# MODEL GSI-110

# FLEXIBLE DISK DRIVE

Technical Manual
Volume I

INTRODUCTION

OPERATION

THEORY OF OPERATION

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# FLEXIBLE DISK DRIVE

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## INTRODUCTION

### GENERAL

This manual provides information on the description, capabilities, operation, and theory of operation information of the Model GSI-110 Flexible Disk Drive (Figure 1-1), designed and manufactured by General Systems International of Anaheim, California.

### SCOPE

The contents of this manual are intended to be used for customer introduction to the GSI-110 disk drive, and as a training document for customer engineers requiring detailed theory of operation information. Installation and maintenance information are provided in Volume 2.

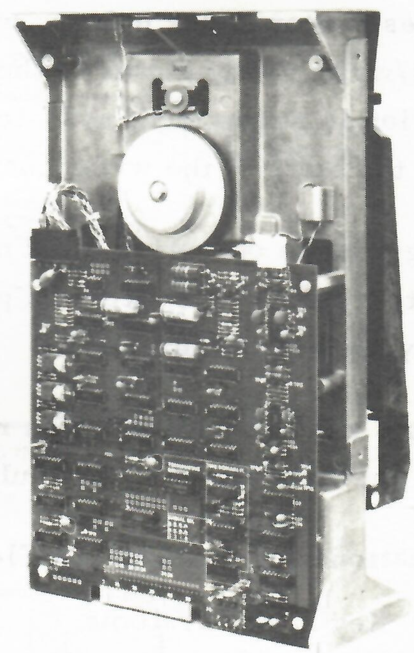

Figure 1-1. Model GSI-110 Flexible Disk Drive

### DESCRIPTION

The GSI-110 is a low-cost, random access storage device, which uses a flexible disk as the storage medium. The single, removable disk cartridge will store up to 6.4 megabits of double-density unformatted data, 3.2 megabits of single-density data (optional), or 1.94 megabits using the compatible IBM 3740 data format. The disk drive is also compatible with the IBM System 32 format.

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 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 hole in the protective envelope is uncovered, the write-protected condition is sensed photoelectrically, and write operations are inhibited.

Up to eight GSI-110 units can be interfaced to a single host controller. The controller controls disk drive selection, head loading, track addressing, and read/write data transfers.

When a disk cartridge is inserted and the access door is closed, the spindle drive motor is energized to rotate the disk at 360 revolutions per minute. After a brief start-up period the disk drive is ready to accept commands.

When selected, the drive accepts a head load command, causing the read/write head to be loaded to the disk. With the drive selected and the head loaded, the drive supplies sector/index pulses, write-protect status, track 00 position status, and a read/write ready status 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 read/write head.

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

Applications for the GSI-110 Flexible 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 GSI-110 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.

Because of the small size and weight, installation can be accomplished in almost any convenient location or orientation. The disk drive can be provided with or without an enclosure.

DISK CARTRIDGE

The disk cartridge is an 8-inch-square plastic protective envelope, in which the flexible 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).

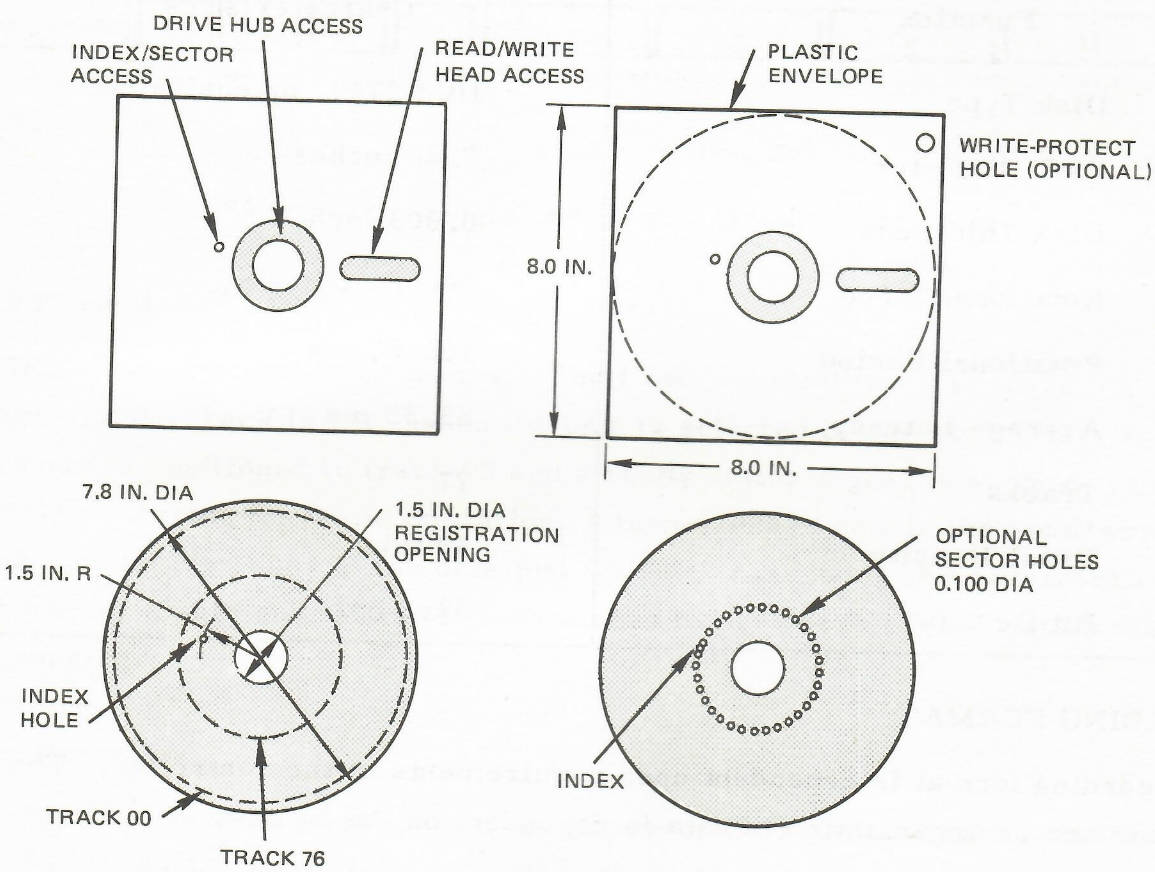


Figure 1-2. Flexible Disk and Protective Envelope

The recording media is a magnetic-oxide-coated, 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. 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, flexible 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 flexible disk is the IBM 3740 Diskette, or GSI-approved equivalent. The flexible disk characteristics are listed in Table 1-1.

Table 1-1. Flexible Disk Characteristics

| Function | Characteristics |
|---|---|
| Disk Type | IBM 3740, or equivalent |
| Disk Diameter | 7.88 inches |
| Disk Thickness | 0.003 inch |
| Rotational Speed | 360 rpm |
| Rotational Period | 166.67 ms |
| Average Latency | 83.33 ms |
| Tracks | 77 |
| Track Density | 48 tpi |
| Bit Density | 3268 bpi |

## 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 GSI-110 provides double-density (standard) and single-density (optional) 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).

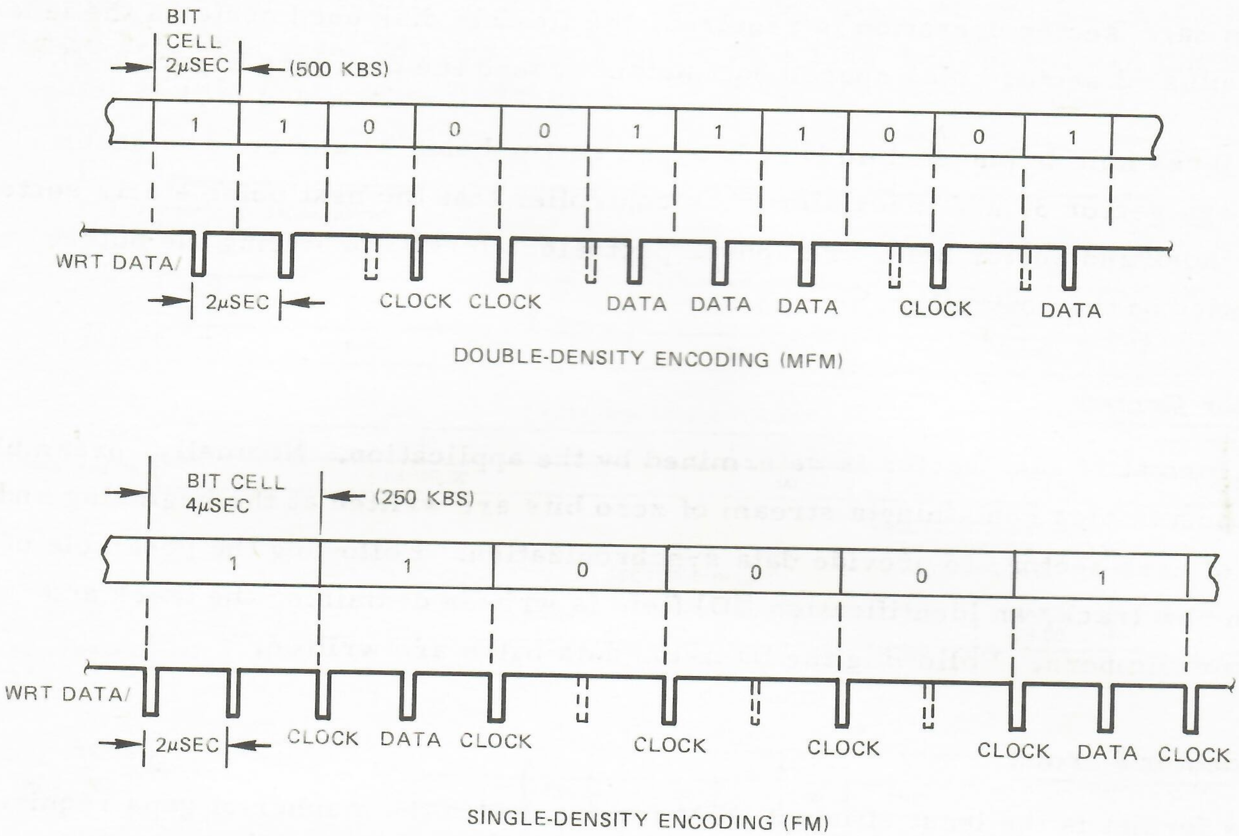


Figure 1-3. Single and Double Density Encoding

Track Format

The flexible disk contains 77 tracks. The first (outside) track is track 00, and the last (inside) track is 76. When the unit is selected by the controller, the read/write head is positioned to track 00 and a ready status signal is supplied to the controller. During the write operation, a tunnel-erase coil in the read/write head erases the outside edges of the data just written, narrowing the data track. In this manner, a safe guard band is established to protect the data from crosstalk, when sensing.

