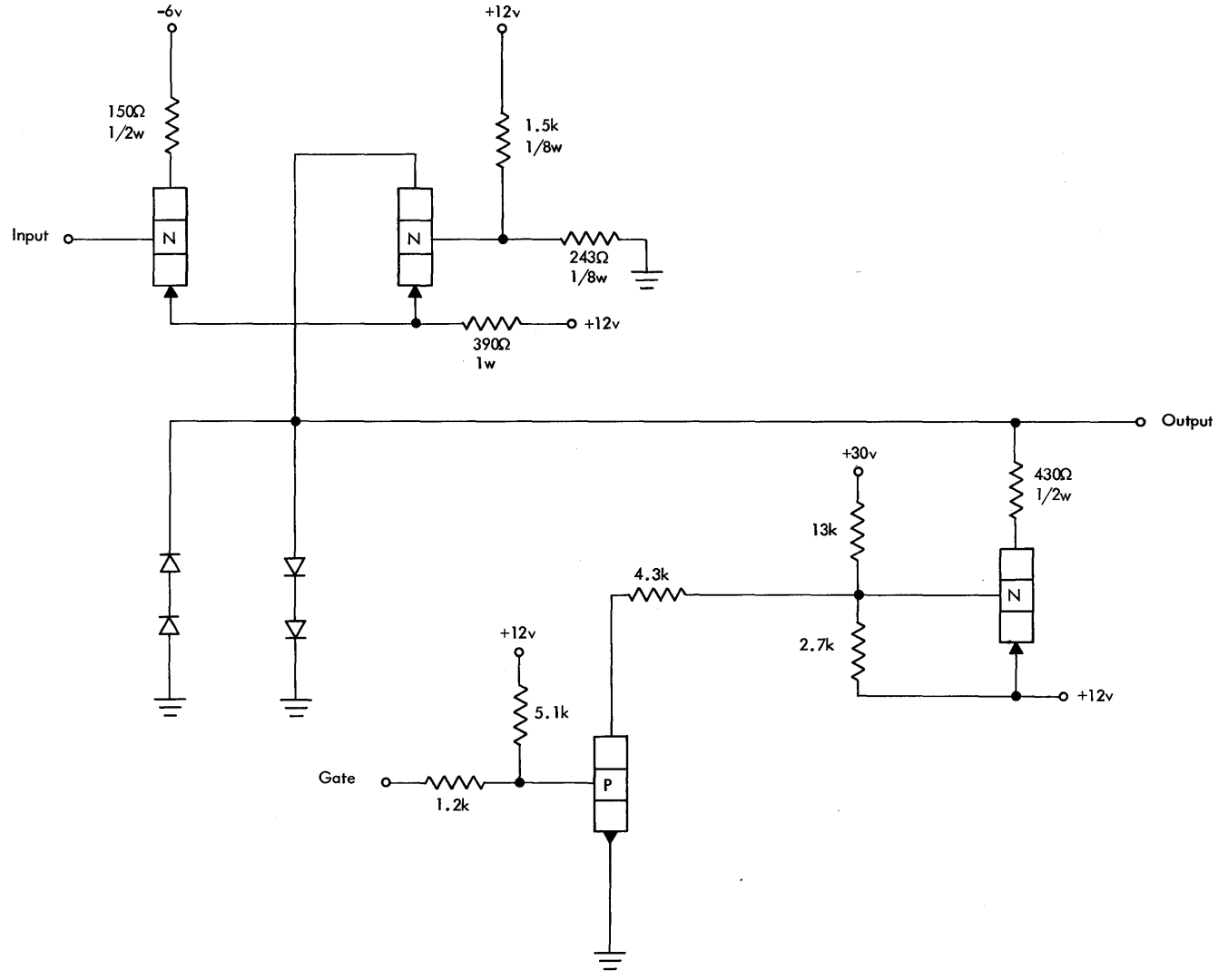


Figure 36. Tape Unit, Models 4-6, Write Bus Receiver

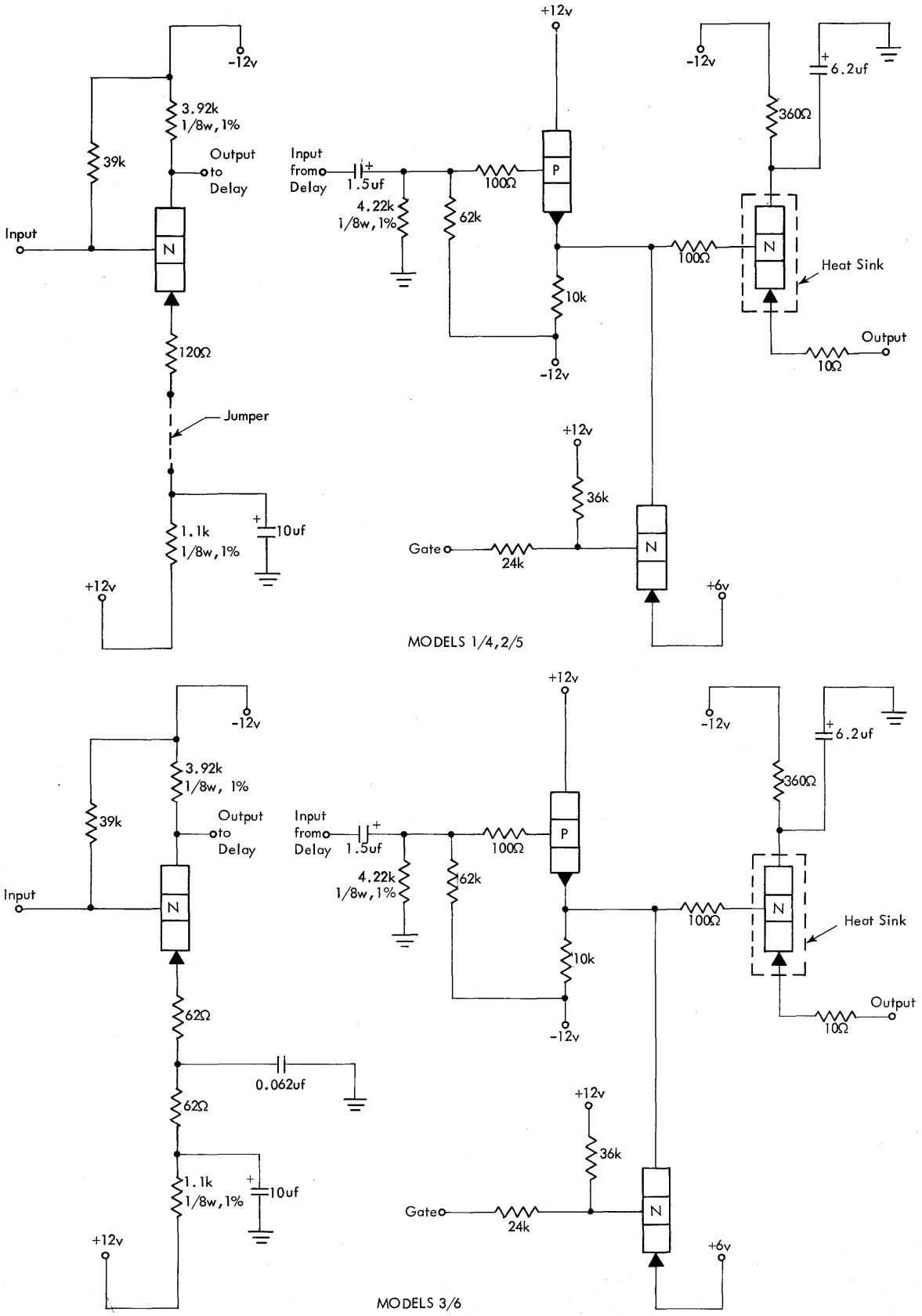


Figure 37. Tape Unit Read Preamplifier Number 2, Models 1-3 and 4-6 NRZI

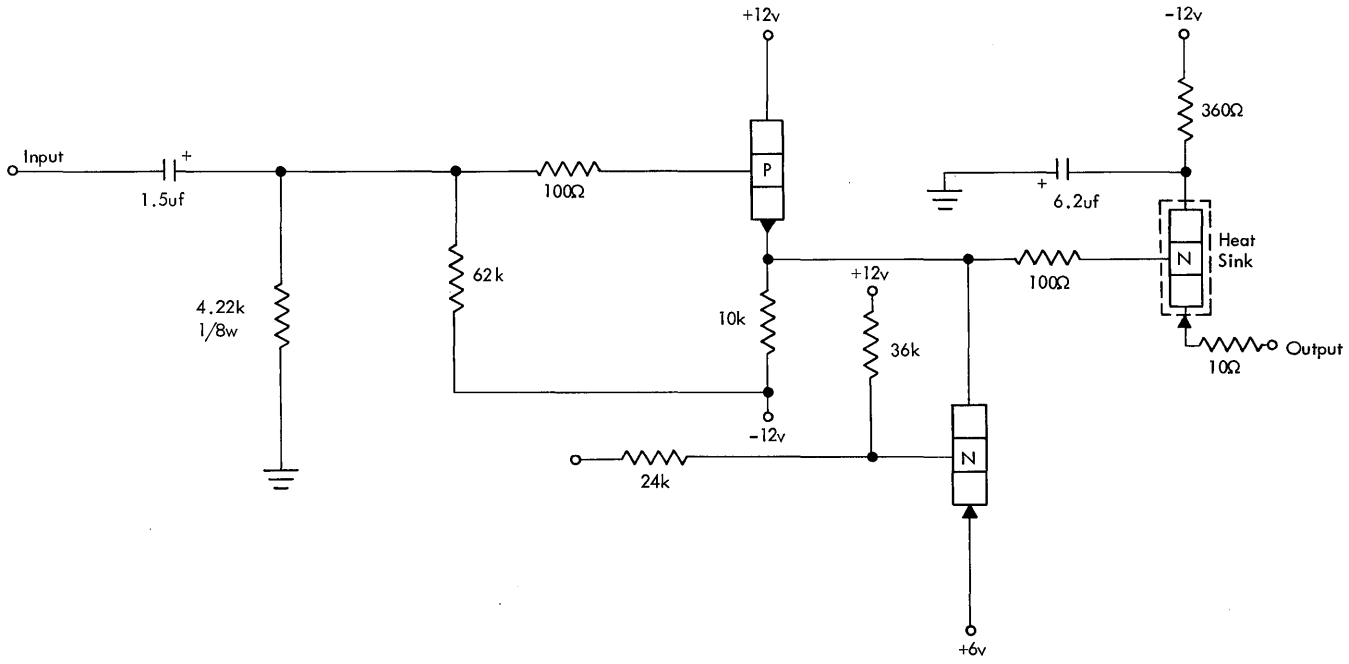


Figure 38. Simultaneous Preamplifier, Models 4-6 NRZI

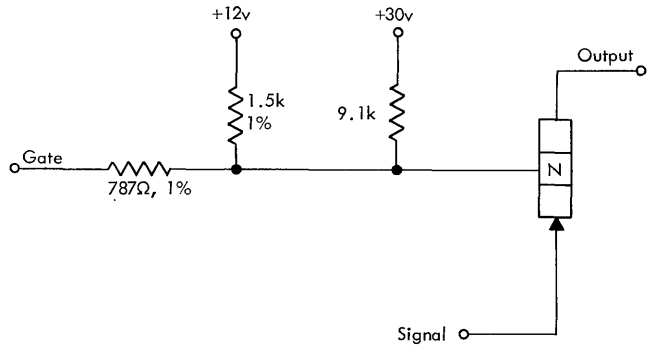


