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MINIDEK

INTERFACE AND APPLICATION NOTES

NRZI OEM INTERFACE

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1. INTRODUCTION

The Digi-Data 1100 Series MINIDEK is a synchronous digital tape transport designed for use with computers and other digital systems. The transport can accommodate tape reels up to seven inches in diameter and will fit conveniently in desk drawers, table top systems and conventional equipment racks. The recording and reading of data is compatible in all respects with IBM compatible tape systems.

In typical applications one 7 inch reel of tape provides storage for 10 to 20 million bits. If punched card images are recorded in the usual format, one reel of tape will store approximately twelve thousand cards.

The MINIDEK includes all circuitry required to move the tape in response to system commands, record input data and convert tape read signals into data characters useful to the external formatter/controller. Control of data format, gap timing and error detection is provided by the external system. Several transports may be connected to a single controller for multiple unit applications.

The MINIDEK operating controls are simple to understand and use and provide for loading, rewinding and unloading the tape. All operating mode decisions are made by the controlling system.

Models are available with read only, write only, write/read or read-after-write capabilities. The read-after-write machines utilize separate write and read heads so that data can be read and verified almost immediately after writing.

This application note presents procedures for controlling Digi-Data NRZI transports. These transports are also available with formatting, computer interface and 1600 bpi phase encoding options which are described in separate publications.

These transports have been designed to be compatible with many controllers currently in use.

2. SPECIFICATIONS

REEL SIZE	7 inches (600 ft. of 1.5 mil tape)
TAPE SPECIFICATIONS	0.5 inches wide, 1.5 mil Computer Grade
TAPE SPEED	12.5 ips (other speeds optional)
REWIND SPEED	50 ips (nominal)
START/STOP TIME	30.0 msec ± 2.0 at 12.5 ips
START/STOP DISTANCE	0.19 inches ± 0.02
LONG TERM SPEED VARIATION	± 1%
INSTANTANEOUS SPEED VARIATION	± 3%
TAPE TENSION	6.5 ounces ± 0.5 ounce
RECORDING MODE	NRZI, IBM compatible
DATA DENSITY	200, 556, 800 cpi, NRZI
NUMBER OF TRACKS	7 or 9 (IBM compatible spacing)
ERASE HEAD	Full width IBM compatible
INTERCHANNEL DISPLACEMENT ERROR	150 microinches (max) at 800 bpi 200 microinches (max) at 556 bpi
BOT/EOT SENSORS	IBM compatible photoelectric sensors
ELECTRONICS	Solid state, Silicon
ELECTRICAL INTERFACE	DTL/TTL compatible (low true) Compatible with many existing controllers
POWER	105 to 125 VAC (220V Optional) 50 to 400 Hz, 1.2 amps
COMMAND DELAY	Motion commands must be separated by at least 32 milliseconds (maximum stop time)
MOUNTING	Standard 19 inch rack (EIA standard) Slides optional
WEIGHT	35 lbs.
DIMENSIONS:	
WIDTH	19.00 Inches
HEIGHT	8.75 Inches
DEPTH (Behind Panel)	9.00 Inches
DEPTH (Total)	11.00 Inches
OPERATING ENVIRONMENT	40 to 110°F., Humidity to 95% relative without condensation
ALTITUDE	0 to 10,000 ft.
CONFIGURATIONS AVAILABLE	Write only. Read only. Write/Read (Single gap head). Read-after-Write (Dual gap Head)

3. OPERATOR CONTROLS AND INDICATORS

3.1. CONTROLS

POWER	A pushbutton switch that applies power to the transport.
LOAD	A pushbutton switch that initiates the tape loading sequence. Pressing the switch will cause the reels to apply tension to the tape. The tape will then advance to the beginning of tape (BOT) mark and halt.
REWIND	A pushbutton switch that initiates rewind operation. Pressing the switch will place the tape transport OFF LINE, and rewind the tape to BOT. Pressing the switch when tape is at BOT will cause tape to unload from the take-up reel at low speed.
ON/OFF LINE	A pushbutton switch that places the transport in the ON LINE mode (enabling remote control) if tape is loaded. The transport may be placed OFF LINE at any time by pressing the switch again.

3.2 INDICATORS

POWER ON	This indicator is illuminated when power is applied to the transport.
ON LINE	This indicator is illuminated when the transport is in ON LINE status (under remote control).
RING IN	This indicator is illuminated when a write ring is on the supply reel, permitting writing or erasing of tape. If the indicator is not illuminated, no writing or erasing of tape is possible.

4. INTERFACING AND CONTROL

4.1 GENERAL

The MINIDEK transport will record and read IBM compatible tapes when properly controlled. This section provides application information for interfacing the OEM transport to read and record such tapes.

An optional formatted version of the transport is also available, and is described in another application note.

4.2 TAPE FORMAT

The data written and read by the transport should be formatted as shown in Fig. 1A for 7-track machines, and Fig. 1B for 9-track machines. The recording mode is non-return to zero, change on ones (NRZI). A "1" is recorded as a change in direction of magnetic flux on the tape, a "0" as no change. Each recorded character must contain at least one "1" to permit read synchronization.

Nine-track systems always employ track P to write an odd parity bit, which will be a "1" in the case of an all zero data character.

Seven-track tapes may be recorded with either an odd or even parity bit written in track P. When written with odd parity, the tapes are called binary tapes. Even parity produces BCD tapes. When writing a BCD (even parity) tape, the all zero data character must be converted to 001010 (binary ten).

Data is recorded on the tape in blocks (records) separated by erased areas created on transport starts and stops. The erased area is referred to as an Inter-Block Gap (IBG). The length of the IBG should conform to the dimensions shown in Fig. 1. The length of the blocks is not standardized and varies with the application. Block lengths of less than 10 characters are generally avoided.