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 flexible disk is being used.

When soft sector operation is required, only an index hole is punched in the flexible disk. With this disk, the controller uses the index pulse to define the sectors.

When hard sector operation is required, the flexible 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 zero bits 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 the least efficient OEM format due to the number of gaps required between data records. The IBM 3740 formats require more gaps but are accepted as the most compatible. A typical 32-sector format is shown in Figure 1-4.

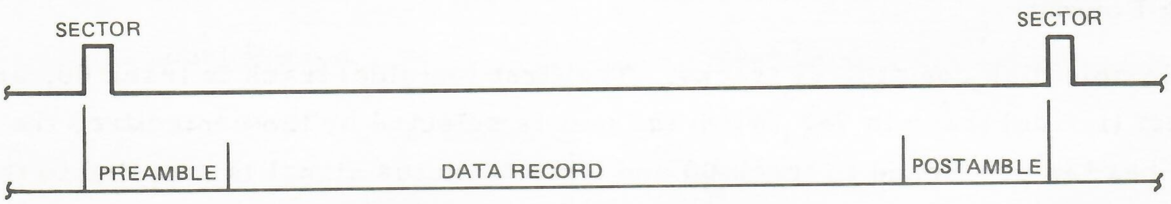


Figure 1-4. 32-Sector Format

## IBM 3740 Format

There are two IBM 3740 formats; Data Set Label and Track. The GS-110 is compatible to both formats.

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 other on-line disk drives. In the GSI-110, 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.

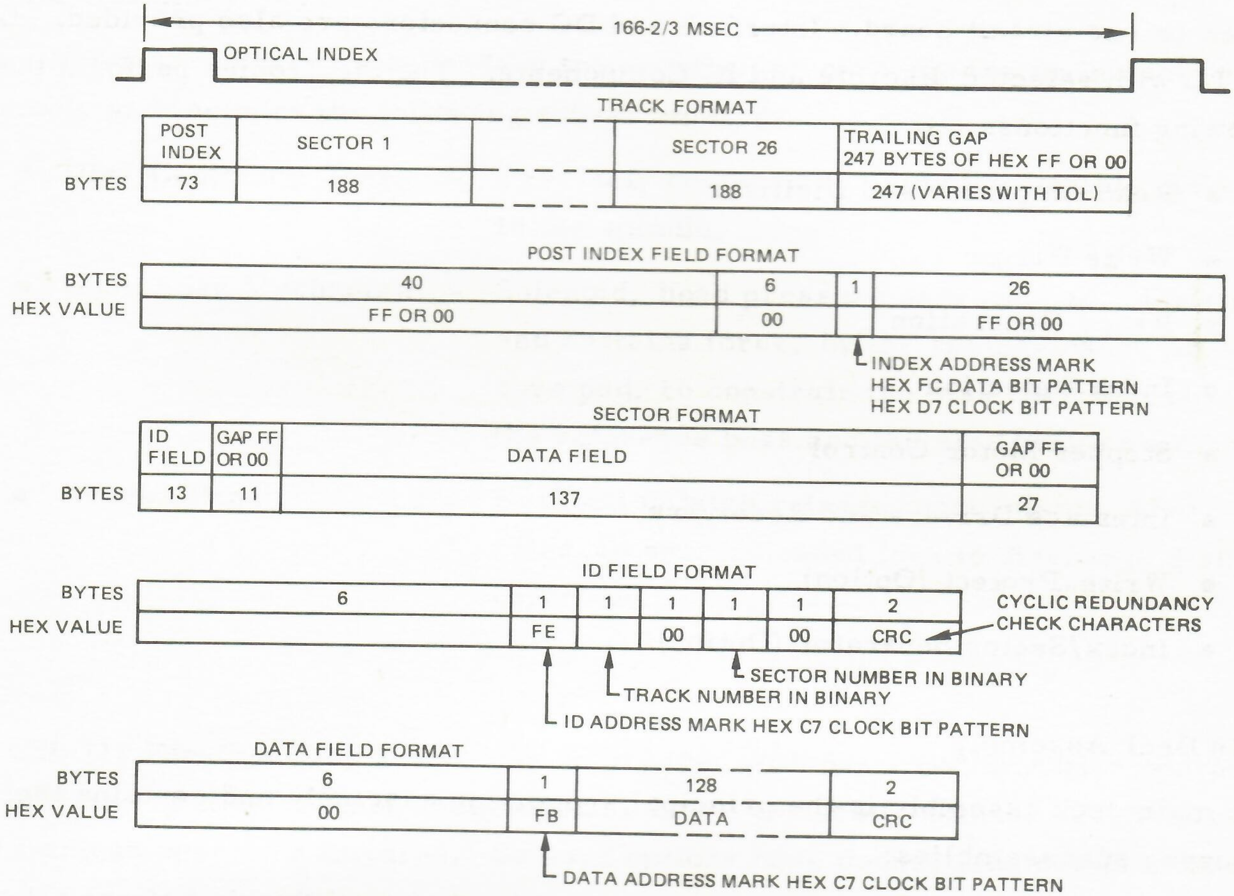


Figure 1-5. IBM 3740 Format

## DISK DRIVE ASSEMBLY

The disk drive assembly can be supplied with or without the cabinet enclosure. Without the encloser, the assemblies can be installed in a standard 19-inch RETMA rack; two horizontally, or four vertically. The drive can also be mounted in a table-top for top loading applications. For detailed information, refer to Volume 2.

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 head and head positioning information is contained on one circuit board. Interface and DC connectors are also provided. Logic is TTL with selected discrete and IC Components. The electronics perform the following functions:

- Read Amplifier and Digitizer
- Write Driver
- Ready Generation
- Index Detection
- Stepper Motor Control
- Interface Drivers and Receivers
- Write-Protect (Option)
- Index/Sector Separator (Option)

### 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 carriage, head pressure arm and pressure pad to accurately drive and position the read/write head to the desired track.
- Read/Write System - Single-gap magnetic recording head with tunnel-erase feature. Read/write head is 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 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 flexible disk to the spindle.
- Head Load Mechanism - Solenoid, head pressure arm and pad. Exerts and sustains force, by the spring-loaded pressure pad, to constrain the disk cartridge to the reference boss and the read/write head.
- Access Handle - Pushbutton latch release mechanism. Also releases spring-loaded lock to discharge disk cartridge.

## OPTIONS

The GSI-110 Flexible Disk Drive may be ordered with basic configuration operating capabilities, or may 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

The write-protect option provides a write-inhibit function when a write-protect flexible disk cartridge is used and the photosensing circuit is installed. The stored data is protected only if the cartridge write-protect hole is open. With the hole covered, all write functions are enabled.

### Binary Select

In the basic configuration four SELECT lines are provided, permitting selection of any one of up to eight disk drives by the controller; one binary code assigned to each disk drive.

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

| SELECT 1/ | SELECT 2/ | SELECT 3/ | DRIVE SELECTED |
|---|---|---|---|
| 1 | 1 | 1 | 0 |
| 0 | 1 | 1 | 1 |
| 1 | 0 | 1 | 2 |
| 0 | 1 | 1 | 3 |
| 1 | 1 | 0 | 4 |
| 0 | 1 | 0 | 5 |
| 1 | 0 | 0 | 6 |
| 0 | 0 | 0 | 7 |

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 radial signals are affected:

- STEP/ and STEP IN/ (Step Command)
- HDLD/ (Head Load Command)
- READY/ (Ready Status)
- INDEX/ and 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 cutting the etched circuitry between the existing etch pads, then connecting a jumper between the desired 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 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 INDEX/ and 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 SECTOR/ output line to the controller.

### Auto Erase

In the basic configuration, the controller activates an ERASE/ line, during a write operation, to start the tunnel erase function. The ERASE/ line is activated 200 microseconds after the WRITE/ line is activated, at the start of every write operation. At the completion of the write operation, the ERASE/ line is deactivated 530 microseconds after the WRITE/ line is deactivated.

When the Auto Erase option is installed, the ERASE/ line is no longer required. The erase turn-on and turn-off delays are internally controlled by the Auto Erase logic. When the controller activates WRITE/, the leading edge of WRITE/ initiates a 200 microsecond erase turn-on delay; the trailing edge of WRITE/ initiates a 530 microsecond erase turn-off delay.

### Data Separator

In the basic configuration, the RAW DATA/ line to the controller produces a pulse for each flux reversal read from the disk. Consequently, the 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 only. When installed, this option separates the data and clock pulses input over the RAW DATA/ line. Data pulses are supplied to the controller over a SEP DATA/ line, and synchronized clock pulses over a SEP CLK/ line.

### -5V Regulator

In the basic configuration, the controller must provide -5 volts, ±5 percent at 0.008 amperes to each disk drive. When this exact voltage is not able to be supplied by the controller, the -5V Regulator option permits operation with a negative voltage input within the range of -7 to -16 volts.

### Auto Load

In the basic configuration, the controller issues a HDLD/ command after the unit has been selected. When the AUTO LOAD option is installed, the read/write head is automatically loaded when the unit is selected, and is automatically unloaded when the unit is deselected.

Etch pads are provided that permit elimination of the requirement for the HDLD/ command; by cutting the existing etch and adding a jumper between the desired etch pads.

### Activity Indicator

In the basic configuration, the activity indicator is on when the head is loaded. The Activity Indicator option provides a means of substituting the HDLD/ status signal for one of the following status signals:

- IN USE/ (signal from controller)
- SELECT/
- RDY/

Etch pads are provided on the main printed circuit board.

### Time Domain Filter

In the basic configuration, the RAW DATA output from the crossover detector in the read logic, may contain zero crossings caused by high resolution interface noise. The time domain filter accepts the RAW DATA, compares the clock and data pulses and outputs a positive pulse for each time crossover.

## PCB Assembly Option Configurations

The main printed circuit board can be supplied in any one of 64 option configurations, as listed in Table 1-2.

