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SECTION 1
INTRODUCTION

GENERAL

This manual provides information on the description, capabilities, operation, and theory of operation information for the Model FDD 200-8P Floppy Disk Drive (Figure 1-1).

SCOPE

The contents of this manual are intended to be used for customer introduction to the disk drive, as a training document for customer engineers requiring detailed theory of operation information and for installation and maintenance information.

DESCRIPTION

The disk drive is a low-cost, random access storage device, which uses a floppy disk as the storage medium. The double-sided, removable disk cartridge will store up to 12.8 megabits of double-density unformatted data, 6.4 megabits of single-density data, or 3.88 megabits using the compatible IBM System 3740 format. The disk drive is also compatible with the IBM System 32 format. Because of its small size and weight, installation can be accomplished in almost any convenient location or orientation. For data accessing the disk is divided into 77 tracks, and each track can be subdivided into as many as 32 sectors. A stepper motor positions the read/write head at the track

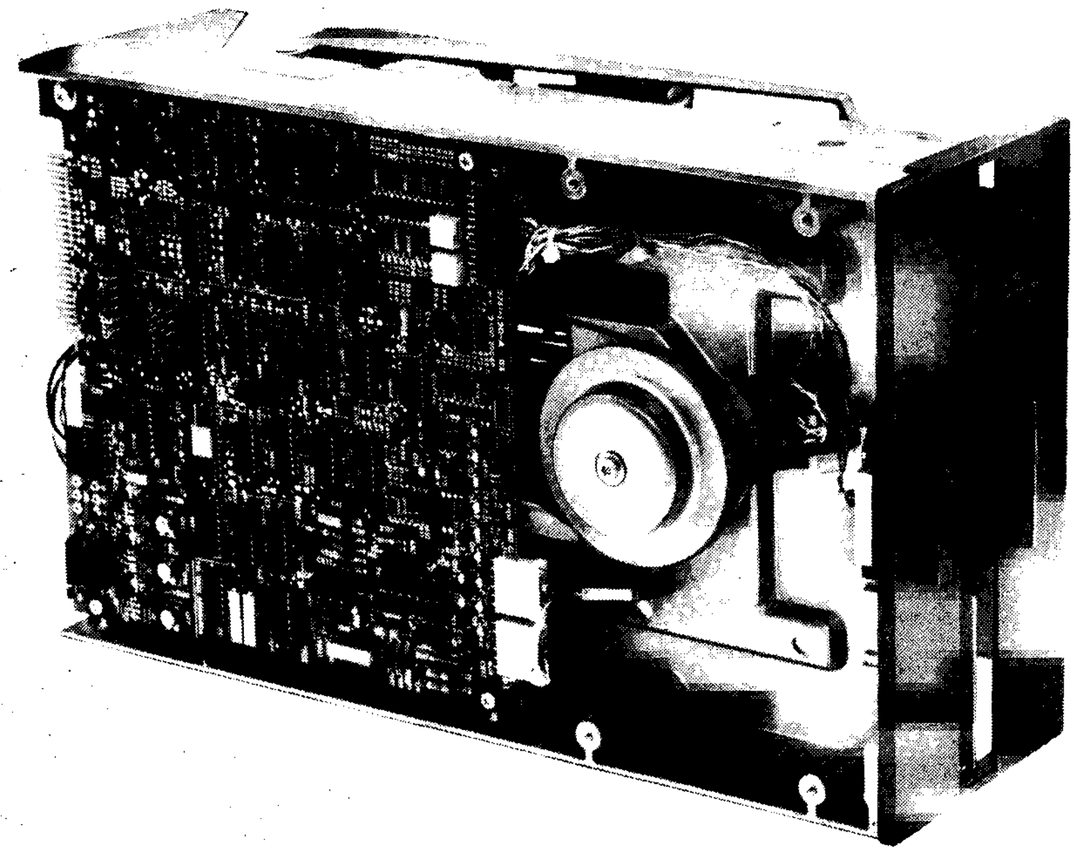


Figure 1-1. Model FDD 200-8P Floppy Disk Drive

to be accessed. Index and sector holes punched into the disk are sensed photoelectrically to produce sector and index pulses that permit accessing of individual sectors of a track. When the optional write-protect slot in the protective envelope is uncovered the write-protected condition is sensed photoelectrically, and write operations are inhibited.

Up to eight drives can be interfaced to a single host controller. The controller controls disk drive selection, head loading, track addressing, head selection, and read/write transfers.

When a disk cartridge is inserted and the access door is closed, the drive spindle rotates the disk at 360 revolutions per minute. When selected, the drive accepts a head load command, causing the read/write heads to be loaded to the disk. With the drive selected, sector/index pulses, write-protect status, track 00 position status, and a read/write ready status is supplied to the controller. At the desired track, a data transfer operation is performed; read-to the controller, write-from the controller, depending on the state of the write command.

During a write operation (disk not write-protected), write data is input to the write circuits. For each write data pulse received, a flux reversal is recorded on the disk by the selected read/write head.

During a read operation, each recorded flux reversal is sensed by the selected read/write head, converted to a raw data pulse and supplied to the controller.

Applications for the Floppy Disk Drive include:

- Key Entry Systems
- Point-of-Sale Recording Systems
- Word Processing Systems
- Batch Terminal Data Storage
- Small Business Systems Data Storage
- Microprogram Loading and Error Logging
- Minicomputer Programs and Auxiliary Data Storage

The drive provides random accessing of data with greater performance and reliability and is an excellent alternate product to paper tape, reel-to-reel tapes, card equipment, cassettes, and cartridge drives.

DISK CARTRIDGE

The disk cartridge is an 8-inch-square plastic protective envelope, in which the floppy disk is sealed. The protective envelope contains apertures for spindle loading, head contact, sector/index detection, and optional write-protect detection, (see Figure 1-2).

The recording media is a magnetic-oxide-coated floppy (flexible) mylar disk sealed within the plastic envelope for protection, self-cleaning, and ease of handling. The disk should be handled and stored in clean environments, free from magnetic influences.

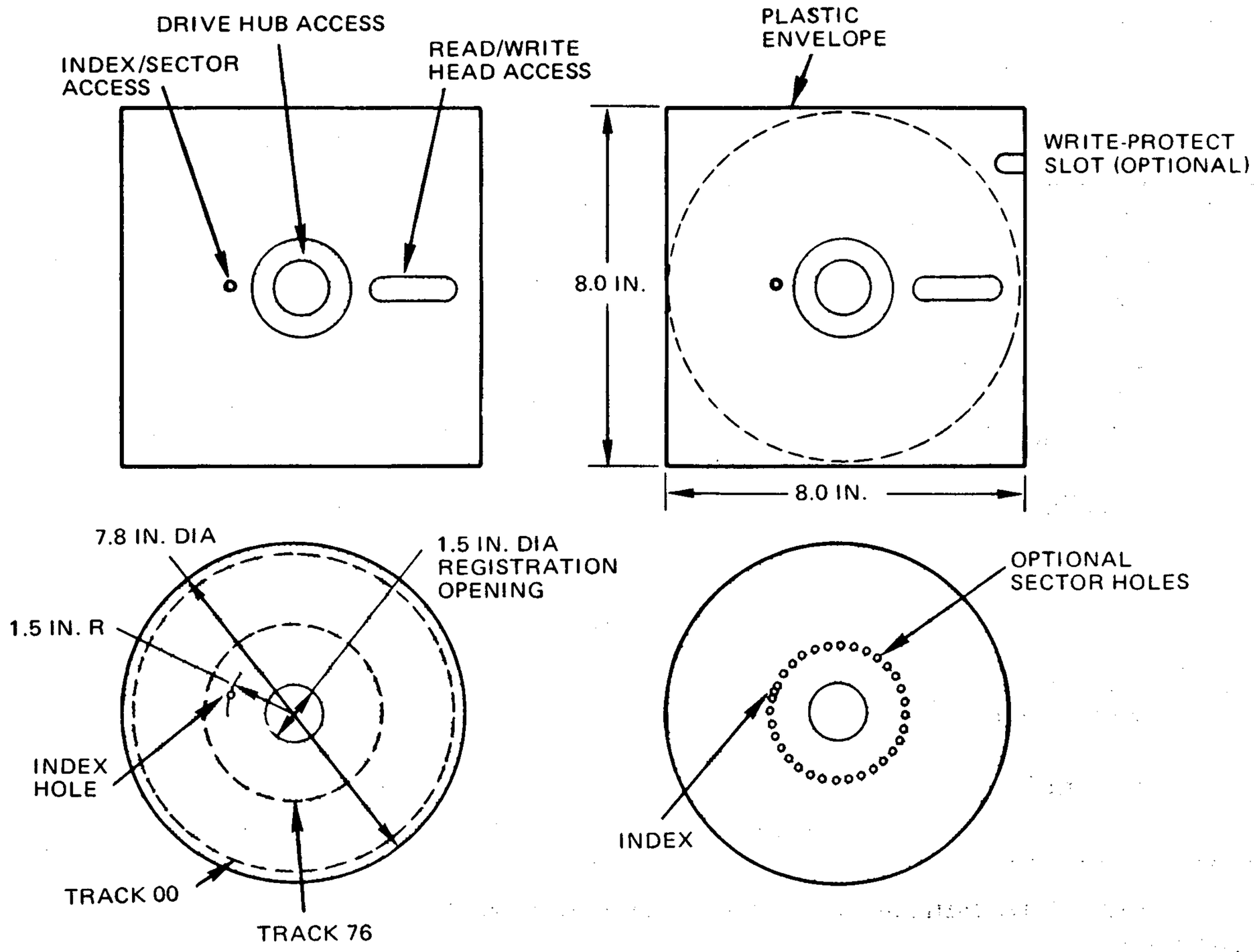


Figure 1-2. Floppy Disk and Protective Envelope

At no time should the surface of the media be touched, or the surface of the envelope be written on. When not in use, the disk cartridge should be returned to its protective storage envelope.

For reliable operation, floppy disks should be stabilized in the same environment as the using disk drives, for a period of at least five minutes, prior to installation. The recommended floppy disk meets the requirements of the following documents:

X3B8/77-118	American National Standard for Single-Sided Unformatted Flexible Disk Cartridge
GA21-9257	IBM Two-Sided, Original Equipment Manufacturers' Information
ECMA/TC 19/77/16	Data Interchange on 200 mm Disk Cartridges using double frequency recording at 13,262 ftprad on one side.

Floppy Disk characteristics are listed in Table 1-1.

Table 1-1. Floppy Disk Characteristics

Functional	Characteristics
Disk Type	ANSI Standard
Disk Diameter	7.88 inches
Disk Thickness	0.003 inch
Rotational Speed	360 rpm
Rotational Period	166.67 ms
Average Latency	83.33 ms
Heads	2
Tracks per Surface	77
Bit Density	3268 bpi (single density) 6536 bpi (double density)

Note: For minimum runout the floppy disk should be loaded while the spindle is turning.

RECORDING FORMAT

The recording format is dependent upon requirements of the controller. The track and sector organization of data is dependent on the format.

Encoding Scheme

The drive allows double-density or single-density encoding schemes. In double-density recording, each bit cell is 2 microseconds wide, in single-density recording, each bit cell is 4 microseconds wide (see Figure 1-3).

Track Format

The floppy disk contains 77 tracks. The first (outside) track is track 00, and the last (inside) track is 76. The top read/write head is for tracks offset from the bottom read/write head. The offset direction is toward the spindle. During the write operation, an erase coil in the read/write head erases the outside edges of the data just written, narrowing the data track. In this manner, a guard band is

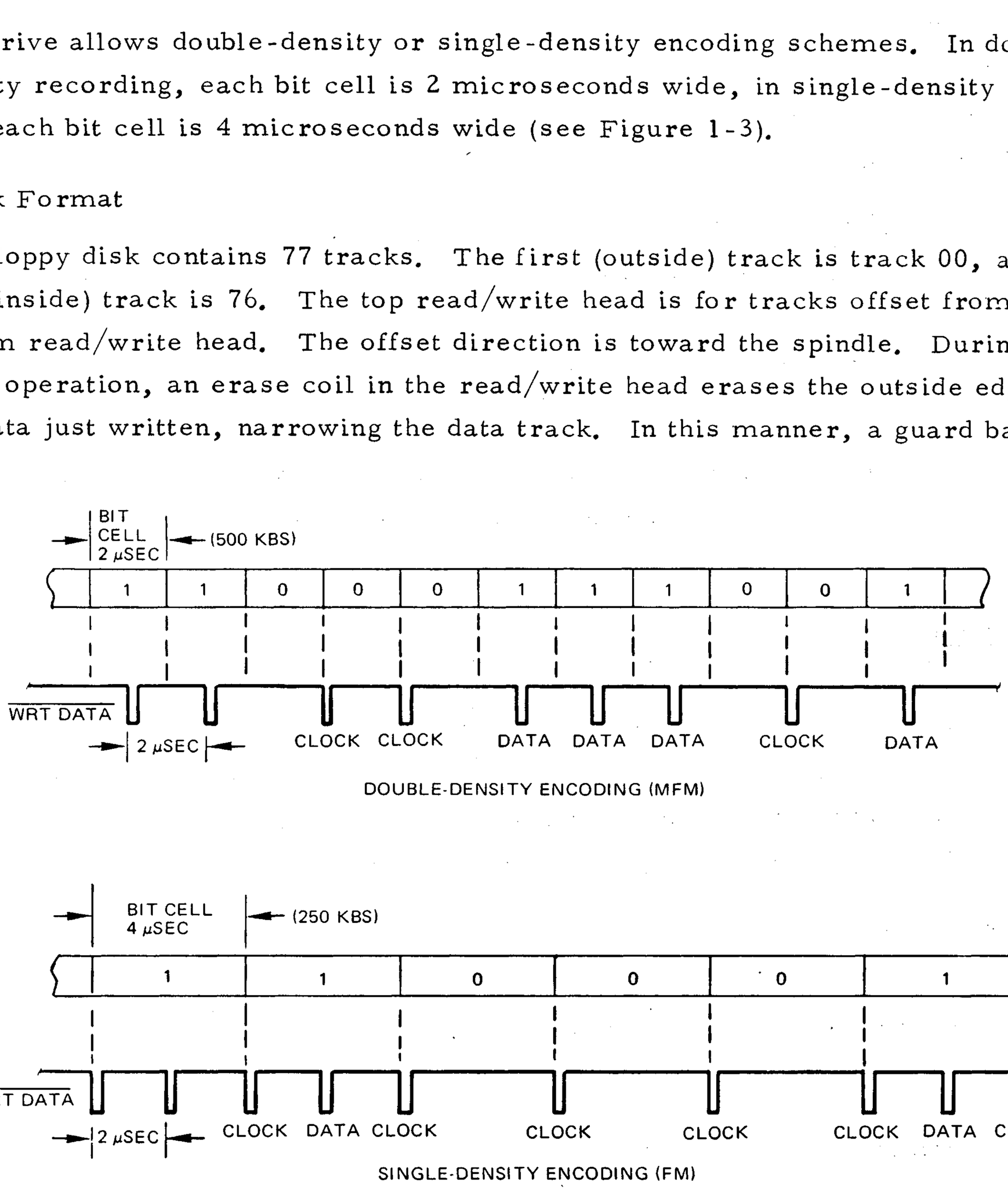


Figure 1-3. Single and Double Density Encoding

established to protect the data from adjacent track crosstalk when reading. The erase coil will be either a tunnel or straddle type. The tunnel erase method requires time delays since it is 34 milliseconds behind the R/W coil. The straddle erase head does not require any time delays.

Sector Format

The number of sectors in each track is determined by the application, and can range from 1 to 32, depending on whether the soft-sector or hard-sector floppy disk is being used.

When soft sector operation is required, only one index hole is punched in the floppy disk. With this disk, the controller uses the index pulse to define the sectors. When hard sector operation is required, the floppy disk used contains the index hole plus 32 sector holes spaced equidistant around the disk (see Figure 1-2).

The index hole is punched midway between sector holes 31 and 0. The double-pulse of sector 31 and index alerts the controller that the next pulse starts sector 0. The index and sector holes are sensed photoelectrically, providing the pulses supplied to the controller.

Sector Content

The format of each sector is determined by the application. Normally, preambles and postambles containing a stream of coded bytes are written at the beginning and end of each sector, to provide data synchronization. Following the preamble of each new track, an identification (ID) field is written containing the track and sector numbers. Following the ID field, data bytes are written.

32-Sector Format

This format is not the most efficient OEM format due to the number of gaps required between data records. A typical 32-sector format is shown in Figure 1-4.

IBM 3740 Format

There are two IBM 3740 formats; Data Set Label and Track. The disk drive is compatible to both formats.

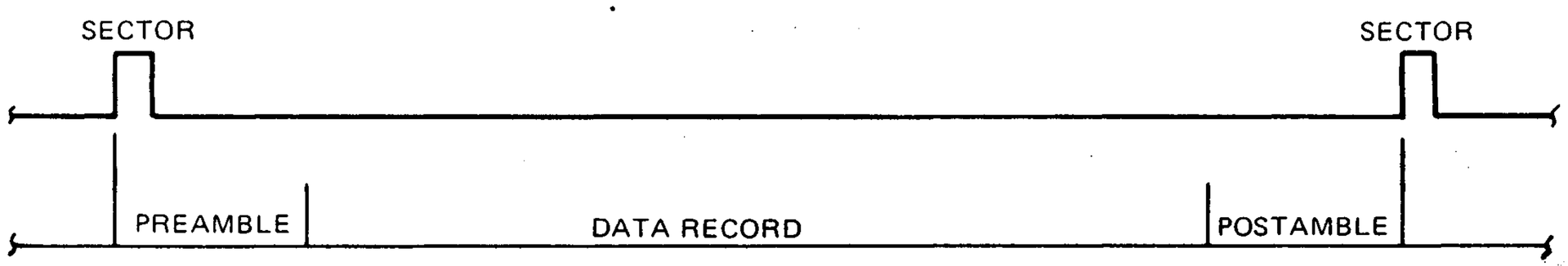


Figure 1-4. 32-Sector Format

Track 00 contains only Data Set Labels that identify the type of information stored in tracks 01 through 76. Tracks 01 through 73, 75, and 76 are allocated 26 sectors, each containing 128 data bytes. A data set may be one or more sectors, including overflow to each on-line disk drives. In the drive, only tracks 01 through 73 are normally used. Track 74 and 75 are reserved as spares to be used when other tracks become flawed, and track 76 is not used. The IBM 3740 format is shown in Figure 1-5. For detailed information on the IBM 3740 data format and initialization, refer to IBM Publication GA21-9190.

DISK DRIVE ASSEMBLY

The disk drive assembly can be installed in a standard 19-inch RETMA rack; two horizontally, or four vertically.

The disk drive comprises three major assemblies:

- Printed Circuit Board (Electronics)
- Main Deck Assembly
- Carrier Assembly

Printed Circuit Board

All electronic circuitry required to convert the digital data input and output to and from analog data for the read/write heads and head positioning information is contained on one circuit board. Interface and DC connectors can be provided. Logic is TTL with selected discrete and IC Components. The electronics perform the following functions:

- Read Chain
- Write Chain
- Ready Generation

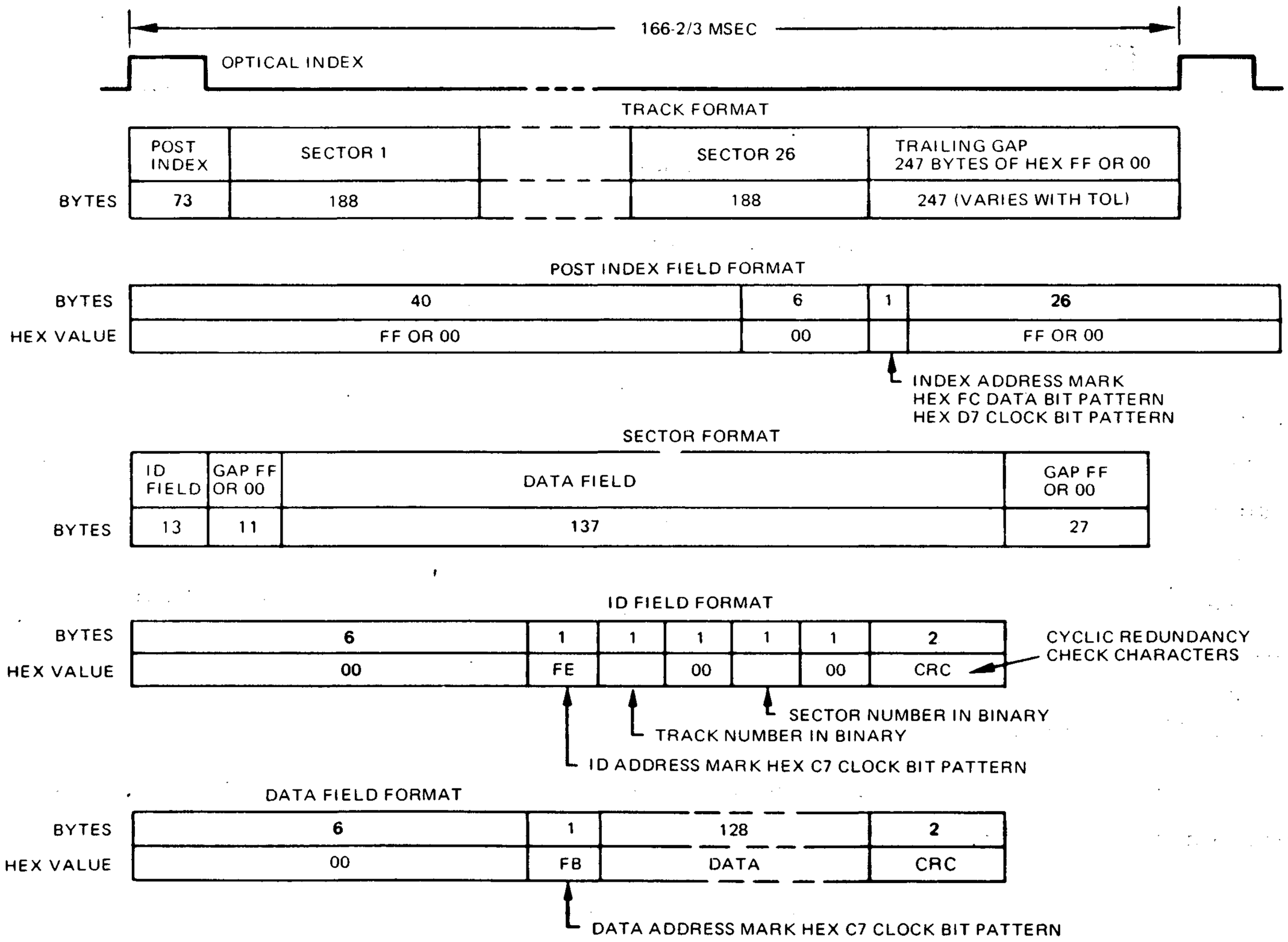


Figure 1-5. IBM 3740 Format

- Index Detection
- Stepper Motor Control
- Interface Drivers and Receivers
- Write-Protect
- Index/Sector Separator (Option)
- FM Data Separator (Option)
- FM Data Separator for Missing Clock Patterns (Optional)*
- Binary Select (Option)

*This option can be used to detect address marks.

Main Deck Assembly

The main deck assembly is the principal supporting assembly and contains the following subassemblies:

- Drive System - Spindle Drive motor, drive belt and pulley to rotate spindle at 360 rpm.
- Positioning System - Stepping motor, lead screw and head assembly carriage to accurately drive and position the read/write heads to the desired track.
- Read/Write System - Single-gap magnetic recording heads with tunnel-erase or straddle-erase feature. Read/write heads are contact type.
- Disk Cartridge Guide and Ejector - Provides positive positioning and locking of disk cartridge allowing proper placement of the disk cone. Spring-loaded ejection provides fast, positive, disk cartridge removal.
- Optical Sensing - Index, Track 00, and write-protect sensing by independent LED and phototransistor sensing circuits.

Carrier Assembly

The carrier assembly is a secondary frame which pivots from the main deck assembly and includes the following subassemblies:

- Disk Centering Cone - Precisely centers and grips the floppy disk to the spindle.
- Head Load Mechanism - Solenoid, dual head assembly, Exerts and sustains force to constrain the disk cartridge to the platen and release the spring-loaded upper head arm to contact the media.
- Access Handle - Pushbutton latch release mechanism. Also releases spring-loaded lock to discharge disk cartridge.

OPTIONS-FEATURES

The Floppy Disk Drive may be ordered with basic configuration operating capabilities, or may be ordered to include any or all available options. Each option offers unique operating features. Several options have connections designed into the main printed circuit board, for low-cost customer enhancement.

Write-Protect

A write-inhibit function is provided when a write-protected floppy disk cartridge is used. The stored data is protected only if the cartridge write-protect slot is present. With the slot covered, all write functions are enabled.

Binary Select

The Binary Select option permits any one of up to eight disk drives to be selected. With the option installed, $\overline{\text{SELECT}}$ lines are not dedicated but are used to contain a binary select code. The $\overline{\text{SELECT 0}}$ line is used to enable/disable unit selection, while the $\overline{\text{SELECT 1}}$, $\overline{\text{SELECT 2}}$, and $\overline{\text{SELECT 3}}$ lines contain a binary code between 0 and 7. When the $\overline{\text{SELECT 0}}$ line is low (true), a decoder in the Binary Select option logic decodes the select code from the controller.

Radial Select

In the basic configuration, the disk drive does not accept commands from the controller, and does not supply status signals to the controller, until selected. The purpose of this option is to allow commands to be accepted and status signals to be supplied, each over separate lines, without the drive selected. The following signals can be optionally configured for radial operation:

- $\overline{\text{STEP}}$ and $\overline{\text{STEP IN}}$ (Step Command)
- $\overline{\text{HDLD}}$ (Head Load Command)
- $\overline{\text{READY}}$ (Ready Status)
- $\overline{\text{INDEX}}$ and $\overline{\text{SECTOR}}$ (Index and Sector Pulses)

When dedicated lines are provided for these signals, the disk drive need not be selected by the controller. Each line must be assigned a separate pin number on the interface connector. Spare pins are provided for this purpose.

The unit is modified for Radial Select operation by changing jumpers between the existing etch pads. The etch pads are located on the main printed circuit board.

Hard Sector

In the basic configuration, the use of a hard sector disk causes the $\overline{\text{INDEX}}$ line to produce one index pulse and 32 sector pulses per each disk revolution.

With the Hard Sector option installed, the index and sector pulses are separated and supplied to the controller on independent $\overline{\text{INDEX}}$ and $\overline{\text{SECTOR}}$ lines.

16/8 Sector

When the Hard Sector option is installed, the addition of the 16/8 Sector option provides a 2-bit binary counter that counts down the 32 sector pulses from a hard-sector disk. This countdown permits each track to be divided into 16 or 8 sectors, instead of 32 sectors. The output of the first stage (16 sectors), or the second stage (8 sectors) is connected to the $\overline{\text{SECTOR}}$ output line to the controller.

Auto Erase

The erase turn-on and turn-off delays are internally controlled by the Erase logic. When the controller activates $\overline{\text{WRITE}}$, the leading edge of $\overline{\text{WRITE}}$ initiates a 200-microsecond erase turn-on delay; the trailing edge of $\overline{\text{WRITE}}$ initiates a 530-microsecond erase turn-off delay. If the straddle-erase configuration is used, a straddle-erase head must be installed. This option removes the time delays. Pads are provided for installation of this option.

Data Separator (FM only)

In the basic configuration, the $\overline{\text{RAW DATA}}$ line to the controller produces a pulse for each flux reversal read from the disk. Consequently, the $\overline{\text{RAW DATA}}$ input contains both clock and data pulses. For this reason, the controller must have circuits that separate the clock and data pulses.

The Data Separator option is installed for the disk drive to operate in the single-density encoding mode (FM) only. When installed, this option separates the data and clock pulses input over the $\overline{\text{RAW DATA}}$ line. Data pulses are supplied to the controller over an $\overline{\text{FM SEP DATA}}$ line, and synchronized clock pulses over an $\overline{\text{FM SEP CLK}}$ line. Proper operation of the Data Separator option is based on a format with no missing clock pulses. A Data Synchronizer circuit is provided to handle formats with missing clock pulses. This is used for address mark detection; it is also FM only.

Auto Head Load

In the basic configuration, the read/write heads are automatically loaded when the unit is selected and automatically unloaded when the unit is deselected. Alternatively, the unit may be configured to load the heads in response to a $\overline{\text{HDLD}}$ command from the controller.

Activity Indicator

In the basic configuration, the activity indicator is on when the drive is selected. The Activity Indicator option provides a means of substituting for the $\overline{\text{SELECT}}$ status signal, one of the following status signals:

- $\overline{\text{HEAD LOAD}}$
- $\overline{\text{RDY}}$

Etch pads are provided on the main printed circuit board to optionally OR either of the above signals with $\overline{\text{IN USE}}$.

PCB Assembly Option Configurations

The main printed circuit board can be supplied in a basic configuration or with the optional configuration including Hard Sector and Data Separator.

SPECIFICATIONS

A comprehensive list of principal specifications are provided in Table 1-2. The list defines both single-density and double-density characteristics, both disk drive and interface logic levels, and all physical and electrical parameters.

Table 1-2. Principal Specifications

Function	Characteristics	
	Single-Density	Double-Density
Disk Type	ANSI Standard	ANSI Standard
Storage Capacity (Unformatted)		
Per Disk	6.4 megabits	12.8 megabits
Per Data Surface	3.2 megabits	6.4 megabits
Per Track	41.7 kilobits	83.4 kilobits
Tracks	154	154
Track Density	48 Tracks Per Inch	48 Tracks Per Inch
Recording Density		
Track 00 (Outside)	1836 bpi (3672 fci)	3672 bpi (3672 fci)
Track 76 (Inside)	3268 bpi (6536 fci)	6536 bpi (6536 fci)
Recording Method	FM	MFM
Rotational Speed	360 rpm ±2.5%	360 rpm ±2.5%
Rotational Latency		
Average	83.33 milliseconds	83.33 milliseconds
Maximum	175.6 milliseconds	175.6 milliseconds
Access Time		
Track-to-Track	3-6 milliseconds	3-6 milliseconds
Track 0 - Track 76	228 milliseconds	228 milliseconds
38-Track Move	111 milliseconds	111 milliseconds
Settling Time	12 milliseconds	12 milliseconds
Head Engage Time	25 milliseconds	25 milliseconds
Data Transfer Rate	250 kilobits/sec	500 kilobits/sec
Erase/Write Recovery Time		
Tunnel-Erase	580 microseconds (req'd for read to stabilize after write completed)	580 microseconds (req'd for read to stabilize after write completed)
Straddle-Erase	50 microseconds	50 microseconds
Read/Write Head	Single-gap with tunnel-erase or straddle-erase	

Table 1-2. Principal Specifications (Continued)

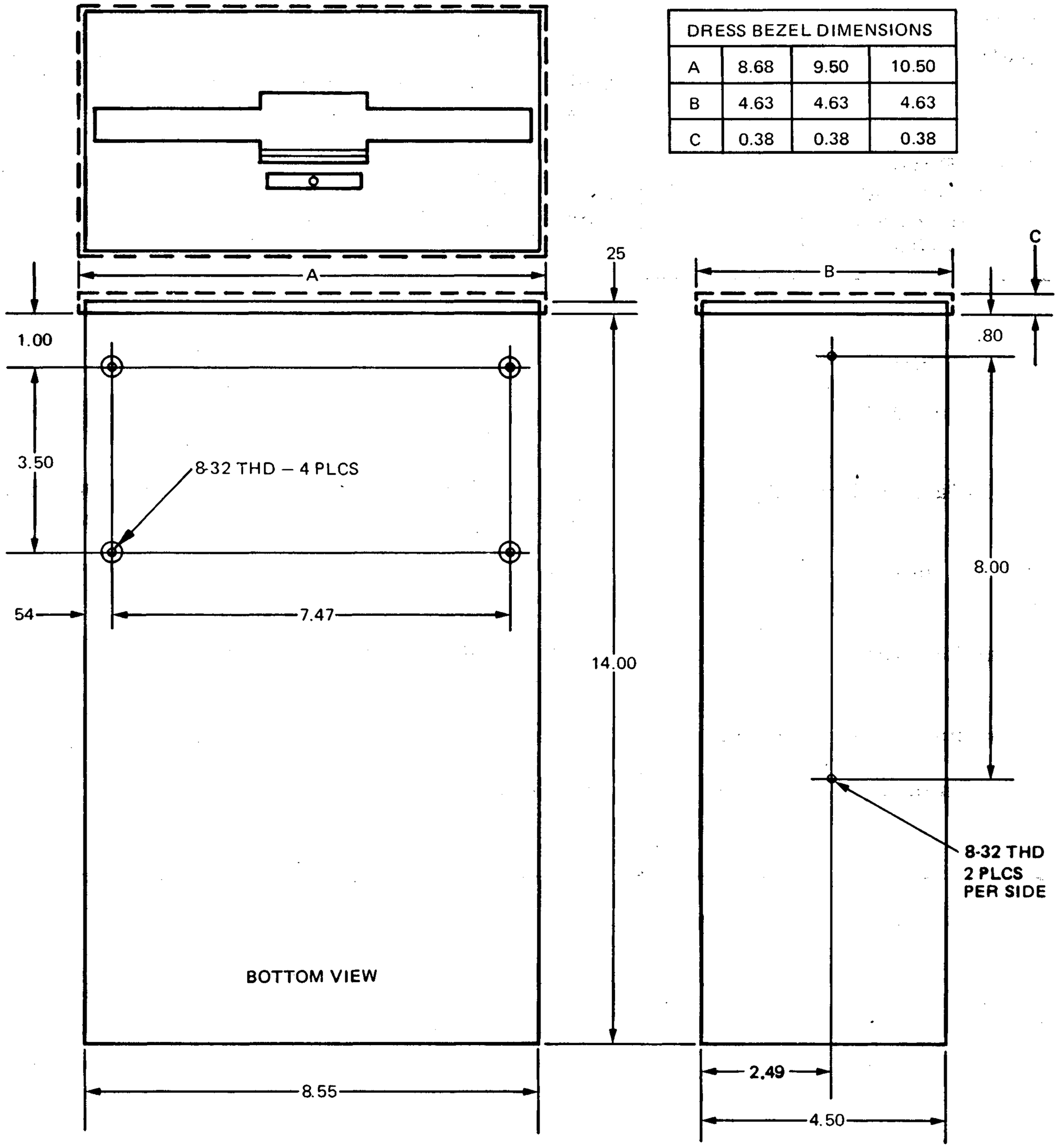
Function	Characteristics
	Single-Density / Double-Density
Read/Write-to-Erase Gap Spacing	0.035 inch (Tunnel Erase)
Track Width	0.013 inch
Erase Width	0.006 inch (on either side of track)
Spacing Between Tracks	0.02083 inch
Track Centerline Radius	$2.029 + \frac{76 - N}{48}$ inch Side "0" $1.9457 + \frac{76 - N}{48}$ inch Side "1" where N = track number
Logic Levels Disk Drive	Logical 1 (True) = +2.5V to +5.5V Logical 0 (False) = 0.0V to +0.4V
Interface	Logical 1 (True) = 0.0V to +0.4V Logical 0 (False) = +2.5V to +5.5V
AC Input Power Standard	115V (90-127V) 60 Hz ± 0.5 Hz
Optional	115V (90-127V) 50 Hz ± 0.5 Hz 230V (180 to 253V) 60 Hz ± 0.5 Hz 230V (180 to 253V) 50 Hz ± 0.5 Hz
Voltage Dropout	100%, 10 milliseconds once each 600 seconds
Motor Current (Max) Start	0.8 ampere for 115 volts AC 0.4 amperes for 230 volts AC
Run	0.4 amperes for 115 volts AC 0.2 amperes for 230 volts AC
DC Input Power	+24 volts ± 5%, 2.0 amperes maximum* +5 volts ± 5%, 1.0 amperes maximum

*Nominally 1.4 amperes

Table 1-2. Principal Specifications (Continued)

Function	Characteristics	
Reliability		
MTBF	6000 hours (after initial 200 hours)	
MTTR	Less than 20 minutes	
Read Errors		
Recoverable	Less than 1 in 10^9	
Non-recoverable (after 10 tries)	Less than 1 in 10^{12}	
	Operating	Non-Operating
Environmental		
Temperature	40° to 115°F (4.4° to 46.1°C)	32° to 150°F (0° to 65°C)
Relative Humidity	20% to 80% without condensation	5% to 90%, without condensation
Altitude	-1000 to +10,000 feet	-1000 to +45,000 feet
Heat Dissipation	300 BTU/Hour (worst case)	NA
Dimensions and Weight		
Dimensions	See Figure 1-6	
Weight	12.5 pounds	

DRESS BEZEL DIMENSIONS			
A	8.68	9.50	10.50
B	4.63	4.63	4.63
C	0.38	0.38	0.38



DIMENSIONAL TOLERANCE ± 0.02

Figure 1-6. Physical Dimensions and Mounting Provisions

SECTION 2
OPERATION

GENERAL

The Floppy Disk Drive operates under complete control of the host controller, after a floppy disk has been manually inserted. A front panel indicator is provided to indicate operating status.