Near the beginning and end of each reel of tape are reflective markers which are optically sensed by the transport. All tape before the Beginning of Tape (BOT) marker is considered leader. Data recording begins just beyond the BOT mark (load point) as shown in the diagrams. The End of Tape (EOT) marker gives a warning to the controlling system that the end is approaching.

Following each block of data special error detection characters must be written in the positions labeled CRCC (9-track only) and LRCC. The CRCC (Cyclic Redundancy Check Character) is a coded cyclic parity check character capable of unambiguously indicating which of the 9 tracks caused a parity error. The character is required for IBM compatibility.

The LRCC (longitudinal Redundancy Check Character) is composed of longitudinal even parity check bits for each track. The NRZI recording scheme is such that simply clearing the NRZI write register (in the transport) will produce the correct LRCC. A special transport input (Write LRCC) is provided to accomplish this. The LRCC should be in the eighth character position after the data (fourth character position on 7-track machines). The LRCC has odd vertical parity in 9-track transports. The LRCC may be even or odd parity in 7-track transports. Certain patterns of data on 7-track tape result in no LRCC character.

4.3 INTERFACE CIRCUITRY

The circuits that interface the MINIDEK with the external controller will operate with twisted pair cabling over distances of up to twenty feet. All line drivers in the transport are open-collector DTL 844/944 power gates. Terminating resistors for these drivers must be employed at the controller.

The resistors serve as collector pull-ups and line terminators to eliminate high frequency reflections and ringing. Fig. 2 illustrates a typical transmitter/receiver pair. Terminating resistors which load the controller are installed on the transport interface connector.

This interfacing scheme permits the connection of up to four MINIDEK units to a single controller on a "wired-or" bus. Each transport receives an individual enabling line (SELECT) from the controller, but shares all other lines on the bus. Additional transports may easily be added to the bus at any time.

The minimum recommended pulse width on the interface lines is 2 microseconds. Transport inputs which elicit immediate confirming responses from the transport may be narrower if they go false upon detecting the transport response.

4.4 INTERFACE SIGNALS

Table 1 lists all interface signals to and from the transport. All signals at the interface connector are Low True DTL/TTL compatible lines.

Logic Levels

True 0 to + 0.4 volts

False + 2.5 to + 5.5 volts

4.5 TRANSPORT CONTROL

The sections below describe procedures which will create and/or read IBM compatible tapes. The various time delays recommended are to some extent industry standards and are designed to produce clean, reliable tapes. Systems employing read only or write only machines or systems not requiring reverse read or backspace operations may be treated as special cases of the generalized controller described here.

4.5.1 WRITE OPERATIONS

The following sequence of events should occur when writing a record. Typical waveforms are shown in Fig. 3. Times are calculated for a tape speed of 12.5 ips. At other speeds the times should be adjusted to produce identical amounts of tape travel.

<u>Writing a Record</u>

1. Wait for deceleration delay associated with previous command to time out, thus ensuring that the tape is at rest.
2. Set FORWARD and WRITE MODE inputs true, starting tape motion.
3. Generate a delay T1 as follows:
   (a) Writing from BOT: 280 msec.
   (b) Writing an EOF: 280 msec.
   (c) Writing, not at BOT:
      1. Single gap head machine: 46 msec
      2. Dual gap head machine: 34 msec.
4. Following delay T1 apply WRITE CLOCK pulses and WRITE DATA inputs to transport. Each WRITE CLOCK strobes in the

7 or 9 track data character and causes the character to be written on the tape. The WRITE CLOCK frequency should be 10.0 Khz ± 0.25% at 12.5 ips for 800 bpi recording. Frequencies for other modes can be calculated by multiplying tape speed by density (ips x bpi = Hz).

5. When the desired record has been written, suppress the first 3 unneeded WRITE CLOCK pulses.

6. During the fourth WRITE CLOCK apply the CRCC character to the WRITE DATA inputs. See below for information on calculating the CRCC. After writing the CRCC suppress WRITE CLOCK for the remainder of the operation.

7. Four WRITE CLOCK intervals later (eighth non-data clock pulse) generate a 2.0 microsecond pulse on the WRITE LRCC input of the transport, writing the LRCC on the tape.

8. Proceed to step 9 for single gap machines. If the machine is a dual gap (read-after-write) unit, wait until the end of the record is observed by the read circuitry (approximately 12 milliseconds).

9. Generate a post-record delay (T2) of 6.0 milliseconds. This delay ensures erasure of any previously written data.

10. Set the FORWARD input false after delay T2. The tape will decelerate and come to rest within 32 milliseconds. Do not apply any motion commands during the deceleration period.

<u>NOTE:</u>

For 7-track machines the above procedure is modified by omitting the CRCC write operation and writing the LRCC at the fourth clock time. Additionally, some of the recommended time delays change as shown in Table 2.

Writing an End of File

A 9-track End of File (EOF) mark is written by setting WRITE DATA bits 3, 6 and 7 true and writing a one character record. An EOF must not contain a CRCC but must include the LRCC.

A 7-track EOF is written by setting WRITE DATA bits 1,2,4 and 8 true and writing a one character record with its LRCC.

Both 7 and 9 track EOF marks should be separated from the previous record by 3.5 inches of blank tape. This requirement is provided for in step 3 above by extending delay T1.

Erasing

Erasing normally occurs automatically while writing. A special erase procedure is desirable for skipping over unusable areas of tape. Any of the following procedures may be employed:

1. Backspace over the improperly written record and re-write it. If all time delays are implemented as recommended, then each time this is done the record will be about one eighth inch further down the tape.

2. Backspace over the erroneous record. Re-write the record with T1 set to the write-from-BOT delay. This operation is called a "skip-write" and skips about 3.5 inches of tape.

3. Backspace over the improperly written record and then write an EOF. Backspace over the EOF and re-write the record over the EOF. This operation will leave a 4 inch erased area on the tape.

   The generation of extended gaps to avoid unusable areas of tape does not impair compatibility with IBM machines.