Table 1-2. PCB Assembly Option Configurations

| Assembly No. | Time Domain Filter | -5V Reg. | Auto Erase | Hard Sector 32, 16, 8 | Data Sep | Binary Sel |
|---|---|---|---|---|---|---|
| 001 | | | | | | |
| 002 | X | | | | | |
| 003 | | X | | | | |
| 004 | X | X | | | | |
| 005 | | | X | | | |
| 006 | X | | X | | | |
| 007 | | X | X | | | |
| 008 | X | X | X | | | |
| 009 | | | | X | | |
| 010 | X | | | X | | |
| 011 | | X | | X | | |
| 012 | X | X | | X | | |
| 013 | | | X | X | | |
| 014 | X | | X | X | | |
| 015 | | X | X | X | | |
| 016 | X | X | X | X | | |
| 017 | | | | | X | |
| 018 | X | | | | X | |
| 019 | | X | | | X | |
| 020 | X | X | | | X | |
| 021 | | | X | | X | |
| 022 | X | | X | | X | |
| 023 | | X | X | | X | |
| 024 | X | X | X | | X | |
| 025 | | | | X | X | |
| 026 | X | | | X | X | |

Table 1-2. PCB Assembly Option Configurations (Continued)

| Assembly No. | Time Domain Filter | -5V Reg. | Auto Erase | Hard Sector 32, 16, 8 | Data Sep | Binary Sel |
|---|---|---|---|---|---|---|
| 027 | | X | | X | X | |
| 028 | X | X | | X | X | |
| 029 | | | X | X | X | |
| 030 | X | | X | X | X | |
| 031 | | X | X | X | X | |
| 032 | X | X | X | X | X | |
| 033 | | | | | | X |
| 034 | X | | | | | X |
| 035 | | X | | | | X |
| 036 | X | X | | | | X |
| 037 | | | X | | | X |
| 038 | X | | X | | | X |
| 039 | | X | X | | | X |
| 040 | X | X | X | | | X |
| 041 | | | | X | | X |
| 042 | X | | | X | | X |
| 043 | | X | | X | | X |
| 044 | X | X | | X | | X |
| 045 | | | X | X | | X |
| 046 | X | | X | X | | X |
| 047 | | X | X | X | | X |
| 048 | X | X | X | X | | X |
| 049 | | | | | X | X |
| 050 | X | | | | X | X |
| 051 | | X | | | X | X |
| 052 | X | X | | | X | X |
| 053 | | | X | | X | X |
| 054 | X | | X | | X | X |
| 055 | | X | X | | X | X |
| 056 | X | X | X | | X | X |
| 057 | | | | X | X | X |

Figure 1-2. PCB Assembly Option Configurations (Continued)

| Assembly No. | Time Domain Filter | -5V Reg. | Auto Erase | Hard Sector 32, 16, 8 | Data Sep | Binary Sel |
|---|---|---|---|---|---|---|
| 058 | X | | | X | X | X |
| 059 | | X | | X | X | X |
| 060 | X | X | | X | X | X |
| 061 | | | X | X | X | X |
| 062 | X | | X | X | X | X |
| 063 | | X | X | X | X | X |
| 064 | X | X | X | X | X | X |

## SPECIFICATIONS

A comprehensive list of principal specifications are provided in Table 1-3. The list defines both single-density and double-density characteristics, both disk drive and interface logic levels, and all physical and electrical parameters.

Table 1-3. Principal Specifications

| Function | Characteristics | |
|---|---|---|
| | Single-Density | Double-Density |
| Disk Type | IBM 3740, or equiv. | IBM 3740, or equiv. |
| Storage Capacity (Unformatted) | | |
| Per Disk | 3.2 megabits | 6.4 megabits |
| Per Track | 41.7 kilobits | 83.4 kilobits |
| Tracks | 77 | 77 |
| Track Density | — | 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 or $M^2$ FM |
| Rotational Speed | 360 rpm ±2.5% | 360 rpm ±2.5% |
| Rotational Latency | | |
| Average | — | 83.33 milliseconds |
| Maximum | — | 171.0 milliseconds |

Table 1-3. Principal Specifications (Continued)

| Function | Characteristics | |
|---|---|---|
| | Single-Density | Double-Density |
| Access Time | | |
| Track-to-Track | — | 6 milliseconds |
| Track 0 - Track 76 | — | 456 milliseconds |
| 38-Track Move | — | 222 milliseconds |
| Settling Time | — | 14 milliseconds |
| Head Engage Time | | 25 milliseconds |
| Data Transfer Rate | 250 kilobits/sec | 500 kilobits/sec |
| Write Recovery Time | — | 50 microseconds (reqd for read to stabilize after write completed) |
| Read/Write Head | Single-gap with tunnel-erase | |
| Read/Write-to-Erase Gap Spacing | 0.035 inch | |
| Track Width | 0.012 inch | |
| Tunnel Erase Width | 0.006 inch (on either side of track) | |
| Spacing Between Tracks | 0.02083 inch | |
| Track Centerline Radius | $2.029 + \frac{76 - N}{48}$, where N = track number (0 to 76) | |
| Logic Levels | | |
| Disk Drive | Logical 1 (True) = +2.5V to +5.5V<br>Logical 0 (False) = 0.0V to +0.4V | |
| Interface | Logical 1 (True) = 0.0V to +0.4V<br>Logical 0 (False) = +2.5V to +5.5V | |
| AC Input Power | | |
| Standard | 100 to 123 volts, 60 Hz | |
| Optional | 100 to 123 volts, 50 Hz<br>200 to 230 volts, 60 Hz<br>200 to 230 volts, 50 Hz | |
| Voltage Dropout | 100%, 10 milliseconds | |

Table 1-3. Principal Specifications (Continued)

| Function | Characteristics | |
|---|---|---|
| AC Input Power (Continued) | | |
| Motor Current | | |
| Start | 1.0 ampere for 100 volts AC<br>0.6 amperes for 220 volts AC | |
| Run | 0.5 amperes for 110 volts AC<br>0.3 amperes for 220 volts AC | |
| DC Input Power | +24 volts ±10%, 1.6 amperes maximum<br>+ 5 volts ± 5%, 1.0 amperes maximum | |
| -Voltage | | |
| Standard | -5 volts ±5%, 0.08 amperes maximum | |
| Optional | -7 to -16 volts (with -5V Regulator option installed) | |
| Reliability | | |
| MTBF | 6000 hours | |
| MTTR | Less than 20 minutes | |
| Read Errors | | |
| Recoverable | Less than 1 in $10^9$ | |
| Non-recoverable (after 10 tries) | Less than 1 in $10^{12}$ | |
| Environmental | Operating | Non-Operating |
| Temperature | $50^\circ$ to $100^\circ F$<br>($10^\circ$ to $30^\circ C$) | $32^\circ$ to $150^\circ F$<br>($0^\circ$ to $65^\circ C$) |
| Relative Humidity | 10% to 80%, without condensation | 5% to 90%, without condensation |
| Altitude | -1000 to +10,000 ft | -1000 to +15,000 ft |
| Heat Dissipation | 300 BTU/hour | NA |
| Dimensions and Weights | | |
| Height | 4.33 inches (110 mm) | |
| Width | | |
| Enclosure | 8.66 inches (220 mm) | |
| Front Panel | 10.04 inches (255 mm) | |

Table 1-3. Principal Specifications (Continued)

| Function | Characteristics |
|---|---|
| Dimensions and Weights (Continued) | |
| Depth | |
| Enclosure | 14.19 inches (360 mm) |
| Front Panel | 1.32 inches (25.4 mm) |
| | 15.51 inches (61.4 mm) overall |
| Weight | |
| W/Enclosure | 16 pounds (7.2 kg) |
| W/o Enclosure | 11 pounds (4.9 kg) |

## TOOLS AND TEST EQUIPMENT

A list of recommended tools and test equipment is provided in Table 1-4.

Table 1-4. Recommended Tools and Test Equipment

| Required | Description |
|---|---|
| Exerciser | Model 100 Disk Drive Exerciser, P/N 215100 |
| Test Equipment | Oscilloscope<br>Voltohmmeter |
| Tools | Common hand tools<br>Penlight |
| Cleaning Material | Alcohol, 91% solution<br>Lint-free cloths |

## DISK DRIVE IDENTIFICATION

The GSI-110 Felxible Disk Drive is available in four different input voltage configurations. Each configuration operates from a specific input voltage and frequency and is listed in Table 1-5.

Table 1-5. Disk Drive P/N and Voltage

| Part Number | AC Input Voltage and Frequency |
|---|---|
| | 120V, 60 Hz (Standard)<br>120V, 50 Hz<br>220V, 60 Hz<br>220V, 50 Hz |

# SECTION 2

# OPERATION

## GENERAL

The GSI-110 Flexible Disk Drive operates under complete control of the host controller, after a flexible disk has been manually inserted. Only one front panel indicator is required for operating status.

## DAILY OPERATION

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

### Flexible Disk Handling and Storage

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

For external error-free operation 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 flexible disk to storage envelope when not in use

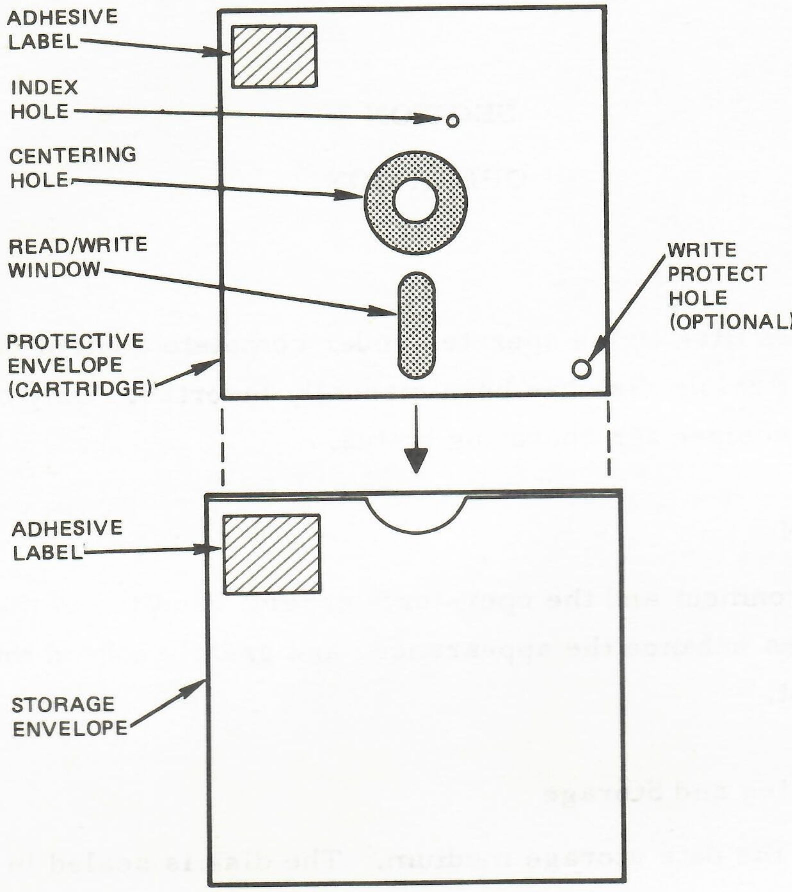


Figure 2-1. Flexible Disk and Storage Envelope

Flexible Disk Loading and Unloading

Correct loading of the flexible disk is essential for proper operation of the disk drive. Normally, only one side of the disk is initialized and used as the recording surface.