Figure 39. Simultaneous Preamplifier, Models 4-6 PE

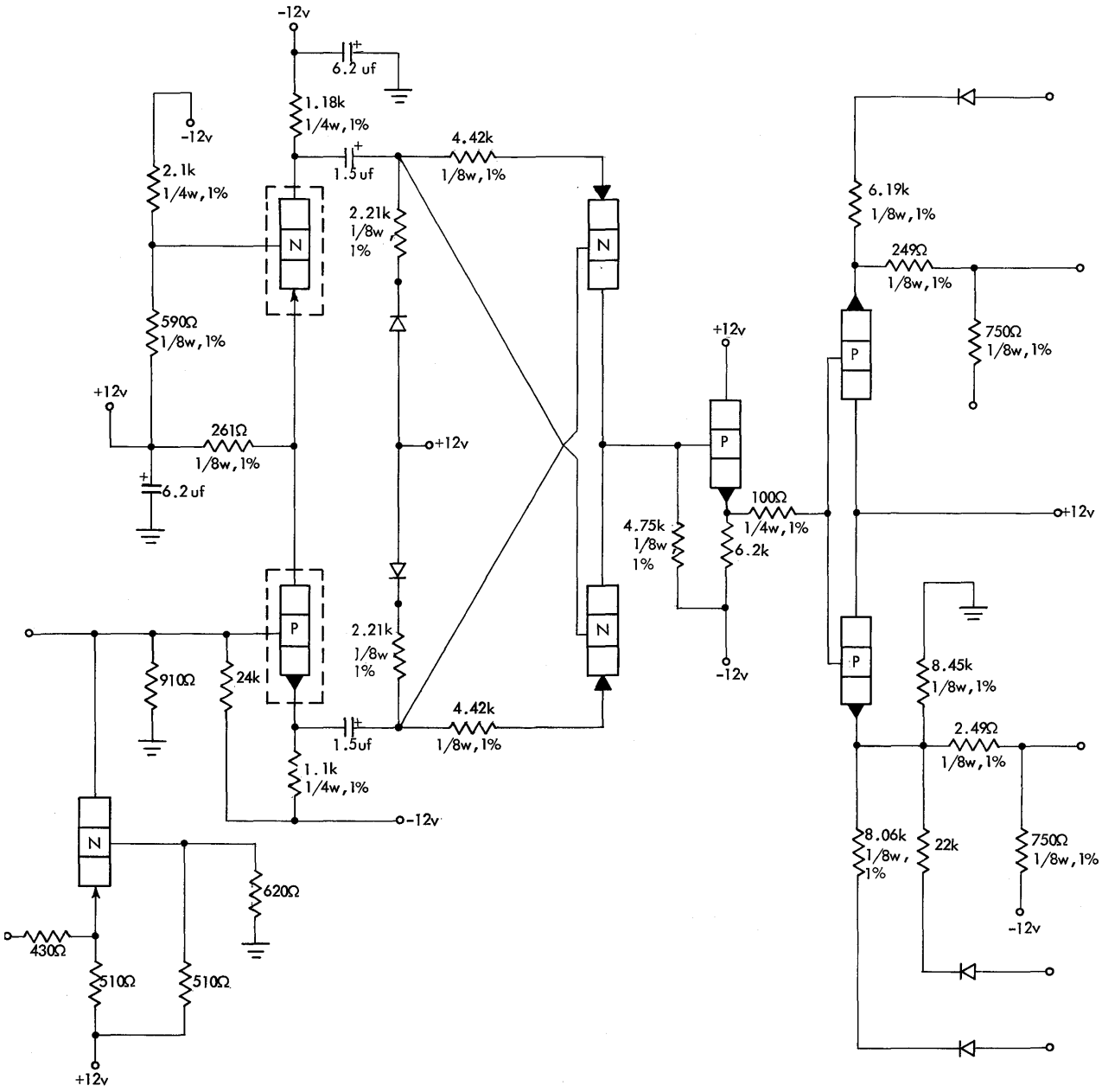


Figure 40. Control Unit Read Bus, Models 1 and 2, Receiver NRZI

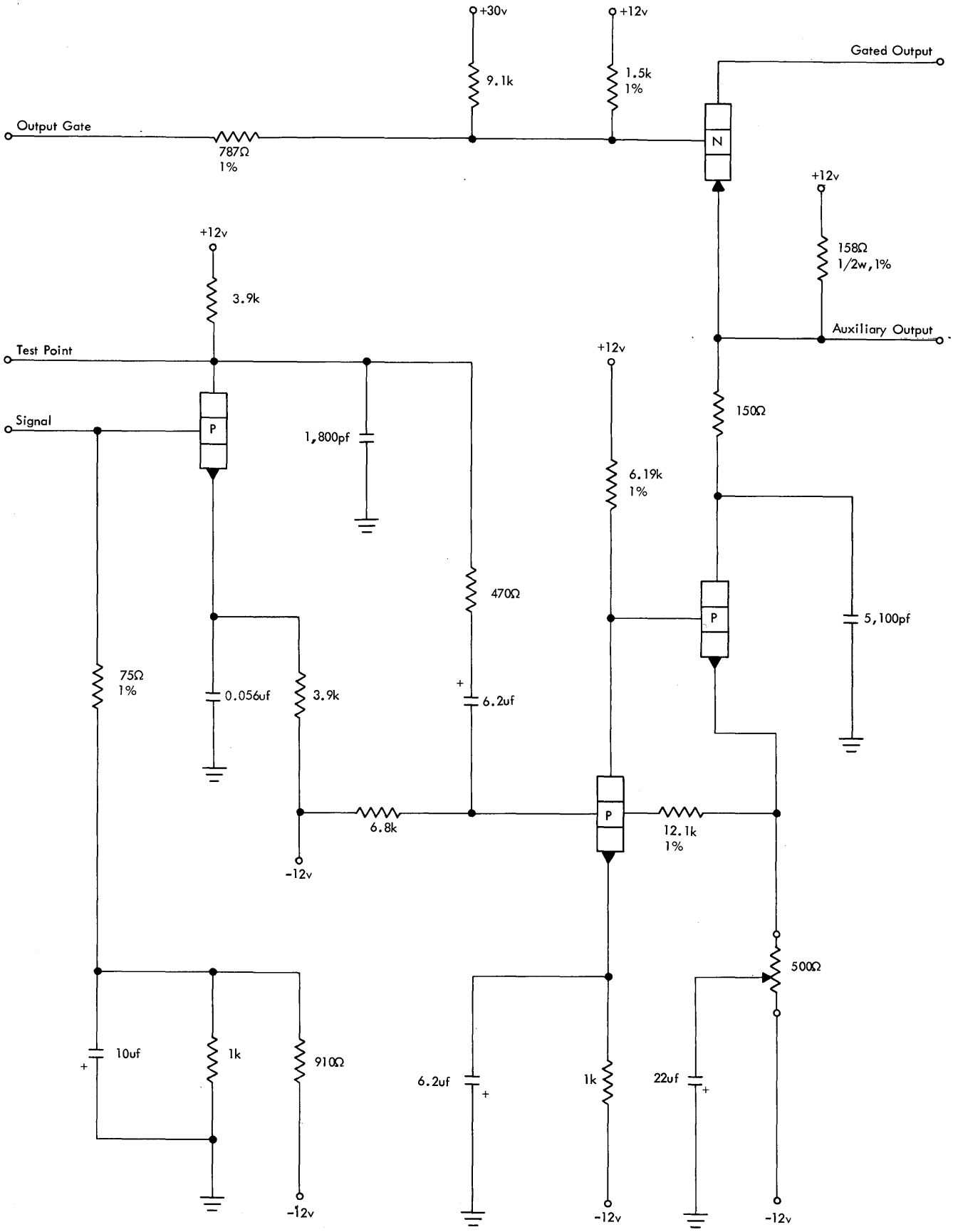


Figure 41. Tape Unit Read Preamplifier, Model 4 PE

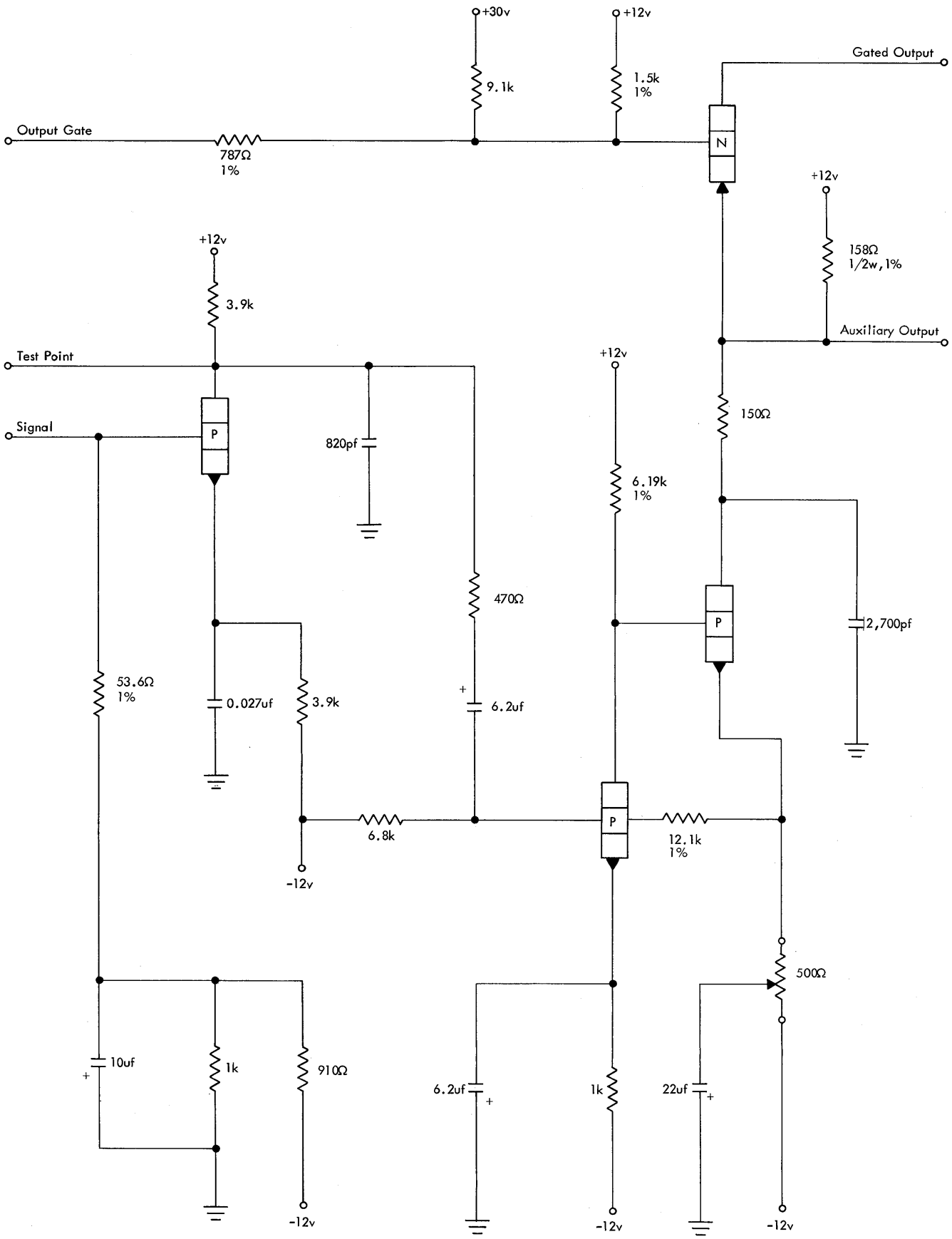