DAILY OPERATION

The operating environment and the operator's careful handling of the disk drive and the floppy disks enhance the appearance, and greatly extend the operating life of the equipment.

Floppy Disk Handling and Storage

The floppy disk is the data storage medium. The disk is sealed in a protective envelope, in which are access holes for the read/write heads, index and sector holes, disk centering hole, and optional write-protect slot (see Figure 2-1).

For external error-free operating of the disk drive, the following disk handling practices are recommended:

- Prior to use, place in same operating environment as disk drive, for at least 5 minutes
- Never - Place heavy objects on envelope
  - write on protective envelope, only on label
  - touch disk surface while handling
  - attempt to clean disk surface
- Always - return floppy disk to storage envelope when not in use.

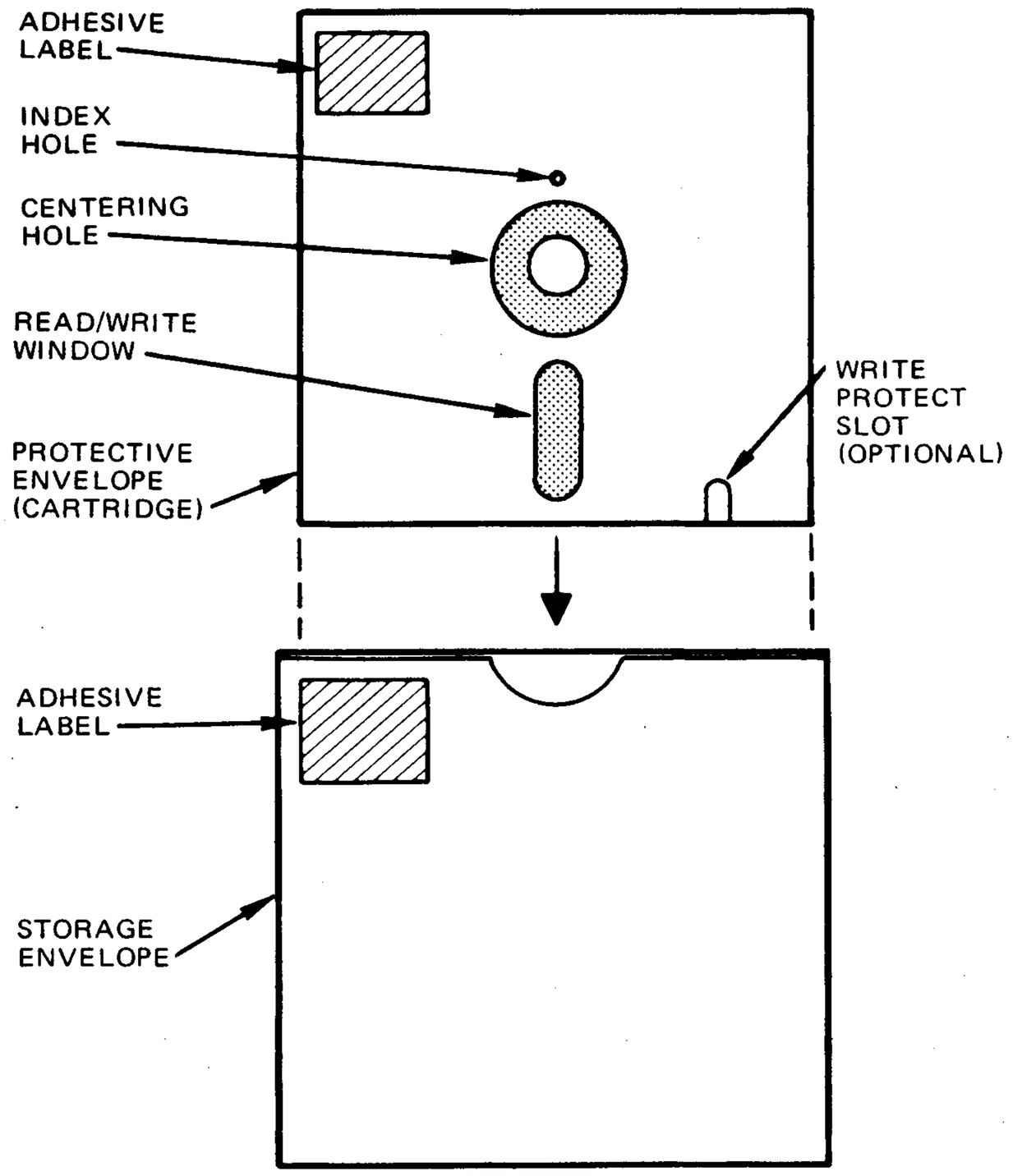


Figure 2-1. Floppy Disk and Storage Envelope

Floppy Disk Loading and Unloading

Correct loading of the floppy disk is essential for proper operation of the disk drive.

The disk is sealed in the protective envelope with an adhesive label in the outside left corner. Refer to Figure 2-1. The disk drive will not operate if the floppy disk is loaded upside-down. The correct load conditions are shown in Figure 2-2.

Loading and unloading procedures for the disk drive are listed in Table 2-1.

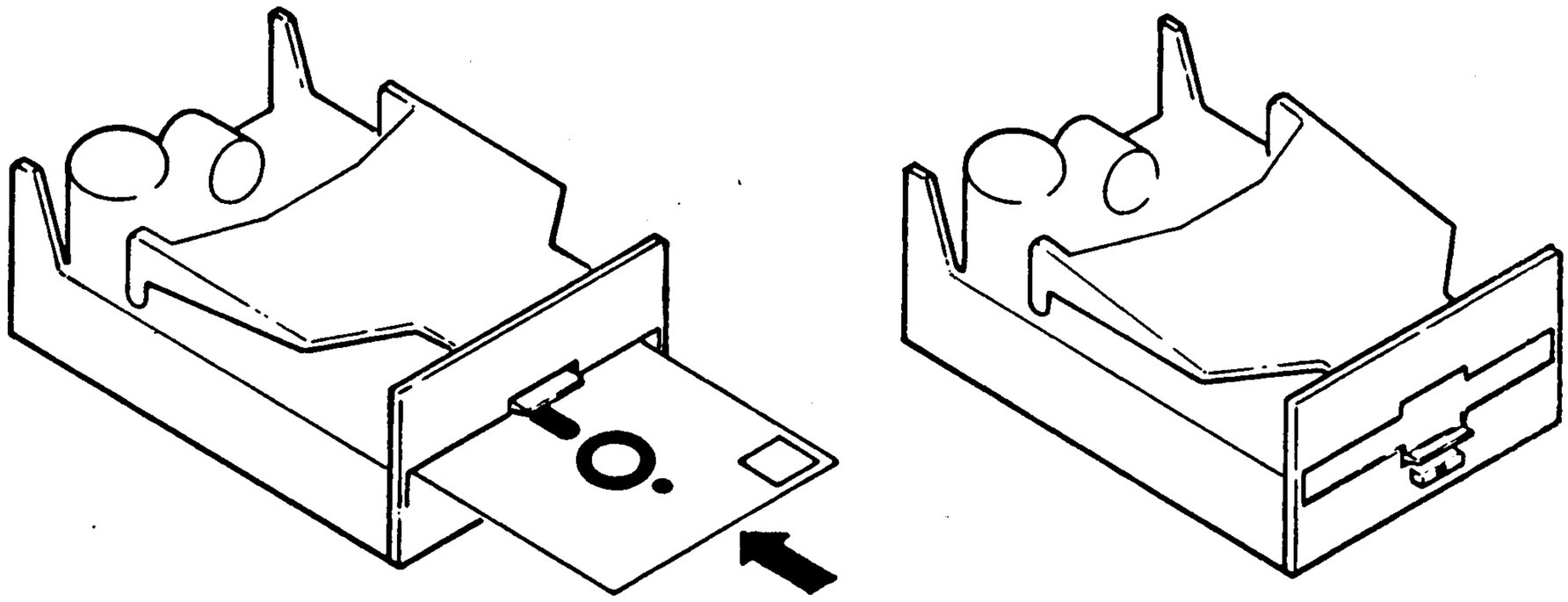


Figure 2-2. Floppy Disk Loading

Table 2-1. Floppy Disk Loading and Unloading

Action	Reaction
Press front panel pushbutton	Front panel unlatches and raises to open position. Spindle cone removed from drive cone. Disk cartridge released from spring-loaded latched condition.
Insert floppy disk, label up, into slot fully until stopped	Disk cartridge correctly positioned over drive spindle and firmly latched in spring-loaded condition
Lower front panel until latched	Spindle cone lowers and centers disk with firm pressure. Disk rotates normally with interlock closed.

Write-Protect

Write-protect guards against the destruction of stored data by circuit malfunctions or during test and operations. A read and write disk cartridge will have no open slot punched in the cartridge, or the slot will be covered with an adhesive opaque tab. A read-only disk cartridge will have an open punched slot ready for light sensing by the write-protect circuit.

SECTION 3
THEORY OF OPERATION

GENERAL

This section contains descriptive information on each function of the disk drive and detailed theory of operation. The information is intended to serve as a training guide for technical personnel requiring in-depth knowledge of the disk drive.

The disk drive contains three major systems, as shown in Figure 3-1:

- Control System
- Positioning System
- Read/Write System

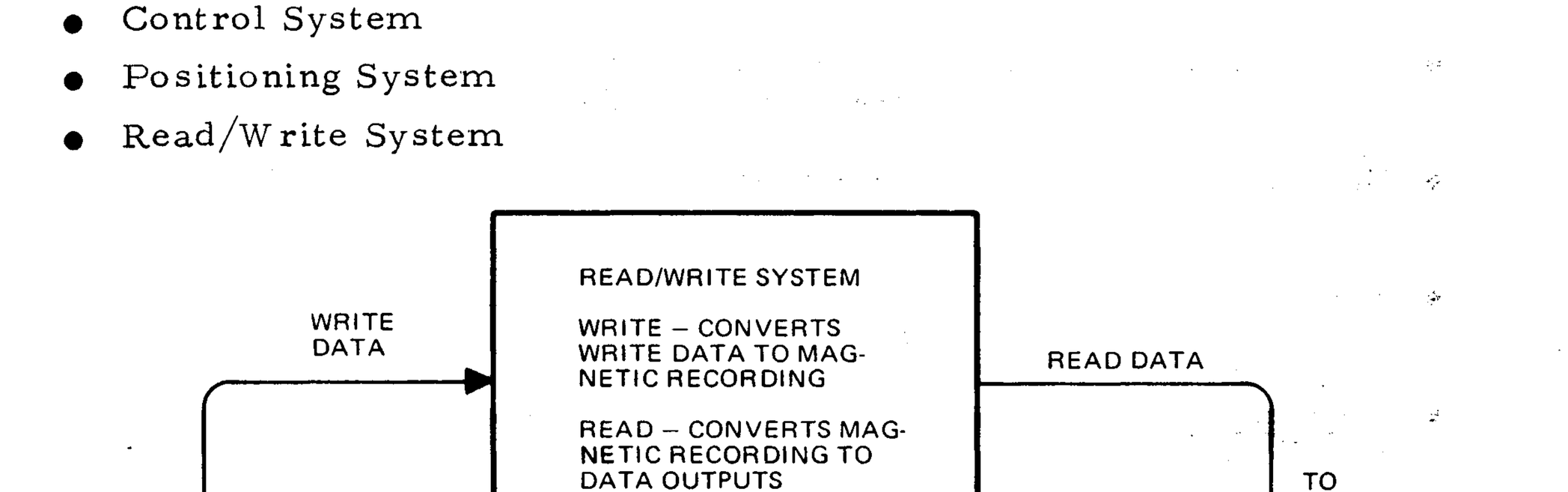


Figure 3-1. Floppy Disk Drive, Simplified Block Diagram

CONTROL SYSTEM

The control system provides the interface circuitry between the disk controller and the disk drive. The operational status is monitored and reported to the disk controller. The disk controller addresses a disk drive for on-line operation by activating a unique select line. Commands are then received and executed by the selected disk drive. This technique allows multiple disk drive units to share common interface lines, while remaining individually selectable.

Command Execution

Commands are received by the disk drive in the form of a low-level interface signal which designates one of the following operations:

- $\overline{\text{SELECT}}$ — Places disk drive on-line with controller
- $\overline{\text{STEP}}$ — Enables read/write head positioning
- $\overline{\text{STEP IN}}$ — Determines read/write head direction
- HEAD LOAD (HDLD) — Places disk recording surface in contact with read/write heads
- $\overline{\text{SIDE SELECT}}$ — Selects the side of the floppy disk for read/write operations
- WRITE ($\overline{\text{WRT}}$) — Enables write current to turn on and inhibits read output
- WRITE DATA ($\overline{\text{WRT DATA}}$) — Enables write data transfer from controller to disk drive

$\overline{\text{SELECT}}$, $\overline{\text{HDLD}}$ and $\overline{\text{SIDE SELECT}}$ commands must precede a read or write operation. $\overline{\text{SELECT}}$ enables all input/output gates, $\overline{\text{HDLD}}$ places the read/write heads in contact with the media and $\overline{\text{SIDE SELECT}}$ enables one of the two heads for a subsequent read or write operation.

$\overline{\text{STEP}}$ moves the read/write heads to either a higher or lower track position depending on the $\overline{\text{STEP IN}}$ line. Since relative track positioning is used, the disk controller maintains current track position and generates the number of pulses necessary to achieve a new track position. Once positioned, the disk controller initiates a read or write operation.

In a Write operation, the disk drive records the data in the same encoding method presented by the disk controller.

Status Sensing

Six disk drive status signals are gated to the I/O lines when the disk controller selects a disk drive.

- WRITE PROTECT (WRT PROTECT) — Hardware write-protect condition exists (if write-protect disk used)
- TRACK 00 — Read/write head positioned at track 00
- INDEX — Start of new track
- SECTOR — Start of new sector (if sectored disk used)
- READY — Signifies disk drive is operational
- ILLEGAL PACK — Signals selection of the second side of a single-sided pack
- DISK CHANGE — Signals that the pack may have been changed

READY, WRT PROTECT, ILLEGAL PACK and DISK CHANGE are static level status signals. Ready status indicates a floppy disk is loaded and up to operating speed. Write-protect status indicates write data cannot be recorded on the disk. Illegal Pack status signals that the uncertified side of pack is selected. Disk Change status indicates the door was opened during drive non-selection. Index status occurs once per disk revolution. Track 00 status is available for initializing the disk controller track address register. This signal is developed from a photo-transistor when the carriage is mechanically aligned with track 00, and the stepper motor is at phase A.

POSITIONING SYSTEM

The positioning system responds to STEP pulses received from the disk controller, by moving the read/write heads one track position per pulse. The following functions accomplish this operation.

- Stepper Motor Control
- Stepper Motor
- Carriage Assembly

Stepper Motor Control

The step motor control converts serial $\overline{\text{STEP}}$ pulses to three sequential control signals. Each signal energizes one of the stepper motor windings, causing a 15-degree rotation of the motor shaft (one track position).

Stepper Motor

The variable-reluctance stepping motor provides precision positioning of the read/write head. The stepper motor is energized by +24 volts dc and operates in either Detent or Positioning mode.

In the Detent mode, an internally generated magnetic field holds the rotor in a fixed position. To move from detent, one of three control lines is grounded, driving the motor to the next detent. Sequentially grounded control windings cause the rotor shaft to rotate through detent positions at a maximum rate of 333 steps per second. A lead screw on the exposed rotor shaft converts rotary movements to linear movement to drive the carriage assembly.

Carriage Assembly

The carriage assembly rides on a lead screw while a fixed way prevents the carriage from skewing. The way serves as a guide while the lead screw drive performs the in and out positioning.

The read/write heads, attached to the carriage assembly, contact the recording surface when the drive is selected. This command releases the spring loaded upper head arm supplying the load force to bring both read/write heads into contact with the media.

READ/WRITE SYSTEM

The read/write system records encoded data during a Write operation, and retrieves data during a Read operation. The write ($\overline{\text{WRT}}$) signal from the controller designates a Read when high or a Write when low.

Read/Write Operation

The read/write head is essentially an electromagnet that can concentrate a high magnetizing force over a very small area of the adjacent recording surface. When recording, the flux field is alternated to magnetize the disk with the desired bit pattern. Each read/write head also contains a tunnel-erase or straddle-erase electromagnet, the function of which is to erase the edges of the recorded track as data is being written. The width of the track is narrowed to approximately 0.013-inch by this technique, to minimize tne effect of data previously written on the track and possible crosstalk between tracks.

When reading, the read/write electromagnet operates as a sensor. A flux reversal on the recorded track induces a voltage across the electromagnet coils. This voltage is amplified and conditioned to recover the recorded information.

FUNCTIONAL DESCRIPTION

The disk drive is a mass memory device featuring a removable floppy disk and contact recording. The 250 khz/bit transfer rate provides a high speed transfer of data between the disk drive and a host disk controller. Multiple disk drives may be connected in a radial or daisy-chained configuration with individual selection and status monitoring.

The disk drive requires operator intervention only for loading and unloading the floppy disk; after which the disk controller remotely operates the unit. Input ac and dc power, control signals and write data are supplied by the controller; the disk drive responds with operating status and read data. A detailed functional block diagram is shown in Figure 3-2.

The disk drive comprises the following functional systems:

- Spindle Drive System
- Spindle System
- Read/Write Head Positioning System
- Head Load System

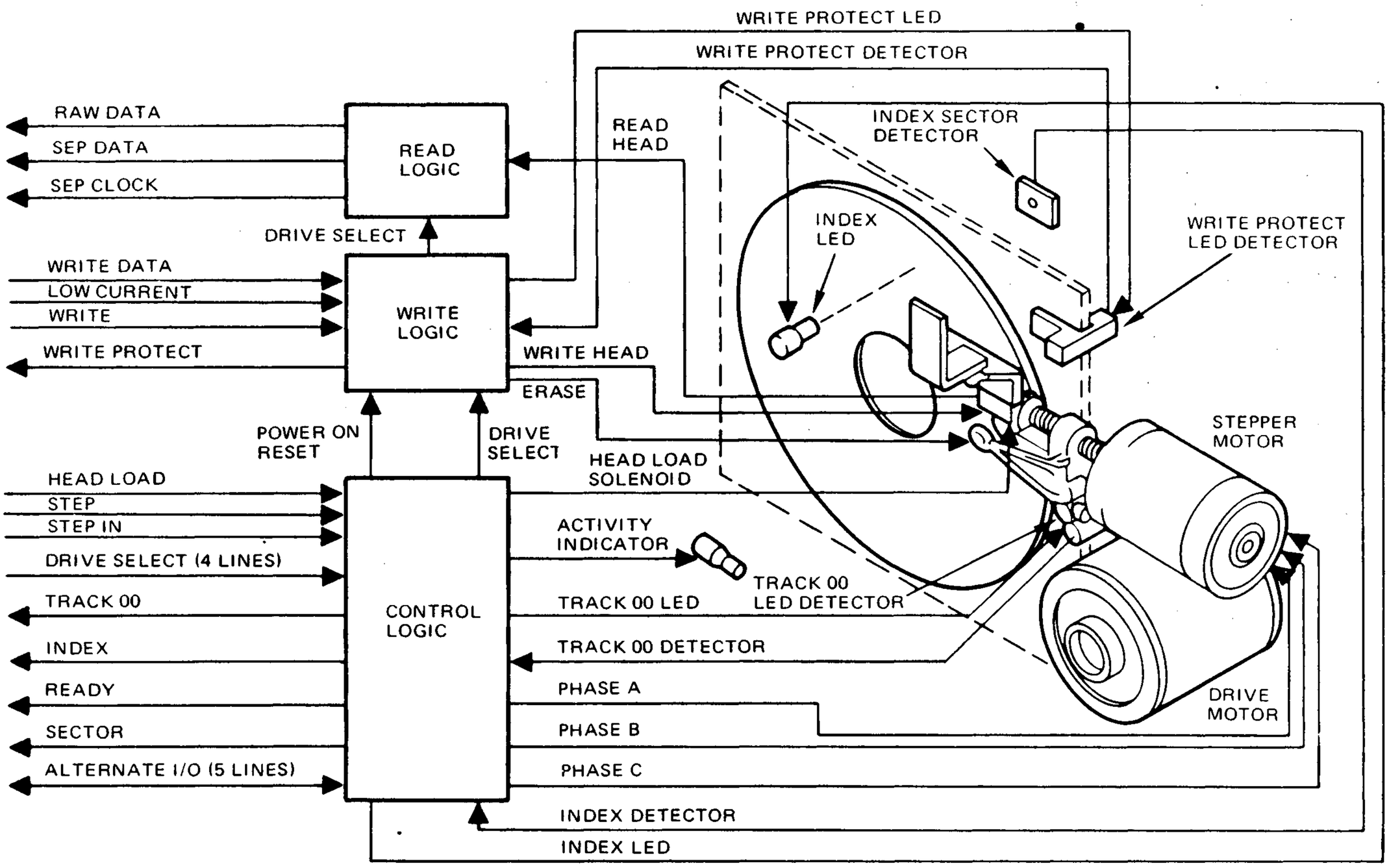


Figure 3-2. Detailed Functional Block Diagram

Spindle Drive System

The spindle drive system provides rotational movement of the spindle using a single-phase motor selected to match primary power of the host system. Various drive motors are available that accommodate primary power requirements of 115 and 230 volts ac at 50 or 60 Hertz.

Rotation of the spindle is provided by a belt and pulley connected to the drive motor rotor shaft (see Figure 3-3). The drive pulley is selectable for either 50 or 60 Hz input power for rotational speed of 360 revolutions per minute. A floppy disk is engaged with the spindle drive hub by the spindle system centering cone.

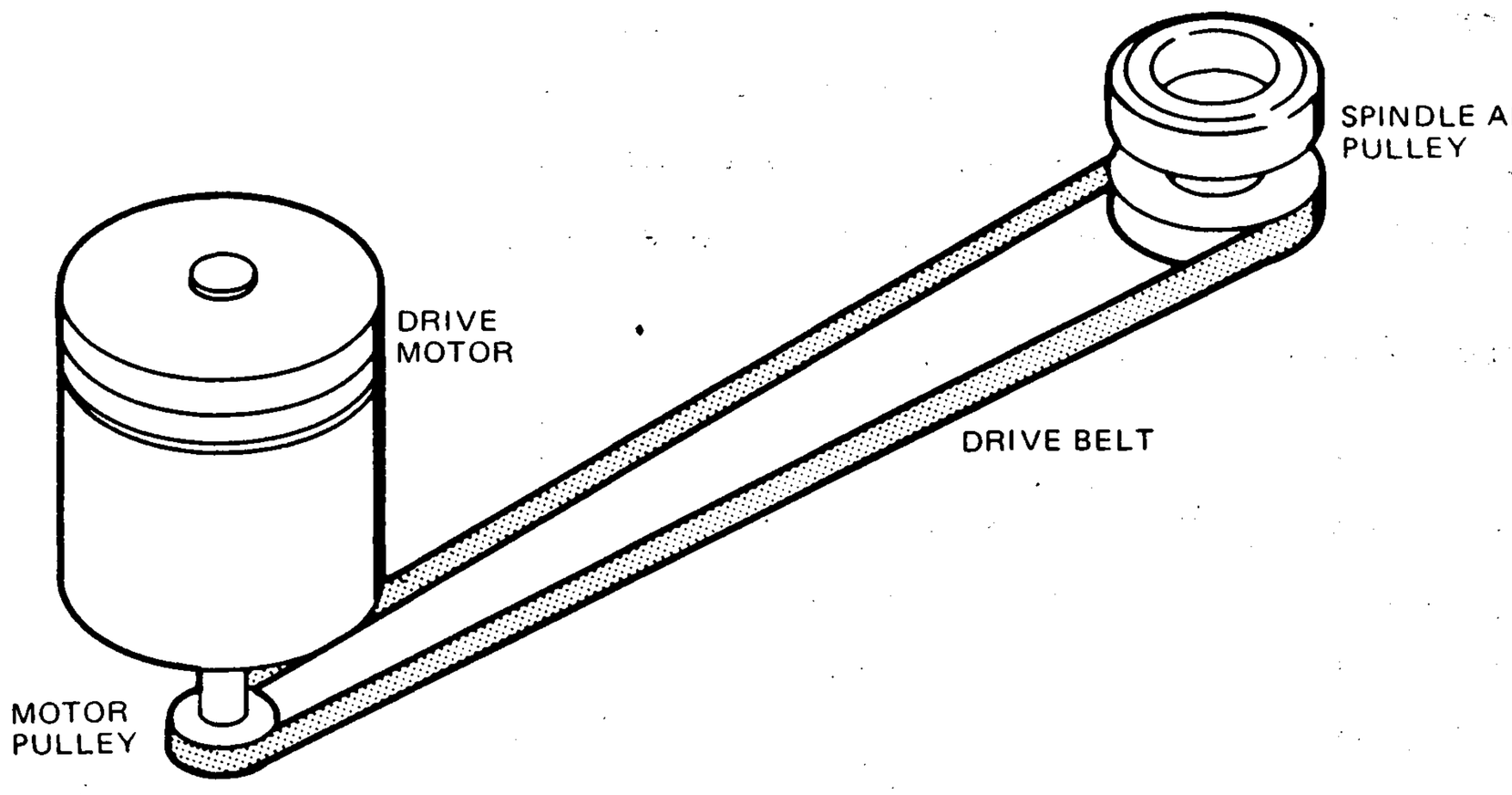


Figure 3-3. Spindle Drive System

Spindle System

The spindle system consists of a spindle and a centering cone mounted on the deck and carrier, respectively. In the unload position, the centering cone carrier is pivoted open creating an aperture through which the floppy disk is inserted. In this position, the centering cone is lifted, disengaging the disk from the spindle hub.

To load a disk, the operator inserts the floppy disk then closes the handle, which latches the carrier in the operating mode. The centering cone (see Figure 3-4) is attached to the carrier and is an open-splined non-metallic device that performs two functions:

- Aligns the disk media to the spindle hub
- Engages the disk media to the spindle drive system

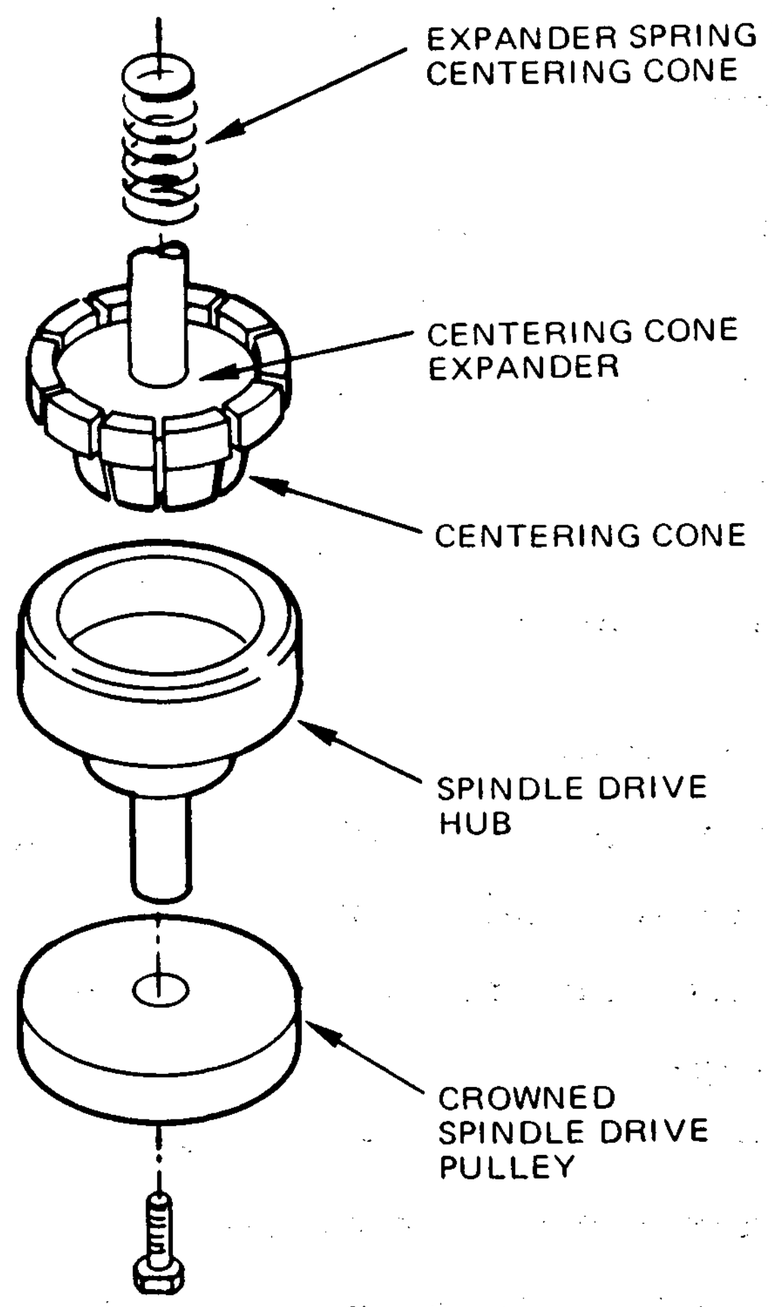


Figure 3-4. Spindle System

As the carrier is pivoted to the load position, the centering cone enters the floppy disk center. Just prior to the fully closed position of the handle, the centering cone expander is automatically activated to expand the centering cone, which grips and aligns the floppy disk to the spindle, thus centering the disk on the spindle.

Read/Write Head Positioning System

The positioning system comprises a carriage assembly containing a fixed read/write head and a second read/write head on a spring loaded arm, a bidirectional stepper motor and a lead screw (see Figure 3-5). The stepper motor rotational movements are converted to linear motion by driving the lead screw and carriage assembly.

The read/write head carriage rides on the lead screw shaft and is held in horizontal alignment. When the stepper motor is pulsed, the lead screw rotates clockwise or counterclockwise, moving the carriage in or out, respectively

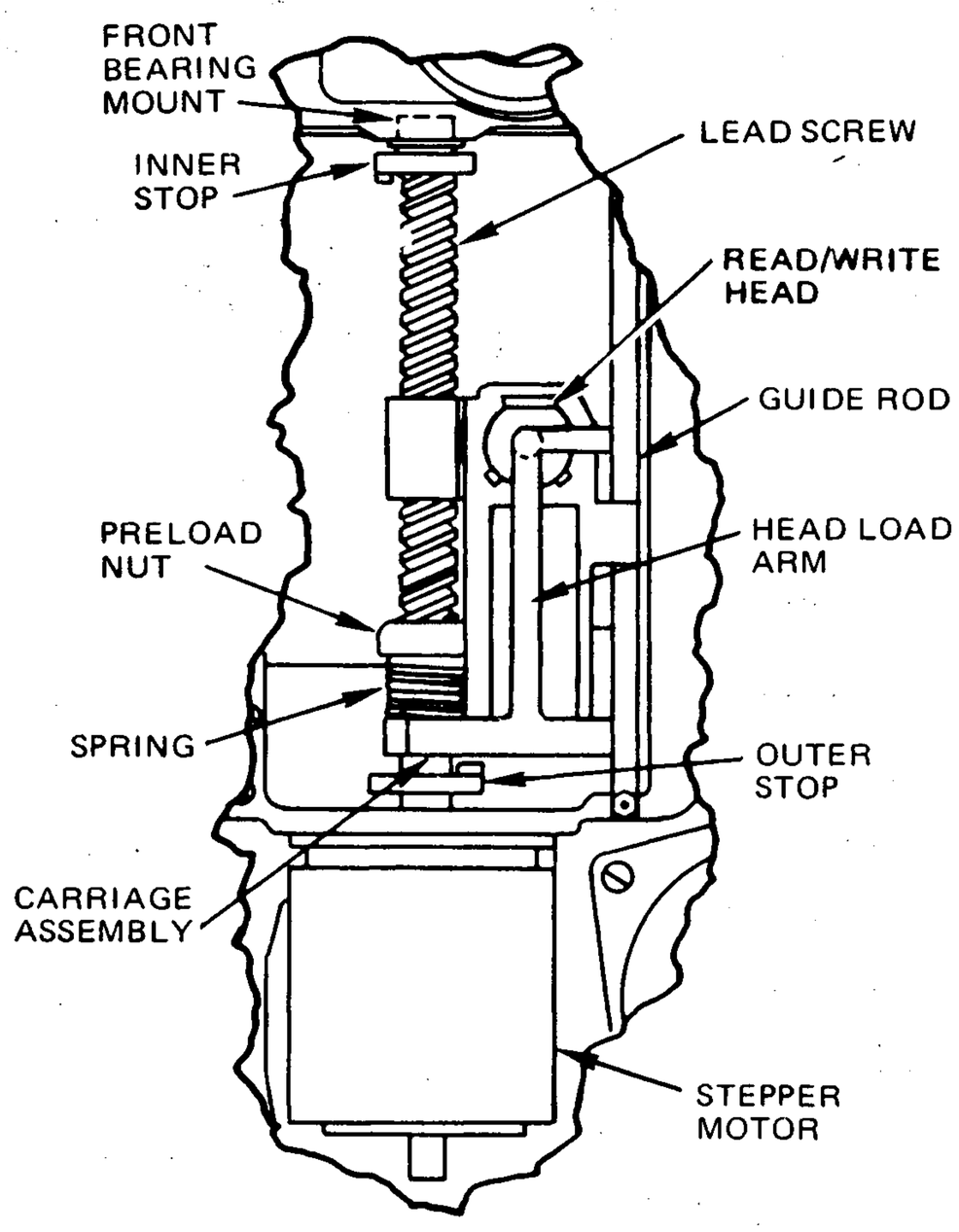


Figure 3-5. Read/Write Head Positioning System

The stepper motor has three pairs of windings. In Detent, current flows in one winding and maintains the rotor in electromagnetic detent. For positioning, the windings are driven sequentially, causing the rotor to rotate through detent positions until the STEP commands are halted. The rotor then locks in that position, with the last winding being driven. The sequence in which the stepper motor windings are pulsed dictates rotational direction and, subsequently, higher or lower track addressing from a relative position.