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

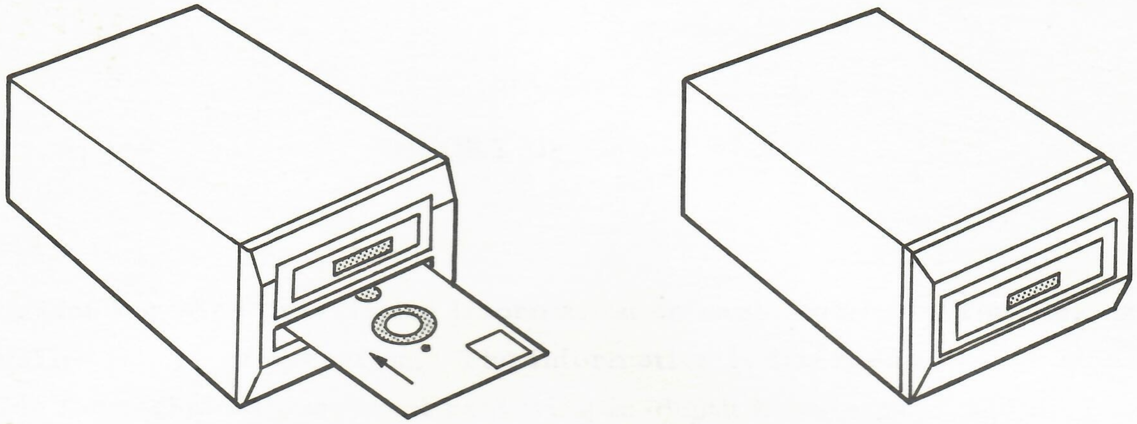


Figure 2-2. Flexible Disk Loading

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

Table 2-1. Flexible 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 flexible 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 (Option)

The write-protect option 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 hole punched in one corner, or the hole will be covered with an adhesive opaque tab. A read-only disk cartridge will have an open punched hole, 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

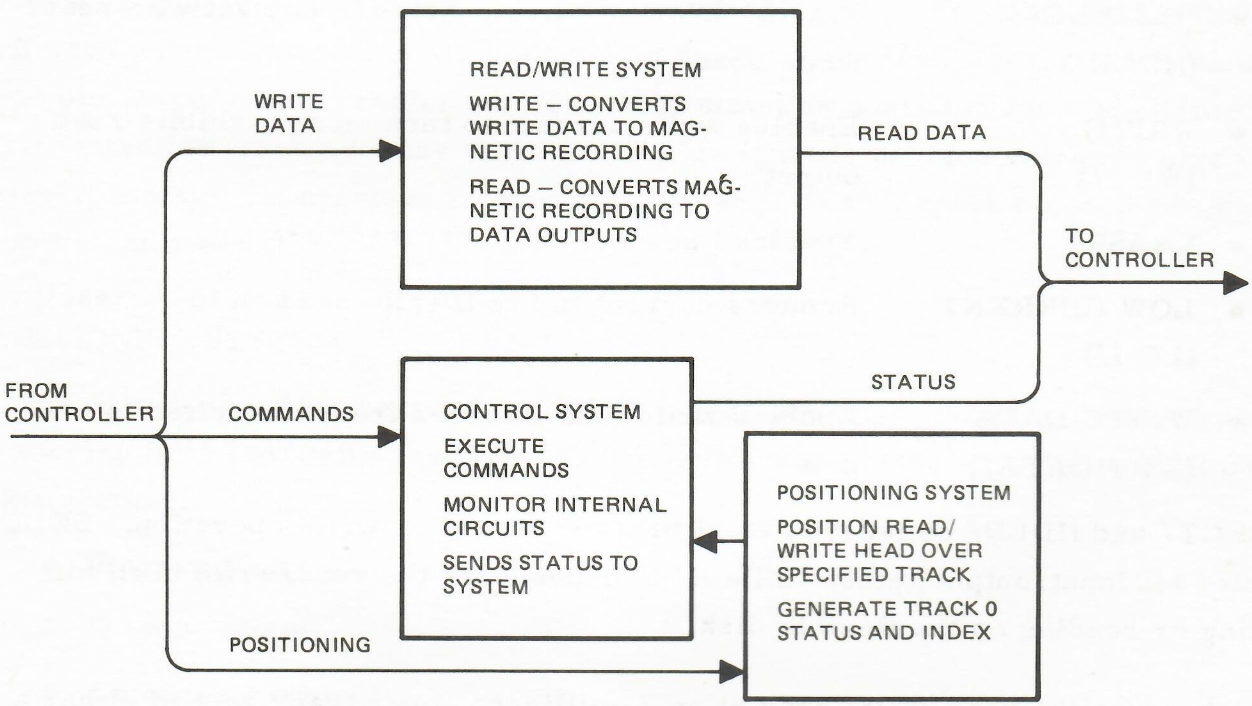


Figure 3-1. Model GS-110 Flexible Disk Drive, Simplified Block Diagram

## CONTROL SYSTEM

The control system provides the interface circuitry between the disk controller and the disk drive. The operational status is continuously 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:

| | |
|---|---|
| • SELECT/ | Places disk drive on-line with controller |
| • STEP/ | Enables read/write head positioning |
| • STEP IN/ | Determines read/write head direction |
| • HEAD LOAD (HDLD/) | Places disk recording surface in contact with read/write head |
| • WRITE (WRT/) | Enables write current to turn on and inhibits read output |
| • ERASE/ | Enables tunnel erase current to turn on |
| • LOW CURRENT (LO I/) | Reduces current in read/write head on in[illegible] track. |
| • WRITE DATA (WRT DATA/) | Enables write data transfer from controller to disk drive |

SELECT/ and HDLD/ commands must precede a read or write operation. SELECT/ enables all input/output gates, while HDLD/ positions the read/write head for writing or reading on the flexible disk.

STEP/ moves the read/write head at an 8-millisecond per track rate to either a higher or lower track position. 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

Five 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 sector disk used) |
| • READY/ | Signifies disk drive is operational |

READY/ and WRT PROTECT/ are static level status signals. Ready status indicates a flexible disk is loaded and up to operating speed. Write-protect status indicates write data cannot be recorded on the flexible disk. Index status occurs once per flexible disk revolution. Track 00 status is available for initializing the disk controller track address register. This signal is developed from a phototransistor 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 head 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 STEP pulses to a 2-bit count-up or count-down sequence. Each decode 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 of 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 rotor to the next detent. Sequentially grounding control windings causes the rotor shaft to rotate through detent positions at a maximum rate of 125 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 head, attached to the carriage assembly, contacts the recording surface when the HDLD/ command is issued. This command releases a spring-loaded head load arm that moves the flexible disk into contact with the read/write head.

## READ/WRITE SYSTEM

The read/write system records encoded data during a Write operation, and retrieves data during a Read operation. The write (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. The read/write head also contains a tunnel-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 0.012-inch by this technique, to minimize the 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.

Flexible Disk

The flexible disk cartridge is an 8.00 x 8.00 x 0.06 inches and is constructed so that the flexible disk (recording media) is free to rotate within the cartridge. The recording media is a mylar substrate with a metal-oxide coating. The disk cartridge is perforated with a large centering hole and a small index hole. The index hole is monitored by a phototransducer that detects leading edge for track-start status. An optional 32-hole disk may also be used.

The centering hole is engaged with the disk drive system and provides non-slippage rotational movement. Tracks are sequentially numbered from 00 through 76, starting with the outside track being identified as track 00.

## FUNCTIONAL DESCRIPTION

The disk drive is a mass memory device featuring a removable flexible 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 flexible 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.

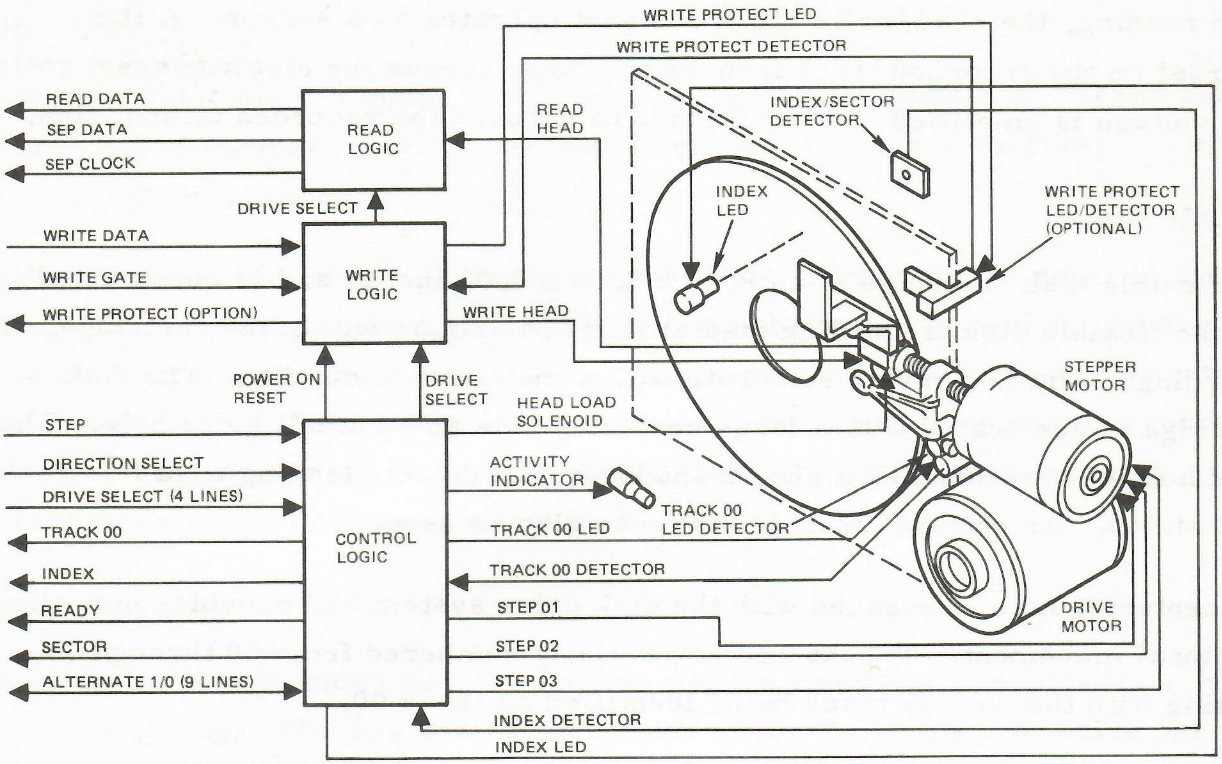


Figure 3-2. Detailed Functional Block Diagram

The disk drive comprises the following functional systems:

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

## 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 ranging between 100 and 220 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 and drive belt are selectable for either 50 or 60 Hz input power for rotational speed of 360 revolutions per minute. A flexible disk is engaged with the spindle drive hub by the spindle system centering cone.