Figure 42. Tape Unit Read Preamplifier, Model 5 PE

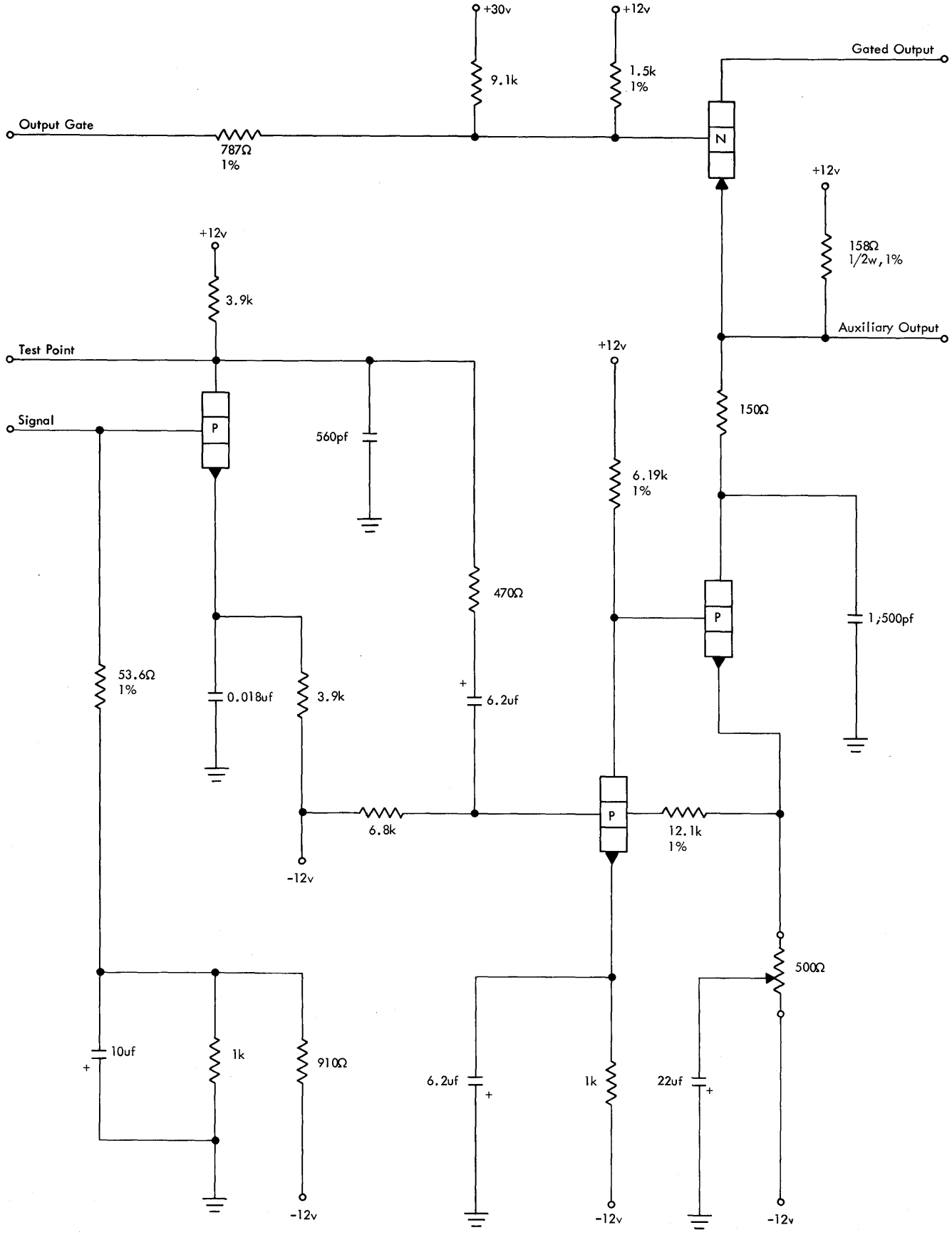


Figure 43. Tape Unit Read Preamplifier, Model 6 PE

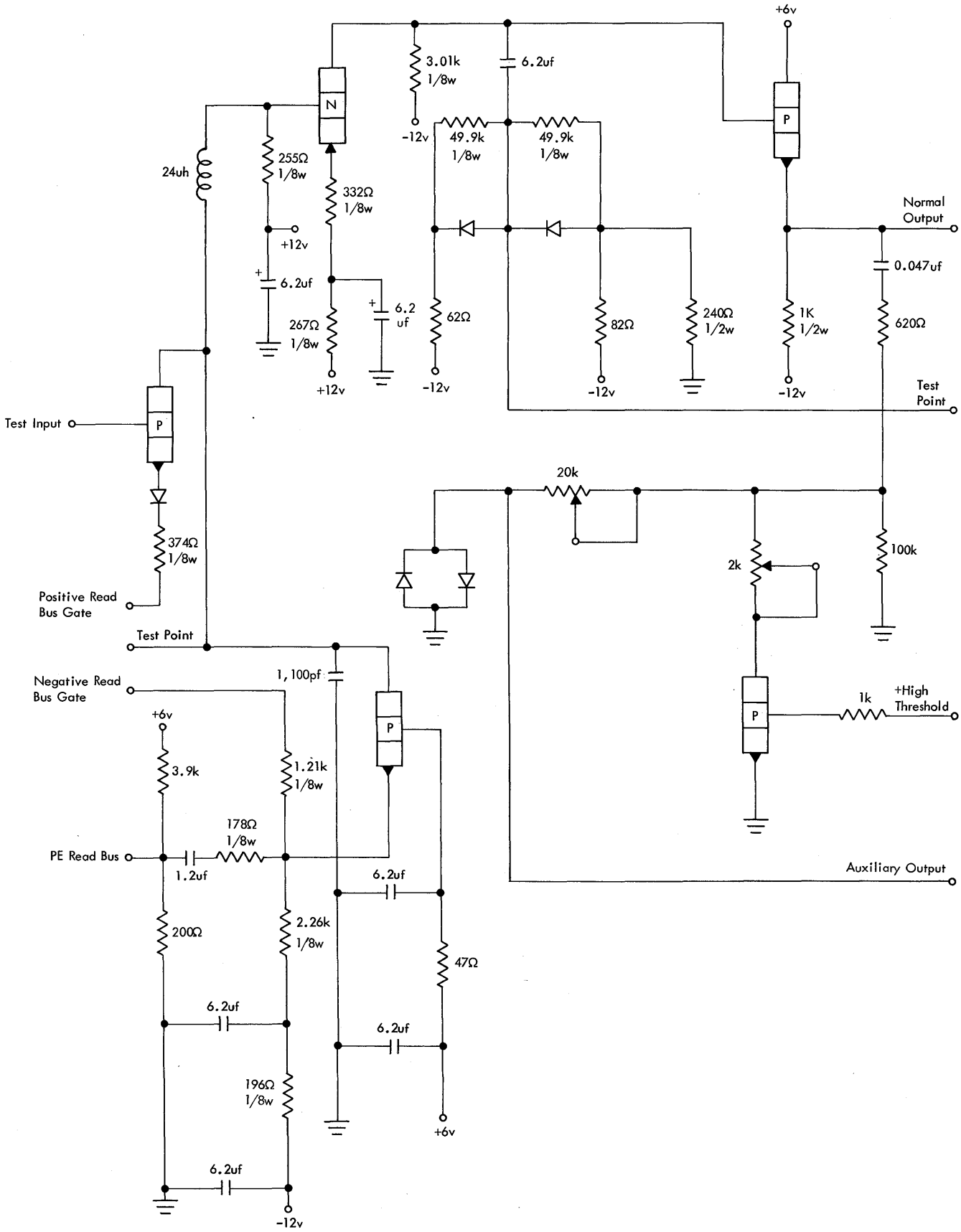


Figure 44. Control Unit, Model 2, Read Bus Receiver PE

A field tester, part 5420330, is used when performing off-line maintenance on 2400-series magnetic tape