Head Load System

The head load system is basically, a solenoid driver and a solenoid. When activated by the $\overline{\text{HDLD}}$ command, the spring-loaded head arm is released and brings the recording surface of the floppy disk into conformance with both heads. At the same time a foam pressure pad is released exerting a force on the disk cartridge against the platen on the deck.

To minimize disk surface and read/write head wear, the $\overline{\text{HDLD}}$ command is gated with $\overline{\text{SELECT}}$. In the deselect or Idle mode, head loading is automatically disabled. The Head Load command requires a 25-millisecond execution time.

Control and Data Timing

Figure 3-6 shows the sequence of control and data timing requirements.

LOGIC CONVENTIONS

The disk drive uses standard 5-volt TTL logic, where a voltage more positive than +2.4 volts (turn-on threshold) is considered a logical one (high), and a voltage more negative than +0.4 volts (turn-off threshold) is considered a logical zero (low).

Interface signal logic levels are inverted by line receivers and line drivers for use by the disk drive and the controller, respectively. For all interface signals, a voltage more positive than +2.4 volts (turn-off threshold) is considered a logical zero, and a voltage more negative than +0.4 volts (turn-on threshold) is considered a logical one (see Figure 3-7).

The logic symbology used in the disk drive is shown in Figure 3-8. Each element is described and all conditions are defined.

DETAILED LOGIC DESCRIPTION

The detailed logic description is divided into three major functions:

- Control Logic
- Read/Write Head Positioning Logic
- Read/Write Logic

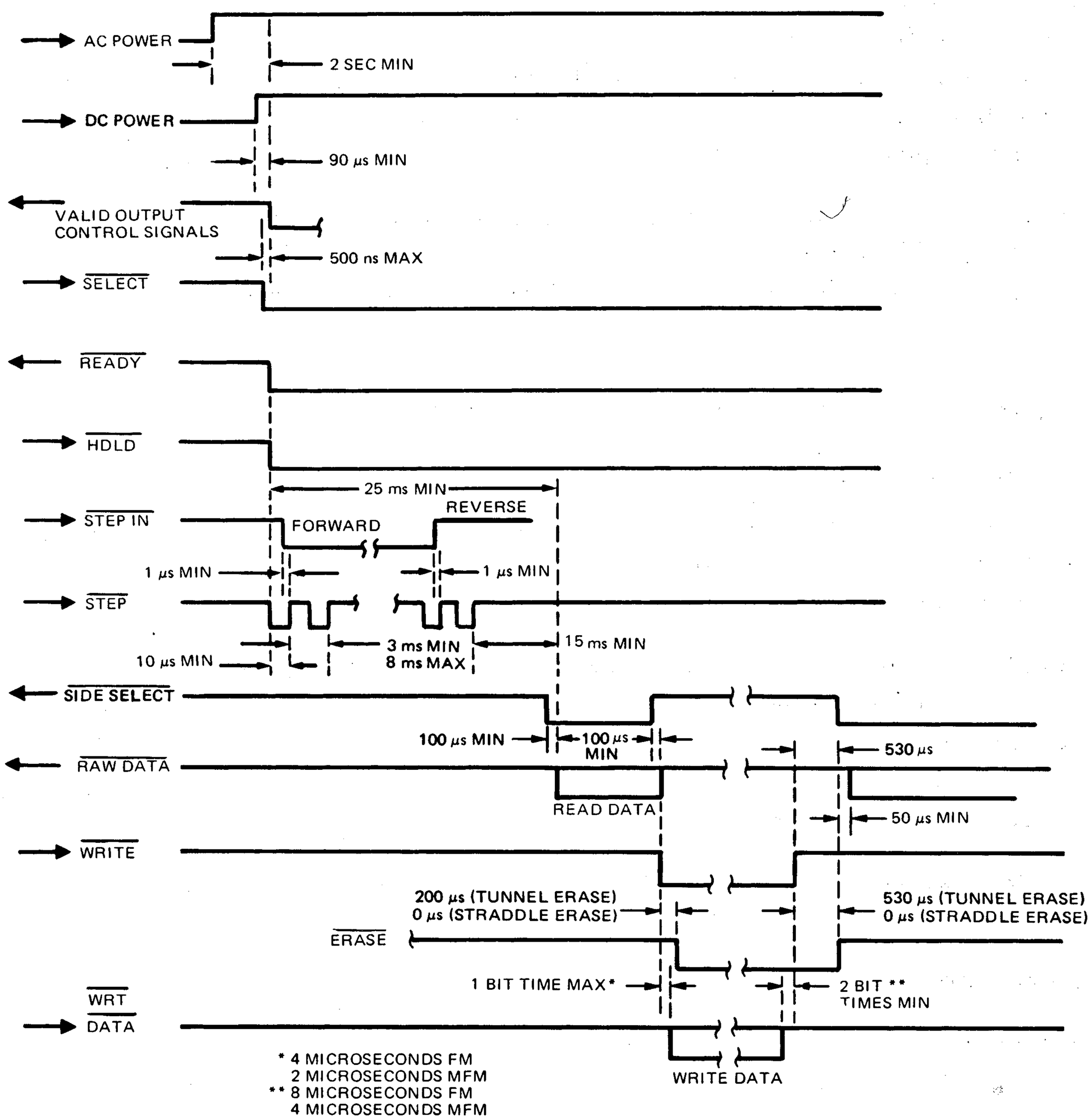


Figure 3-6. Control and Data Timing

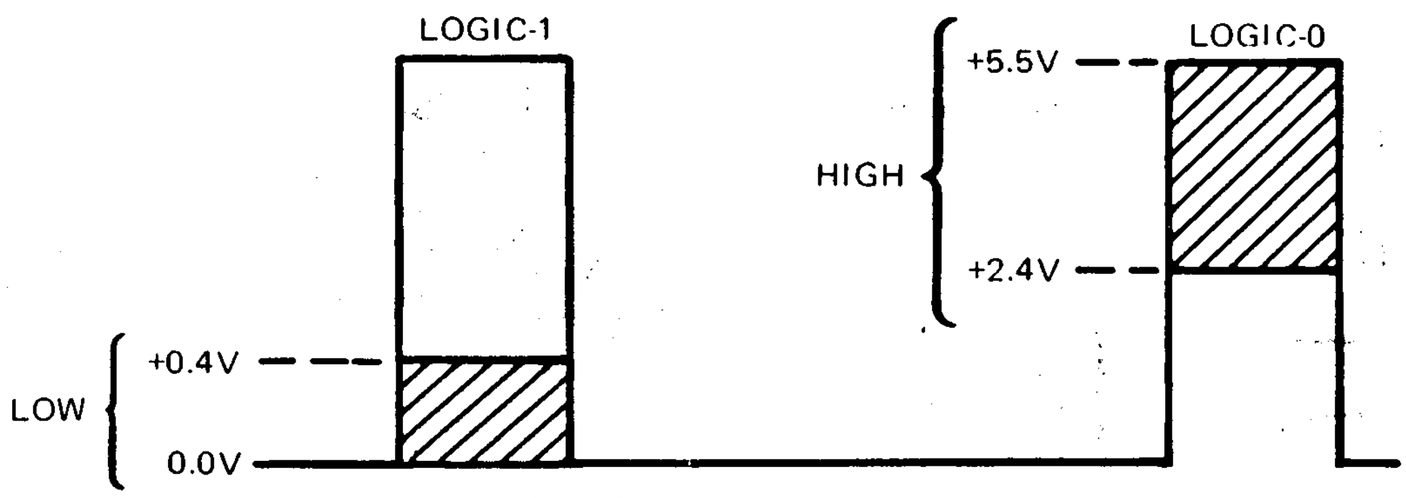


Figure 3-7. Interface Logic Levels

CONTROL LOGIC

The control logic contained in the disk drive performs three prime functions:

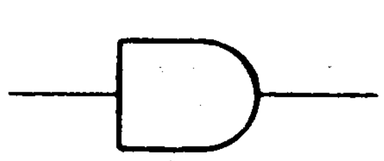
- Accepts controller $\overline{\text{SELECT}}$ command and enables all interface logic
- Detects and provides index and optional sector pulses
- Monitors floppy disk rotation to develop a ready status for the controller
- Reports to the controller the type of floppy disk in use

Select

When $\overline{\text{SELECT}}$ is inactive (high), the select logic inhibits all interface input receivers and output drivers to and from the disk drive. The select logic is primarily comprised of AND gate 3C, NOR gate 7C and inverter 5C (see Figure 3-9).

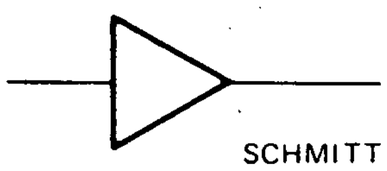
When $\overline{\text{SELECT}}$ is inactive, gate 3C outputs a high SELECT signal to inhibit all ready, index sector, write-protect, and track 00 logic. NOR gate 4B outputs a low $\overline{\text{SELECT}}$ to inhibit all head load and step logic.

As shipped from the factory, a jumper plug is installed between the "0" Radial Select pads, causing SELECT 0 to drive 3C. This assigns physical address 0 to the disk drive. One of three other addresses can be assigned, $\overline{\text{SELECT 1}}$, $\overline{\text{SELECT 2}}$, or $\overline{\text{SELECT 3}}$, by removing the jumper between the "0" pads and installing it between the desired Radial Select pads. Only one jumper can be connected to the disk drive. With the Radial Select feature, up to four disk drives can be connected in daisy-chain fashion.



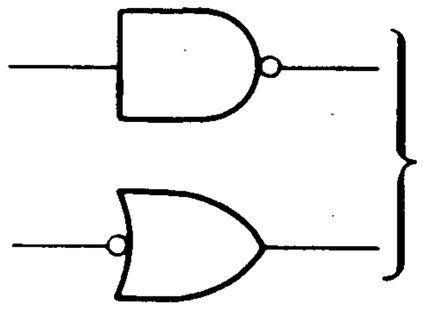
GATES

HIGH IN, HIGH OUT



LINE DRIVER

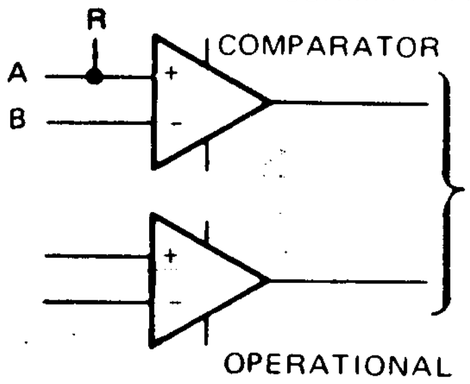
HIGH IN, HIGH OUT.



HIGH IN, LOW OUT.
LOW IN, HIGH OUT

SCHMITT AMPLIFIERS

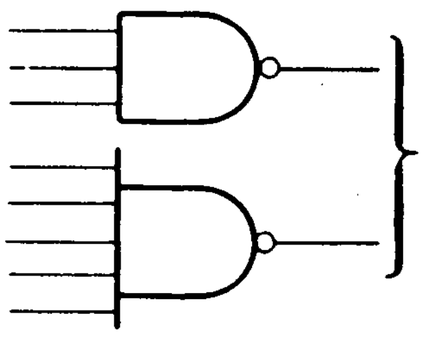
R



COMPARATOR

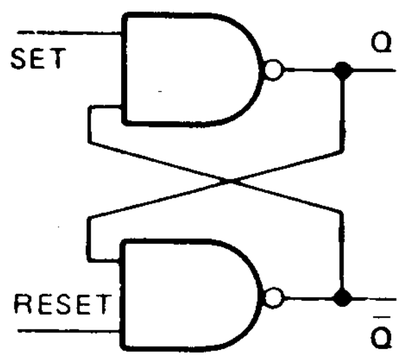
R = REFERENCE VOLTAGE OUTPUT VOLTAGE RANGE DEPENDS ON REFERENCE VOLTAGES AND RANGE OF A AND B INPUTS. A IS SEEN AMPLIFIED AT THE OUTPUT B IS SEEN AMPLIFIED AND INVERTED AT THE OUTPUT. IF BOTH A AND B ARE ACTIVE, OUTPUT IS AN ALGEBRAIC ADDITION OF INPUTS

OPERATIONAL



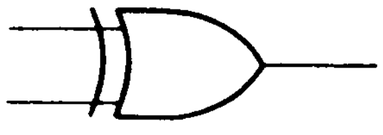
ALL HIGHS IN, LOW OUT.
ANY LOW IN, HIGH OUT

CROSS-COUPLED LATCH



BOTH SET AND RESET HIGH, NO CHANGE. SET INPUT LOW, Q IS HIGH AND $\bar{Q}$ IS LOW. RESET LOW, Q IS LOW AND $\bar{Q}$ IS HIGH. BOTH SET AND RESET LOW, Q AND $\bar{Q}$ BOTH HIGH.

EXCLUSIVE OR GATE



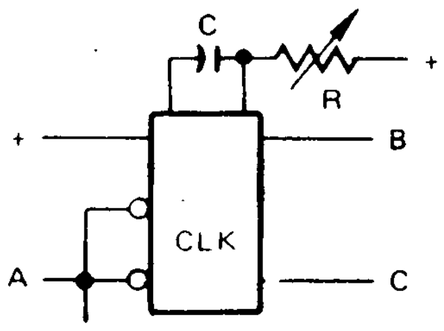
INPUTS NOT IDENTICAL, HIGH OUTPUT. INPUTS IDENTICAL, LOW OUTPUT

B

LIGHT EMITTING DIODE

IF A IS MORE POSITIVE THAN B, LIGHT IS EMITTED. IF B IS MORE POSITIVE THAN A, NO LIGHT IS EMITTED

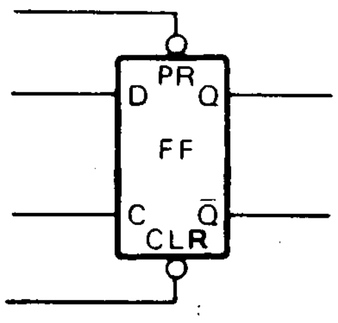
IC ONE-SHOTS



OUTPUT PULSE DURATION DETERMINED BY EXTERNAL R/C. VARIABLE RESISTOR INDICATES TIME ADJUSTABLE OVER A RANGE

!F A GOES LOW, B GOES HIGH FOR X TIME AND C GOES LOW FOR X TIME.

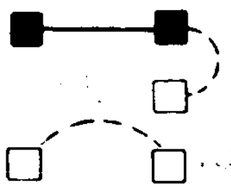
D FLIP-FLOP



D HIGH AND C POSITIVE TRANSITION = Q HIGH; D LOW AND C POSITIVE TRANSITION = Q LOW. EXCEPT: PR LOW HOLDS Q HIGH; CLR LOW HOLDS $\bar{Q}$ HIGH. $\bar{Q}$ IS ALWAYS THE INVERSE OF Q, EXCEPT WHEN PR AND CLR ARE BOTH AT THE SAME TIME (Q AND $\bar{Q}$ WILL BOTH BE HIGH)

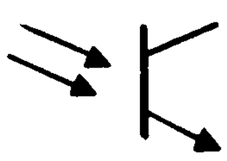
JUMPERS

DARK PADS INDICATE JUMPERS NORMALLY FACTORY INSTALLED



LIGHT PADS INDICATE OPTIONAL JUMPER INSTALLATION

PHOTO TRANSISTOR



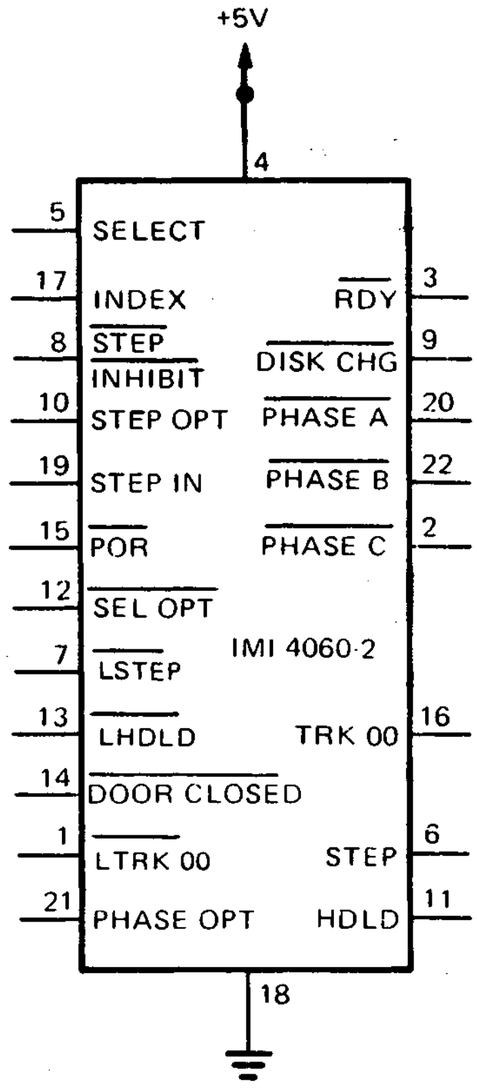
LIGHT ACTIVATES PHOTO TRANSISTOR

Figure 3-8. Logic Symbology (Sheet 1 of 2)

LOGIC LSI CHIP

THIS LOGIC CHIP IS A SEMI-CUSTOM LSI 22-PIN INTEGRATED CIRCUIT. THE CHIP USES C-MOS FET PAIRS AS BUILDING BLOCKS FOR GENERATING THE REQUIRED LOGIC FUNCTIONS. THE C-MOS REQUIRES LITTLE CURRENT AND IS INSENSITIVE TO NOISE. ALL OUTPUTS WILL SINK 2.0 MILLIAMPERES. ALL INPUTS REQUIRE 0.2 MILLIAMPERES TO BE DRIVEN AND THE INPUT AND OUTPUT SIGNALS AND PINS ARE IDENTIFIED AS SHOWN AND AS LISTED BELOW.

PIN INPUTS		PIN OUTPUTS	
1	$\overline{\text{LTRK 00}}$	2	$\overline{\text{PHASE C}}$
4	+5V	3	$\overline{\text{RDY}}$
5	SELECT	6	STEP
7	$\overline{\text{LSTEP}}$	9	$\overline{\text{DISK CHG}}$
8	$\overline{\text{STEP INHIBIT}}$	11	HDLD
10	$\overline{\text{STEP OPT}}$	16	TRK 00
12	$\overline{\text{SEL OPT}}$	20	$\overline{\text{PHASE A}}$
13	$\overline{\text{LHDLD}}$	22	$\overline{\text{PHASE B}}$
14	$\overline{\text{DOOR CLOSED}}$		
15	$\overline{\text{POR}}$		
17	INDEX		
18	GND		
19	STEP IN		
21	PHASE OPT		



INPUTS – THE DERIVATION OF THE INPUTS IS EXPLAINED IN OTHER SECTIONS OF THIS MANUAL.

OUTPUTS – A BRIEF DESCRIPTION OF ALL OUTPUTS AND THEIR EQUATION IS LISTED BELOW.

HDLD = (LHD LD) (SEL OPT) (DOOR CLOSED)
READ/WRITE HEAD LOADED IF DRIVE IS SELECTED, IF A HEAD LOAD COMMAND IS RECEIVED, AND PROVIDED THAT THE ACCESS DOOR IS CLOSED

TRK 00 = (LTRK 00) (PHASE A)
TRACK 00 SIGNAL SENT TO CONTROLLER IF OPTICAL SWITCH INDICATES THAT CARRIAGE IS BETWEEN TRACK 00 AND TRACK 1-1/2, AND THAT PHASE A OUTPUT IS PRESENT

STEP = (STEP OPT) (LSTEP) ($\overline{\text{STEP INHIBIT}}$)
STEP OUTPUT ACTIVE IF STEP OPT AND LSTEP BOTH ACTIVE AND NOT DISABLED BY STEP INHIBIT

$\overline{\text{RDY}}$ = ($\overline{\text{POR}}$) (DOOR CLOSED) (TWO INDEX PULSES)
READY IS INACTIVE (HIGH) DURING POWER-ON AND IF DOOR IS OPEN
READY IS ACTIVE (LOW) IF POWER IS APPLIED WITH DOOR CLOSED, FOLLOWING TWO INDEX PULSES AT INPUT

$\overline{\text{PHASE A}}$ = ACTIVE AT TRACK 00 WITH PHASE OPT HIGH. $\overline{\text{PHASE A}}$ ACTIVE EVERY THIRD TRACK (0, 3, 6, ETC)

$\overline{\text{PHASE B}}$ = ACTIVE AT TRACKS 1, 4, 7, ETC

$\overline{\text{PHASE C}}$ = ACTIVE AT TRACKS 2, 5, 8, ETC

Figure 3-8. Logic Symbology (Sheet 2 of 2)

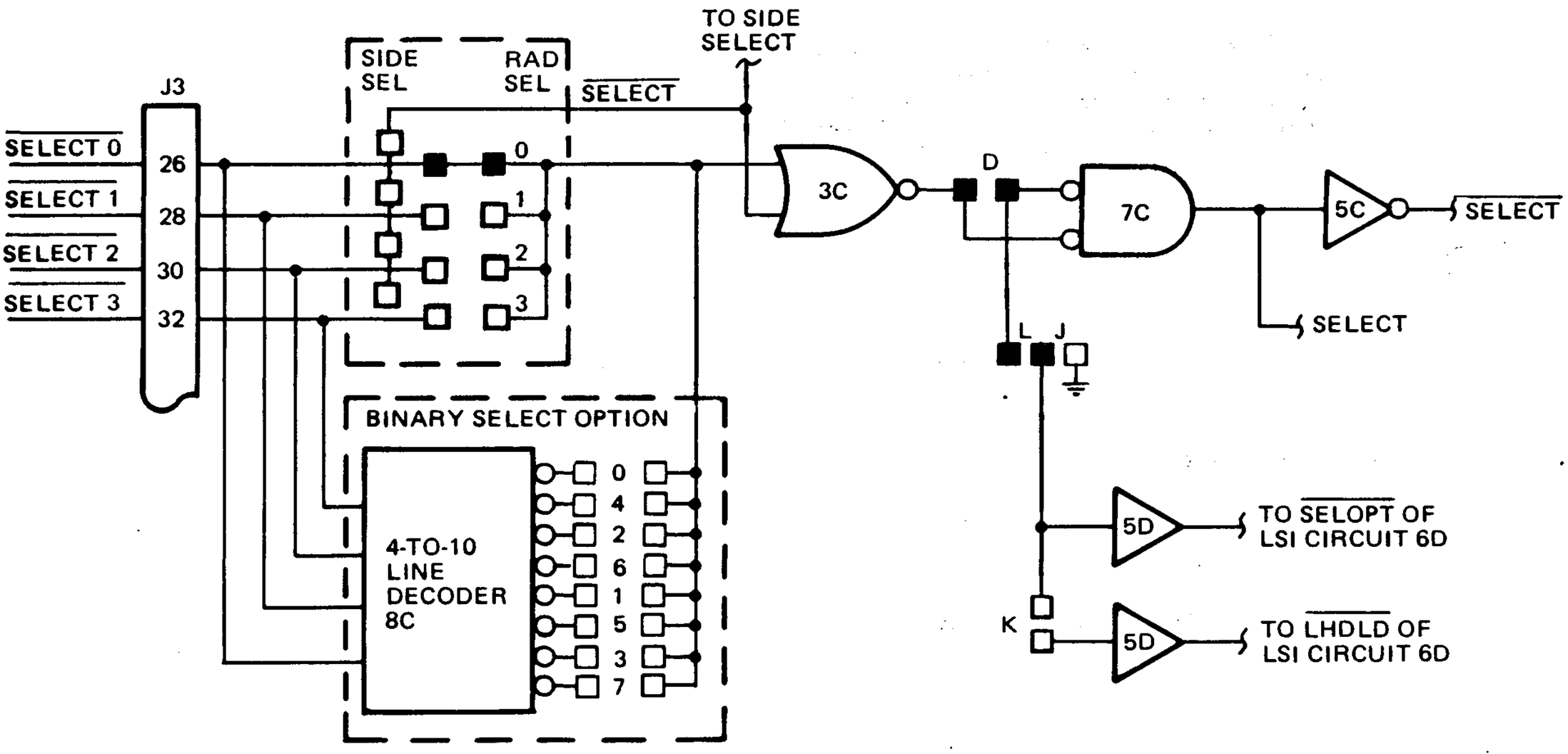


Figure 3-9. Select Logic

Binary Select (Option)

The Binary Select option allows up to eight disk drives to be daisy-chained to the controller, with addresses 0 through 7. The option is comprised of 4-to-10 line decoder 8C, and eight sets of jumper pads (see Figure 3-9).

When $\overline{\text{SELECT 0}}$ is inactive, the decoder is inhibited and all outputs are high. When $\overline{\text{SELECT 0}}$ is active, the decoder is enabled and only one low output is produced. The decoder accepts a binary coded address on three select lines, $\overline{\text{SELECT 1}}$ through $\overline{\text{SELECT 3}}$, and decodes them to produce a low output decimal equivalent corresponding to the desired address.

The jumper plug is removed from the Radial Select option and installed between the pads desired to assign the independent physical address of the disk drive. Table 3-1 indicates the logic state of the $\overline{\text{SELECT}}$ lines for selecting each drive.

Index/Sector Detection

A light-emitting diode (LED) and phototransistor are physically positioned in the disk drive to sense the index and sector (optional) holes in the floppy disk. Since the index holes are positioned differently for single-sided and double-sided floppy

Table 3-1. Disk Drive Selection

$\overline{\text{SELECT 1}}$	$\overline{\text{SELECT 2}}$	$\overline{\text{SELECT 3}}$	Drive Selected
1	1	1	0
0	1	1	1
1	0	1	2
0	0	1	3
1	1	0	4
0	1	0	5
1	0	0	6
0	0	0	7

1 = Inactive state of interface signal (high)

0 = Active state of interface signal (low)

disks, two LED/phototransistor pairs are included. If the Hard Sector option is installed, a 32-sector disk should be used. Index pulse detection logic is shown in Figure 3-10.

The index detection logic is comprised of an LED, a phototransistor and a comparator for each index position and an output line driver. The negative input to comparator 3A is driven by the output of the activated phototransistor. For INDEX 0, resistor R3 supplies bias current to the LED.

When the media blocks the LED output from the phototransistor, the input to the comparator is high. When the index hole is sensed, the input to the comparator is low. Resistors R11, R12 and R26 provide a positive reference threshold voltage of +2.5 volts. For each index hole sensed, the comparator output is a positive INDEX pulse, nominally 1.7 millisecond in duration, and occurring once per disk revolution. An identical circuit is used for INDEX 1. The two index pulses are input to flip-flops 4A. AND gate 3C then enables INDEX 1 if no INDEX 0 has been

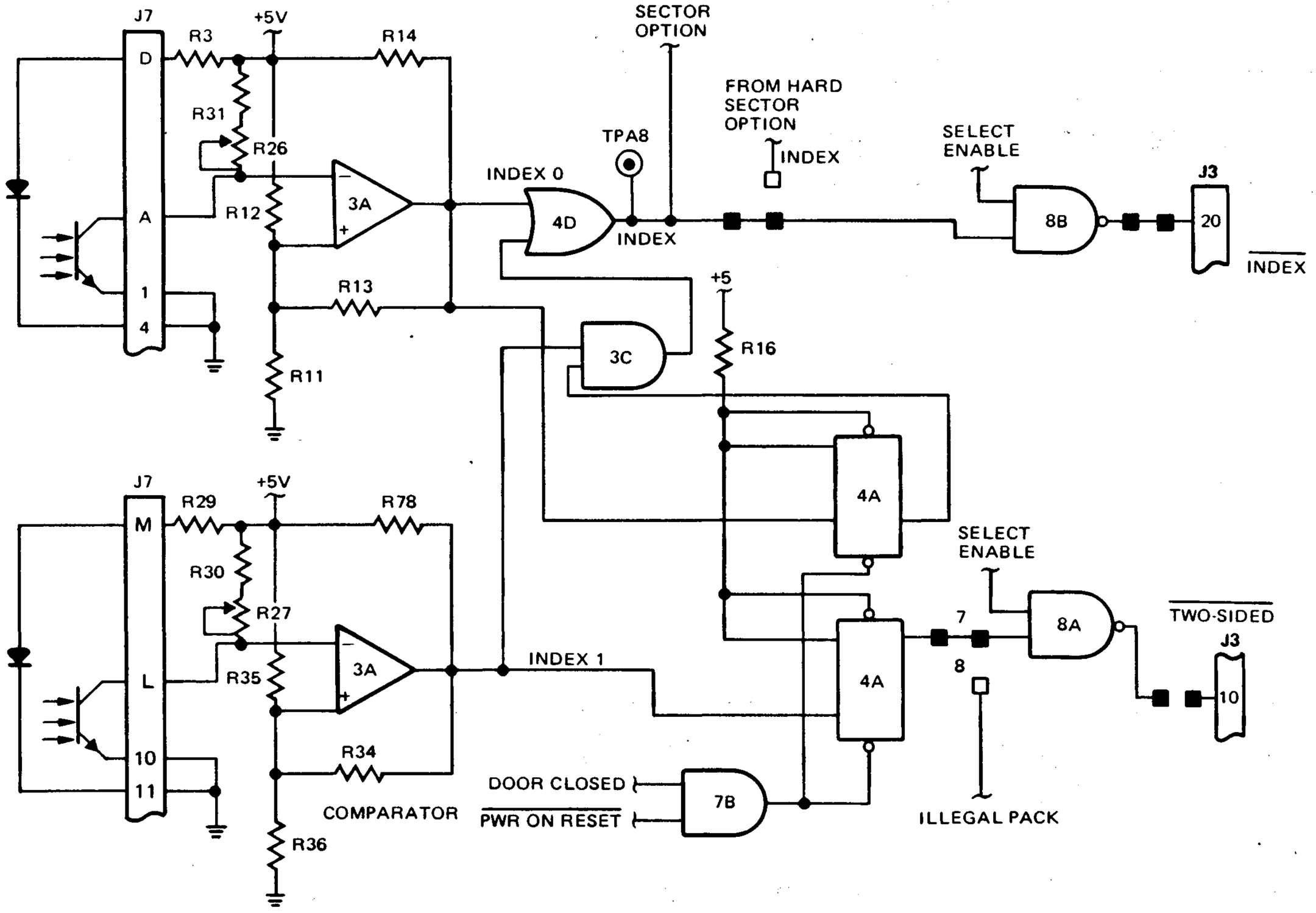


Figure 3-10. Index Detection Logic

detected to OR gate 4D. The INDEX pulse is input to interface line driver 8B. Figure 3-11 shows index pulse timing.

Hard Sector (Option)

With the Hard Sector option installed, and by using a 32-sector floppy disk, the comparator provides 32 SECTOR pulses, equally spaced 5.2 milliseconds apart, during each disk revolution, plus an INDEX pulse that occurs halfway between sector pulses 31 and 0. Refer to Figure 3-12.

Figure 3-11. Index Timing

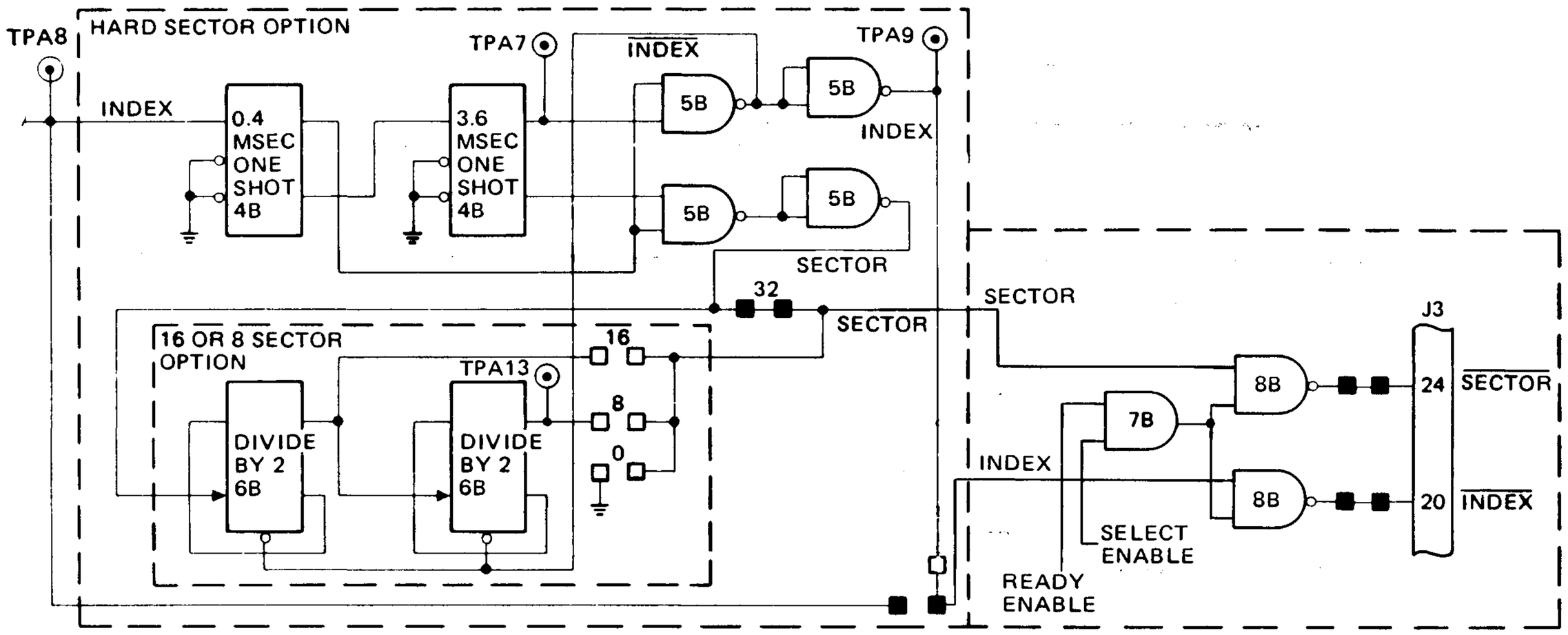


Figure 3-12. Hard Sector and 16/8 Sector Option Logic

The positive-going leading edge of the detected INDEX pulse (Figure 3-12) triggers one-shot 4B to produce a 0.4 millisecond pulse, and complement. The positive-going trailing edge of the complement ($\overline{Q}$), triggers one-shot 4B which times for 3.6 milliseconds. After being triggered by SECTOR pulse 31, the one-shot is timing out. During this period the INDEX pulse occurs and one-shot 4B can not be triggered.

The output of $\overline{\text{INDEX}}$ gate 5B drives INDEX gate 5B and resets flip-flop 6B of the 16 or 8 Sector divider logic. The output of INDEX gate 5B and SECTOR gate 5B, if the 32-sector jumper is installed, connect $\overline{\text{INDEX}}$ and $\overline{\text{SECTOR}}$ to the interface through drivers 8B. Gate 7B provides gating of $\overline{\text{INDEX}}$ and $\overline{\text{SECTOR}}$ as a function of READY and SELECT.

The output of SECTOR gate 5B also drives the clock input to the 16 or 8 Sector option, if it is installed. Divide-by-2 flip-flop 6B produces 8 and 16 SECTOR pulses per disk revolution. If the 16-sector jumper is installed, 16 pulses per revolution are sent to the controller by interface SECTOR driver 8B. If the 8-sector jumper is installed, 8 pulses per revolution will be provided by the controller. Figure 3-13 shows $\overline{\text{INDEX}}$ and $\overline{\text{SECTOR}}$ timing.