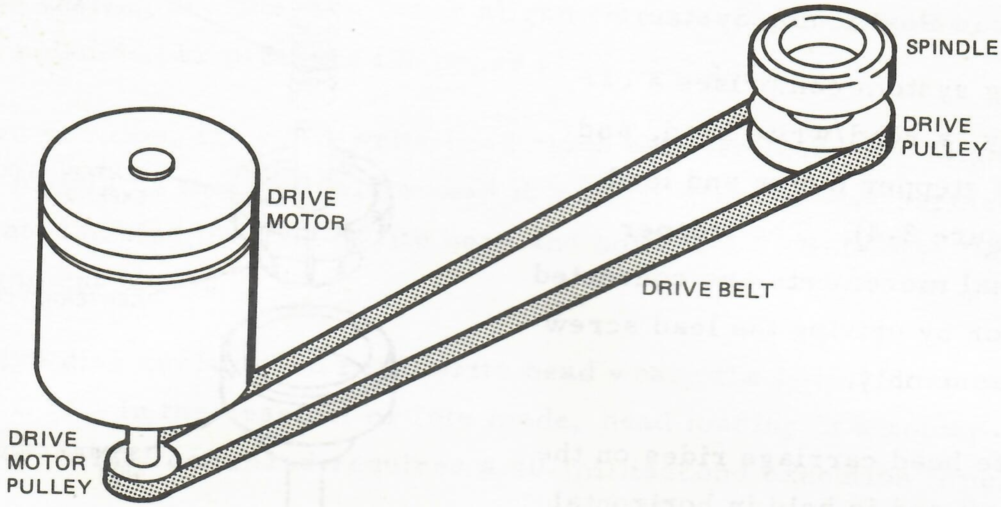


Figure 3-3. Spindle Drive System

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 aperature through which the flexible 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 flexible disk then closes the handle, which latches the carrier in the operating mode. The centering cone (see Figure 3-3) is attached to the carrier and is an open-splined nylon device that performs two functions:

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

As the carrier is pivoted to the load position, the centering cone enters the flexible 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 flexible disk to the spindle, thus centering the disk on the spindle.

Read/Write Head Positioning System

The positioning system comprises a carriage assembly, a read/write head, and a bidirectional stepper motor and lead screw (see Figure 3-4). The stepper motor rotational movements are converted to linear motion by driving the lead screw and carriage assembly.

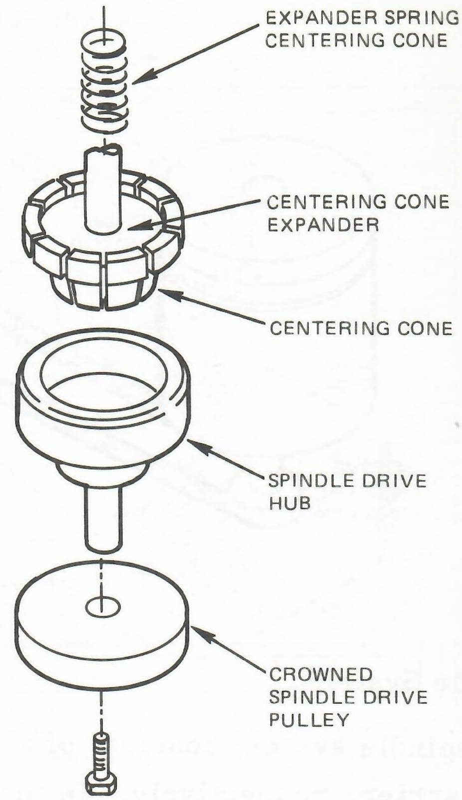

Figure 3-4. Spindle System

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.

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.

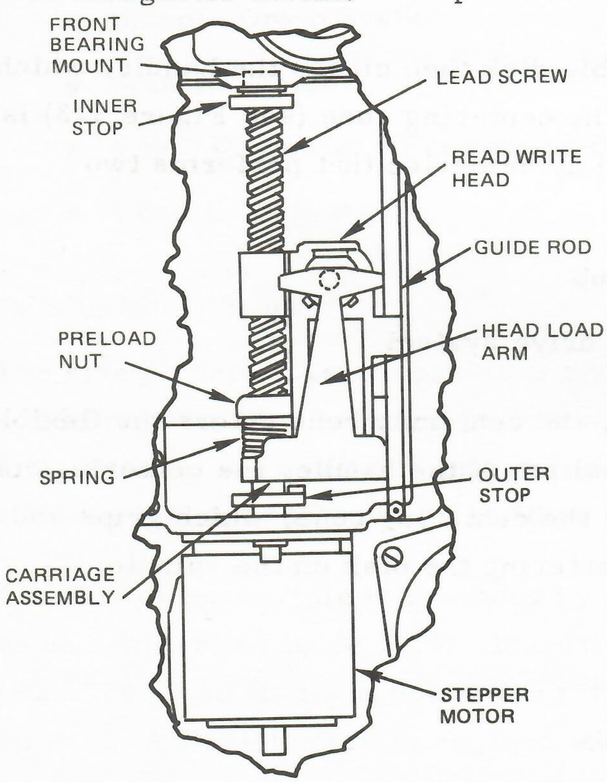

Figure 3-5. Read/Write Head Positioning System

Head Load System

The head load system is, basically, a solenoid driver and a solenoid. When activated by the HDLD/ command, the spring-loaded head load pad is released and rests in precise parallel alignment with the recording surface of the flexible disk.

Part of the casting provides the lower alignment surface for the disk, while the head load solenoid bar provides the upper alignment surface.

In the Load position, the read/write head rides between these two alignment surfaces and maintains the read/write head in contact with the disk surface. The load pad is located behind the read/write head and holds the flexible disk flat against the lower alignment block.

To minimize disk surface and read/write head wear, the HDLD/ command is gated with SELECT/. In the deselect or Idle mode, head loading is automatically disabled. The HDLD/ command requires a 40-millisecond execution time.

Operation Sequences

The sequence of operations performed by the disk drive are shown in flow diagrams, Figure 3-6 through Figure 3-11. Six operations are sequenced and defined, as follows:

- Select
- Ready
- Step
- Head Load
- Sector/Index
- Read/Write

<u>Select</u>

When the assigned unit SELECT/ line becomes active, the unit is selected by the controller, and the following actions occur (see Figure 3-6):

- If the Write-Protect hole in the disk is uncovered, the WRT PROTECT/ status signal is made active and sent to the controller.
- If the head is positioned at track 00, the TRACK 00/ status signal is made active, if a STEP operation is not in progress.
- If the activity indicator is monitoring SELECT/, the indicator is turned on.

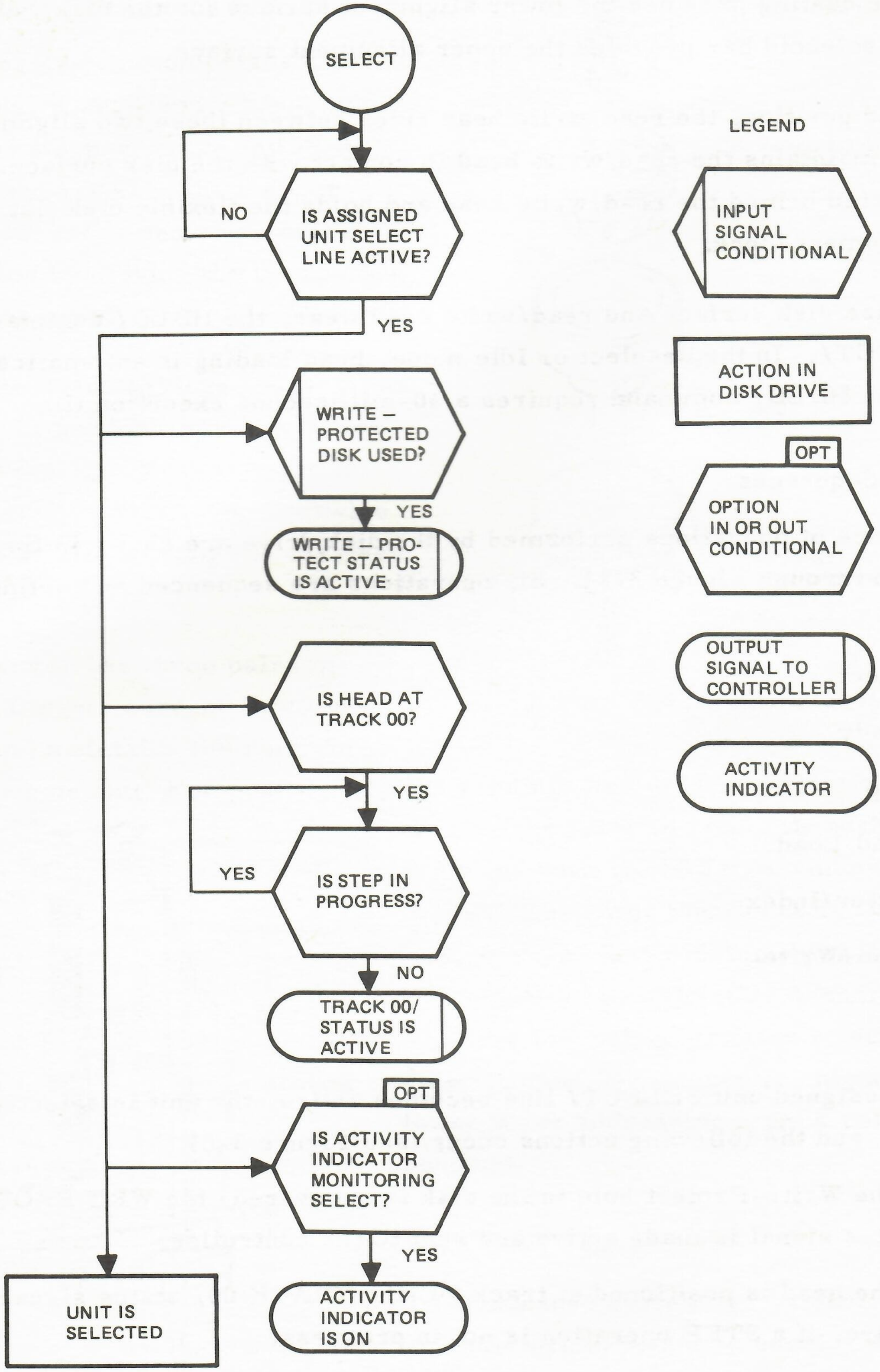


Figure 3-6. Select Sequence, Flow Diagram

### Ready

The Ready sequence (Figure 3-7) is performed when the disk initially begins rotating after power is applied by the controller, or after a disk is inserted and the access door is closed.