units. External power cable (part 460663) is required to power the tape unit and tester. To check tape unit operation, set the model switch on the tester to appropriate model number. Turn tape power off, connect the tester cable to tape unit signal connector A, and insert a line terminator (part 5417910) in signal connector B. Turn tape power on. Mount and load a work tape.

If the tape indicate indicator is on in the tape unit, space tape away from load point and press the rewind pushbutton to reset the tape indicate trigger. The tape unit must be in ready status for the rewind pushbutton to be effective.

FIELD TESTER CONTROLS AND SIGNAL HUBS (FIGURE 45)

Switches

Rewind/Unload

This spring-loaded switch sends a rewind/unload signal to the tape unit to rewind and unload tape if the start/stop switch is in the stop position.

Rewind

This spring-loaded switch sends a rewind signal to the tape unit to rewind tape to load point if the auto-cycle switch is off.

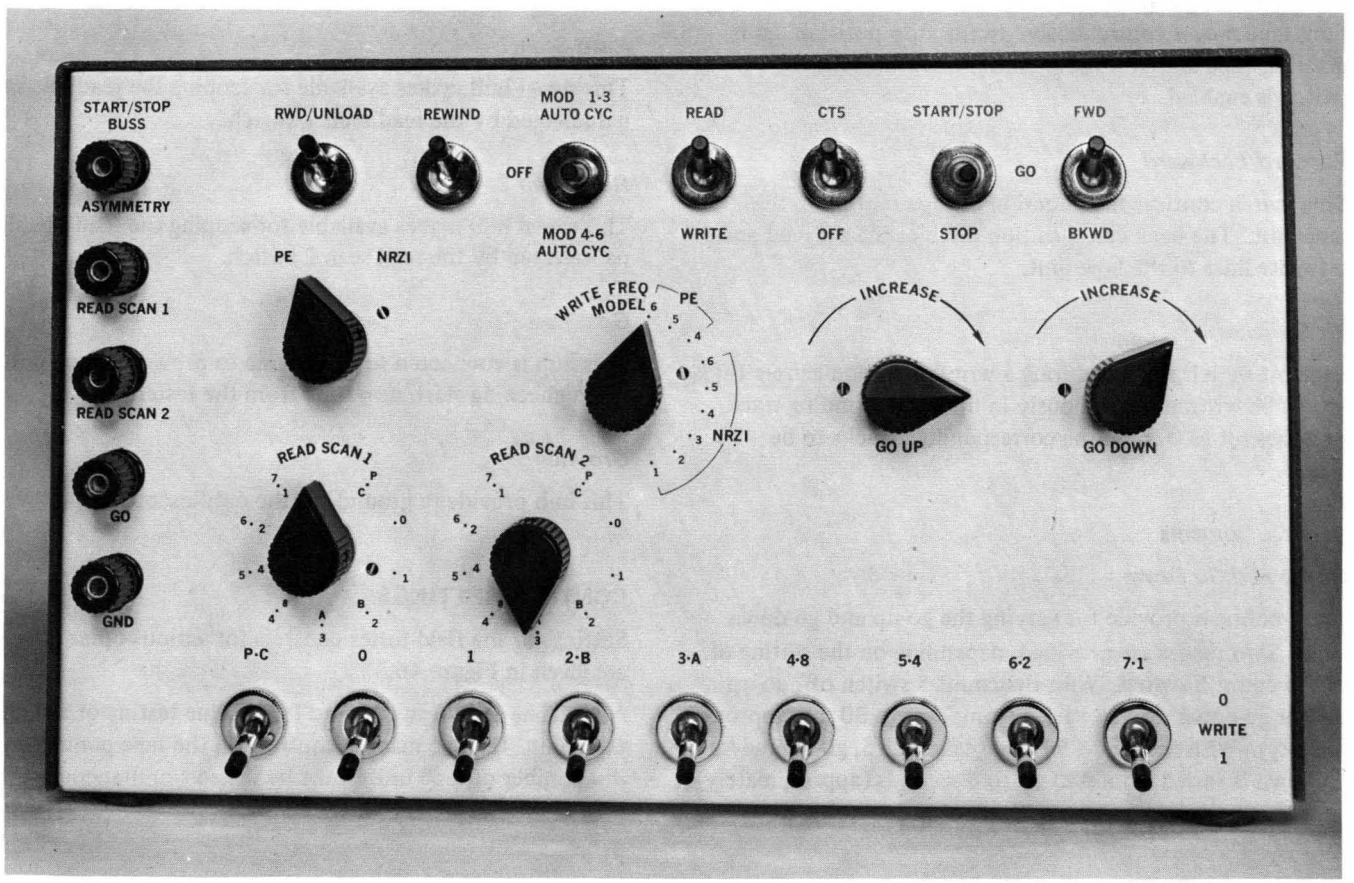


Figure 45. 2400-Series Models 1-6 Field Tape Tester

Auto-Cycle

This two-position switch is set to the auto cycle position to cause a rewind signal to be gated to the tape unit when the end-of-tape reflective marker is sensed; in this position, the rewind switch is disabled. In the off position, it enables the rewind switch.