4.5.2 READ OPERATIONS

Fig. 4 illustrates the waveforms associated with a read operation. The sequence of events is as follows:

Reading a Record

1. Wait for the deceleration delay associated with the previous command to time out, thus ensuring that the tape is at rest.

2. Set the FORWARD input true with the WRITE MODE input held false.

3. Generate a pre-record delay (T1) of 24 milliseconds (120 milliseconds at BOT). Any data appearing during this per iod should be suppressed.

4. Accept READ CLOCK pulses and READ DATA bits from the transport. Process as desired. Each received character should be checked for proper vertical parity. The CRCC and LRCC characters may be employed for error detection if desired.

5. A missing pulse detector (re-triggerable monostable multi-vibrator or equivalent) circuit should be employed to sense the end of data and gate to suppress the end of record check characters. 2.5 to 3 READ CLOCK intervals during which no READ CLOCK pulses occur defines the end of data.

6. A second missing pulse detector set to approximately 16 READ CLOCK intervals should detect the physical end of record and set the FORWARD command false. In the case of a reverse read operation, a delay of 6 milliseconds should be inserted between detection of physical end of record and the termination of the REVERSE command.

7. The tape will decelerate and come to rest within 32 milliseconds. No motion commands should be applied during the deceleration interval.

Reading in reverse or backspacing is handled similarly to reading forward. The LRCC and CRCC check characters will occur prior to the data when reading in reverse.

Single gap transports have a HIGH THRESHOLD input which should be held false during normal read operations. This input may be utilized to check the quality of data recorded in a system designed to write, backspace and then check the data just written. The HIGH THRESHOLD input is held true only during the read-after-write check. This feature permits checking for marginally written blocks. A similar threshold change is made automatically in dual gap read-after-write machines while writing. In addition, some machines include an optional LOW THRESHOLD input to assist in the recovery of data from severe dropouts. The LOW THRESHOLD input must be held true for the entire duration of the block containing the dropout.

Reading an End of File

The external controller is generally required to identify an EOF when reading in either the forward or reverse direction. In addition to checking for the proper EOF character, the controller should verify that it has received only the EOF character and its associated LRCC. The LRCC character will be identical to the EOF character.

4.5.3. GAP TIMING

The time delays listed in Table 2 assure that all previously recorded data on the tape will be erased under any combination of write forward, read forward and read backward series of commands. Table 3 lists all of the delays and the gap lengths they produce for a simple series of commands on a single gap machine.

4.5.4. CRCC GENERATION

The CRCC written on 9-track tapes isolates parity errors within the record. If the errors are confined to a single track, the CRCC can be decoded to indicate which of the tracks is in error. With this information it is possible to re-read the data while employing the redundancy available in the vertical parity and/or CRCC scheme to regenerate the data in the incorrect track. The correct CRCC should always be written on the tape to maintain compatibility with other systems.

Fig. 5 is a logic diagram illustrating a circuit which will generate the proper CRCC. Each 9-bit character to be written is parallel shifted into the register through a network of exclusive or gates.

At the end of the record the register must be shifted one extra time with all inputs zero. The recorded CRCC is obtained by complementing the outputs of all bit positions except 2 and 4 as shown in Fig. 5. This schematic is applicable for high true inputs and outputs.

4.5.5. EDITING

Machines equipped with the optional OVERWRITE input may be employed to update (re-write) an existing block provided that the old and new blocks are of the same length. This operation is performed as outlined below.

1. Locate the block to be changed and position the transport just beyond the block.
2. Backspace over the block to be updated with T2 (Post-record Delay) set to the read reverse edit delay listed in Table 2 This positions the write head for the overwrite operation.

3. Write the new block by setting WRITE MODE, OVERWRITE and FORWARD true and proceeding with the normal write sequence.

The new block of data cannot be located precisely over the old due to the tolerances on tape speed and start/stop distances. This problem is particularly restrictive if it is necessary to update a tape written by a different machine. Systems employing the overwrite feature should minimize the block length and number of times a block is rewritten to insure reliable operation. If excessive updating of the same block is attempted the succeeding data block may be partially erased.

5. CABLING INFORMATION

The interface connector on the MINIDEK is a standard 44 pin PC card receptacle (Viking No. 2VK22D12-3 or equivalent) which is mounted horizontally on a PC board at the rear of the transport. The mating PC board provided by Digi-Data has facilities for twisted pair termination and twisted pair "daisy-chain" bussing. The mating PC board also contains the line terminating resistors for the line transmitters in the controlling system. The resistors are powered by the MINIDEK. Cabling composed of #22 or #24 wire twisted pairs should be employed between the controller and transport. A minimum of one twist per inch is recommended. Isolation of input wires and output wires into separate bundles is recommended to help avoid any possible crosstalk problems. The interface cable may be up to twenty feet in length. In multiple transport applications the total cable length from controller to the last machine on the bus should be limited to twenty feet. The twisted pair grounds should be connected at each end of the cable. The grounds should be connected within six inches of their associated transmitter/receivers at the controller.

Table 4 lists all interface signals and their associated pin numbers. All interface lines except SELECT are common to all four transports. These lines go from the controller to the first transport in the system where they are attached to that transport's connector. Another cable then runs from the first transport to the second. The third and fourth transports are added in the same manner.

The PC board connector at each transport includes holes providing for the attachment of the additional cabling. The board also has pads available which permit it to "pass along" up to three SELECT lines to other transports. (See Fig. 6)

Each connector board includes line terminating resistors on the controller outputs. In multiple unit installations the resistors should be removed (except for those on each SELECT line), from all but the last connector on the bus.