When the disk reaches nominal 360 revolution per minute operating speed, three consecutive revolutions at that speed must occur before the unit becomes "ready".

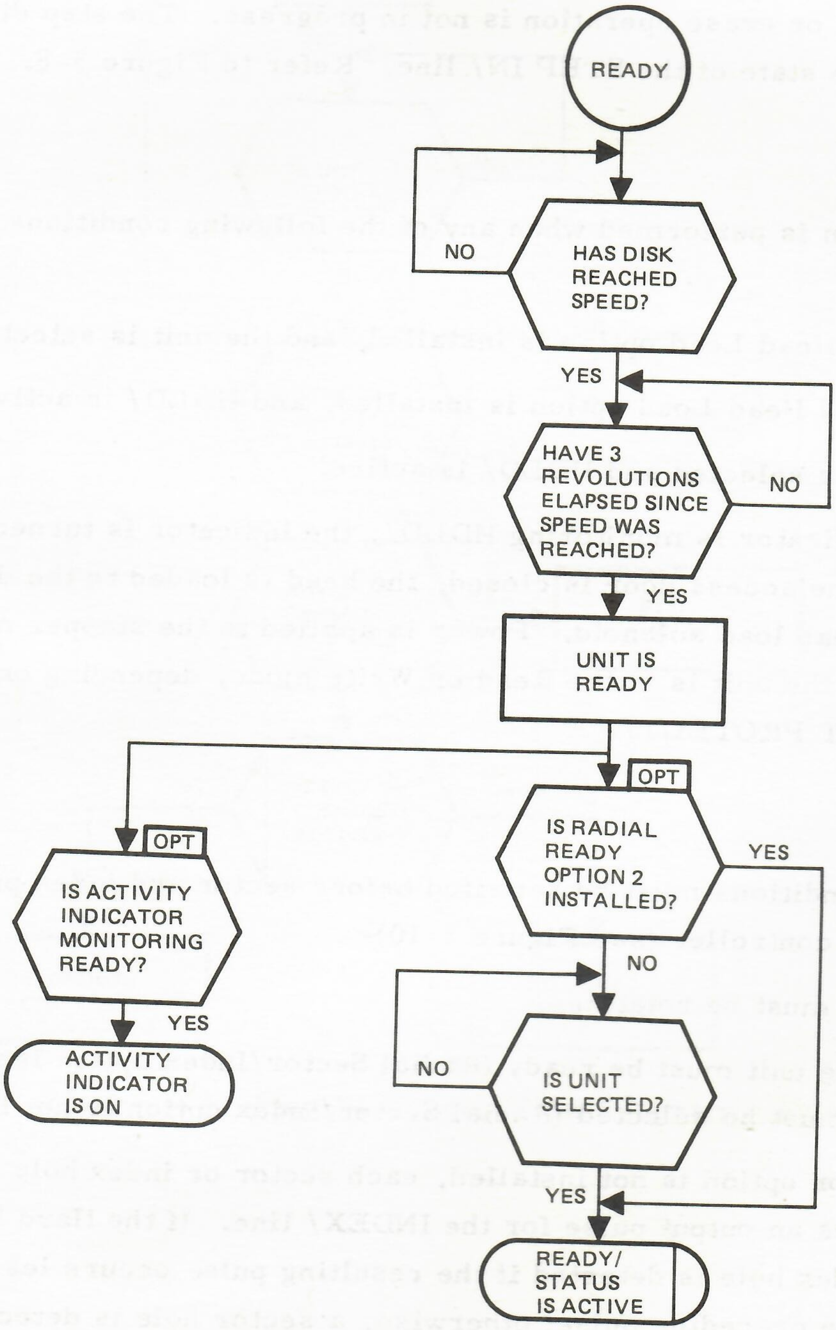


Figure 3-7. Ready Sequence, Flow Diagram

If the Radial Select option is installed, the READY/ status signal becomes active; otherwise, READY/ becomes active when the unit is selected. If the front-panel activity indicator is monitoring READY, the indicator is turned on.

### Step

If the Radial Step option is not installed, the unit must first be selected and ready. When the STEP/ command is active, a one-track step action is performed, provided that a write or erase operation is not in progress. The step direction is determined by the state of the STEP IN/ line. Refer to Figure 3-8.

### Head Load

A head load action is performed when any of the following conditions are satisfied (see Figure 3-9):

- The Auto Head Load option is installed, and the unit is selected
- The Radial Head Load option is installed, and HDLD/ is active.
- The unit is selected and HDLD/ is active.

If the activity indicator is monitoring HDLD/, the indicator is turned on. If a disk is inserted and the access door is closed, the head is loaded to the disk by HDLD/ energizing the head load solenoid. Power is applied to the stepper motor. If the unit is selected, the unit is in the Read or Write mode, depending on the state of WRITE/ and WRT PROTECT/.

### Sector/Index

The following conditions must be satisifed before sector and index pulses are supplied to the host controller (see Figure 3-10):

- The disk must be rotating
- Either the unit must be ready (Radial Sector/Index option installed), or the unit must be selected (Radial Sector/Index option is not installed).

If the Hard Sector option is not installed, each sector or index hole detected in the disk produces an output pulse for the INDEX/ line. If the Hard Sector option is installed, an index hole is detected if the resulting pulse occurs less than 4 milliseconds after the preceding pulse; otherwise, a sector hole is detected. When an index hole is detected, a pulse or voltage transition is produced on the SECTOR/