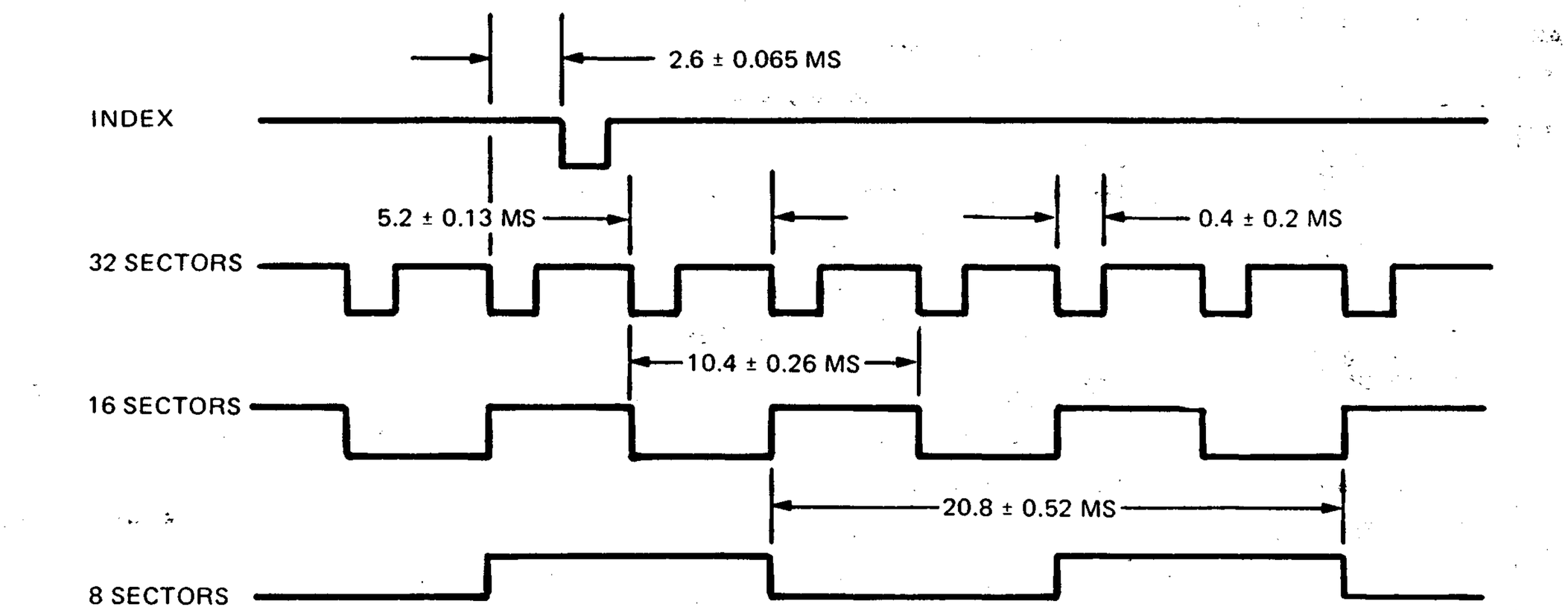


Figure 3-13. INDEX/SECTOR Timing

Ready

The Ready logic is used to monitor the INDEX pulse for the rotational speed of the floppy disk. When the required disk speed is reached, the READY status is sent to the controller. Once per revolution the INDEX pulse is input to the LSI circuit 7D (see Figure 3-14).

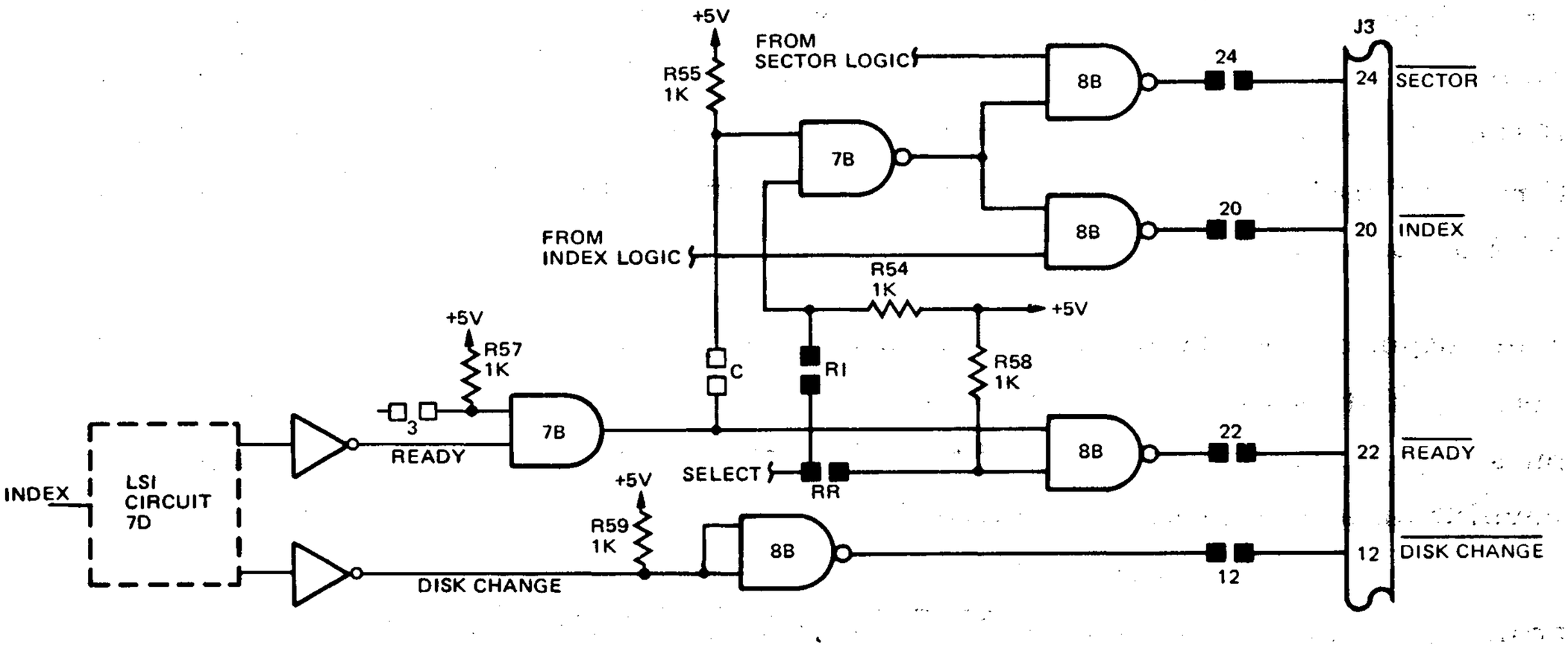


Figure 3-14. Ready Logic

With $\overline{\text{POWER ON RESET}}$ inactive and the door closed, the LSI circuit generates a Ready signal ($\overline{\text{RDY}}$) after receiving two index pulses.

If the Radial Index/Sector option, jumper RI, is removed, the SELECT signal is not required to enable the INDEX and SECTOR interface drivers. If the Radial Ready option, jumper RR, is removed, the SELECT signal is not required to enable the $\overline{\text{READY}}$ interface driver. In both conditions, the disk drive need not be selected by the controller until the disk is up-to-speed and ready. Optionally, jumper C can be installed to disable Index and Sector until Ready is active. The Activity LED option can be connected to use the $\overline{\text{RDY}}$ signal to alert the operator when the unit is up-to-speed and ready. Enabled at the same time, is the head load solenoid logic and the door lock option (see Figure 3-15).

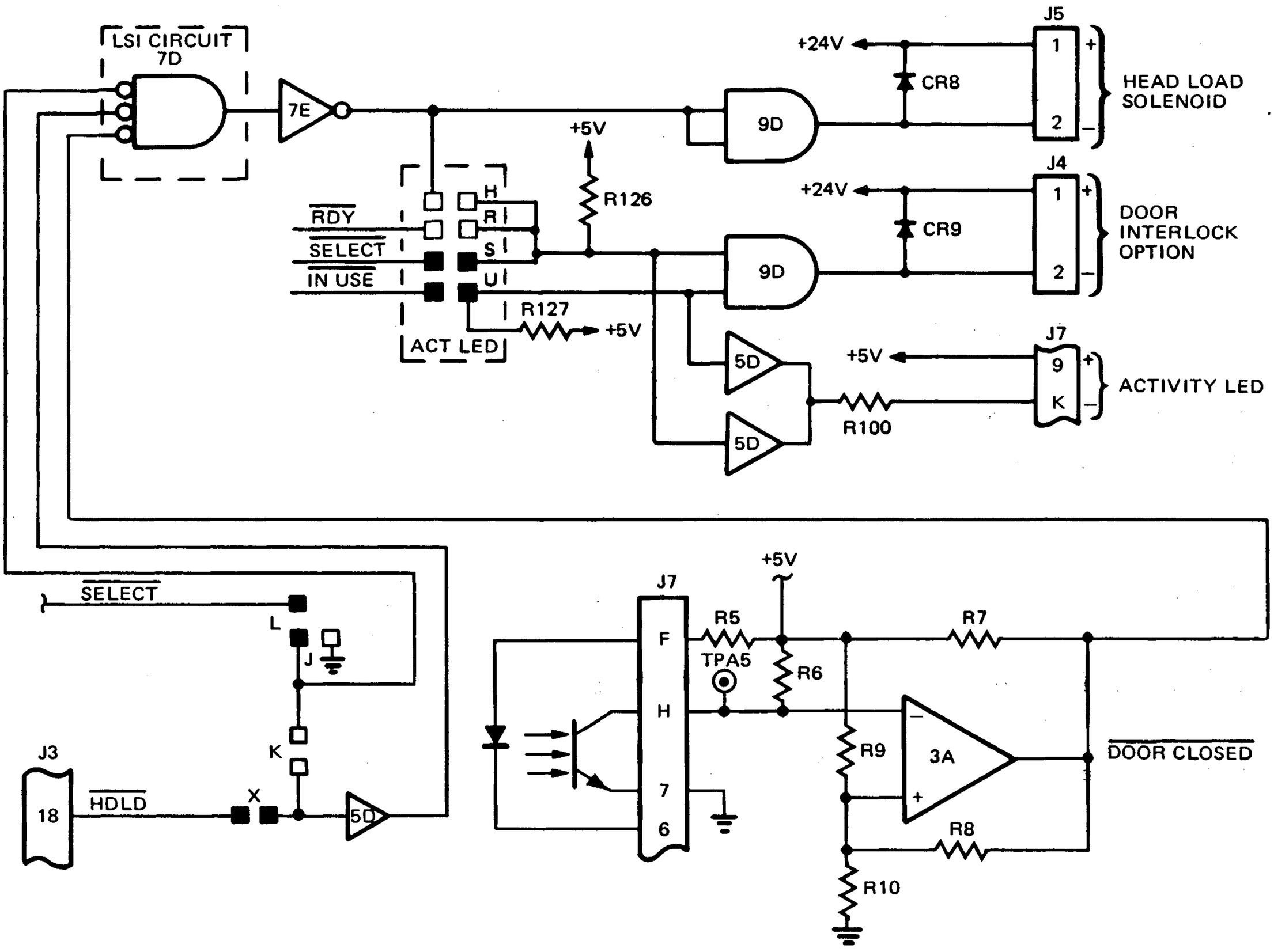


Figure 3-15. Head Load Logic

Activity Indicator

The activity indicator is an LED, mounted in the door open pushbutton. It can be optionally connected to indicate one of four disk drive signals: $\overline{\text{HDLD}}$, $\overline{\text{RDY}}$, $\overline{\text{SELECT}}$ or $\overline{\text{IN USE}}$. Refer to Figure 3-15.

As supplied from the factory, the $\overline{\text{SELECT}}$ or $\overline{\text{IN USE}}$ commands enable the LED. When $\overline{\text{SELECT}}$ or $\overline{\text{IN USE}}$ are inactive, ACT LED drivers 5D output a high and the LED remains off. When $\overline{\text{SELECT}}$ or $\overline{\text{IN USE}}$ are active, one driver outputs a low, the resistor supplies bias current, and the LED is turned on.

In lieu of $\overline{\text{SELECT}}$, the activity LED can be turned on by any one of two different inputs (see Figure 3-15).

Door Lock (Option)

The Door Lock option (when installed) is active when the activity indicator is on. When active, this option prevents the operator from opening the door. Refer to Figure 3-15.

Disk Change

This signal notifies the controller that the floppy disk may have been changed. It will be active following either of two conditions: first, when the drive is selected following turn-on of dc power, secondly, when the drive is selected after the door has been opened.

Two-Sided

The drive as shipped is configured to present $\overline{\text{TWO-SIDED}}$ on the interface. This signal will be active whenever a dual-sided pack is installed in the disk drive. The D input of flip-flop 4A is jumpered to R16 and the clock input to Index 1 (Figure 3-10). The flip-flop will then be set when Index 1 is detected and reset when the door is opened or $\overline{\text{POWER ON RESET}}$ is activated.

Illegal Pack (Option)

With this option enabled, an attempt to access the uncertified side of a single-sided floppy disk installed in the disk drive will result in the $\overline{\text{ILLEGAL PACK}}$ interface signal to the controller (see Figure 3-10). Gate 5A decodes the condition of Head 1 being selected during the time a single-sided certified floppy disk is installed in the drive. The resulting signal is gated to the interface by driver 8A, replacing $\overline{\text{TWO-SIDED}}$.

READ/WRITE HEAD POSITIONING LOGIC

The read/write head positioning logic performs four prime functions:

- Activates the head load/unload solenoid
- Detects position of read/write heads at track 00 and signals controller
- Detects position of read/write heads at track 00 and switches low write current
- Activates stepper motor and determines direction of read/write head movement, in response to controller commands

The heads are loaded, track position is determined, and the stepper motor moves the read/write heads in and out over the surface of the rotating floppy disk. The heads are stopped over the accessed track and read or write operations are performed. If a write-protect disk cartridge is used, the slot detection logic inhibits all write operations.

Head Load

The function of the head load logic is to accept the $\overline{\text{HDLD}}$ command from the controller and energize the head load solenoid. The energized solenoid releases the spring-loaded head arm and gently forces the media against the read/write heads. The head logic is comprised of interface input, door closed detection logic, and drivers required to enable the stepper motor drive logic, drive a solenoid, turn on the front panel activity indicator, and energize the door lock (option) (see Figure 3-15).

The LSI circuit, 7D, products $\overline{\text{SELECT OPT}}$, $\overline{\text{LHDLD}}$ and $\overline{\text{DOOR CLOSED}}$ and outputs HDLD. This signal is inverted by 7E and driver 9D provides an active low output to energize the Head Load solenoid (see Figure 3-15).

The production configuration is provided to load the heads when the drive is selected and the $\overline{\text{HDLD}}$ signal on the interface is active.Optionally, the heads can be loaded with $\overline{\text{SELECT}}$ only, independently of $\overline{\text{HDLD}}$.

As a condition on the loading of heads, the door must be closed. A photoswitch mounted on the deck assembly is activated by a tab on the floppy disk carrier blocking the LED output when the door is closed. The output of comparator 3A will be low providing an enable to the LSI circuit.

Track 00 Switch

The track 00 logic monitors the position of the read/write head by means of a photoswitch and comparator, and signals the controller when the head is at track 00.

The photoswitch is mounted on the deck assembly and is inactivated by a tab on the carriage blocking the LED output. The output of comparator 3A is low enabling the LSI circuit (see Figure 3-16).

Phase A of the stepper motor control is decoded internally in the LSI circuit and producted with the $\overline{\text{LTRK00}}$ input. The high output of the LSI circuit drives 7E and

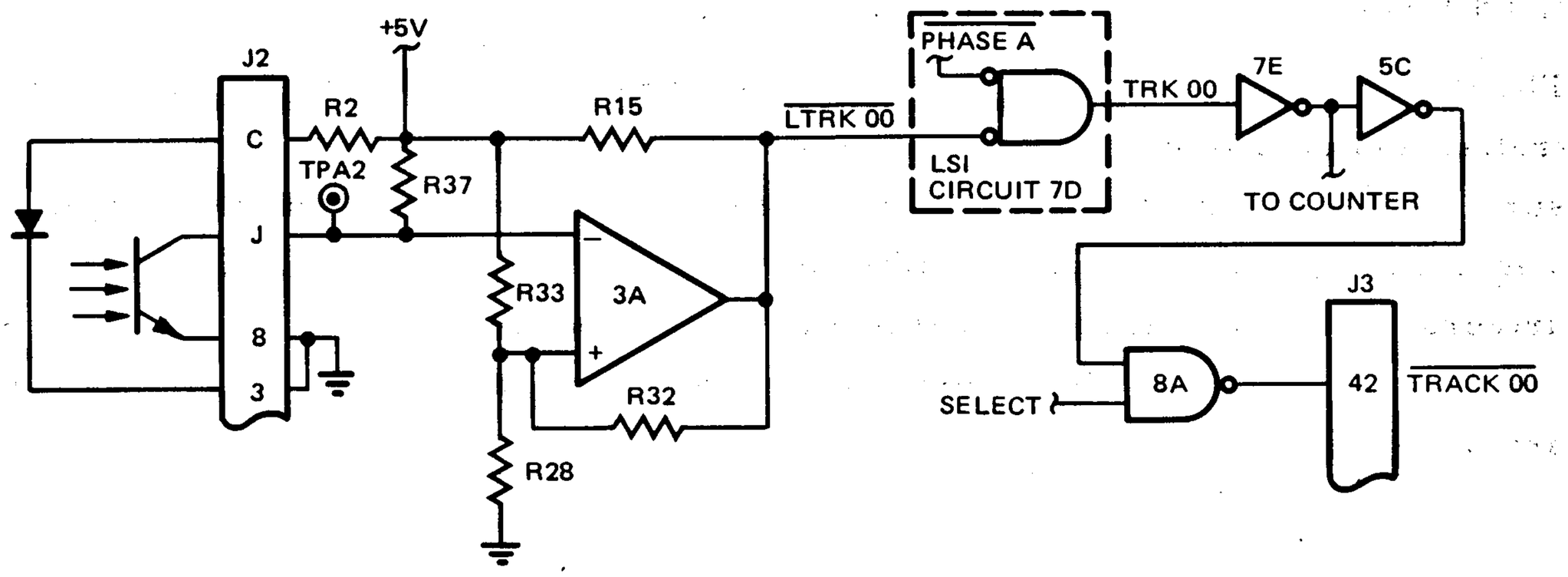


Figure 3-16. Track 00 Logic

5C to enable gate 8A to send an active low $\overline{\text{TRACK 00}}$ signal to the host controller. Refer to timing diagram Figure 3-17.

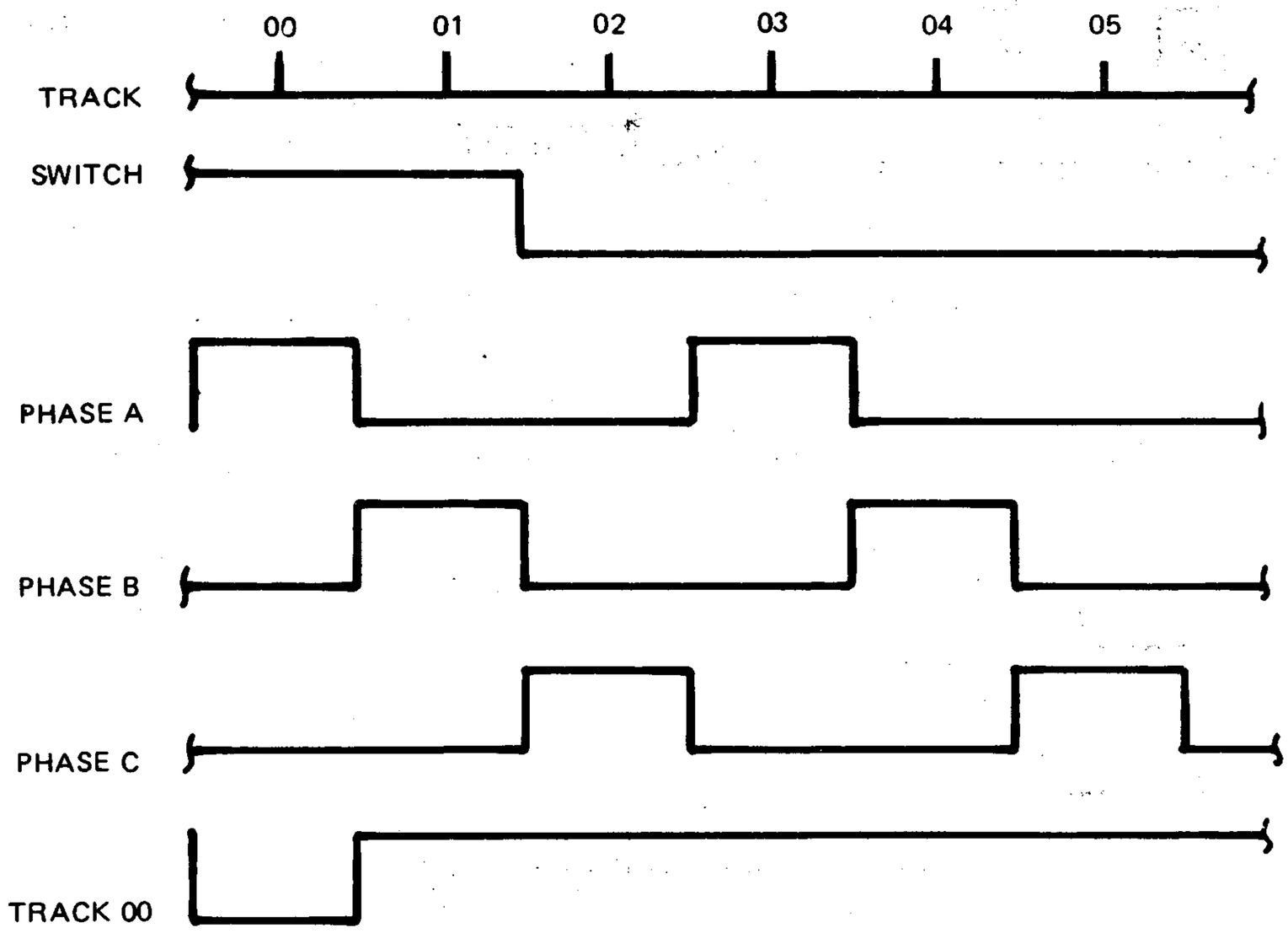


Figure 3-17. Track 00 Timing

Stepper Motor Drive

The positioning logic performs all stepper motor drive functions. The logic causes the head to move one track distance for each active $\overline{\text{STEP}}$ command, and in a direction determined by the high or low state of the $\overline{\text{STEP IN}}$ command. The positioning logic comprises interface gates, the LSI circuit and the stepper motor drive logic.

Interface Gating

When an active $\overline{\text{STEP}}$ pulse occurs, interface $\overline{\text{STEP}}$ gate 5D outputs a negative pulse driving the LSI circuit (Figure 3-18). If it has been enabled by an inactive $\overline{\text{STEP INHIBIT}}$, the internal logic is triggered by the trailing edge of the step pulse and clocks a 3-state counter, causing forward or reverse stepper motor pulses, as determined by the $\overline{\text{STEP IN}}$ interface signal. Refer to Figure 3-19 for stepper timing

If $\overline{\text{STEP IN}}$ is not active the counter is set to the count-down mode or reverse mode.

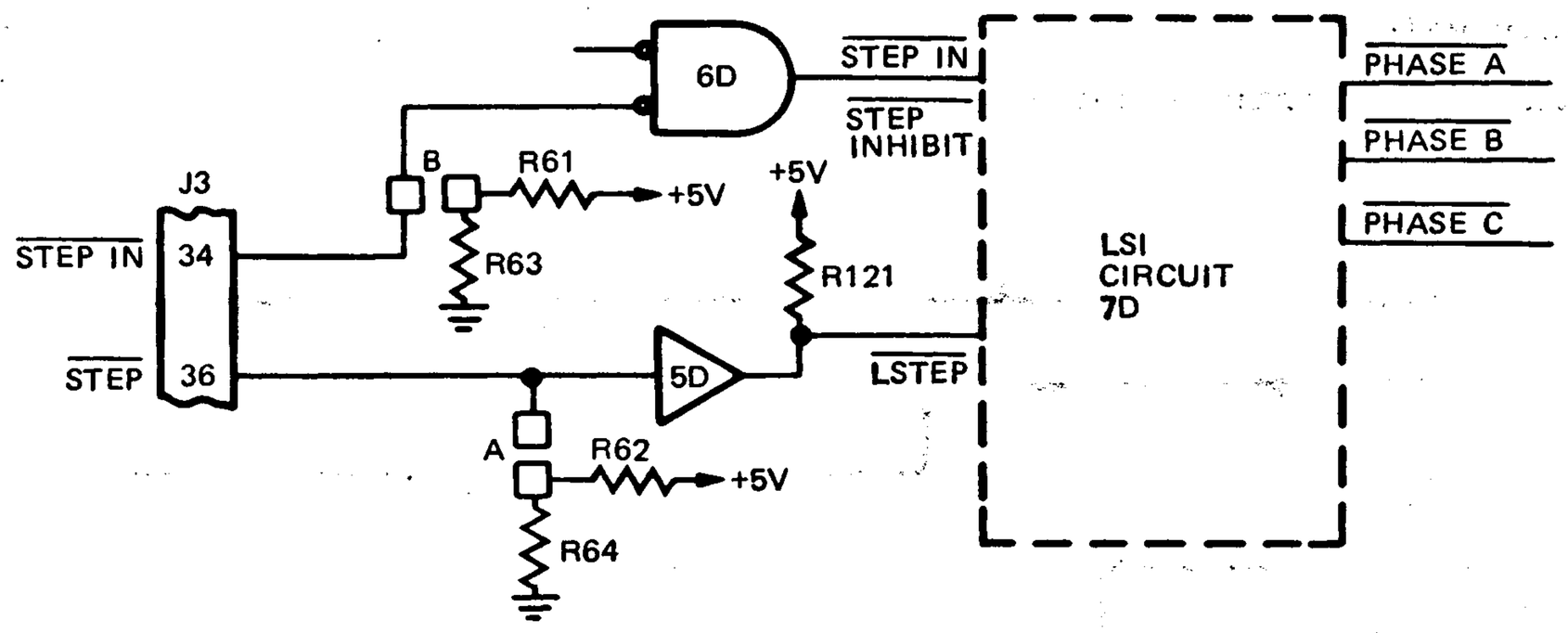


Figure 3-18. Stepper Motor Interface Gating Logic

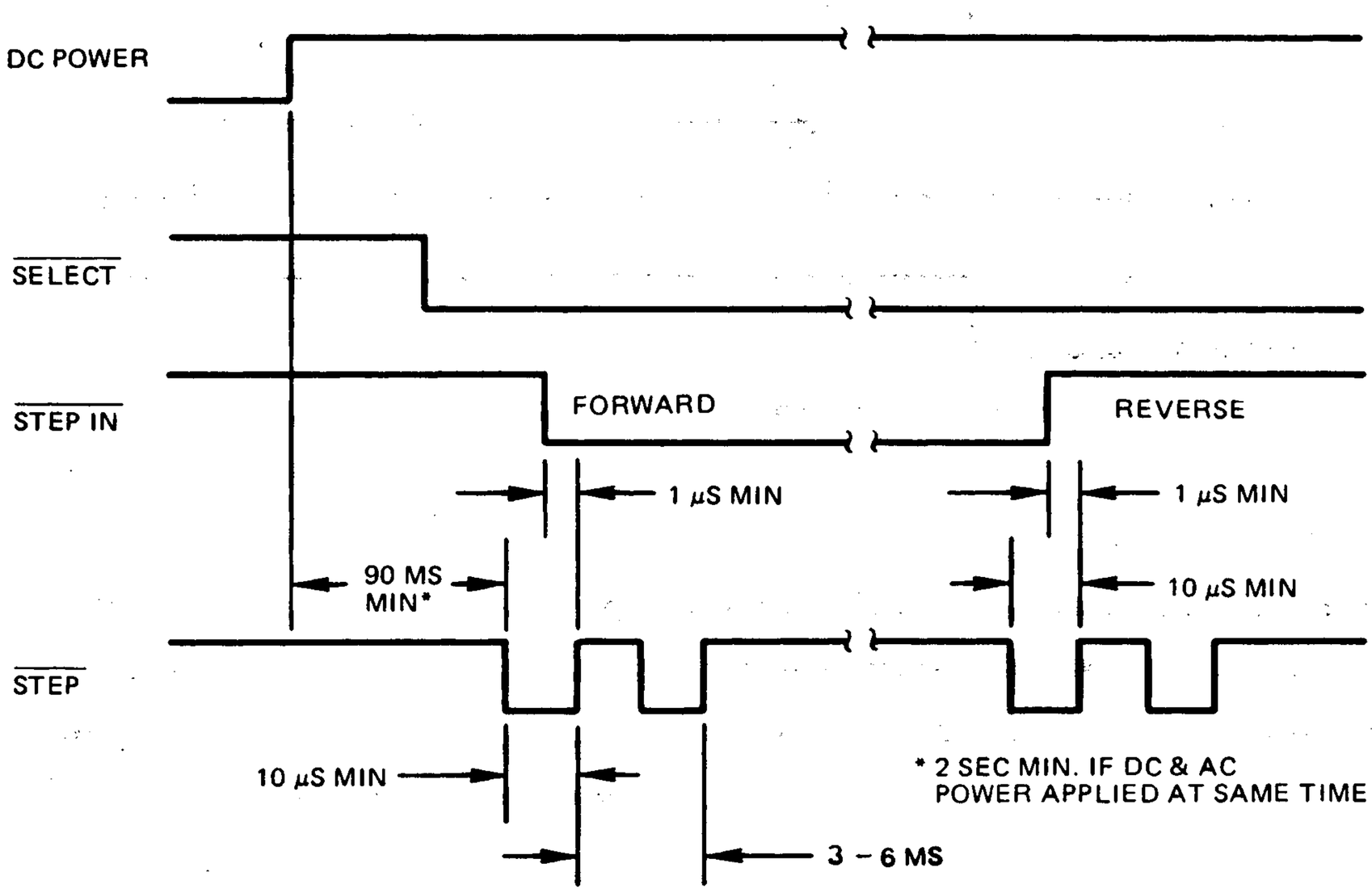


Figure 3-19. Stepper Motor Timing

When STEP IN becomes active, the counter is set to the forward mode.

State Counter

The state counter contained in the LSI circuit is comprised of a shift register only one position of which can be active concurrently. When initial power is applied to the disk drive, the power-on reset logic forces the register to a Phase A state. If the register is in the forward mode, it will advance to Phase B when a STEP

pulse occurs. The next $\overline{\text{STEP}}$ pulse advances the counter to Phase C, and the next pulse advances the register to Phase A. Subsequent pulses will continue the cycle until the STEP command becomes inactive (Figure 3-17).

If the counter is in the reverse mode, it will decrement to Phase C on the next $\overline{\text{STEP}}$ pulse. Subsequent pulses will continue the count-down cycle until the $\overline{\text{STEP}}$ command becomes inactive.

The PHASE OPT input to the LSI circuit serves to disable, when low, the Phase A, Phase B and Phase C outputs.

Stepper Motor Drivers

The stepper motor is a 3-phase motor having three independent and identical drive circuits (see Figure 3-20).

Phase A drive logic is comprised of drivers 7E, pull up resistor R158, transistors Q18 and Q15, and flyback diode CR13. When the decoder gate outputs a high (Phase A) the drivers produce a low output, Q15 is cut off and Phase A is not energized. When the LSI circuit outputs a low (code 00 detected), the drivers produce a low output turning on Q15, and Phase A is energized. When Q15 turns off, diode

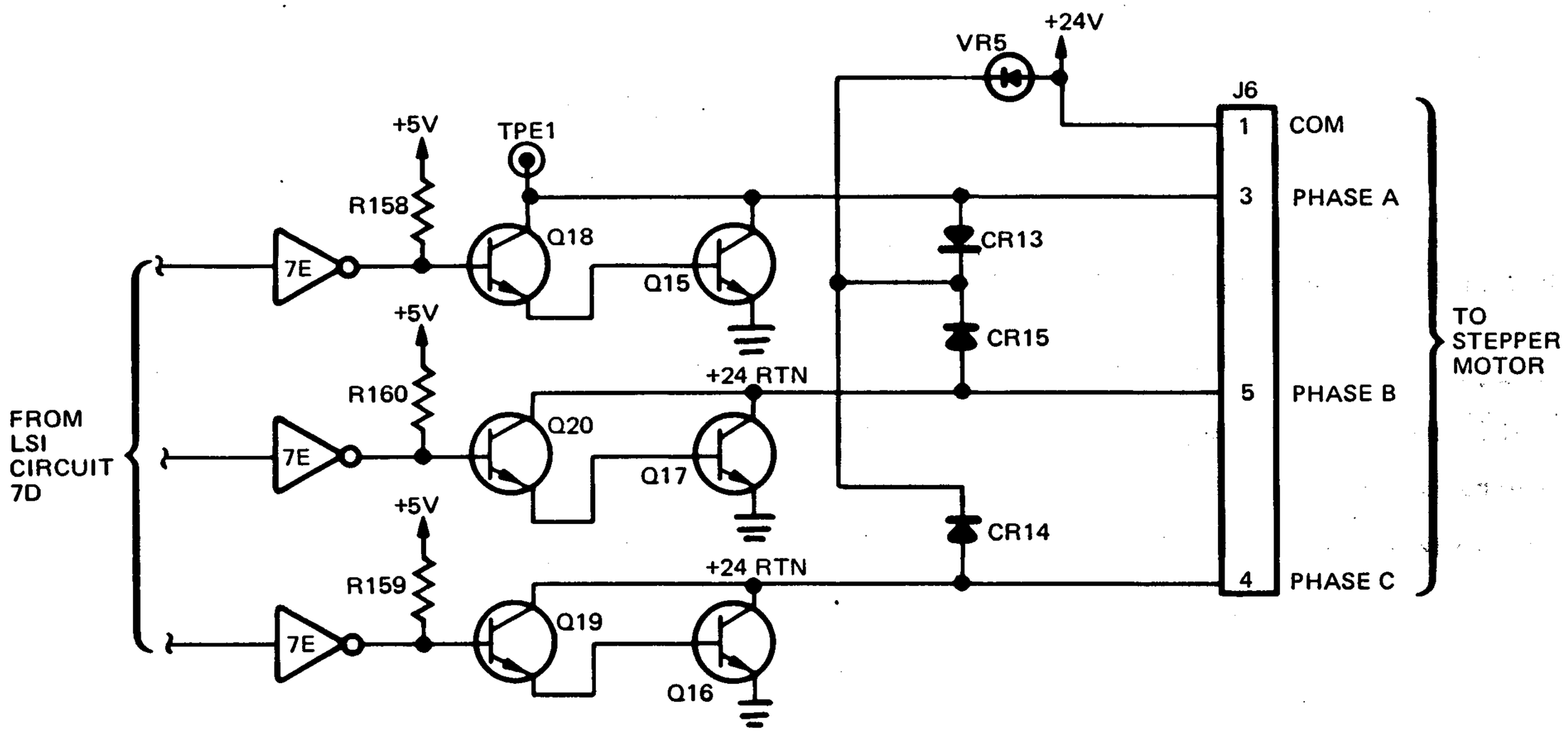


Figure 3-20. Stepper Motor Driver Circuit

CR13 restricts the emitter of Q15 from going more positive than +24 volts. Each driver circuit is identical and operates in the same way to energize the corresponding phase of the stepper motor.