TABLE I

OEM NRZI INTERFACE SIGNALS

Signal Name	Description	Signal Type
SELECT	This input gates all Transport inputs and outputs. A False SELECT line will immediately terminate any tape motion except rewind.	Input Level
WRITE MODE	This input must go true concurrently with the forward command, and remain true for a period of at least 20 microseconds following initiation of a FORWARD or REVERSE Command to energize the transport write and erase circuitry. The circuitry will remain energized until initiation of a FORWARD or REVERSE command with the WRITE MODE input held False or until receipt of a REWIND or OFF LINE command. Transports with the file protect ring option will not write unless a write ring is installed on the tape reel.	Input Level
FORWARD	The transport moves in the forward direction as long as this input is true. The command is blocked if the transport is not in READY status.	Input Level
REWIND	This input causes the transport to move in the reverse direction at high speed until reaching the BOT mark. At the completion of a rewind the transport will move the tape forward to the BOT mark and stop. Write current is turned off. A REWIND command will be ignored if the transport is already at BOT.	Input Pulse
OFF LINE	This input will place the transport off line, disabling remote control and turning off the front panel ON LINE indicator. The transport will remain off line until the operator presses the ON LINE button. This input is gated only by SELECT, permitting the transport to accept an OFF LINE command while rewinding.	Input Pulse

TABLE I - continued

OEM NRZI INTERFACE SIGNALS

Signal Name	Description	Signal Type
WRITE CLOCK	The WRITE CLOCK input strobes the information on the WRITE DATA lines into the transport write circuitry. A pulse width of approximately two microseconds is recommended. The frequency is determined by tape speed and desnity and should be 10.0 Khz for 12.5 ips, 800 bpi operation.	Input Pulse
REVERSE	The transport moves in the reverse direction at normal speed when this input is true. The command is blocked if the transport is not in READY STATUS. If the BOT marker is sensed while in REVERSE, the transport will halt with the marker positioned approximately 0.6 inch closer to the head than the normal load point.	Input Level
WRITE LRCC	This input will reset the transport NRZI flip flops. This automatically writes the LRCC character on the tape. The character should be written in the eighth character position after the last data character of a record. (Fourth character position on 7-track machines.) No WRITE CLOCK should be supplied when writing the LRCC.	Input Pulse
WRITE DATA 7 or 9 lines	A true level spanning the WRITE CLOCK pulse causes a "one" to be recorded on the tape in the associated track. The data character should be present prior to the WRITE CLOCK leading edge and remain stable until 0.1 microseconds after the trailing edge.	Input Level
HIGH THRESHOLD	This input raises the read amplifier threshold level so that marginal recording may be detected in read-after-write checks. Dual gap machines perform threshold switching automatically in read-after-write.	Input Level

TABLE I - continued

OEM NRZI INTERFACE SIGNALS

Signal Name	Description	Signal Type
LOW THRESHOLD	A true level on this input will increase the read amplifier sensitivity as an aid to data recovery in severe dropouts. (Optional feature.)	Input Level
OVERWRITE	This input is employed to place the transport in the overwrite mode. If the OVERWRITE and WRITE MODE inputs are true for a period of at least 20 microseconds following initiation of a FORWARD or REVERSE command the transport will go into the overwrite mode, causing the write and erase heads to be slowly turned off after the LRCC is written. (Optional feature.)	Input Level or Pulse
HIGH DENSITY	This input is available only on machines equipped with the 7-track dual density option. The input must be held true during read operations to select the higher of the two possible densities.	Input Level
ON LINE	A true output indicates that the operator has placed the transport under remote control.	Output Level
READY	When this line is true, the transport is on line, selected, loaded with tape and not rewinding. Motion commands will be ignored if READY is false.	Output Level
LOAD POINT	A true output indicates that the tape is positioned at the BOT marker.	Output Level
END OF TAPE	A true output indicates that the EOT marker is being sensed. This output may be noisy if the transport stops at the edge of the marker.	Output Level
WRITE DISABLED	A true output indicates that no write ring has been installed on the reel. The transport will not write when this output is true.	Output Level
REWIND STATUS	A true output indicates that the transport is in the rewind or advance to load point mode.	Output Level

TABLE I - continued

OEM NRZI INTERFACE SIGNALS

Signal Name	Description	Signal Type
READ CLOCK	A true 2 microsecond pulse occurs when a character has been assembled in the read register.	Output Pulse
READ DATA 7 or 9 lines	A true level during the READ CLOCK pulse indicates a "one" bit was read in the associated track. The READ DATA outputs will appear prior to the READ CLOCK pulse and remain present until after its trailing edge.	Output Level
DENSITY INDICATOR	On machines equipped with the 7-track dual density option this output will be true while the machine is in the higher of the two possible densities. On other machines the output may be connected with internal jumpers to be true or false. It may be employed to indicate tape speed, density, unit number, etc. in multiple unit installations.	Output Level
LOW SPEED	May be connected with an internal jumper to go true when the transport is selected.	Output Level
SINGLE GAP	This output will go true when a single gap transport is selected.	Output Level
NRZI	This output will go true when any NRZI transport is selected.	Output Level
7 TRACK	This output will go true when any 7 track transport is selected.	Output Level

TABLE 2

RECOMMENDED DELAYS AT 12.5 IPS (in milliseconds)

Operation	Prerecord Delay		Postrecord Delay	
	9-Track	7-Track	9-Track	7-Track
Read Forward From BOT	120	120	0	0
Read Forward Normal	24	24	0	0
Read Reverse Normal	24	24	6	16
Read Reverse Edit	24	24	14.4	24.4
Write from BOT	280	280	6	6
Write Normal Single Gap	46	56	6	6
Write Normal Dual Gap	34	32	6	6
Write EOF or Skip Write	280	280	6	6