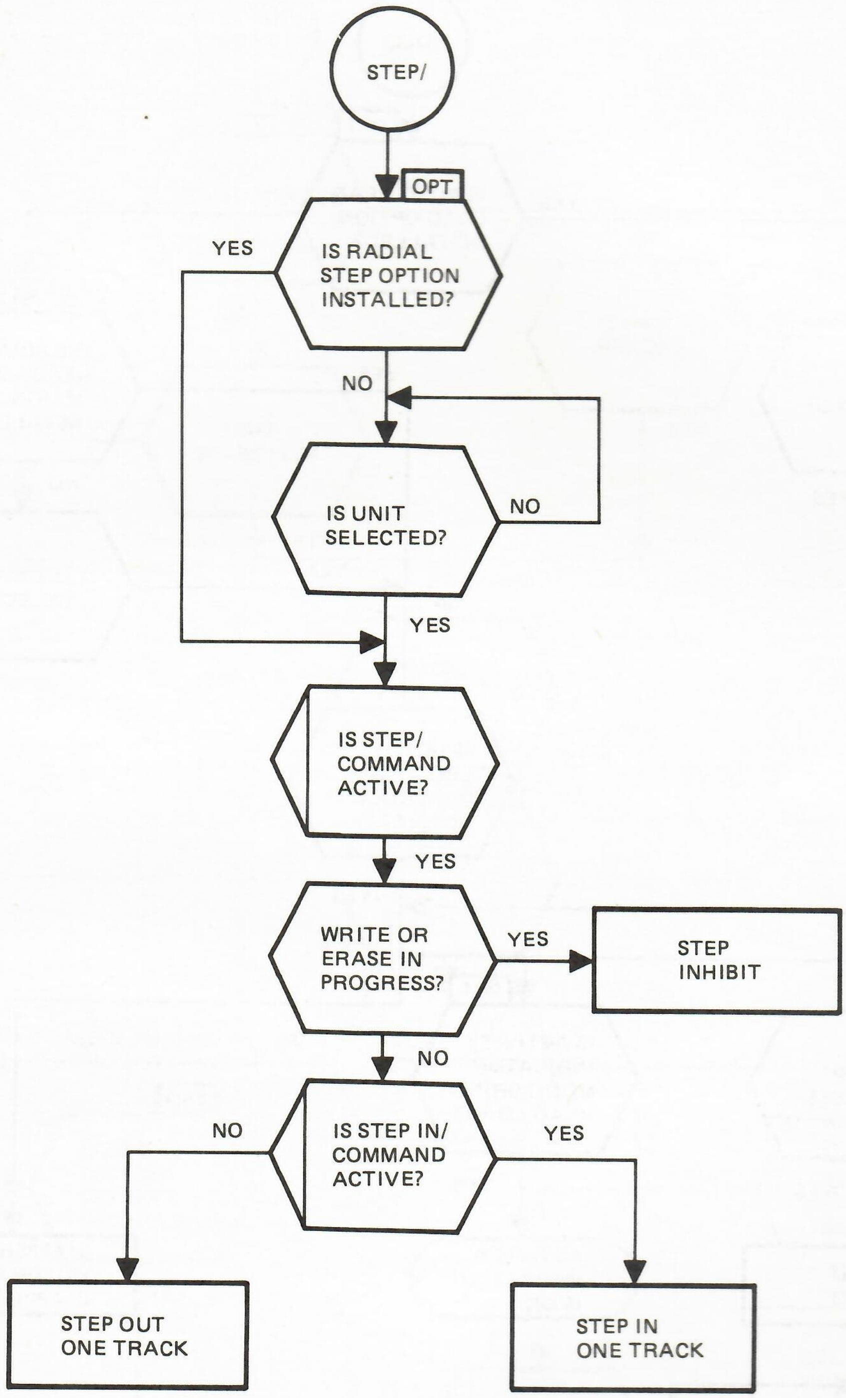


Figure 3-8. Step Sequence, Flow Diagram

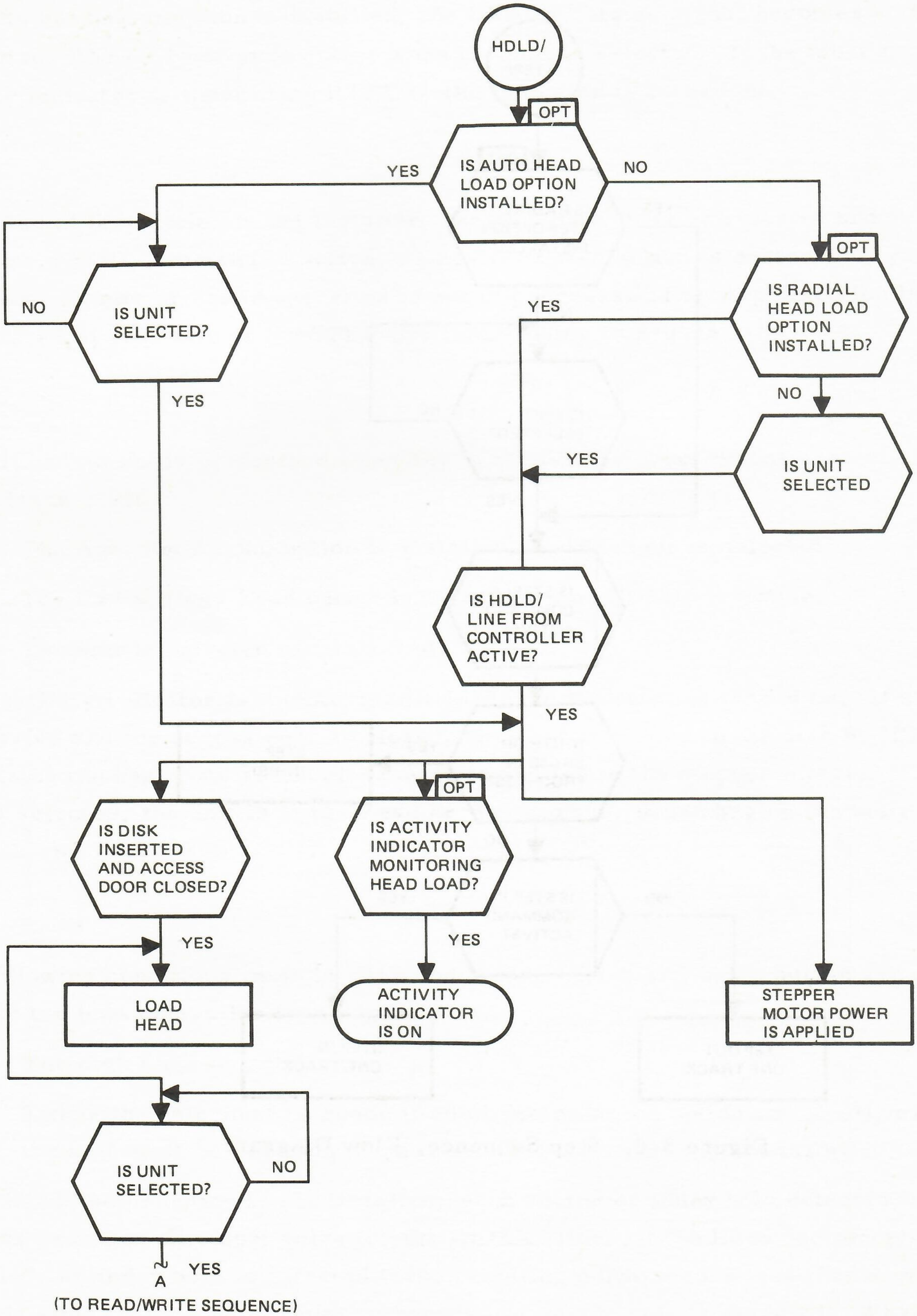


Figure 3-9. Head Load Sequence, Flow Diagram

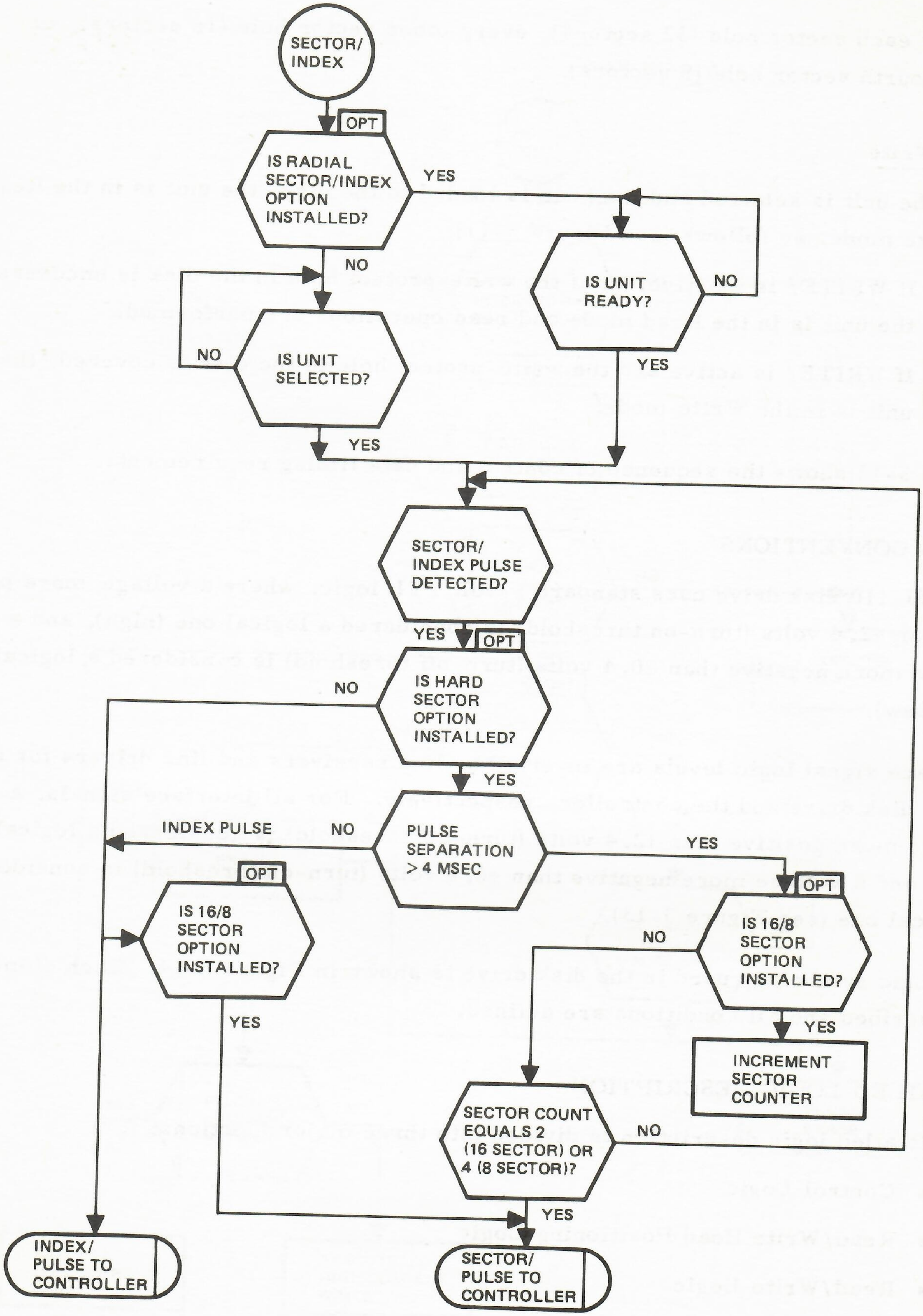


Figure 3-10. Sector/Index Sequence, Flow Diagram

line for each sector hole (32 sectors), every other sector hole (16 sectors), or every fourth sector hole (8 sectors).

### Read/Write

When the unit is selected and the head is loaded to the disk, the unit is in the Read or Write mode, as follows (see Figure 3-11):

- If WRITE/ is inactive, or if the write-protect hole in the disk is uncovered, the unit is in the Read mode and read operations are performed.
- If WRITE/ is active and the write-protect hole in the disk is covered, the unit is in the Write mode.

Figure 3-12 shows the sequence of control and data timing requirements.

## LOGIC CONVENTIONS

The GSI-110 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 3-13).

The logic symbology used in the disk drive is shown in Figure 3-14. 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