Stepper Motor

The stepper motor shaft changes 15 degrees of angular position with each $\overline{\text{STEP}}$ pulse. Three windings are provided with the center taps connected to +24 volts drive power. The three windings are energized sequentially, producing a stepped forward or reverse action. The bidirectional shaft rotation is dependent on the sequence in which the windings are pulsed; to step the motor either clockwise (forward) or counterclockwise (reverse). A lead screw connected to the motor shaft causes the read/write head to be precisely positioned over one of 77 tracks on the disk. Track 00 is used to establish the starting point.

READ/WRITE LOGIC

The read/write logic converts digitally encoded serial data from the controller to analog flux patterns that are magnetically recorded (written) on the surface of a rotating floppy disk. The recorded data is sensed and decoded during a read operation and restored to digital read data for the controller. Common read/write heads are switched to either mode by a single enable/disable command. The read/write logic performs two prime functions:

- Write controller data on the disk
- Read recorded data for the controller

Figure 3-21 shows the write initiate timing.

A write operation is initiated by the disk controller by activating the $\overline{\text{WRITE}}$, and $\overline{\text{WRT DATA}}$ interface lines. The lines remain active for the duration of the write operation to enable write data logic and tunnel erase logic. The write current developed records the data, and the erase logic contains the recorded track width to 0.013-inch.

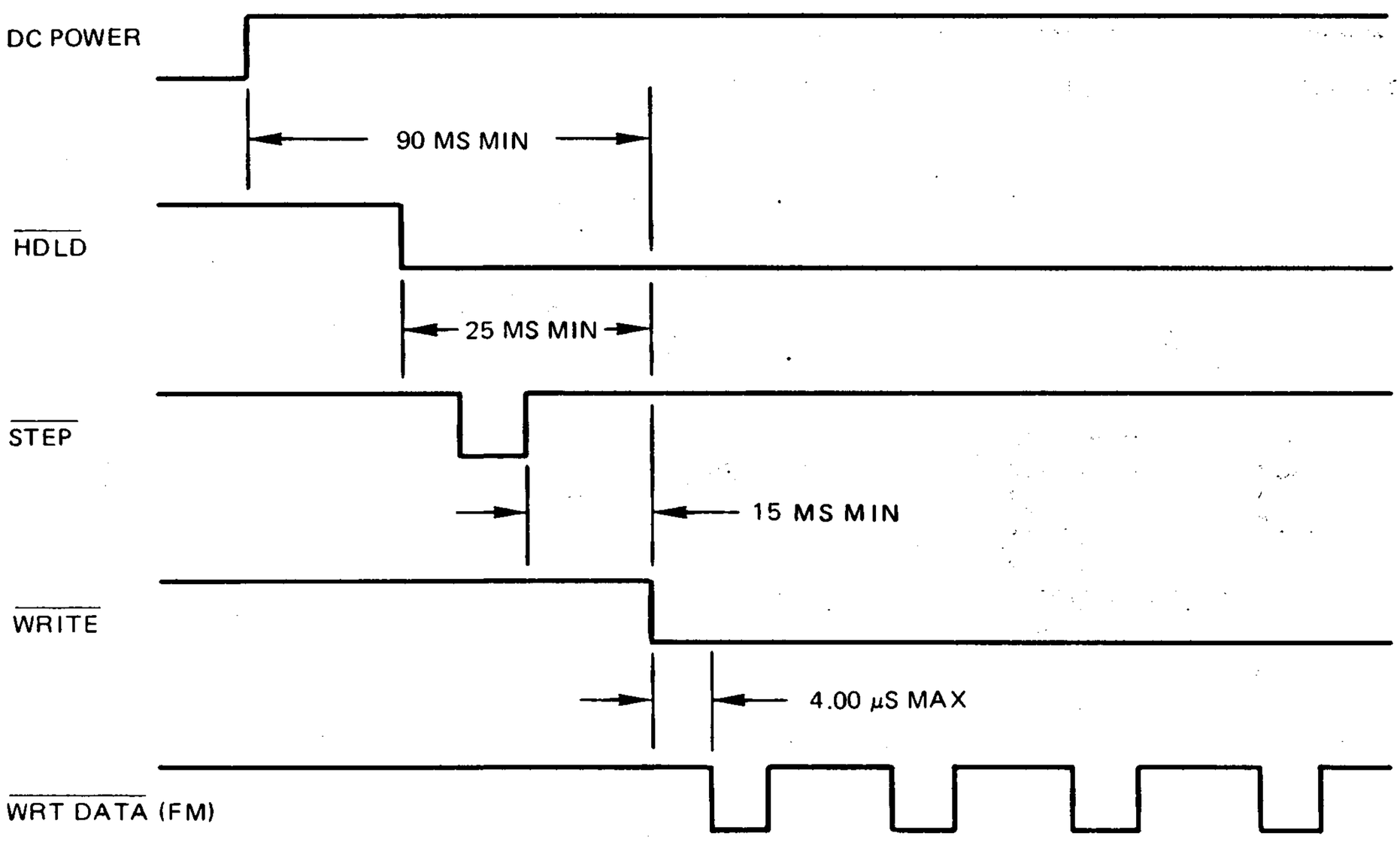


Figure 3-21. Write Initiate Timing

Write-Protect

When the disk cartridge has a write-protect slot, the disk drive disregards any WRITE command and all write logic is disabled. When the slot is covered, normal read/write operation can be performed. The write-protect cartridge is used in conjunction with a light-sensing LED/transistor circuit.

When a write-protect disk cartridge is used, the LED output is sensed, causing the phototransistor to provide a low output to the negative input of comparator 2C (see Figure 3-22).

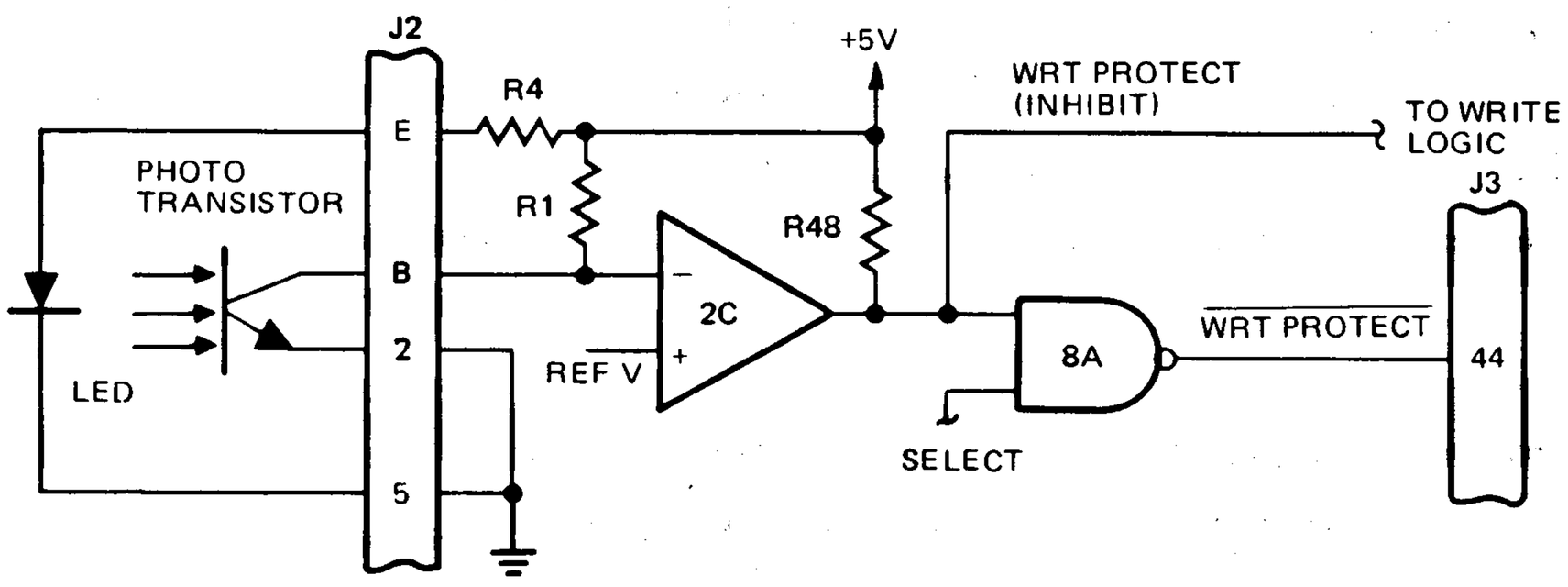


Figure 3-22. Write Protect Logic

The output of comparator 2C is high, providing an input to interface line driver 8A, and inhibiting write gate 5A (see Figure 3-23).

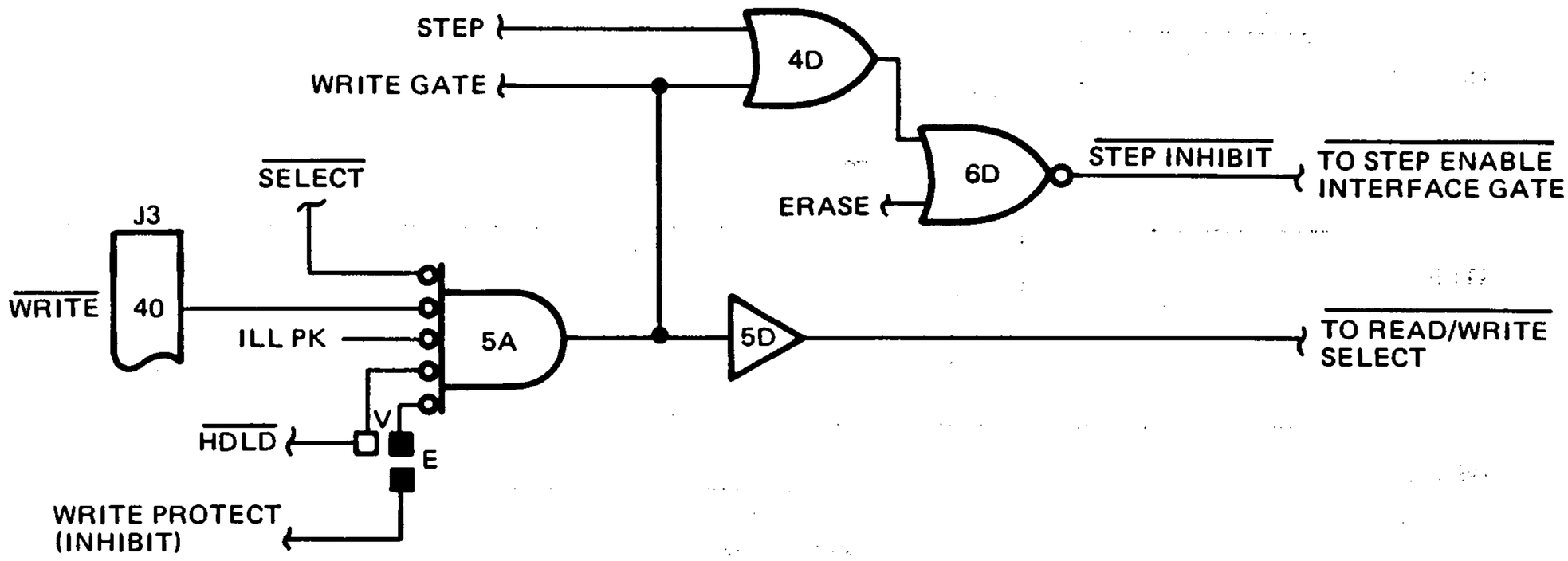


Figure 3-23. Write and Erase Gating Logic

When the disk cartridge write-protect slot is covered, or a non-write-protect cartridge is used, the phototransistor is inactive, and the negative input to comparator 2C is high. The output produced is low, enabling write operations.

Write Mode

The read/write logic is switched to a Write mode by an active $\overline{\text{WRITE}}$ command followed by encoded data in the $\overline{\text{WRT DATA}}$ interface line.

Write and Erase Gating

When $\overline{\text{WRITE}}$ is active, gate 5A outputs a high active signal provided the head is loaded ($\overline{\text{HDLD}}$), the write-protect circuit does not sense a write-protected disk cartridge, the drive is selected and ILLEGAL PACK is inactive. The output produced by gate 5A is high, enabling Write Gate. Gate 6D produces a low output, $\overline{\text{STEP INHIBIT}}$, to disable stepping during write. WRT GATE high switches the read/write select circuit to the write mode (see Figure 3-23).

Erase Logic

Erase Logic is comprised of dual one-shots 4C, flip-flop 6C, gates 6D, driver 1B, transistor Q1, resistors R79, R80, R69, R70, R92, R102 and capacitors C20 and C21 (see Figure 3-24).

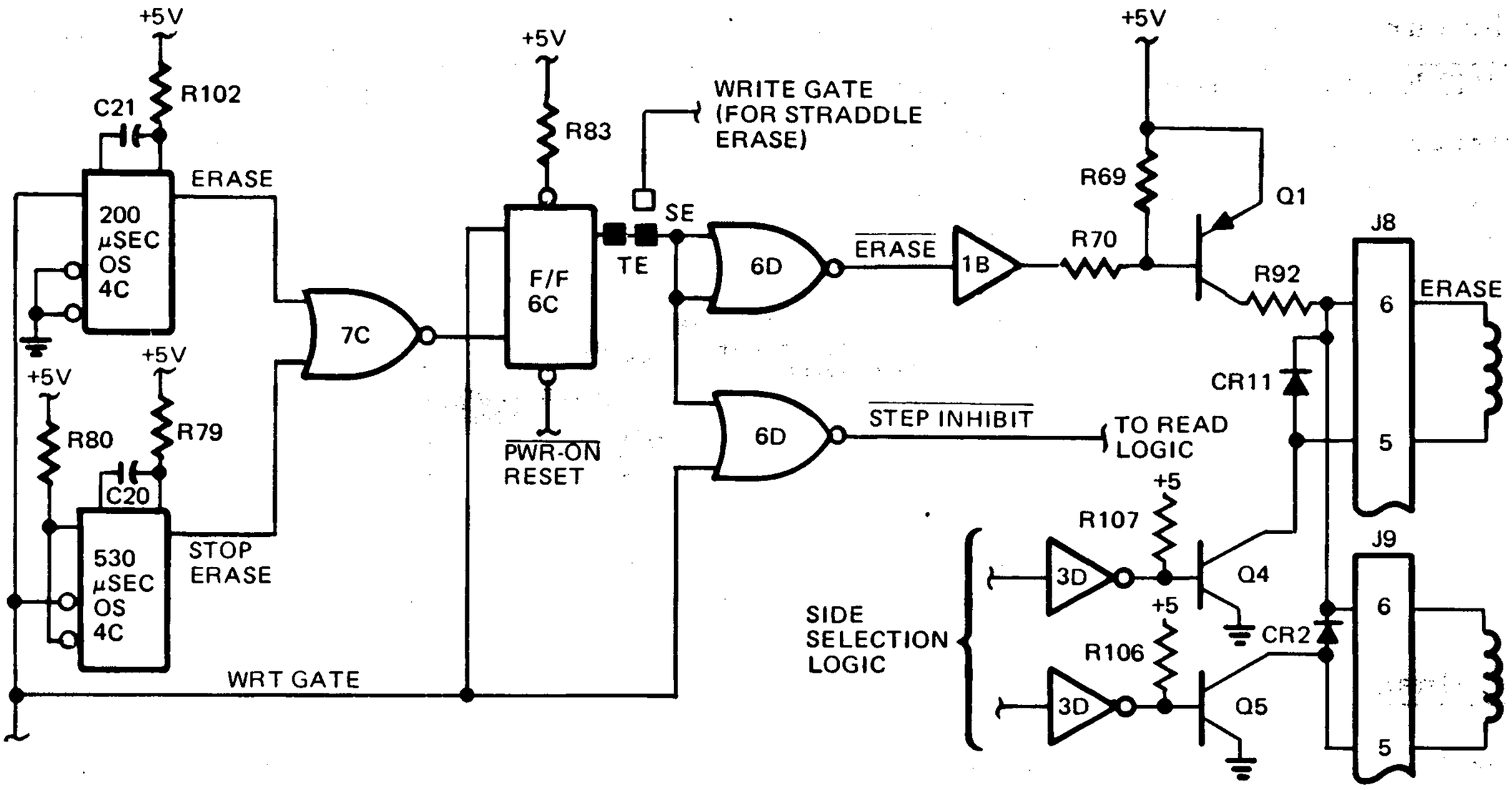


Figure 3-24. Erase Logic

The purpose of the auto erase feature with tunnel-erase heads is to provide the necessary turn-on delay between active $\overline{\text{WRITE}}$ and $\overline{\text{ERASE}}$ and the turn-off delay after $\overline{\text{WRITE}}$ goes inactive. When straddle erase heads are used, jumper SE bypasses the erase timing.

When $\overline{\text{WRITE}}$ goes active, WRT goes high to trigger one-shot 4C for a 200-microsecond time-out. The one-shot output is inverted by gate 7C and the trailing edge clocks Erase flip-flop 6C on.

When $\overline{\text{WRITE}}$ goes inactive, WRT goes low to trigger one-shot 4C for a 530-microsecond time-out. The one-shot output is inverted by gate 7C and its trailing edge clocks Erase flip-flop 6C to a false state, removing Erase from gates 6D.

When $\overline{\text{ERASE}}$ is inactive, driver 1B outputs a high to bias current source transistor Q1 off. When $\overline{\text{ERASE}}$ is active, 1B outputs a low turning Q1 on. With Q1 on, +5 volts is developed across R92 causing erase current to flow through the erase coil of the read/write head enabled by the side selection logic. Gates 3D and transistors Q106 and Q107 provide a ground to the erase coil of one head, as determined by interface line $\overline{\text{SIDE SELECT}}$.

The current for tunnel-erase heads is turned on 200 microseconds after an active $\overline{\text{WRITE}}$ and remains on until 530 microseconds after $\overline{\text{WRITE}}$ goes inactive. The current for straddle-erase heads is turned on whenever WRITE is active. The erased data pattern is shown in Figure 3-25.

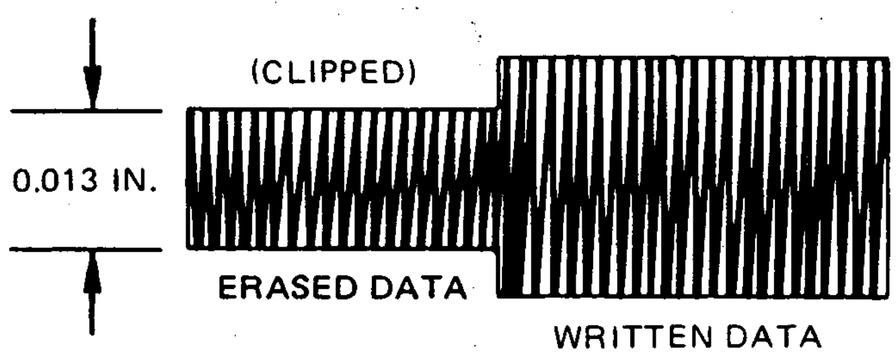


Figure 3-25. Erased Data Pattern

DC Unsafe

The DC Unsafe logic comprises comparator 2C, transistor Q12, resistors R44 through R47, R76, R77, R97, R98 and capacitors C9, C10, C47 and C48. The purpose of the DC Unsafe circuit is to monitor the +24-volt and +5-volt levels and compare each level with a precise reference voltage. If the voltage parameters are exceeded, +24 volts is turned off to disable the write and erase logic (see Figure 3-26).

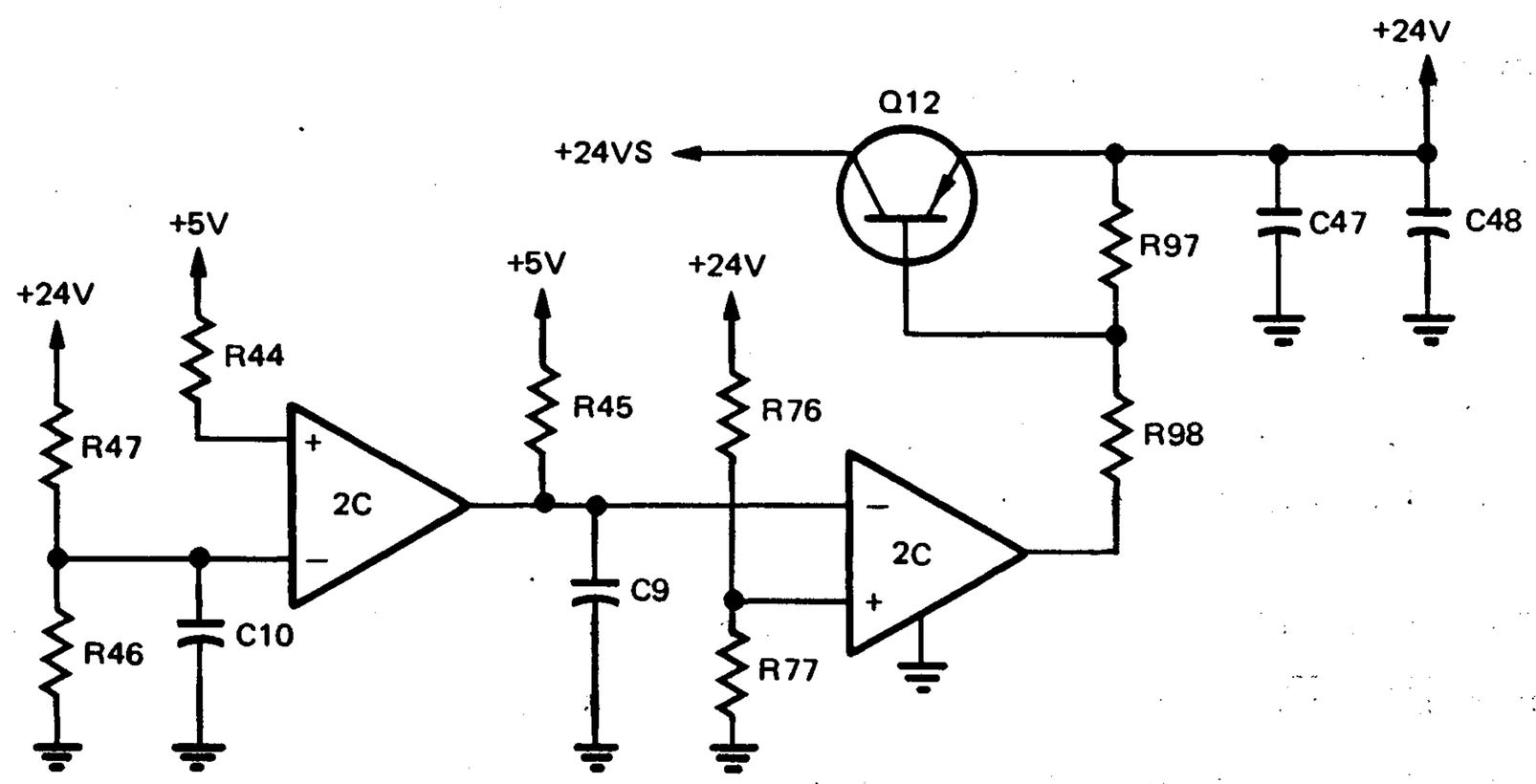


Figure 3-26. DC Unsafe Logic

Write Current Control

The write current control logic is shown in Figure 3-27. This circuit is used to control the flow of write current through the read/write head in response to the direction by the $\overline{\text{WRT DATA}}$ interface line.

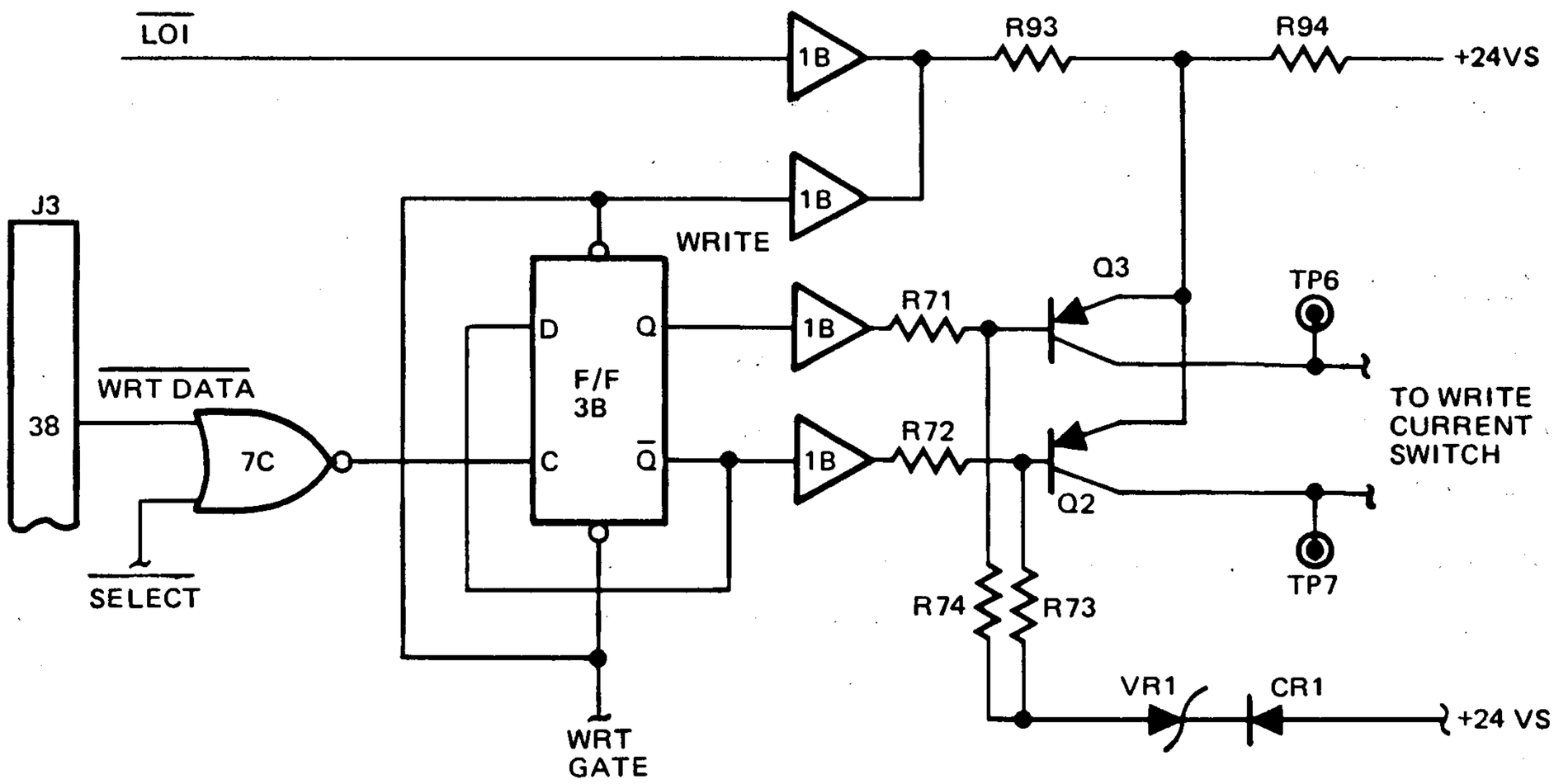


Figure 3-27. Write Current Control Logic

When the drive is not selected, write current flow is inhibited. When the drive is selected, interface line receiver 7C is enabled and gates $\overline{\text{WRT DATA}}$ to write flip-flop 3B. If the $\overline{\text{WRITE}}$ command is active, the flip-flop is enabled and the output of Q3 driver 1B is low. Current flows through VR1, CR1, R71, and R74 causing current source transistor Q3 to turn on. Q2 driver 1B outputs a high and current source transistor Q2 is turned off.

When $\overline{\text{WRITE}}$ becomes inactive and the flip-flop toggles to the opposite state, Q2 driver 1B outputs low, and current flows through VR1, CR1, R72 and R73 causing current source transistor Q2 to turn on. Q3 driver 1B outputs a high and transistor Q3 is turned off.

Transistors Q2 and Q3 are used as write driver switches. When Q3 is turned on, the voltage developed at the emitter causes peak write current to flow through R94, Q3, the FET switching network and through one-half of the coil in the read/write head.

When Q2 is turned on, peak write current flows through R94, Q2, the FET switching network and through the other one-half of the coil in the READ/WRITE head.

When $\overline{\text{WRITE}}$ is inactive, WRT GATE goes low to the set and clear inputs of Write flip-flop 3B causing both outputs to go high. Accordingly, both transistor drivers provide high outputs and both Q2 and Q3 are turned off to stop all current flow. Also, transistor bias driver 1B outputs a low which produces a voltage through R94 and R93, ensuring that Q2 and Q3 are biased off.

Low Write Current Control

An 8-bit counter increments and decrements with the $\overline{\text{STEP}}$ pulses from the interface and provides a decode for tracks 44 through 76, to develop $\overline{\text{LOI}}$. Two 4-bit counters, 6A and 7A, are cascaded to provide a track counter. At Track 00 the counter is loaded with a value of Hex 6A. Each STEP pulse causes decrementing of the counter when STEP IN is high or incrementing when it is low. When the counter decrements to Hex 3F, the output at 7A6 generates a low active $\overline{\text{LOI}}$ signal (see Figure 3-28).

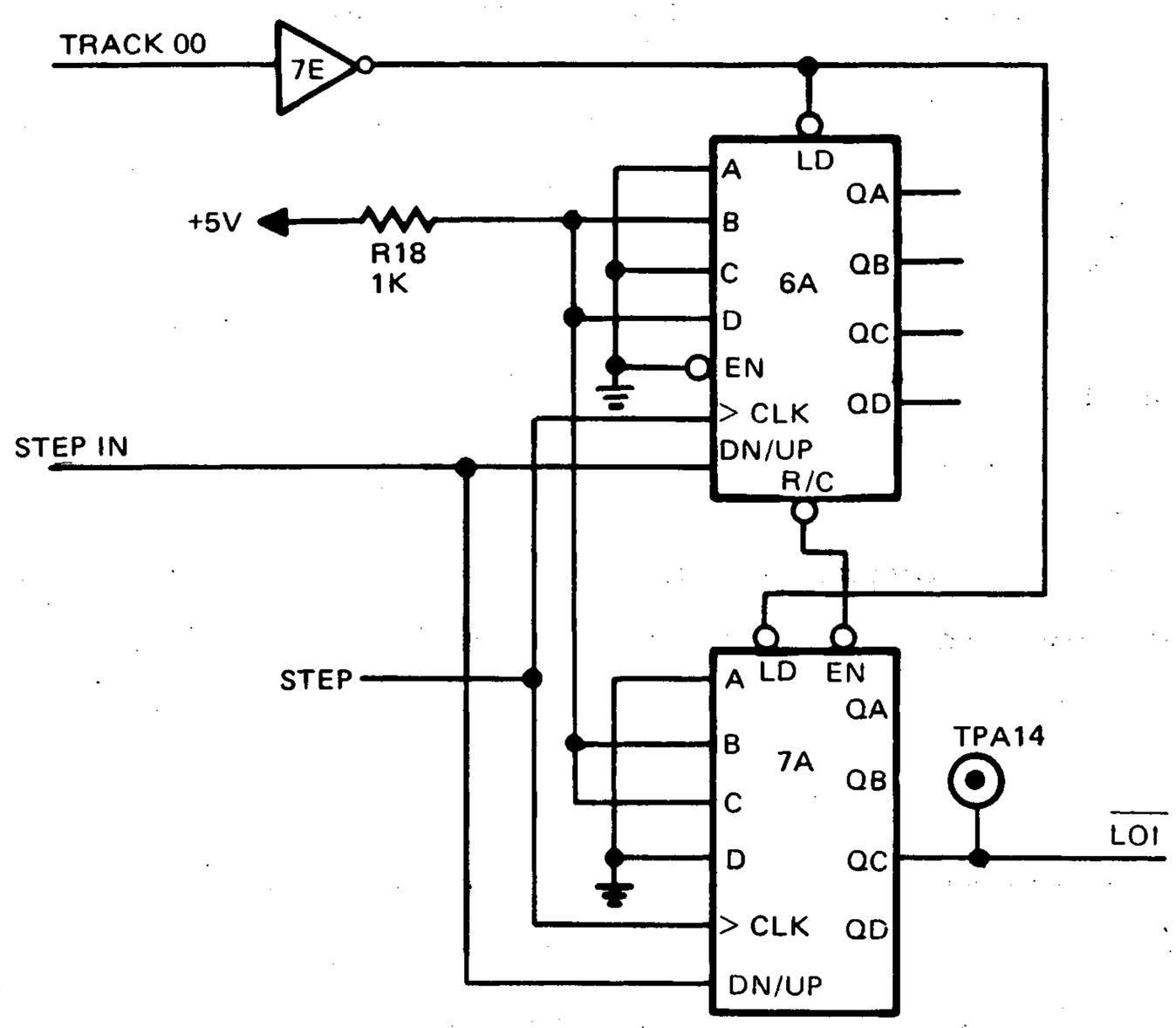


Figure 3-28. Write Current Switching

Head Selection and Write Current Switching

The logic controlling the selection of the read/write head for writing and switching of write current to the selected head is shown in Figure 3-29. In response to interface signals, drivers 3D and transistors Q13 and Q14 provide the control for FET's Q6 through Q11.

When $\overline{\text{SIDE SELECT}}$ is high, inverter-drivers 3D bias transistor Q14 off and transistor Q13 on. As a result of Q14 off, FET pair Q6, Q7 conduct, enabling Head 0. Since Q13 is on, FET pair Q8, Q9 disable Head 1. With WRT GATE active (Figure 3-23) gate 3E is high, disabling FET pair Q10, Q11. The write signal from Write Current Control is gated to Head 0 and is blocked from the read amplifier. In a similar manner, when $\overline{\text{SIDE SELECT}}$ is low, Head 1 is enabled for the flow of write current.