Read/Write

When the tape unit is ready and in forward status, this switch sets or resets the tape unit read/write status trigger.

Count 5

This switch provides two ranges for the variable go-up and go-down controls. When in the off position, go-up and go-down time may be independently varied from approximately 2 ms to 30 ms. When this switch is set to CT5, go-up and go-down may be varied from approximately 300 ms to 6 seconds, permitting the start/stop envelope to be checked for count 5 conditions.

Start/Stop

The starting and stopping of tape is controlled by this three-position switch. In the start position, tape moves intermittently under control of a multivibrator, the count 5 setting, and go-up and go-down controls. In the go position, tape moves continuously. In the stop position, go is inactive, tape does not move, and the rewind/unload switch is enabled.

Forward/Backward

This switch controls the direction of tape motion in the tape unit. The backward position disables the set read and set write lines to the tape unit.

Bit Switches

Each bit switch set to 1 during a write operation causes 1-bits to be written continuously in the corresponding track. Switches set to 0 cause the corresponding tracks to be erased.

Variable Controls

Go-Up and Go-Down

These controls provide for varying the go-up and go-down time. Two ranges are provided, depending on the setting of of the count 5 switch. With the count 5 switch off, go-up and/or go-down may be varied from 2 ms to 30 ms (approximately). With the count 5 switch set to CT5, go-up and/or go-down is varied from 300 ms to 6 seconds (approximately).

Write Frequency/Model

This rotary switch selects the proper recording mode and write frequency for the model of tape unit being tested.

Mode

This two-position rotary switch selects the proper circuitry for either PE or NRZI recording, as required by the model of tape unit being tested.

Read Scan 1

This rotary switch connects any one of the nine read buses to the read scan 1 signal hub. This same read signal is amplified and available for checking at the asymmetry jack if the mode switch is set to NRZI.

Read Scan 2

This rotary switch connects any one of the nine read buses to the read scan 2 signal hub.

Signal Hubs

Asymmetry

This signal hub provides a simulated final amplifier read signal that may be used to check NRZI asymmetry. See "Read Scan 1" under "Variable Controls."

Read Scan 1

This signal hub makes available for scoping the read bus signal selected by the read scan 1 switch.

Read Scan 2

This signal hub makes available for scoping the read bus signal selected by the read scan 2 switch.

Go

This hub is connected to the go line to provide a sync pulse when checking start/stop time from the tester.

Ground

This hub provides a ground for the oscilloscope.

CONTROL SETTINGS

Settings of the field tester controls for various operations are given in Figure 46.

Note: The field tester is used for off-line testing of a single tape unit. Use the manual controls on the tape control unit if a number of tape units must be tested simultaneously.

Operation	Switch	Setting	Scope	Observe
Write (all tracks)	Bit Switches	All "1"	Read Scan 1 Hub	Output of each track while writing. (Rotate Read Scan 1 Switch to view output from all tracks.)
	Write Frequency/Model	Model Number		
	Fwd/Bkwd	Fwd		
	Start/Stop	Go		
	Read/Write	Write		
	PE/NRZI	As required		
Read (continuous)	Read Scan 1	Any track containing information	Read Scan 1 Hub	Output of each read track while reading. (Rotate Read Scan 1 Switch to view output from all tracks.)
	Fwd/Bkwd	Fwd		
	Start/Stop	Go		
	Read/Write	Read		
Read Start/Stop	Read Scan 1	Any track containing information	Read Direct Sync on Go (1 ms/cm, 2v/cm)	Start/stop Envelopes
	Go-Up and Go-Down	Vary (See "Observe")		With Count 5 switch off, "Go-Up and Go-Down" time can be varied from 2 to 30 ms by turning Go-Up and Go-Down controls.
	Count 5	Either (See "Observe")		With Count 5 switch on, "Go-Up and Go-Down" time can be varied from 300 ms to 6 seconds, allowing check of start/stop envelope for Count 5 indication.
	Fwd/Bkwd	As desired		
	Start/Stop	Start		
	Read/Write	Read		
Read (Auto-Cycle)	Read Scan 1	Any track containing information		Tape unit reads forward continuously. When the EOT reflective marker is sensed, reading stops, and the tape unit rewinds to load point. Reading recommences automatically, and continues until EOT is again sensed.
	Fwd/Bkwd	Fwd		
	Start/Stop	Go		
	Read/Write	Read		

Figure 46. Field Tape Tester Control Settings

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