TABLE 3

Typical IBG Length Calculation

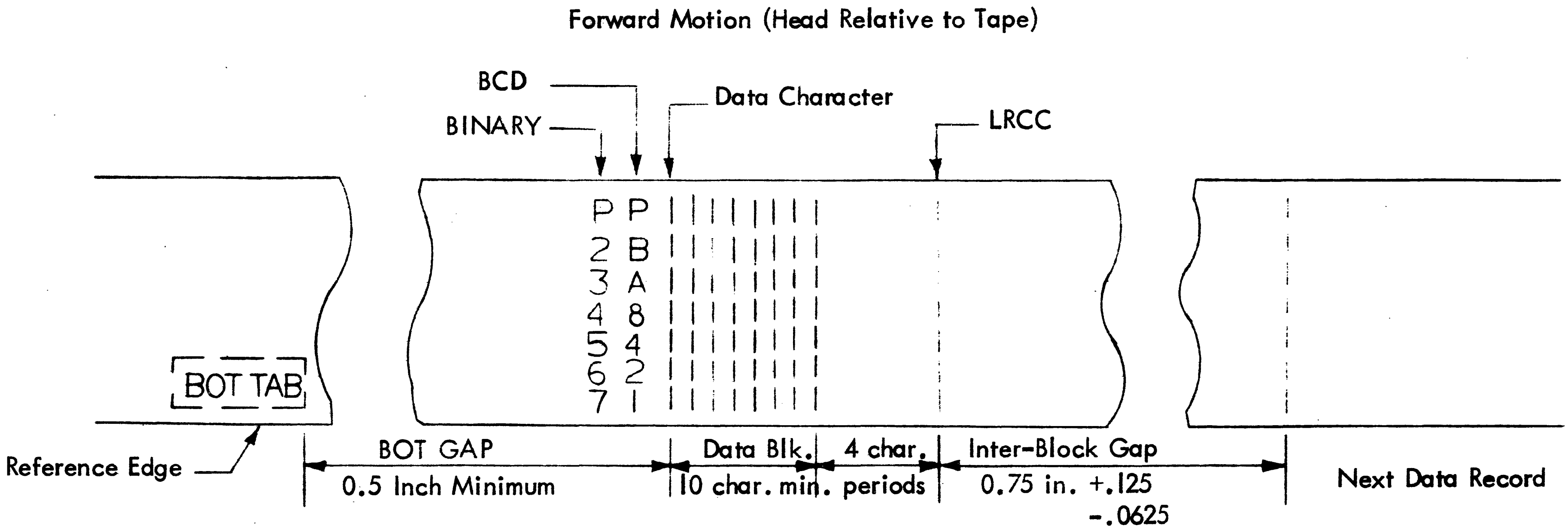
Delay	9-Track	7-Track
	Inches	Inches
Postrecord delay T2 at 12.5 ips	.075	.075
Stop Distance	.190	.190
Start Distance	.190	.190
Prerecord delay T1 less 30 msec	.200	.325
Total Gap Length	.655	.780

TABLE 4

OEM NRZI INTERFACE CONNECTOR

Pin No.	Signal Name		Input/Output
1			
2			
3	Off Line		I
4	Select		I
5	Rewind Status		0
6	EOT		0
7	Load Point		0
8	Rewind		I
9	Write Mode		I
10	Overwrite		I
11	Ready		0
12	On Line		0
13	Write Disabled		0
14	Reverse		I
15	Forward		I
16	Read Data	P (C) *	0
17	"	0	0
18	"	1	0
19	"	2 (B)	0
20	"	3 (A)	0
21	"	4 (8)	0
22	"	5 (4)	0
23	"	6 (2)	0
24	"	7 (1)	0
25	High Threshold		I
26	Read Clock		0
27	Write Data	7 (1)	I
28	"	6 (2)	I
29	"	5 (4)	I
30	"	4 (8)	I
31	"	3 (A)	I
32	"	2 (B)	I
33	"	1	I
34	"	0	I
35	"	P (C)	I
36	Density Indicator		0
37	Write LRCC		I
38	Write Clock		I
39	Low Threshold		I
40	Low Speed		0
41	High Density		I
42	7 Track		0
43	NRZI		0
44	Single Gap		0