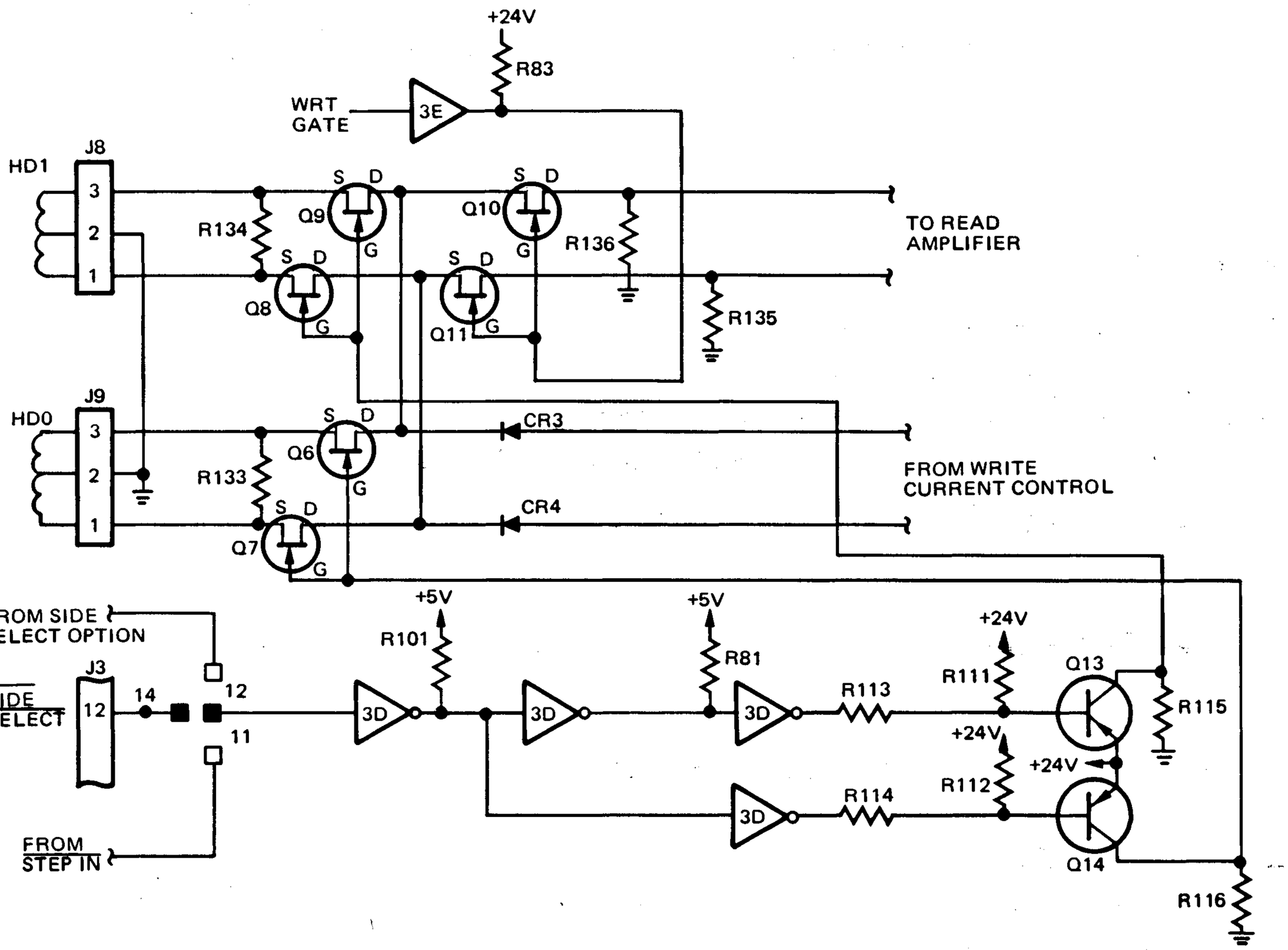


Figure 3-29. Head Selection

As an optional means of head selection, the logic can be configured to allow $\overline{\text{STEP IN}}$ or the side selection jumper block to replace $\overline{\text{SIDE SELECT}}$.

Write data timing and write current flow are shown in Figure 3-30.

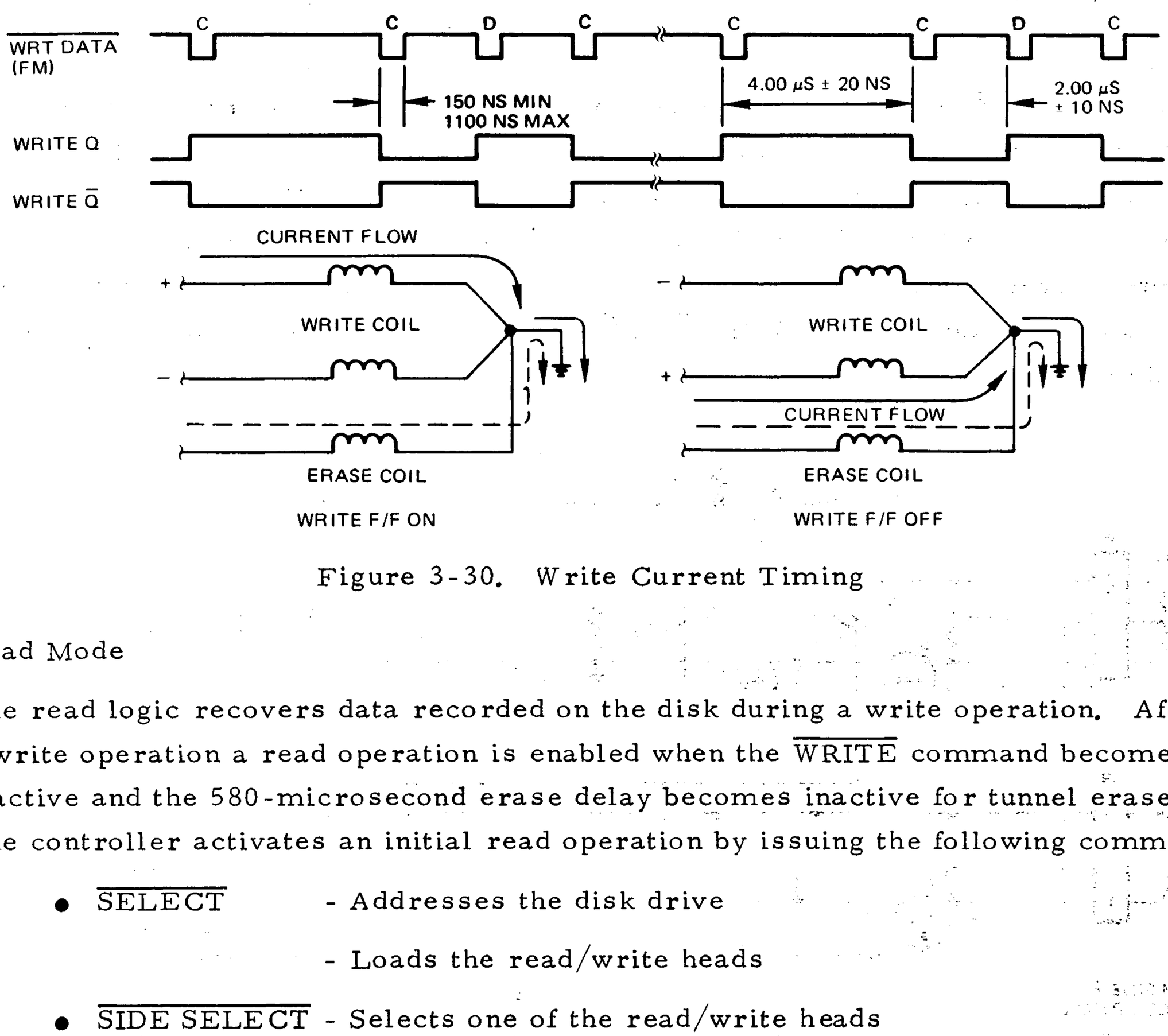


Figure 3-30. Write Current Timing

Read Mode

The read logic recovers data recorded on the disk during a write operation. After a write operation a read operation is enabled when the $\overline{\text{WRITE}}$ command becomes inactive and the 580-microsecond erase delay becomes inactive for tunnel erase. The controller activates an initial read operation by issuing the following commands:

- $\overline{\text{SELECT}}$ - Addresses the disk drive
  - Loads the read/write heads
- $\overline{\text{SIDE SELECT}}$ - Selects one of the read/write heads
- $\overline{\text{WRITE}}$ - Provides a high (inactive) enable signal

Figure 3-31 shows the read initiate timing.

Read/Write Select

The read/write select logic circuit is shown in Figure 3-32. The source inputs to FET's Q10 and Q11 are connected to the head switching network. The output drains

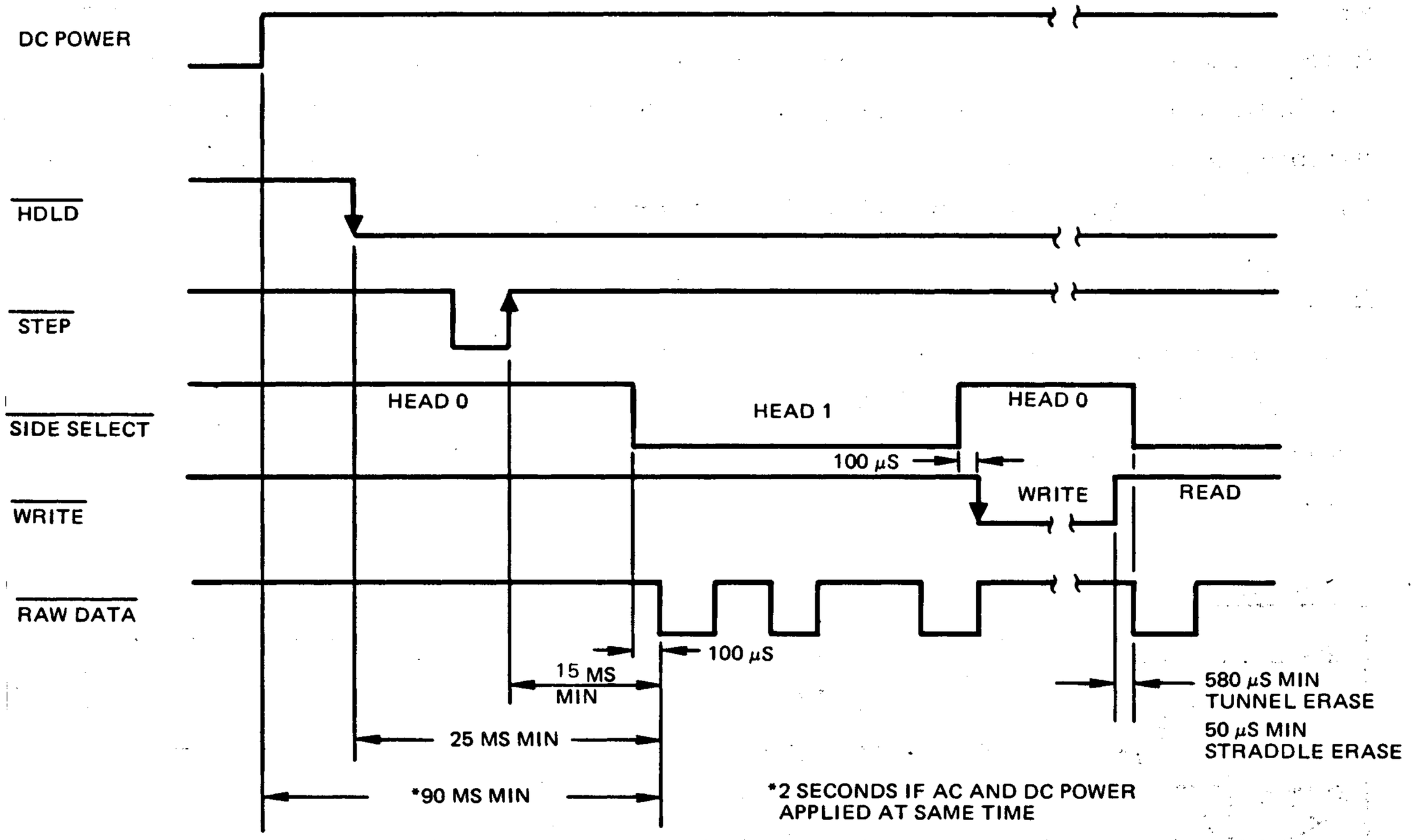


Figure 3-31. Read Initiate Timing

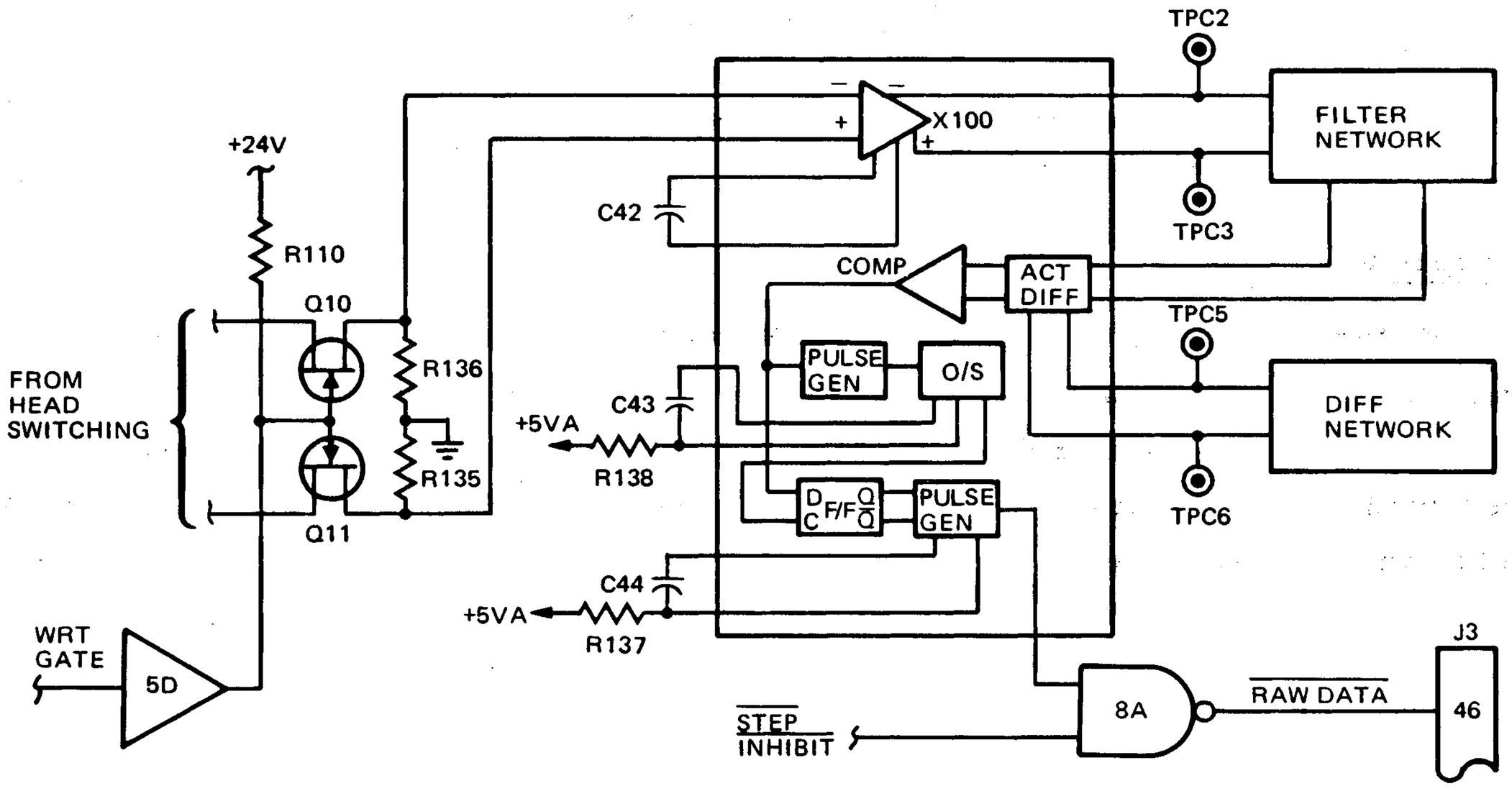


Figure 3-32. Read Logic, Simplified Diagram

are connected to the inputs of read circuit 2E. When the disk drive is operating in the Read mode, the output of WRT GATE driver 5D is low. Both Q10 and Q11 are in the on state and the selected head output is gated to the preamplifier. Read damping is determined by R135 and R136 in parallel with R133 or R134 (shown in Figure 3-29) dependent upon which head is selected.

Read LSI Circuit, Read Preamplifier and Filter

The input stage of LSI read circuit 2E, is a high-gain linear amplifier used to increase the read data signal amplitude by a nominal gain of 100. The preamplifier outputs are used to drive a 3-pole linear-phase bandpass filter network (see Figure 3-33).

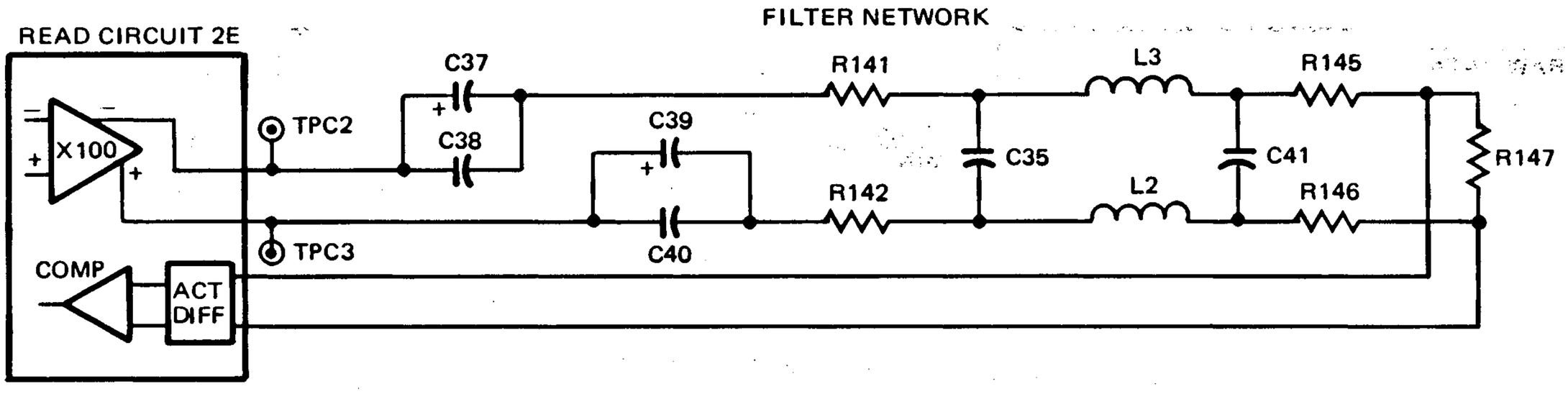


Figure 3-33. Read Preamplifier and Filter Circuit

The filter has a -3 db bandwidth of 800 kilohertz. Resistors R145 through R147 divide the output voltage to constrain the buffer amplifier within its linear range.

Differentiating Network

The differentiating network provides a 90-degree delay to convert the incoming read data signal peaks to distorted zero crossings for the crossover detector (see Figure 3-35). Capacitor C46, inductor L4 and resistor R143 form a series circuit, resonant at 750 kilohertz. A dc offset adjustment is provided by resistors R144, R148 and potentiometer R149.

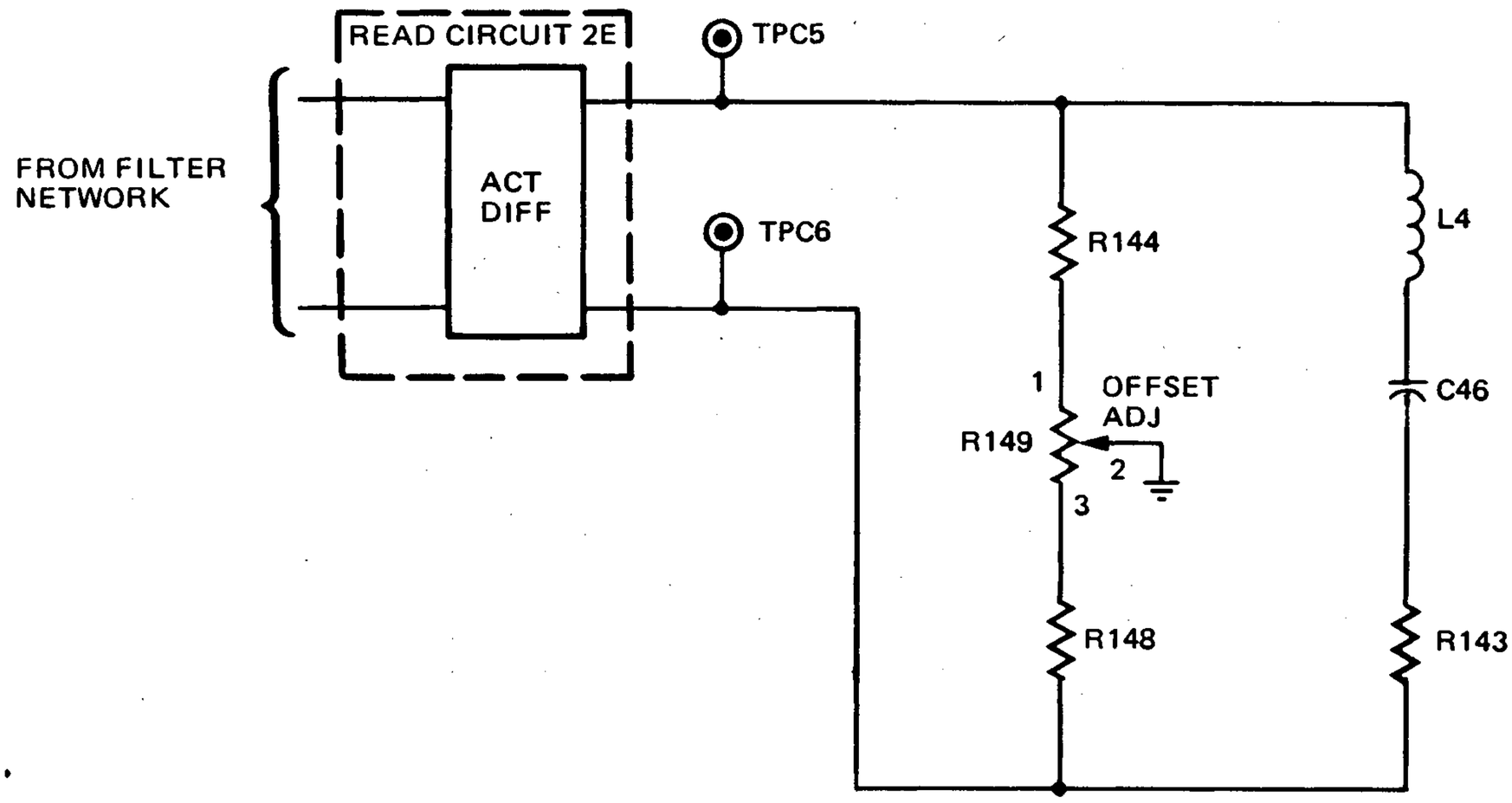


Figure 3-34. Differentiating Network

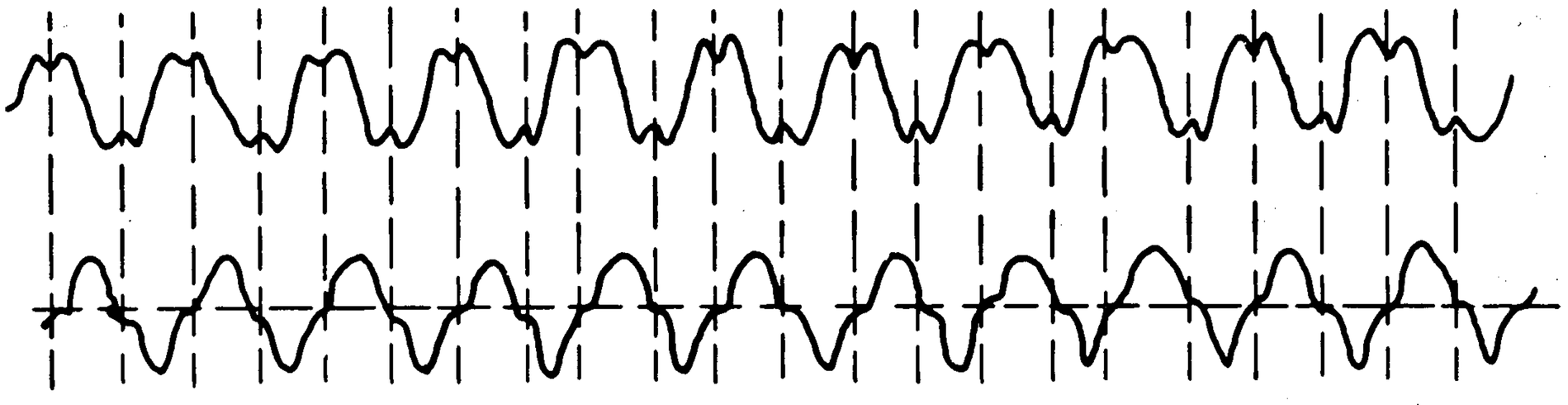


Figure 3-35. Read Data Waveforms

Crossover Detector

The crossover detector is a comparator and bidirectional one-shot. The comparator is driven by the analog output of the differentiator and provides a RAW DATA pulse for each zero crossing. The one-shot outputs a nominal 1000-nanosecond pulse determined by R138, and C43 (see Figure 3-36).

Time Domain Filter

The purpose of the time domain filter (Figure 3-36) is to disregard false zero crossings in the RAW DATA, caused by the high resolution head-to-disk interface.

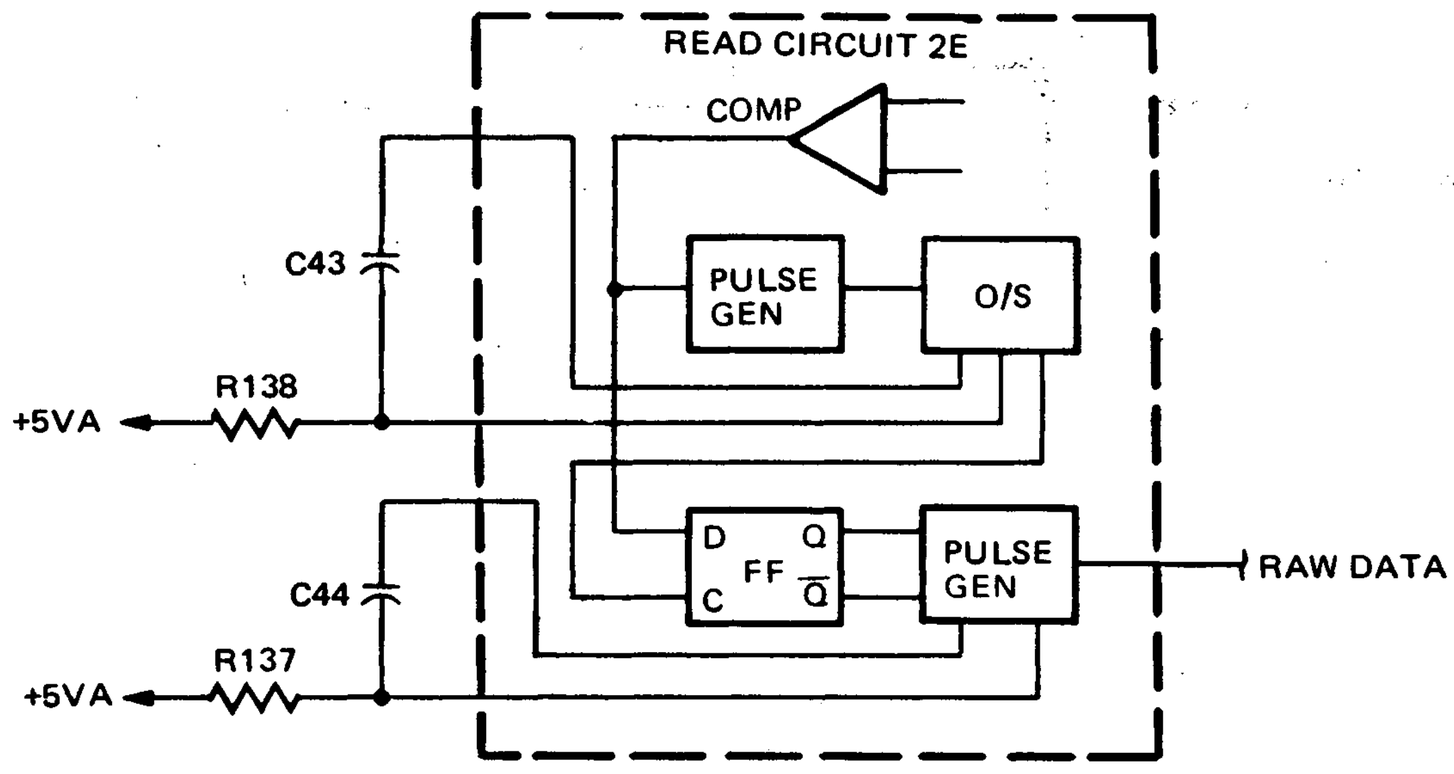


Figure 3-36. Time Domain Filter Logic

Two inputs are received from the crossover detector. The zero crossings are input to a flip-flop from the comparator, and the clock input is from the one-shot. The trailing edge of the one-shot clocks the input flip-flop to the state dictated by the comparator and is delayed 1000 nanoseconds. The flip-flop, resistor R137, and capacitor C44 form a bidirectional one-shot, the output of which is a positive pulse for each transition produced by the input flip-flop. The positive edge of each output pulse triggers the one-shot to output a 200-nanosecond pulse for interface driver 8B and the Data Separator option (if installed for single-density recording). The time domain filter logic is shown in Figure 3-36.

FM Data Separator (Option)

The FM Data Separator option is usable only when the disk drive is used for single-density recording. Frequency modulated (FM) encoding is defined as being a pulse train wherein a clock pulse occurs every 4 microseconds, a binary one data bit pulse occurs midway between clock pulses, and no pulse occurs if the data bit is a binary zero. The logic is shown in Figure 3-37.

The purpose of the data separator is to separate the RAW DATA pulse train of clock and data pulses into separate clock and data pulses.

When enabled by SELECT, RAW DATA from the LSI read circuit is input to AND gates 5E. The 6E one-shot gates RAW DATA alternately to SEPARATED DATA

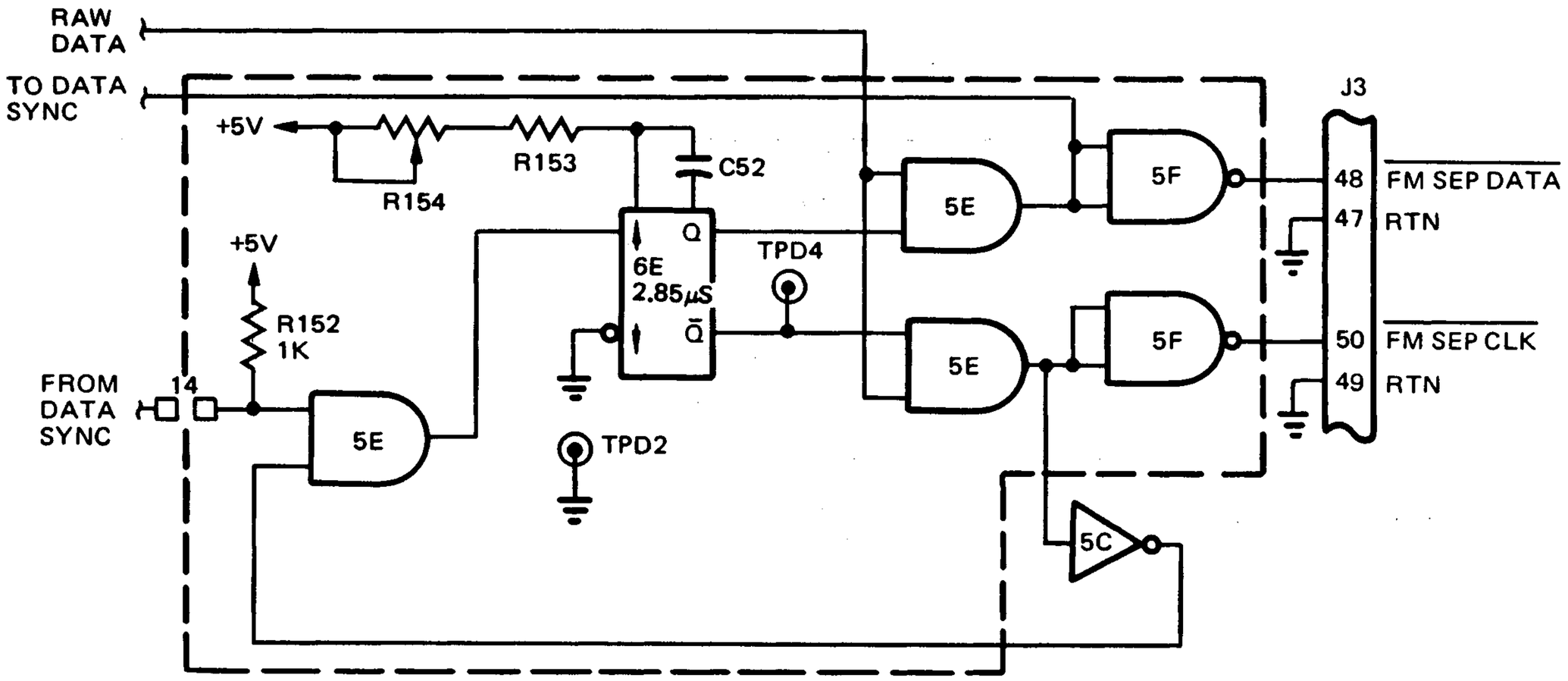


Figure 3-37. FM Data Separator (Option) Logic

and SEPARATED CLOCK. The trailing edge of each SEPARATED CLOCK pulse triggers the one-shot to time for 2.85 microseconds. Therefore, since the time between a clock pulse and a data "1" pulse is 2 microseconds, the pulse that triggers the one-shot is output as the $\overline{\text{SEP CLK}}$ pulse and the next pulse is the $\overline{\text{SEP DATA}}$ pulse. Potentiometer R154 is provided to vary the time delay. Figure 3-38 shows the data separator output timing. The recommended setting for the one-shot delay is 2.8 to 2.9 microseconds. However, the user may want to vary the adjustment due to inherent delays of the particular controller used. The proper operation of the Data Separator option is based on a format with no missing clock pulses.

Data Synchronizer

When a format for FM data is used with missing clock pulses (address marks), the data synchronizer circuit (Figure 3-39) can be connected by installing a wire jumper across the 14 pads. This circuit provides a counter 7F and an additional one-shot 6E. One-shot 6E provides a gating term into gate 5E of the data separator one-shot. Counter 7F allows up to three missing clock pulses from SEPARATED CLOCK before providing an inhibit to gate 5E. This inhibit causes the data separator to resynchronize the RAW DATA input and reverse the SEPARATED CLOCK and DATA outputs.