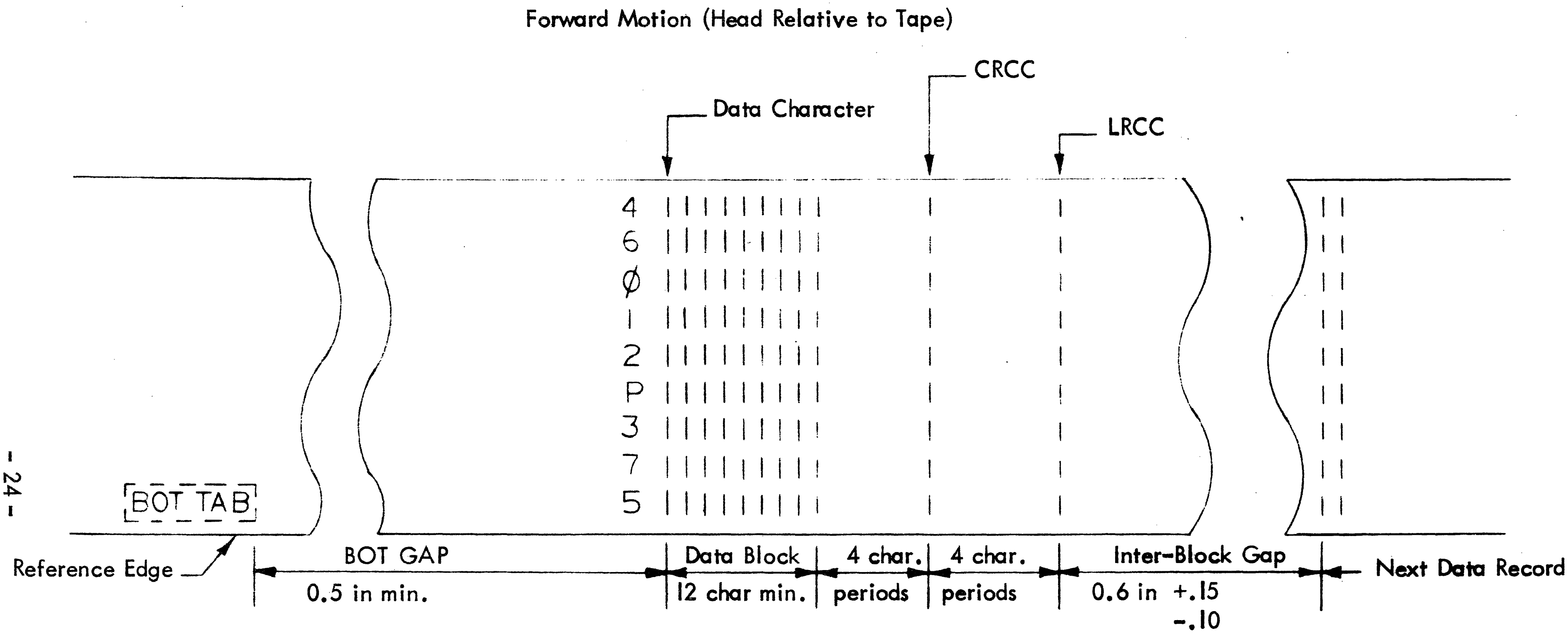
* 7 Track connections in parenthesis



NOTES:

1. Tape shown with oxide side up.
2. Channels 2 through 7 contain data bits in descending order of significance.
3. Data packing density may be 200, 556 or 800 characters per inch.

Figure IA. 7-Track Format



NOTES:

1. Tape shown with oxide side up.
2. Channels 0 through 7 contain data bits in descending order of significance.
3. Data packing density is fixed at 800 characters per inch.

Figure IB. 9-Track Format

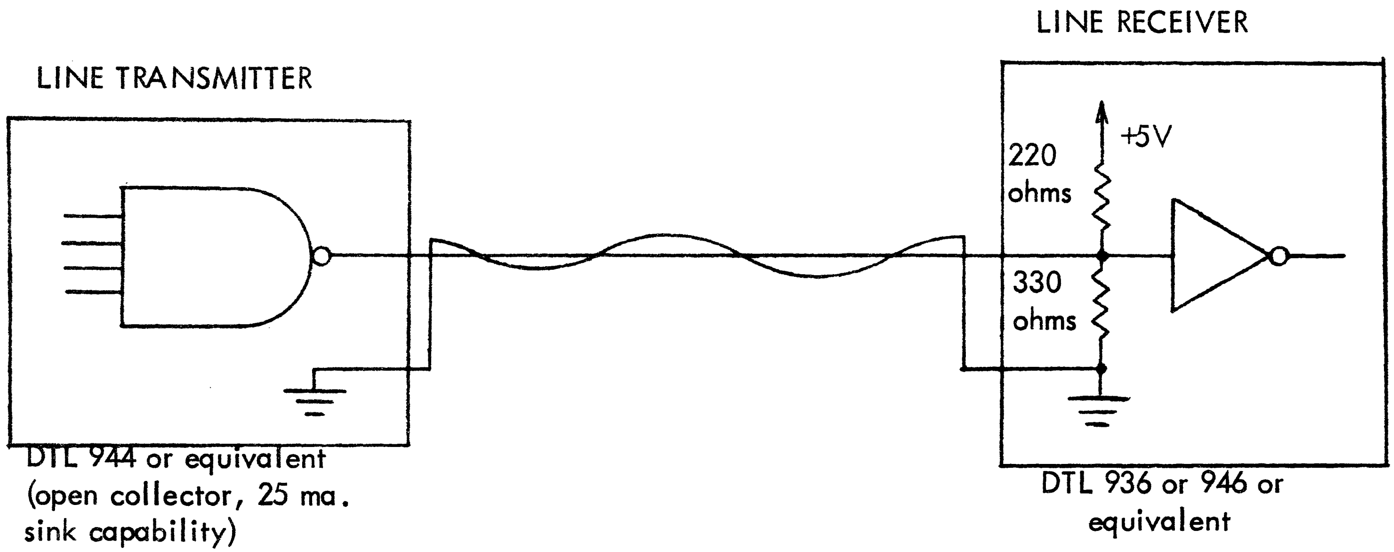


Figure 2. Transport/Controller Interface Circuit.