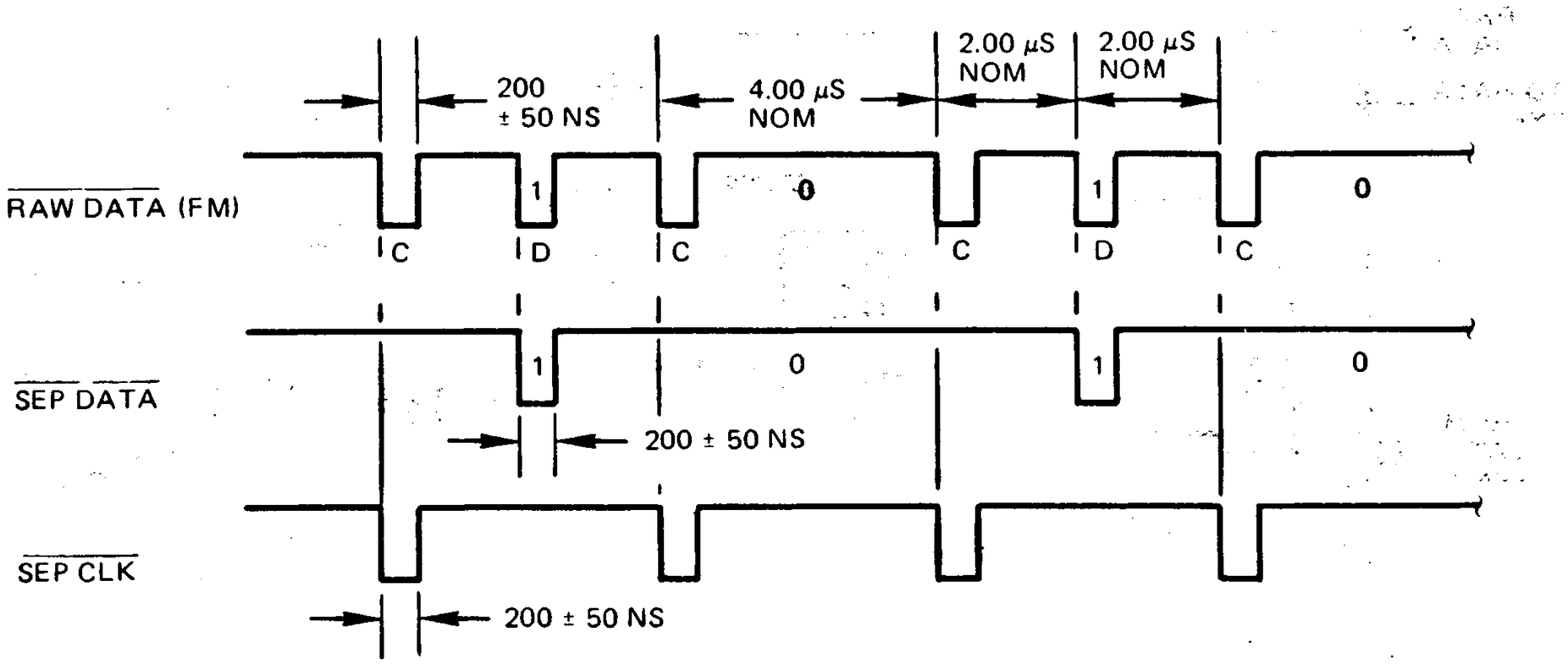


Figure 3-38. FM Data Separator Output Timing

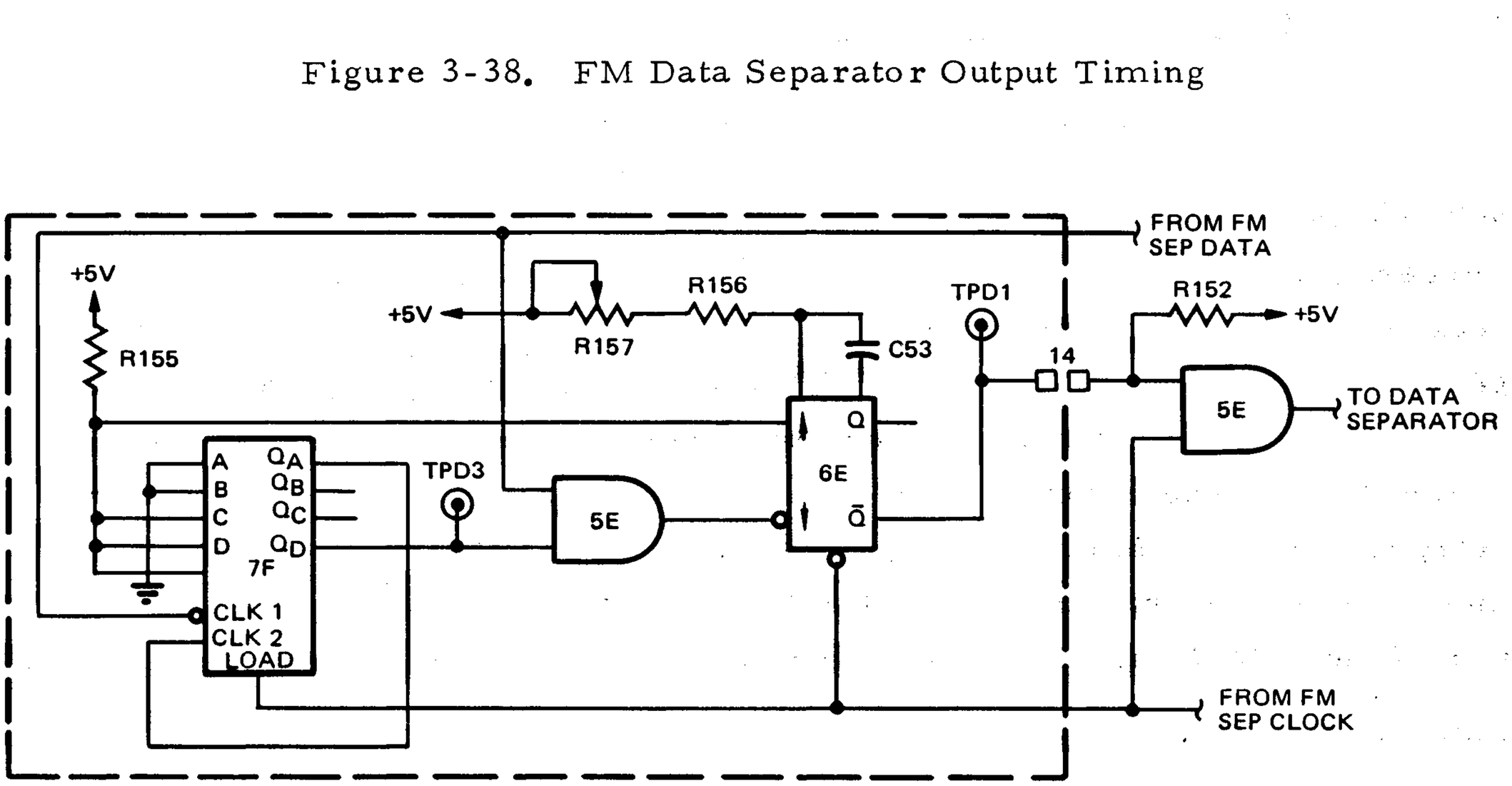


Figure 3-39. Data Synchronizer

Terminating Resistor Network

Terminating resistor network 8D (Figure 3-40), is a dual-inline IC package containing a terminating resistor network for all input interface lines. For each input line there is a 220-ohm resistor to +5 volts, and a 330-ohm resistor to ground. When the disk drives are radially connected to the controller, all drives must have the terminator IC installed. When the drives are connected in daisy-chain fashion, only the last drive must have the terminator IC installed.

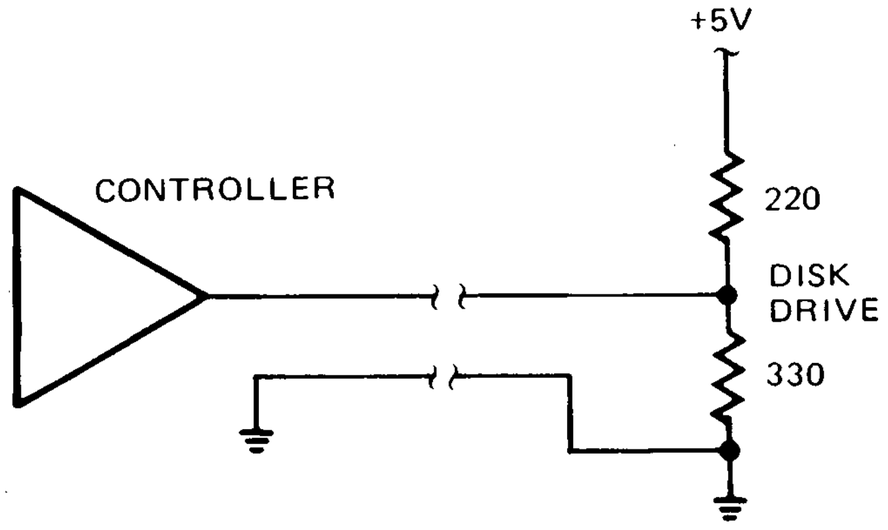


Figure 3-40. Terminating Resistor Network

Additional pull-up options are provided for radial operation. The options are as follows:

M - $\overline{\text{HEAD LOAD}}$

A - $\overline{\text{STEP}}$

B - $\overline{\text{STEP IN}}$

SECTION 4
INSTALLATION

GENERAL

This section provides information necessary to prepare the disk drive for operational readiness. Preliminary inspection, mechanical checks and cable fabrication and verification checks are made to ensure operational integrity.

The disk drive may be configured and shipped in one of many ways, depending on customer requirements. Information for the installation of additional options and multi-drive connecting configurations are included in this section.

INSPECTION

The disk drive is packaged in a heavy duty container, designed to ensure adequate protection during shipping and handling. When the disk drive is installed, store the container and all packing material for possible future use.

Immediately upon receipt, inspect the container for any signs of possible damage. If the container is damaged, there is a possibility that the disk drive may also be damaged. Notify both the carrier and the manufacturer after inspecting the contents.

UNPACKING

A complete inspection of the disk drive is necessary to ensure equipment acceptability. Unpack the disk drive as follows:

a. Remove all packing material around disk drive.

b. Remove disk drive carefully from container and place on bench surface.

c. Remove all wrapping and internal shipping restraints.

d. Check all items against shipping list. Report all discrepancies to manufacturer.

e. Check all items for damage. Report all discrepancies to carrier and manufacturer. If no damage or shipping discrepancies are evident, continue to Mechanical Checks. Otherwise, hold disk drive for return to manufacturer.

MECHANICAL CHECKS

The disk drive is designed for ease of operation. Most mechanical checks can be made, without having power applied, as follows (see Figure 4-1):

a. Place disk drive on clean bench surface with printed circuit board (PCB) on side and front panel facing checker.

b. Manually rotate spindle pulley. Observe that spindle rotates freely and drive belt rides smooth and evenly.

c. Press front panel release button. Observe that carrier mechanism opens to insert floppy disk cartridge, and that centering cone is released from spindle hub.

d. Insert disk cartridge fully. Observe that spring-loaded latch is engaged and that disk cartridge is seated properly over drive mechanism.

e. Close front panel to fully latched position. Observe that centering cone and spindle grasp floppy disk firmly.

f. Rotate spindle drive mechanism. Observe smooth rotation of floppy disk.

CONNECTING CABLES

The disk drive is connected to the host controller by three connecting cables, the lengths of which are determined at the installation site. The ac and dc cables are independent cables requiring direct connection to each disk drive, regardless of connecting configuration. However, the interface signal cable is connected according to the various connecting configurations, and should not exceed 15 feet in length.

The cables are connected directly to disk drive connectors as shown in Figure 4-1, and are identified as follows:

- J1, AC Power (Spindle Drive Motor)
- J2, DC Power (Electronics and Stepper Motor)
- J3, Interface Signals (Input Commands and Write Data, Output Status and Read Data)

Fabricate all cables using recommended connecting jacks, plugs and pins. All input and output lines to interface connector J3 (signal), should be cabled using one of the two following methods:

- Twisted pair (AWG 26 or larger) with at least one twist per inch, for each signal. One wire connected to assigned signal pin on P3, and the other wire connected to signal ground at both ends. Cable length should not exceed 25 feet.

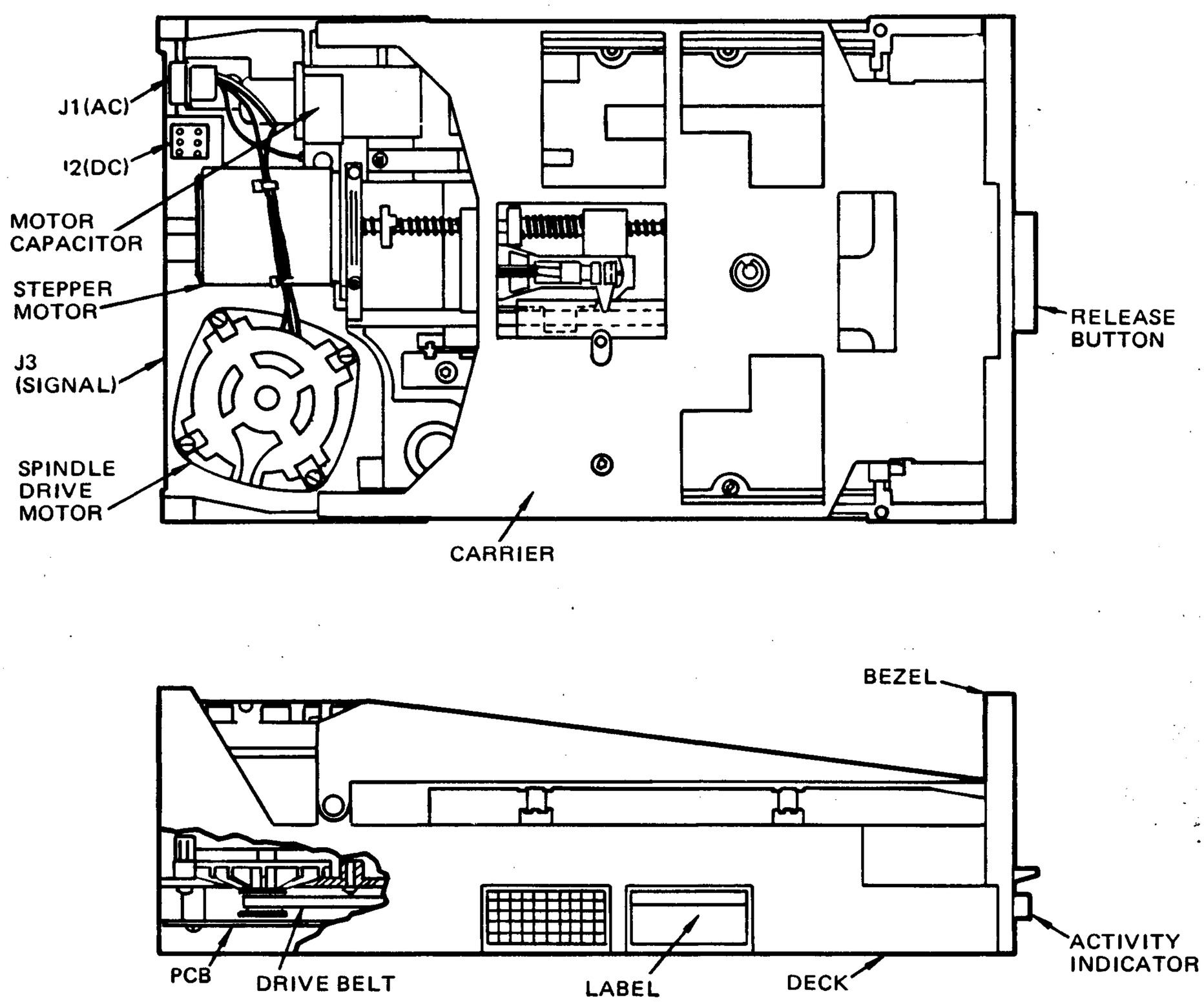


Figure 4-1. Principal Parts Location

- 50-conductor flat ribbon cable. Connect alternate signal and ground wire using recommended material. Maximum ribbon cable length is 10 feet.

Using a voltohmmeter (set to measure continuity), verify that all cables have been fabricated correctly by the following checks on each connector:

a. Check each pin with all other pins on same connector to ensure pin-to-pin short does not exist.

b. Verify cable has no broken lines by checking each pin with corresponding pin on opposite end of cable.

c. Adjust voltohmmeter to measure ac line voltage; apply ac power and check disconnected ac connector pins (P1) for correct input voltage. Remove ac power when check complete.

d. Adjust voltohmmeter to measure dc voltage; apply dc power and check disconnected dc connector pins (P2) for correct input voltages. Remove dc power when check complete.

AC Power Cable

AC power is connected to the disk drive through connector J1 (AC). The input pin assignments and optional voltage/frequency requirements are listed in Table 4-1.

Table 4-1. AC Power Requirements

Pin No. (P1)	60 Hertz		50 Hertz	
	115V	230V	115V	230V
1	90-127 VAC	180-253 VAC	90-127 VAC	180-253 VAC
2	Frame Gnd	Frame Gnd	Frame Gnd	Frame Gnd
3	AC Ret	AC Ret	AC Ret	AC Ret
I_{MAX}	0.3 Amps	0.15 Amps	0.4 Amps	0.2 Amps
Frequency Tolerance	±0.5 Hertz		±0.5 Hertz	

AC power input connector J1 is mounted inside the frame, in front of the drive motor capacitor (see Figure 4-1). The 3-pin connector is AMP P/N 1-480305-0 using pin P/N 60620-1 or AMP P/N 1-480701-0 using pin P/N 350669-1 and pins (2) P/N 350705-1. Recommended mating connector P1, is AMP P/N 1-480303-0 or 1-480304-0, both using pin P/N 60619-1 or AMP P/N 1-480700-1 using pin P/N 350550-1. Figure 4-2 shows connector J1 as seen from the rear of drive.

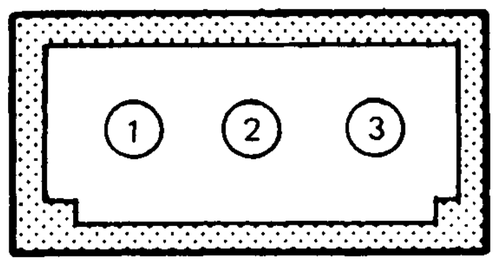


Figure 4-2. AC Connector J1

DC Power Cable

DC power is connected to the disk drive through twisted-pair at connector J2 (DC). The input pin assignments and voltage requirements are listed in Table 4-2.

Table 4-2. DC Power Requirements

Pin No. (P2)	DC Voltage	Tolerance	Current	Maximum Ripple (p-p)
1	+24 VDC	±1.2 VDC	2.0A Max. 1.4 Typical	100 mv
2	+24V Ret	-		-
5	+5 VCD	±0.25 VDC	1.0A Max.	50 mv
6	+5V Ret	-	-	-

DC power input connector J2 is mounted on the noncomponent side of the PCB, just below the drive motor capacitor and the stepper motor (see Figure 4-1). The 6-pin connector is AMP Mate-N-Lock P/N 1-380999-0 and is soldered directly to the PCB. Recommended mating connector P2, is AMP P/N 1-480270-0 using pin P/N 60619-1. Figure 4-3 shows connector J2, as seen from the rear of the disk drive.

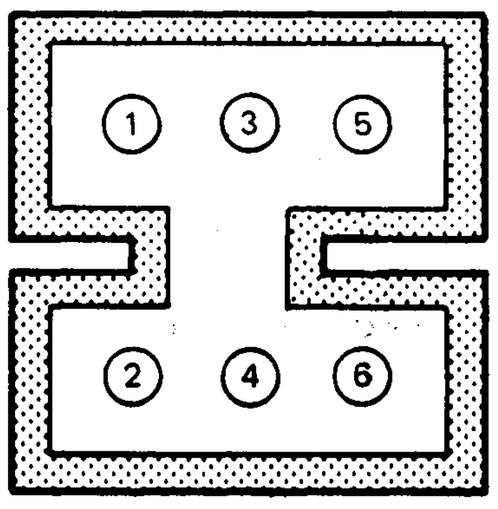


Figure 4-3. DC Connector J2

Interface Signal Cable

All controller commands, read/write data, and disk drive status signals are transferred through connector J3. Connections are made between the controller and the disk drive in either radial or daisy-chain fashion, depending on the installed configuration required.

Connector J3 is a 50-pin PCB edge-card connector, located at the rear of the disk drive (see Figure 4-1). The pins are numbered 1 through 50, with all even-numbered pins on the component side. A key slot is provided between pins 4 and 6 for connector keying. Recommended mating connectors for J3, are listed in Table 4-3.

Table 4-3. Recommended J3 Mating Connectors

Cable Type	Manufacturer	Connector P/N	Contact P/N
Twisted Pair #26 (crimp or solder)	AMP	1-583717-1	583615-5 (Crimp) 583854-3 (Solder)
Twisted Pair #26 (solder terminal)	VIKING	3VH25/1JN-5	NA
Flat Cable (Scotchflex)	3M AMP	3415-0001 888083-1	NA NA

All connections to and from the read/write and control logic printed circuit board are shown in Figure 4-4.

Figure 4-4 is provided as an interconnection diagram and shows that, except for AC power connector J1, all connections are made directly to or from the PCB. Connector J4, J5, J6, J7, J8 and J9 are for internal disk drive use.

INTERFACE SIGNAL DESCRIPTIONS

All interface signal levels are low active (0 volt), inverted by the disk drive line receivers or line drivers, and all input signals are terminated according to the system configuration used; radial or daisy chain.

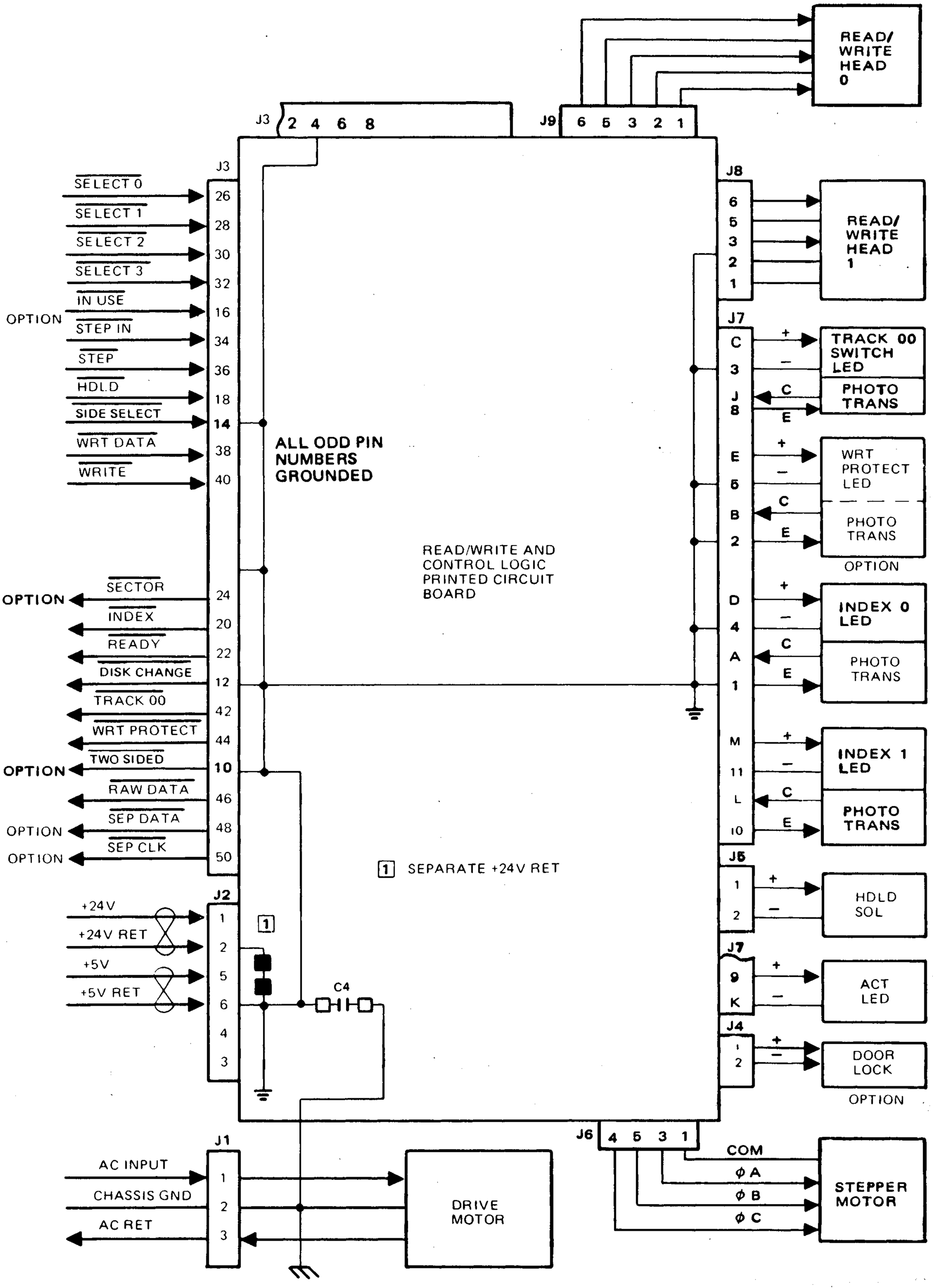


Figure 4-4. Interconnection Diagram

Logic Levels and Termination

Interface signals to and from connector J3 have the logic levels represented by Figure 3-7 and all signal inputs are terminated as shown in Figure 3-40.

Input Signals

Input signals from the controller to the disk drive are listed and defined in Table 4-4. Logic 1 is low (active) and Logic 0 is high (see Figure 3-7).

Output Signals

Output signals from the disk drive to the controller are listed and defined in Table 4-5. Logic 1 is low (active) and logic 0 is high (see Figure 3-7).

INTERFACE TIMING

The timing for interface input/output signals is shown in Figure 3-6.

Disk drive operations begin when the disk cartridge is inserted and the access door is closed. The floppy disk begins rotating and, during the "ready" delay, the unit is selected by the controller to check the ready status.

At completion of the ready delay, $\overline{\text{READY}}$ becomes active to the controller and the controller makes $\overline{\text{HDLD}}$ active in return. After a 25-millisecond head load time the unit is in the Read mode and the read data is present on the $\overline{\text{RAW DATA}}$ line.

The controller issues one or more $\overline{\text{STEP}}$ pulses, causing the read/write heads to be moved one or more tracks from its initial position. During the 30 milliseconds after the last $\overline{\text{STEP}}$ pulse, the head has settled on the track and $\overline{\text{WRITE}}$ is made active, placing the disk drive in the Write mode.

After a maximum delay of 1 bit time (4 microseconds for single-density, 2 microseconds for double-density), write data is accepted on the $\overline{\text{WRT DATA}}$ line and written on the disk. Approximately 200 microseconds after $\overline{\text{WRITE}}$ goes active, the erase function within the drive is made active.

After the last write bit has been transferred to the disk drive, $\overline{\text{WRITE}}$ becomes inactive 2 bit times later. The drive continues erasing for 530 microseconds after the trailing edge of $\overline{\text{WRITE}}$.

Table 4-4. Interface Input Signals

Signal	Definition
$\overline{\text{SELECT 0}}$ through $\overline{\text{SELECT 3}}$	In the basic configuration one select line is assigned to each drive. Logic 1 (low) selects the corresponding drive and all interface logic is enabled. When the line is at logic 0 (high) all inputs are disabled except $\overline{\text{SELECT}}$ lines and all outputs are disabled (see Figure 3-9). When the binary select option is installed, an active (low) $\overline{\text{SELECT 0}}$ enables unit selection. SELECT 1, SELECT 2 and $\overline{\text{SELECT 3}}$ contain a 3-bit binary code to select the unit (see Table 3-1). The activity indicator is turned on and the door lock option (if installed) is activated if the activity indicator option is monitoring $\overline{\text{SELECT}}$. The $\overline{\text{SELECT}}$ lines may be optionally jumpered to select side 0 or side 1 of a two-sided floppy disk instead of using the $\overline{\text{SIDE SELECT}}$ interface line.
$\overline{\text{HDLD}}$	Logic 1 (low) energizes the head load solenoid. The energized head load solenoid releases the head load arm to bring the media into contact with the read/write heads (see Figure 3-15). A delay of 25 milliseconds is required after the $\overline{\text{HDLD}}$ command, before data can be read and written. To enable $\overline{\text{HDLD}}$ the unit must be selected. An active HDLD is not required if the selected HDLD option is installed. The activity indicator is turned on and the door lock option (if installed on a low profile drive) is activated if the activity indicator is monitoring $\overline{\text{HDLD}}$.
$\overline{\text{STEP}}$	The trailing edge of each logic 1 $\overline{\text{STEP}}$ pulse (low to high transition) causes the read/write heads to move one track distance (see Figure 3-18). Each pulse must remain active for at least 10 microseconds and the time between pulses must be at least 3 milliseconds and not more than 8 milliseconds for a multiple track movement (see Figure 3-19). The following conditions must be met to allow read/write head movement: 1. Write operation inhibited 2. Unit selected or radial step option installed

Table 4-4. Interface Input Signals (Continued)

Signal	Definition
$\overline{\text{STEP IN}}$	Logic 1 level (low) enables the read/write heads to move forward (in toward track 76) and logic 0 level (high) enables the read/write heads to move in reverse (out toward track 00) (see Figure 3-18). The signal must not change state less than 1 microsecond before the trailing edge of the $\overline{\text{STEP}}$ pulse (see Figure 3-19). To enable $\overline{\text{STEP IN}}$ the unit must be selected or the radial step option must be installed. The STEP IN line may be optionally multiplexed to select side 1 of a two-sided floppy disk instead of using the $\overline{\text{SIDE SELECT}}$ interface line.
$\overline{\text{WRITE}}$	Logic 1 level (low) disables both the read logic and read/write head movement and causes write current to be turned on in the selected read/write head (see Figure 3-23 and 3-27). $\overline{\text{WRITE}}$ should be active 1 bit time before the first $\overline{\text{WRT DATA}}$ pulse and remain active 2 bit times after the last $\overline{\text{WRT DATA}}$ pulse (see Figure 3-21). Erase current is turned on and off by WRITE GATE for straddle erase. Erase current is turned on 200 microseconds after WRITE becomes active (low) and is turned off 530 microseconds after WRITE becomes inactive (high) for tunnel erase (see Figure 3-24). The following conditions must be met to enable $\overline{\text{WRITE}}$: 1. Unit selected 2. $\overline{\text{HDLD}}$ active 3. A disk cartridge without a write protect slot must be loaded.
$\overline{\text{WRT DATA}}$	Transitions of the $\overline{\text{WRT DATA}}$ pulse from high to low and low to high change the polarity of the write current flow through the read/write head (see Figure 3-27). $\overline{\text{WRT DATA}}$ remains low for 150 to 1100 nanoseconds to establist nominal data and clock pulse durations (see Figure 3-30). To enable $\overline{\text{WRT DATA}}$ the unit must be selected.
$\overline{\text{SIDE SELECT}}$	Logic 0 level (high) enables Head 0 for Read/Write operations. Logic 1 level (low) enables Head 1.
$\overline{\text{IN USE}}$ (Option)	This optional input can be used to turn on the activity indicator and activate the door lock option if the activity indicator option is monitoring $\overline{\text{IN USE}}$.

Table 4-5. Interface Output Signals

Signal	Definition
$\overline{\text{READY}}$	Active status (low) indicates AC and DC power applied and the floppy disk is rotating at 62.5 percent of speed (see Figure 3-14). If a floppy disk is already loaded, $\overline{\text{READY}}$ will go low nominally 2 seconds after the application of AC and DC power (see Figure 3-6).
$\overline{\text{WRT PROTECT}}$	Active status (low) indicates write-protect disk (see Figure 1-2) cartridge in use and all write logic is disabled. Output is available only when unit is selected (see Figure 3-22).
$\overline{\text{TRACK 00}}$	Active status (low) indicates that the read/write heads are positioned at track 00. Output available only when unit is selected (see Figure 3-16).
$\overline{\text{INDEX}}$	Low active 1.7 millisecond pulse (see Figure 3-11) occurs once per disk revolution (see Figure 3-10). If the hard sector option is installed (see Figure 3-12) the pulse duration is reduced to 0.4 milliseconds nominal (see Figure 3-13). The index pulse timing is used to synchronize controller data format transfers.
$\overline{\text{SECTOR}}$ (Option)	This line used only if the hard sector option is installed (see Figure 3-12). Low active 0.4-millisecond pulses occur 5.2 milliseconds apart indicating the start of each of the 32 sectors marked by the 32 sector holes in the soft sectored floppy disk cartridge (see Figure 1-2). If the 16/8 sector option is installed, a low level pulse occurs at every other sector hole (16 sector) or at every fourth sector hole (8 sector) (see Figure 3-13).
$\overline{\text{RAW DATA}}$	A low active pulse is produced for each flux reversal read from the disk (see Figure 3-31). This pulse train is restored data transferred to the controller. Each pulse width is 200 nanoseconds duration (see Figure 3-38).

Table 4-5. Interface Input Signals (Continued)

Signal	Definition
$\overline{\text{FM SEP DATA}}$ $\overline{\text{FM SEP CLK}}$	These lines are used only if the FM data separator option is installed. (See Figure 3-37). A low active 200-nanosecond pulse ($\overline{\text{FM SEP DATA}}$) is produced for each data transition in the RAW DATA pulse train (see Figure 3-38).
$\overline{\text{ILLEGAL PACK}}$ (Option)	This line goes to Logic 1 (low) when a single-sided floppy disk is used and side 1 head is selected. This enables the controller to sense when the uncertified side of a single-sided disk is selected.
$\overline{\text{TWO-SIDED}}$ (Option)	With this option installed, the interface signal is activated when a two-sided floppy disk is installed and the heads are loaded. The signal will be inactive with the heads unloaded or with a single-sided floppy disk installed and the heads loaded. This option is mutually exclusive with the Illegal Pack option.

A 50-microsecond read stabilization delay is required following a write operation, before valid read operations can be performed.

SYSTEM CONFIGURATIONS

The disk drive can be used in single-drive applications or can be connected in a multi-drive configuration for greater storage capabilities.

Single-Drive Configuration

When a single disk drive is to be used with the host controller, all cables are connected directly to the disk drive (see Figure 4-5). It is the simplest form of radial configuration. The unit can be selected to accept commands and respond with status signals. Selected head load or radial options may be installed.

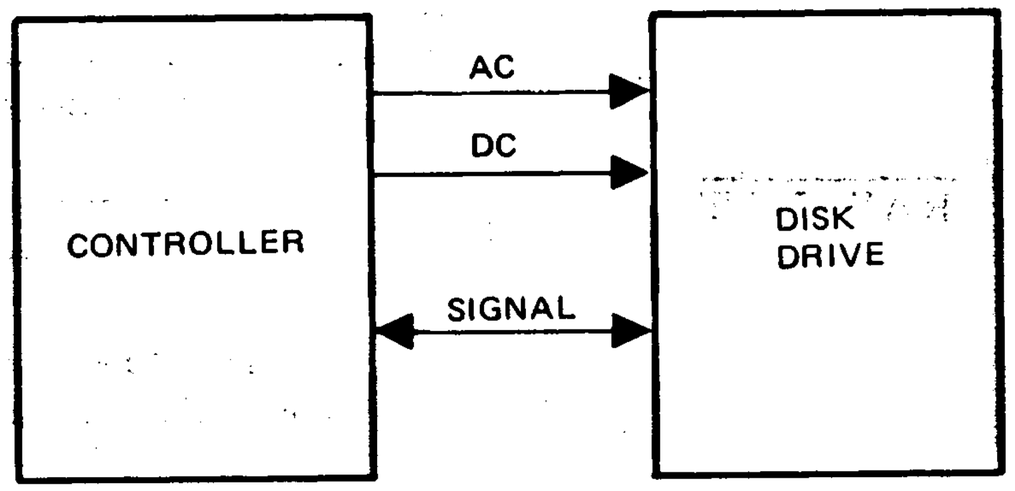


Figure 4-5. Single-Drive Configuration

In this application, all input signal lines are terminated by an integrated circuit containing the terminating networks, which are located on the printed circuit board.

Radial Select

When multi-drive applications are required, one method used is the radial select (Figure 4-6). The purpose of this type operation is to allow the disk drive to accept commands and send status signals, without having been selected. All radial options can be installed. Signal input lines are terminated in each disk drive.

Daisy-Chained Radial Select

The radial select configuration may be daisy-chained to allow a multi-drive system both select and non-select operations. This configuration is shown in Figure 4-7.