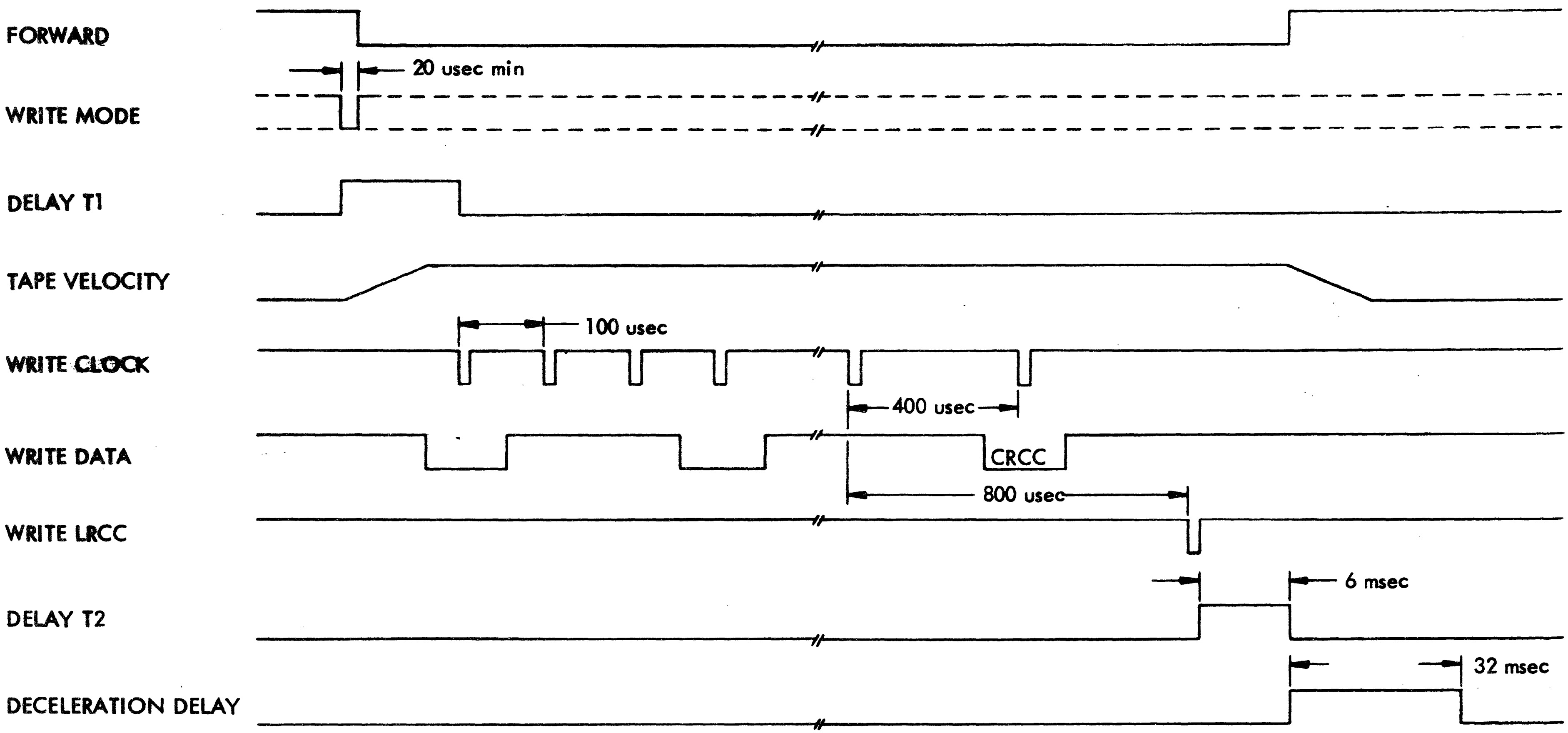


Figure 3. Write Operation Timing Diagram

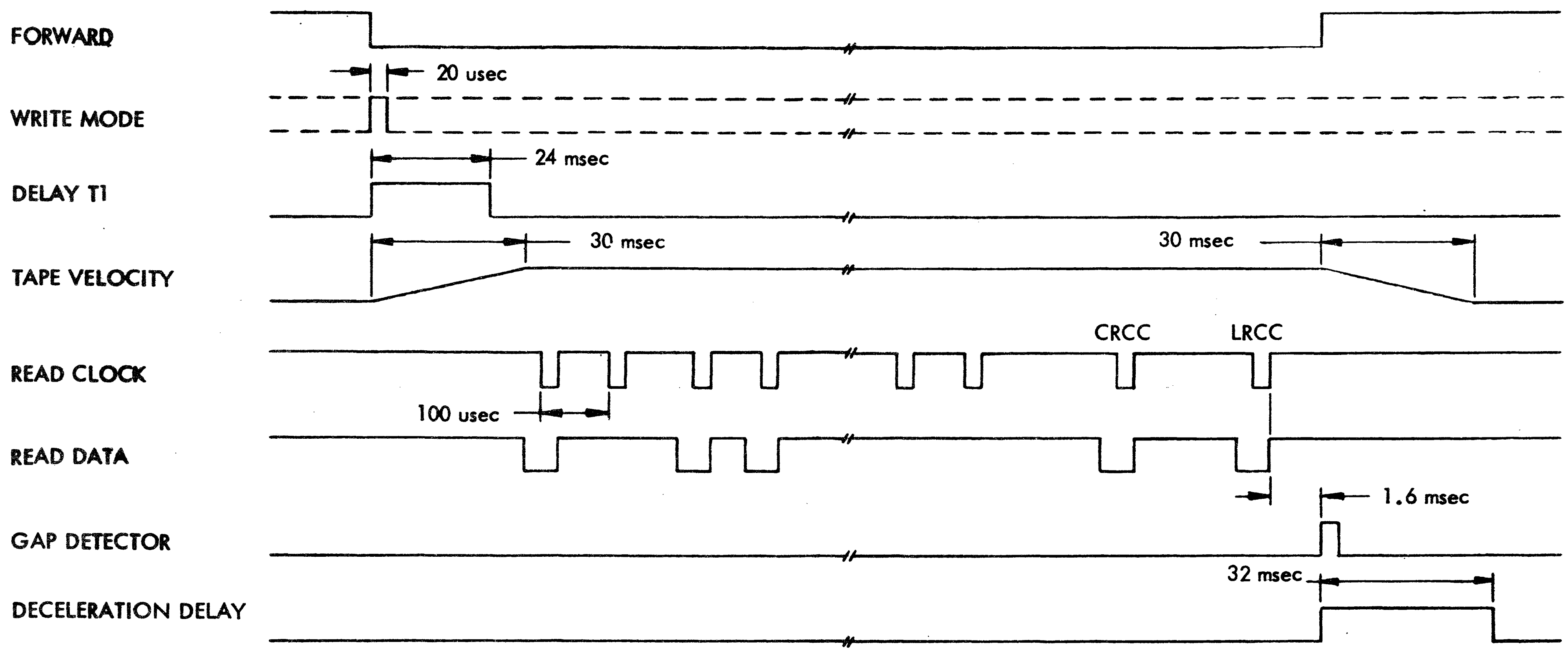


Figure 4. Read Operation Timing Diagram