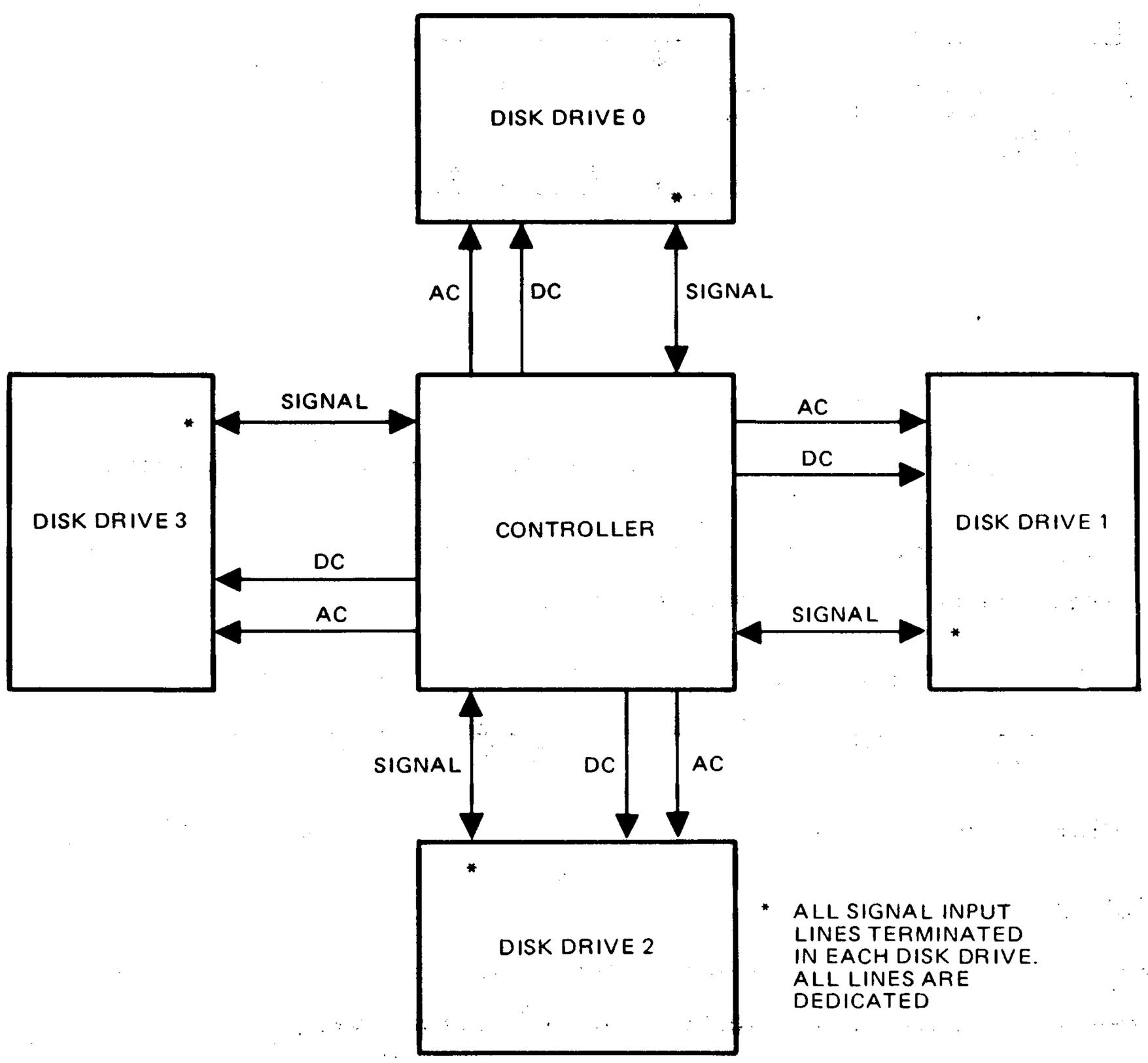


Figure 4-6. Radial Select Configuration

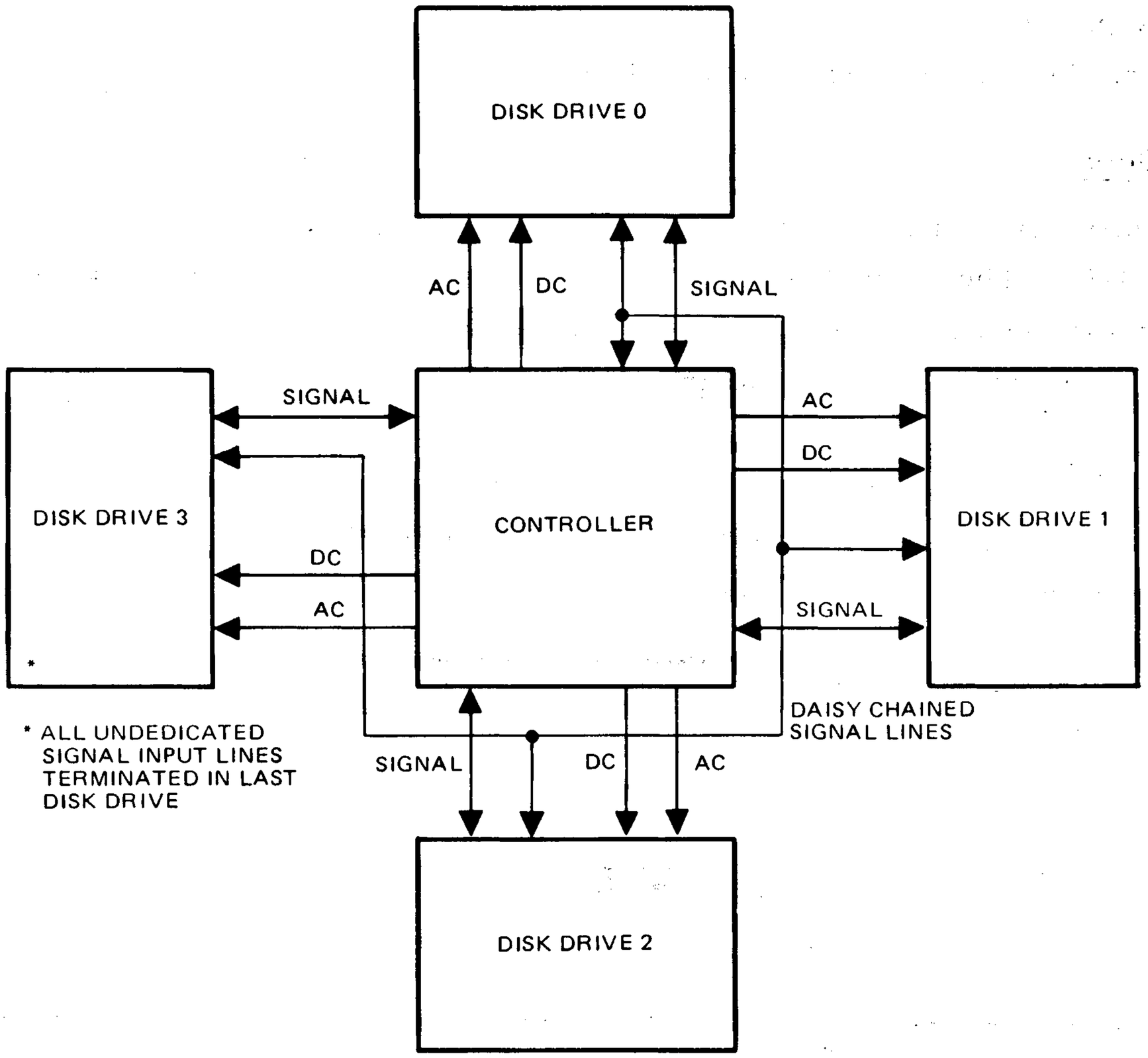


Figure 4-7. Daisy-Chained Radial Select Configuration

Undedicated lines under select control are daisy-chained. All undedicated signal lines are terminated in the last disk drive.

It is possible to install any one of the following radial options with four disk drives:

$\overline{\text{STEP}}$, $\overline{\text{STEP IN}}$, $\overline{\text{HDLD}}$, $\overline{\text{READY}}$, $\overline{\text{INDEX}}$ or $\overline{\text{SECTOR}}$ -

With two disk drives, any five of the radial options can be installed.

Binary Select

The binary select configuration multiplexes the select lines to allow up to eight disk drives to be individually selected by a binary code. This configuration is shown in Figure 4-8. All signal lines are daisy-chained. All signal input lines are terminated in the last disk drive.

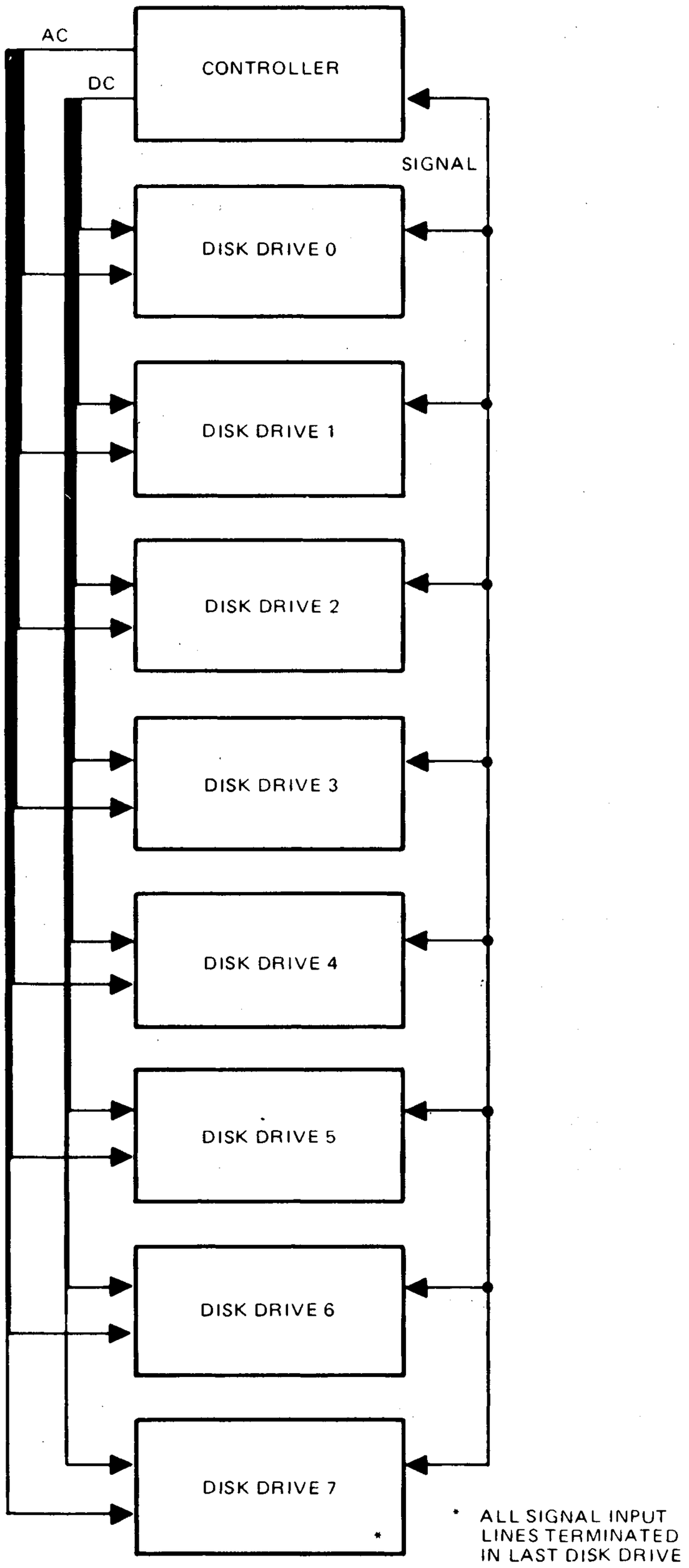


Figure 4-8. Binary Select Configuration

To select one of eight disk drives when using only four select lines the following scheme is used (refer to Table 3-1):

$\overline{\text{SELECT 0}}$	= Decoder Enable
$\overline{\text{SELECT 1}}$ $\overline{\text{SELECT 2}}$ $\overline{\text{SELECT 3}}$	Binary coded from 0 through 7 to produce only one select signal

INTERFACE/INTERNAL OPTIONS INSTALLATION

The disk drive may be supplied with or without any options installed.

All options except door lock can be installed at a later date. All etched circuitry is predesigned into the PCB and low-cost option kits (components) are available.

The following paragraphs provide procedural information necessary to install the options. Figure 4-9 shows the PCB outline and the unique manner by which an option can be installed. Refer to this illustration for the location of each option.

Note

If alternate I/O lines are assigned as an option, the resultant configuration should be checked for proper terminator resistors.

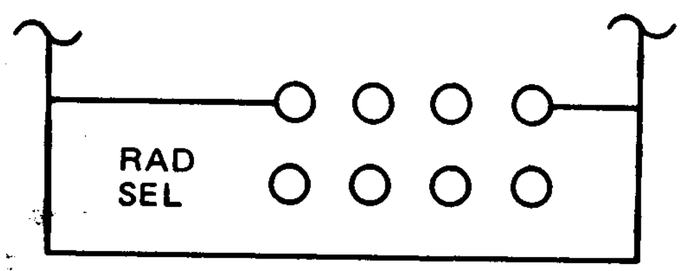
Radial Select (See Figure 3-9)

In the radial select configuration, a dedicated $\overline{\text{SELECT}}$ line is provided for each disk drive. The assigned $\overline{\text{SELECT}}$ line must be connected across the etch pads for connection to the interface.

Units are supplied with a jumper assembly installed across the 0 pads. For disk drives 1, 2 or 3:

a. Remove jumper assembly from 0 pads.

b. Install jumper assembly on 1, 2 or 3 pads.



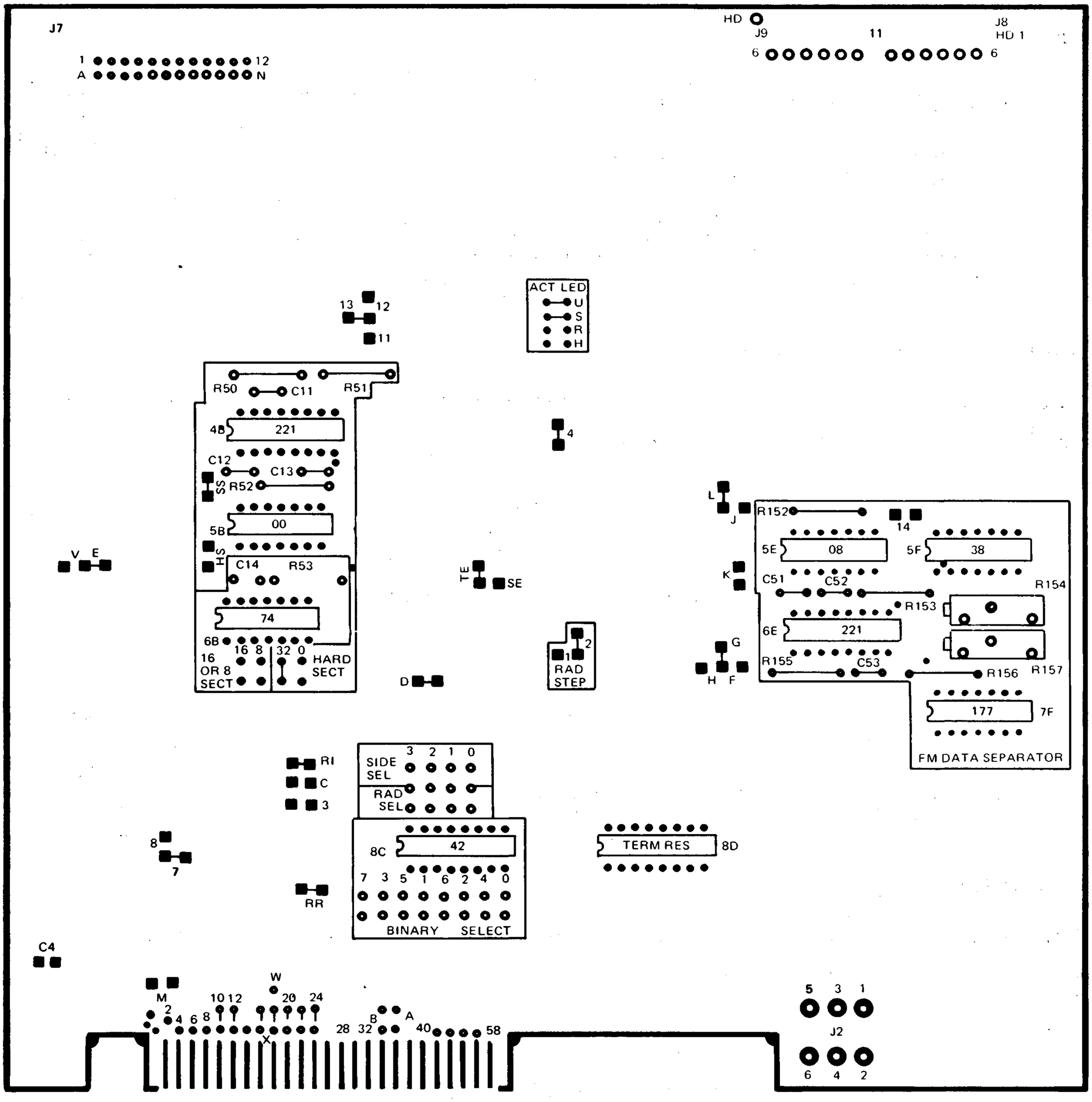


Figure 4-9. Interface/Internal Options

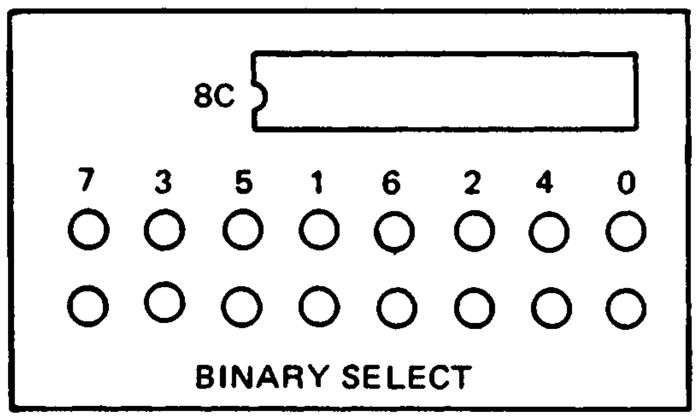
Binary Select (See Figure 3-9 and Table 3-1)

This option allows the select function to be multiplexed to a maximum of eight drives.

To install the Binary Select Option:

a. Remove jumper assembly from RAD SEL terminals.

b. Install jumper assembly on BINARY SELECT terminals assigning desired address.



Radial Step (See Figure 3-19)

This option allows $\overline{\text{STEP}}$ and $\overline{\text{STEP IN}}$ commands to be accepted to position the read/write heads without the drive being selected.

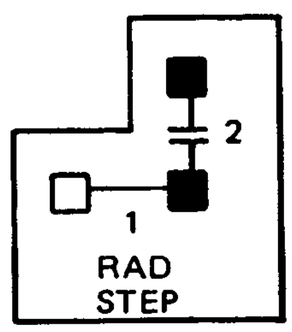
Note

This option can not be installed if the $\overline{\text{STEP}}$ I/O line is daisy-chained to two or more disk drives.

To install this option:

a. Remove wire jumper between vertical 2 RAD STEP pads.

b. Install a wire jumper between the horizontal 1 pads.



Radial Ready (See Figure 3-14)

This option allows the ready status of the drive to be sent to the host controller without the drive being selected.

Note

This option can not be installed if the READY I/O line is daisy-chained to two or more disk drives.

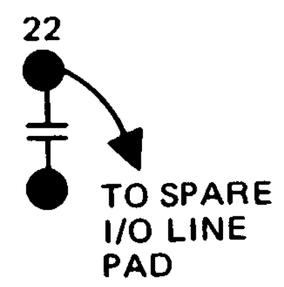
To install this option:

a. Remove wire jumper between the horizontal RR pads (RR).

If more than one drive is configured in the system, then only one drive may use J3, interface connector, pin 22 for its $\overline{\text{READY}}$ line and each other drive must be assigned one of the spare I/O lines as follows:

a. Remove wire jumper between the vertical 22 pads.

b. Install a wire jumper between the upper 22 pad and one of the spare I/O line pads.



Ready Option

The Index and Sector signals can be optionally conditioned to be disabled on the interface until Ready is active. To enable this option install a wire jumper between the horizontal C pads.

Radial Index/Sector (See Figures 3-12 and 3-14)

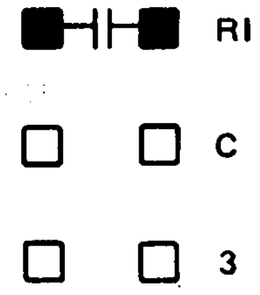
This option allows the $\overline{\text{INDEX}}$ and $\overline{\text{SECTOR}}$ pulses to be sent to the host controller whenever the unit is ready, without the drive being selected.

Note

This option cannot be installed if the $\overline{\text{INDEX}}$ and $\overline{\text{SECTOR}}$ I/O lines are daisy-chained to two or more disk drives.

To install this option:

a. Remove wire jumper between the RI pads.

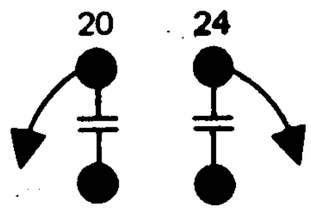


If more than one drive is configured in the system, then only one drive may use J3, interface connector, pin 20 for the $\overline{\text{INDEX}}$ line and pin 24 for the $\overline{\text{SECTOR}}$ line. Each other drive must be assigned one of the spare I/O lines as follows:

a. Remove wire jumpers between 20 and 24 pads.

b. Install a wire jumper between the upper 20 pad and one of the spare I/O line pads.

c. Install a wire jumper between the upper 24 pad and one of the spare I/O line pads.



Auto Head Load Option (See Figure 3-15)

With the auto head load option installed, the read/write heads are loaded whenever the drive is selected. Install the option as follows:

a. Remove the wire jumper between the vertical 18 pads.

b. Add a wire jumper between vertical K pads.

Radial Head Load Option (See Figure 3-15)

This option allows $\overline{\text{HDLD}}$ commands to be accepted to load the read/write head without the drive being selected.

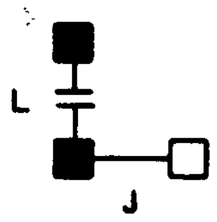
Note

This option cannot be installed if the $\overline{\text{HDLD}}$ I/O line is daisy-chained to two or more disk drives.

To install this option:

a. Remove wire jumper between vertical L pads.

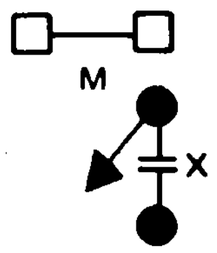
b. Install a wire jumper between the horizontal J pads.



If more than one drive is configured in the system, only one drive may use J3, interface connector, pin 18 for its $\overline{\text{HDLD}}$ line, and each other drive may be assigned one of the spare I/O lines as follows:

a. Remove the wire jumper between the vertical X pads (pin 18).

b. Install a wire jumper between the upper X pad and one of the spare I/O line pads.



c. Install a wire jumper between the M-pads to provide a terminator resistor for drives without 8D installed.

CAUTION

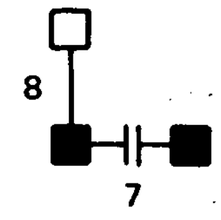
If the auto head load option is installed when the radial head load option is installed, the read/write heads will be loaded whenever DC power is applied to the drive.

Illegal Pack Option (See Figure 3-10)

To provide the signal $\overline{\text{ILLEGAL PACK}}$ to the interface in place of $\overline{\text{TWO SIDED}}$:

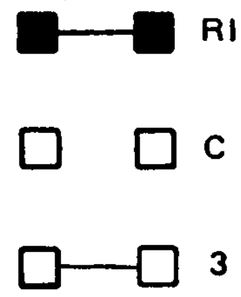
a. Remove the wire jumper between the horizontal 7 pads.

b. Install a wire jumper between the vertical 8 pads.



To provide $\overline{\text{ILLEGAL PACK}}$ as an enable term for gating READY to the interface driver:

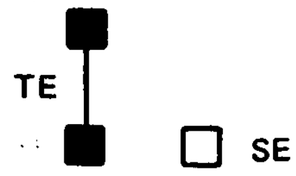
a. Install a wire jumper between the horizontal 3 pads.



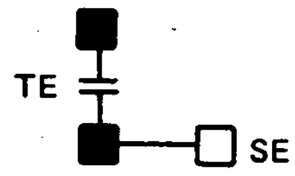
Tunnel-Erase/Straddle-Erase Options

The installation of either the tunnel-erase option or the straddle-erase option must ensure that the installed read/write heads correspond to the option selected.

a. If the tunnel-erase read/write heads are installed, install a wire jumper between the vertical TE pads.



b. If straddle-erase read/write heads are installed, remove the wire jumper between the TE pads and install a wire jumper between the horizontal SE pads.



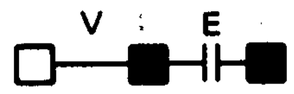
Write Protect Option

The write protect option is designed to inhibit the write function by disabling the write logic.

To disable the capability:

a. Remove the wire jumper between the horizontal E pads.

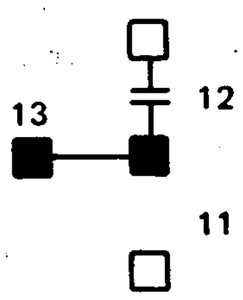
b. Install a wire jumper between the horizontal V pads.



Disk Change Option

This option alerts the controller that the disk drive access door has been opened and the floppy disk may have been changed.

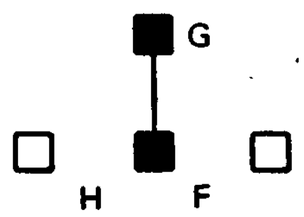
To disable the status capability remove the wire jumper between the vertical 12 pads.



Phase Option

The phase option is designed to control the drive power to the stepper motor, under certain conditions. The option can be connected to function in any one of the following ways:

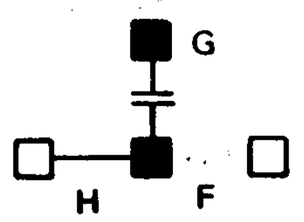
a. To remove drive power when the read/write heads are unloaded - install a wire jumper between the vertical G pads (normal configuration).



b. To remove drive power when the disk drive is not selected -

1. Remove the wire jumper between the vertical G pads.

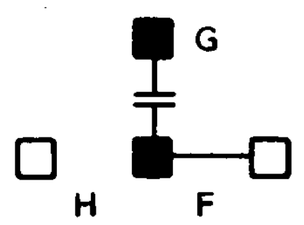
2. Install a jumper wire between the horizontal H pads.



c. To apply drive power at all times -

1. Remove the wire jumper between the vertical G pads.

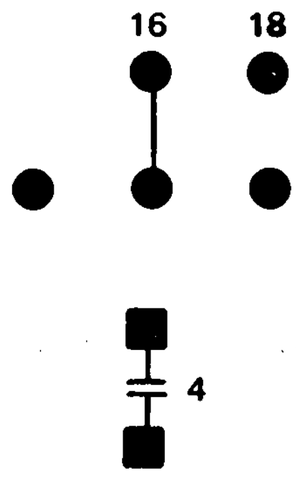
2. Install a wire jumper between the horizontal F pads.



In Use Option

The $\overline{\text{IN USE}}$ interface line can be connected to activate the door interlock and the activity indicator. The state of the $\overline{\text{IN USE}}$ line is sampled and latched when the drive is selected. The OR of $\overline{\text{IN USE}}$, the latch output, and HEAD LOAD, READY, or SELECT provide the drive to the door interlock and activity LED.

To enable $\overline{\text{IN USE}}$, jumper the pads at input pin 16 of J3.

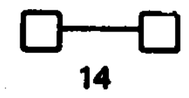


The IN USE latch can be disabled by removing the wire jumper from the vertical 4 pads.

Data Separator Option

As delivered, the disk drive is capable of providing separated data and clock pulses from single density FM data read from the floppy disk.

To provide FM data separation, using a format with recorded address marks (missing clock pulses) the additional data synchronizer circuit can be enabled by adding a jumper between the horizontal 14 pads.



Hard Sector (See Figure 3-12)

The Hard Sector option allows the use of a 32-sector floppy disk. The 32 holes in the disk are sensed by the index hole photosensing circuit and are used to synchronize timing of write data assigned sectors of the disk.

To install the option:

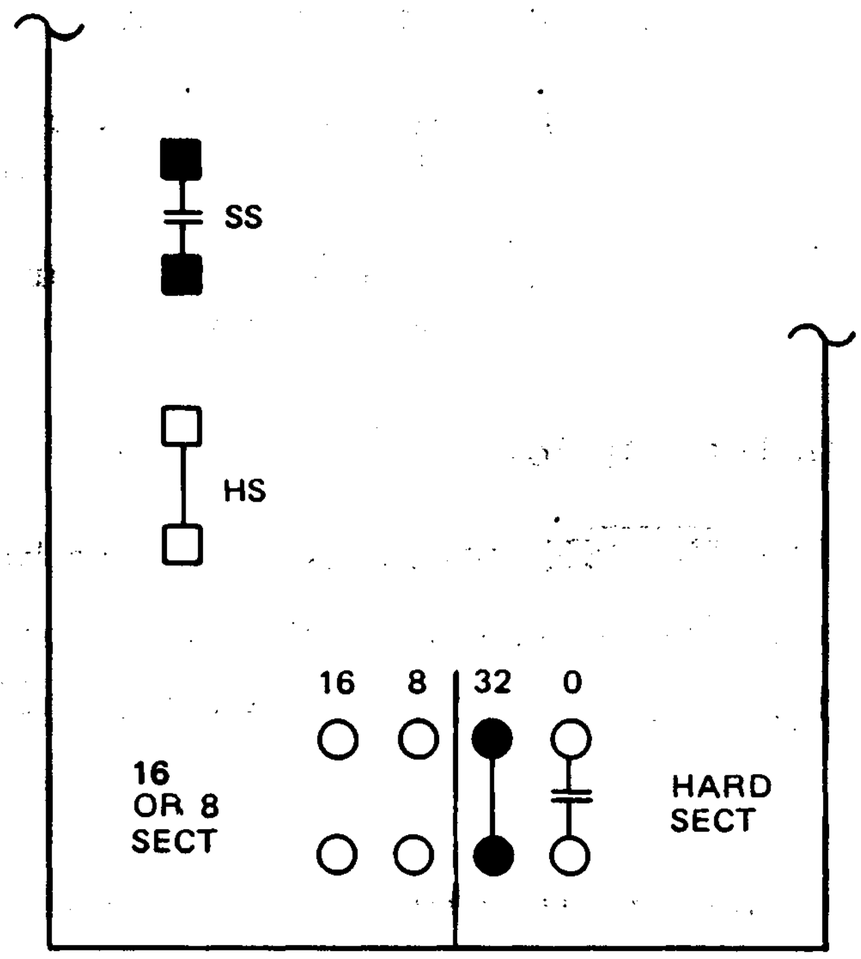
a. Install all components in Hard Sector Option Kit.

b. Remove wire jumper between the vertical SS pads.

c. Add wire jumper between the vertical HS pads

d. Remove wire jumper between pads 0.

e. Install wire jumper between pads 32.

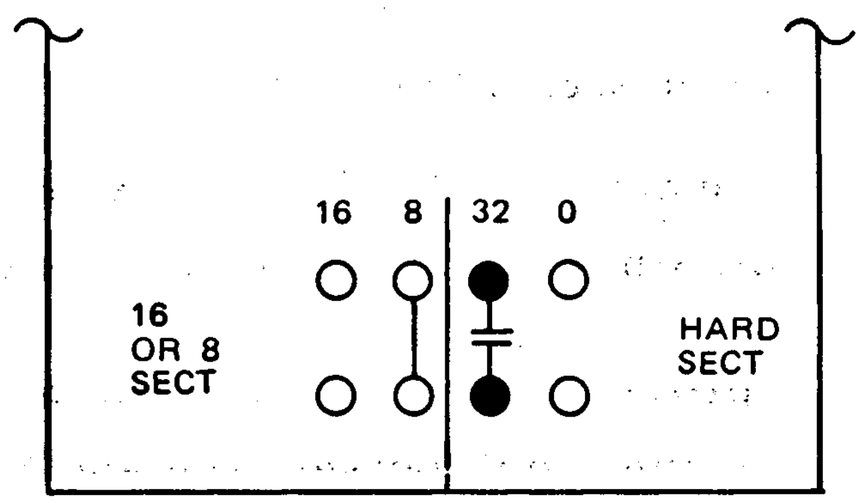


16 or 8 Sector (See Figure 3-12)

The 16 or 8 Sector option allows the 32 sector pulses detected in the hard sector floppy disk, to be used for dividing down to 16 sectors or 8 sectors. The Hard Sector option must be previously installed. To install the Sector Select option:

a. Remove wire jumper between pads 32.

b. Install wire jumper between either 16 or 8 pads, as desired.



Activity Indicator Select (See Figure 3-14)

In the basic configuration of the disk drive, the front panel activity indicator is turned on when the drive is selected. The purpose of the Activity Indicator Select option is to allow one of two additional signals, $\overline{\text{HEAD LOAD}}$ or $\overline{\text{READY}}$, to be substituted for $\overline{\text{SELECT}}$. Only one of these can be used at a time.

If the door lock option is installed the door lock will be activated by the same signal driving the activity indicator.

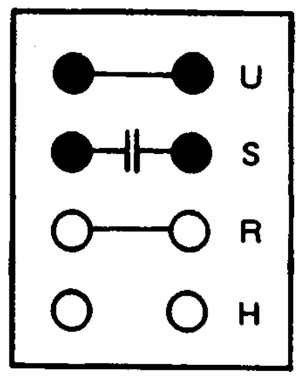
Modify the option as follows:

a. Remove wire between S pads.

b. Install a wire jumper across desired status signal for activity indicator.

   H - $\overline{\text{HDLD}}$

   R - $\overline{\text{READY}}$



Side Select Option (See Figure 3-9)

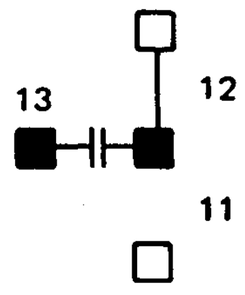
In this option a dedicated input $\overline{\text{SELECT}}$ line may be used to select Head 0 and a second line to select Head 1. To install this option:

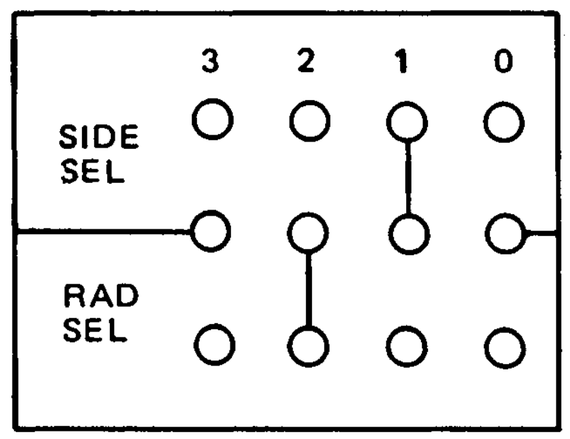
a. Remove the wire jumper between the horizontal 13 pads.

b. Install a wire jumper between the vertical 12 pads.

c. Place jumper assembly in position 0, 1, 2, or 3 of Radial Select option corresponding to desired Head 0 selection.

d. Place a second jumper assembly in positions 0, 1, 2 or 3 of Side Select option for Head 1 selection





Note

This option can not be installed with the Binary Select option. Since only four positions are available, a maximum of two drives may be daisy-chained when using this option.

Alternatively, the $\overline{\text{STEP IN}}$ line may be used to multiplex Side Select information.

To install this option:

a. Remove the wire jumper between the horizontal 13 pads.

b. Install a wire jumper between the vertical 11 pads.