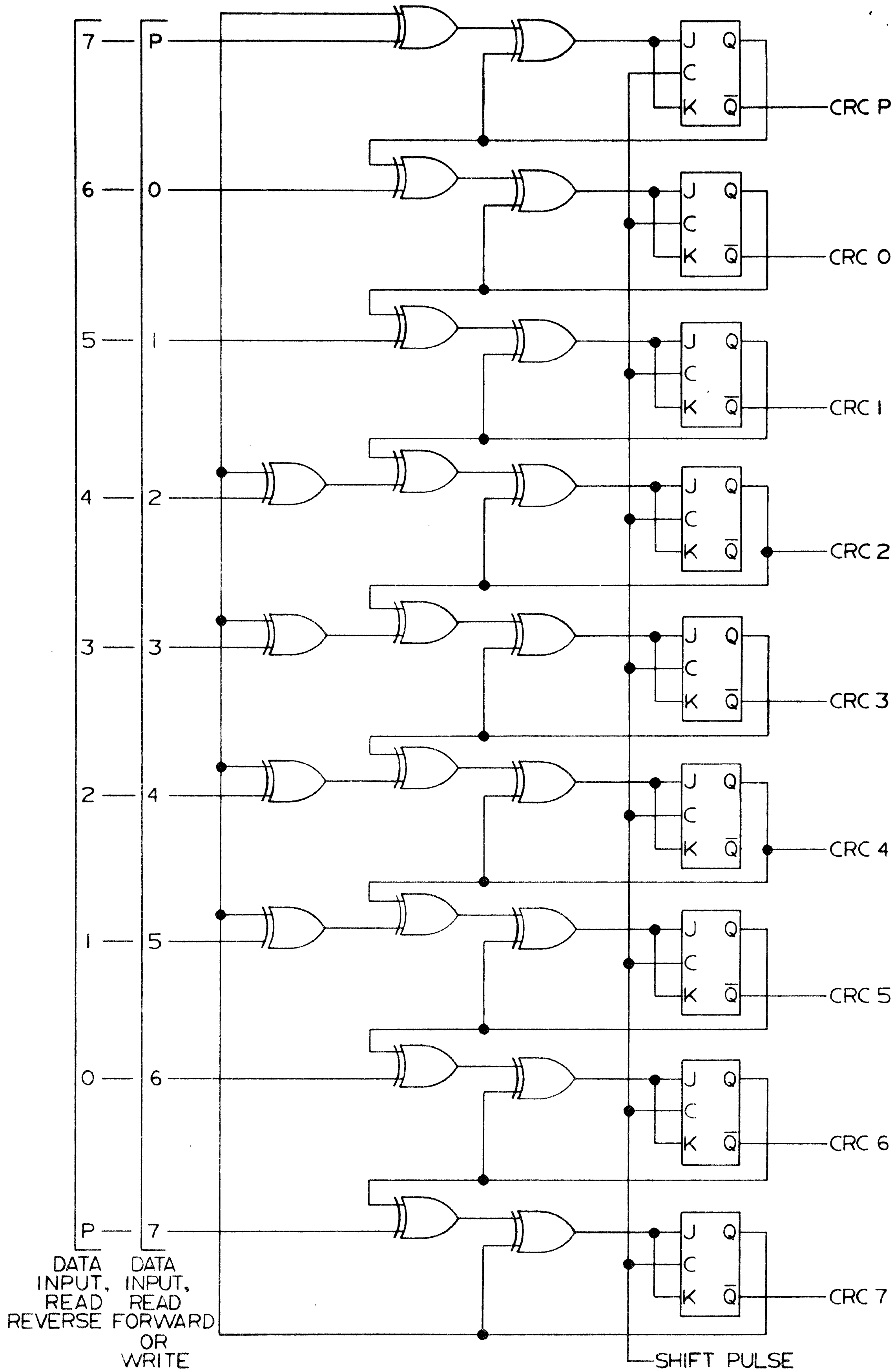


Figure 5. CRCC Generator

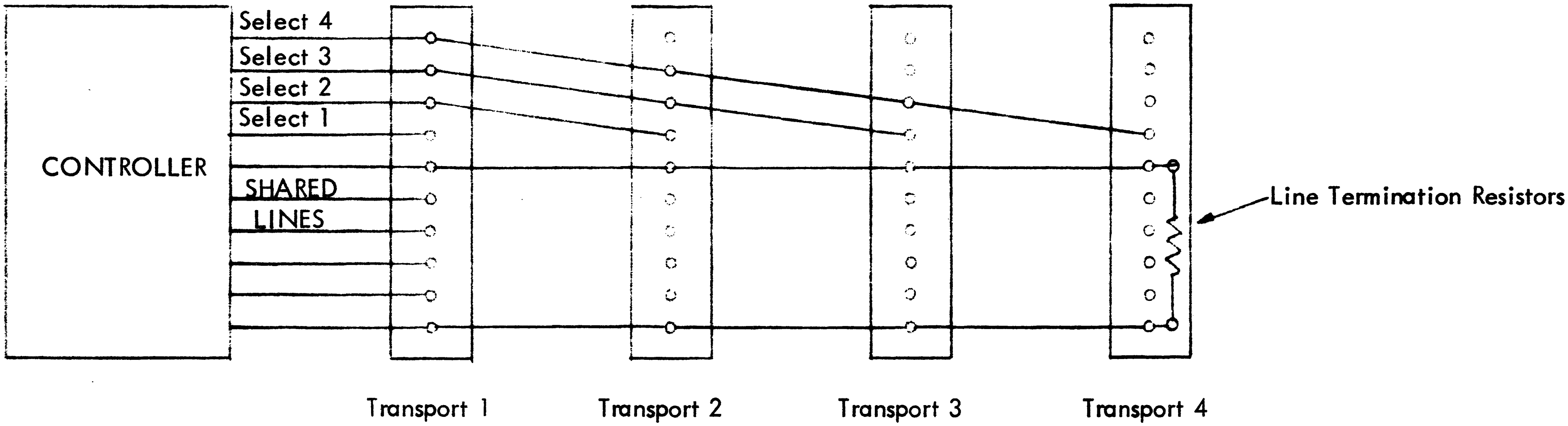


Figure 6. Multiple Transport Installation