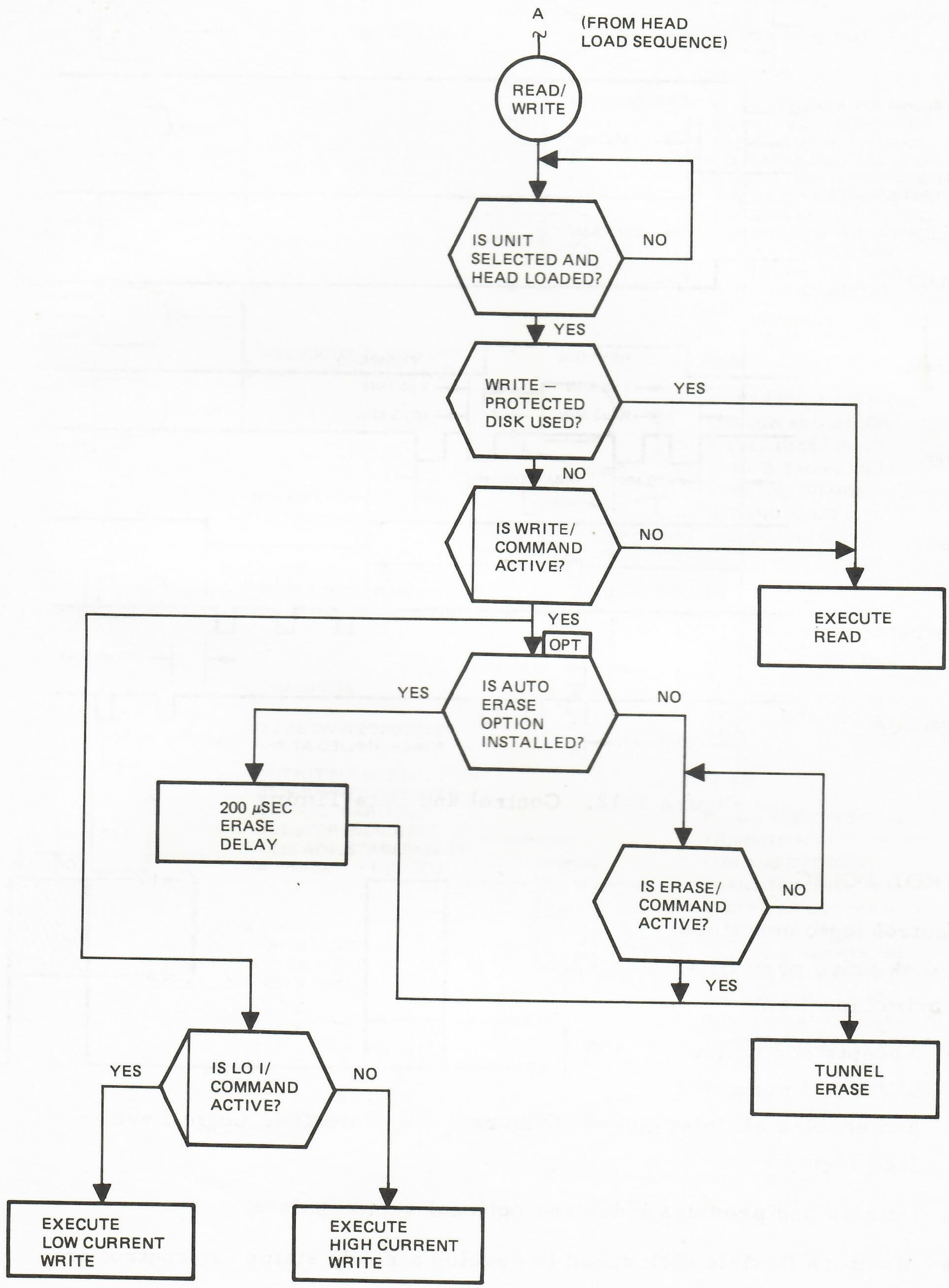


Figure 3-11. Read/Write Sequence, Flow Diagram

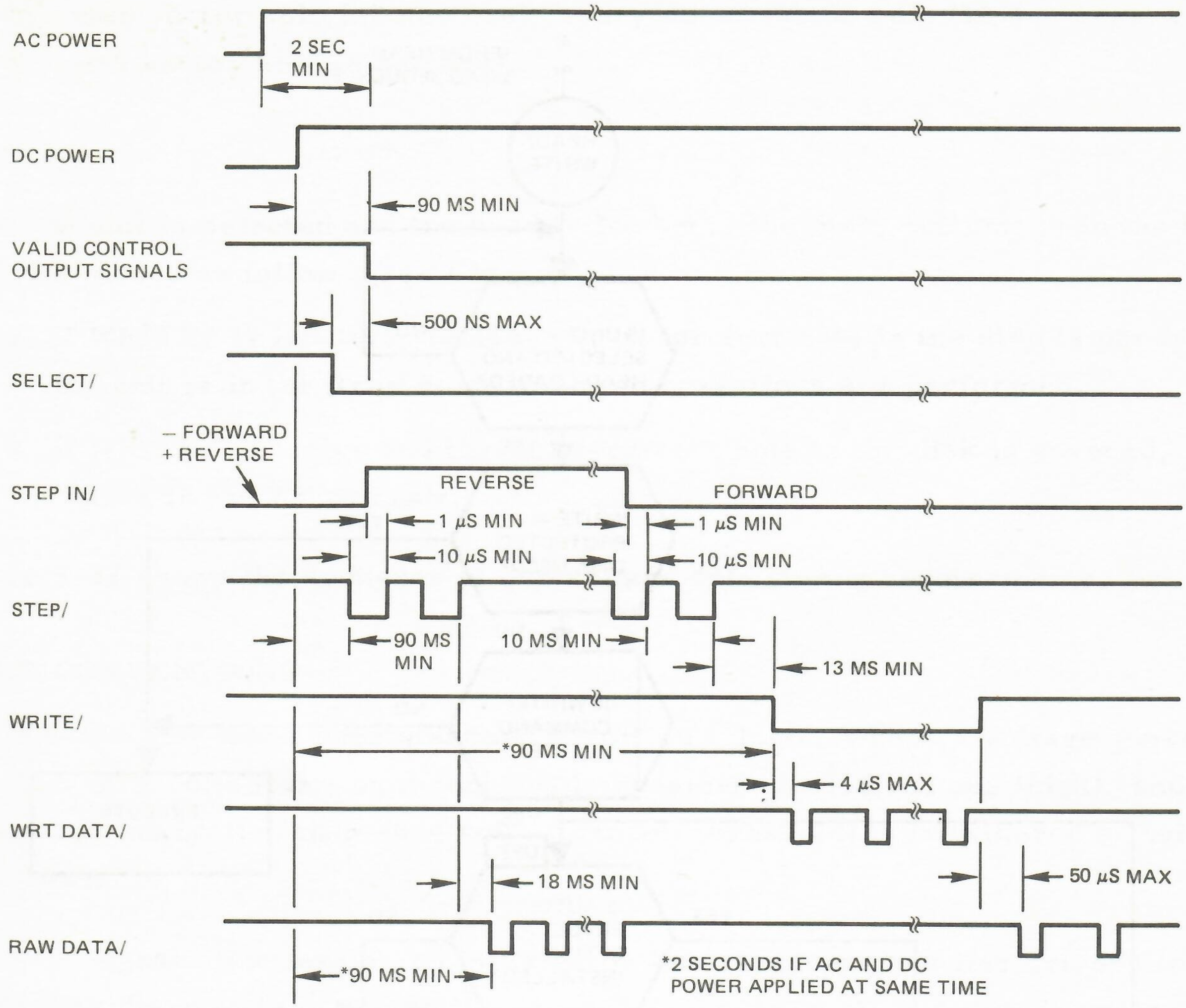


Figure 3-12. Control and Data Timing

## CONTROL LOGIC

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

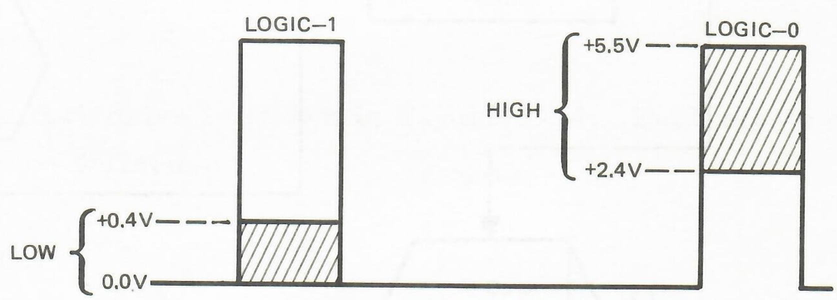


Figure 3-13. Interface Logic Levels

- Accepts controller SELECT/ command and enables all interface logic
- Detects and provides index and optional sector pulses
- Monitors flexible disk speed to develop a ready status for controller

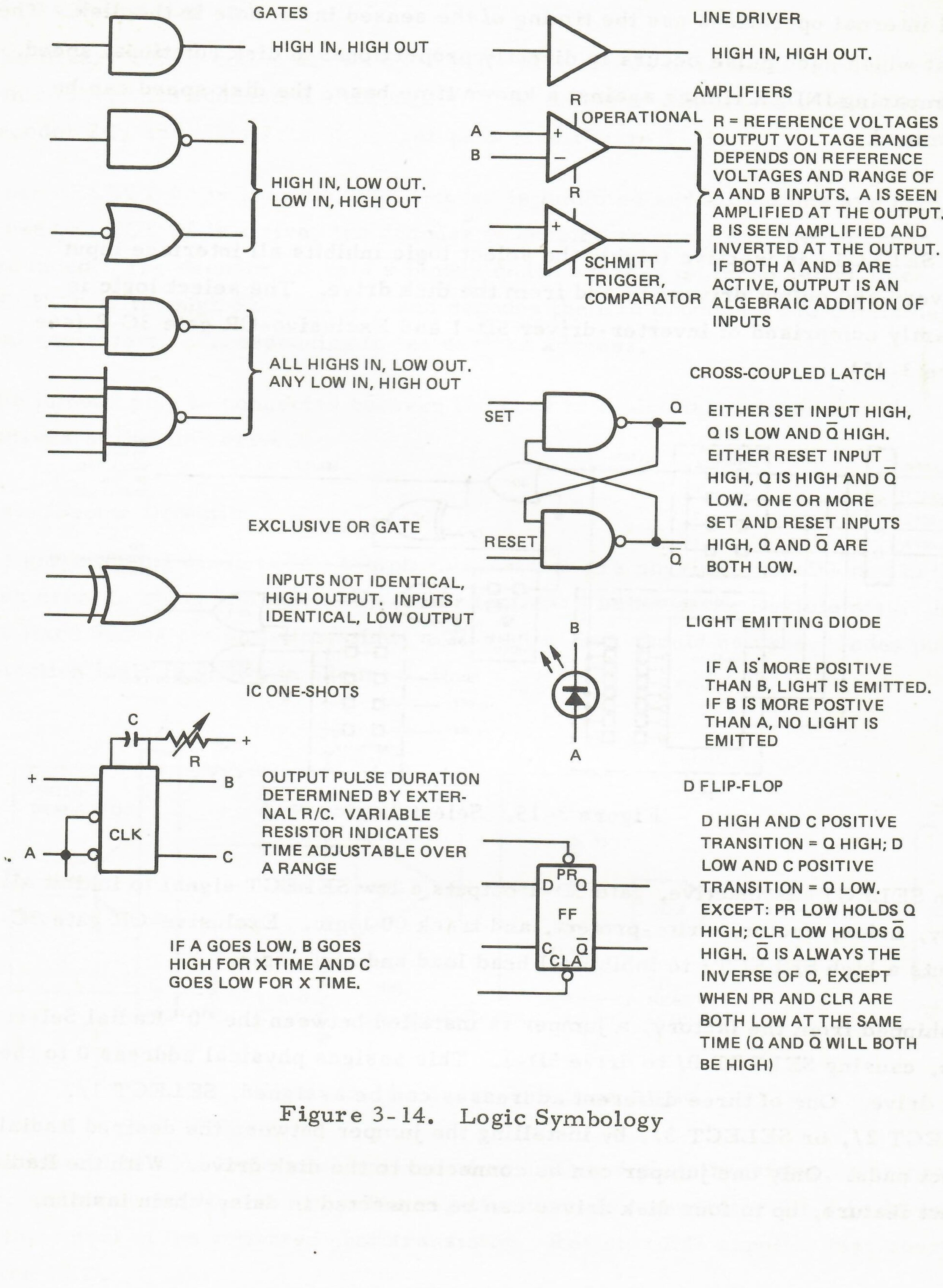


Figure 3-14. Logic Symbology

Initial internal operations use the timing of the sensed index hole in the disk. The time at which each pulse occurs is directly proportional to disk rotational speed. By comparing INDEX timing against a known time base, the disk speed can be determined.

### Select

When 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 inverter-driver 5D-1 and Exclusive-OR gate 3C-2 (see Figure 3-15).

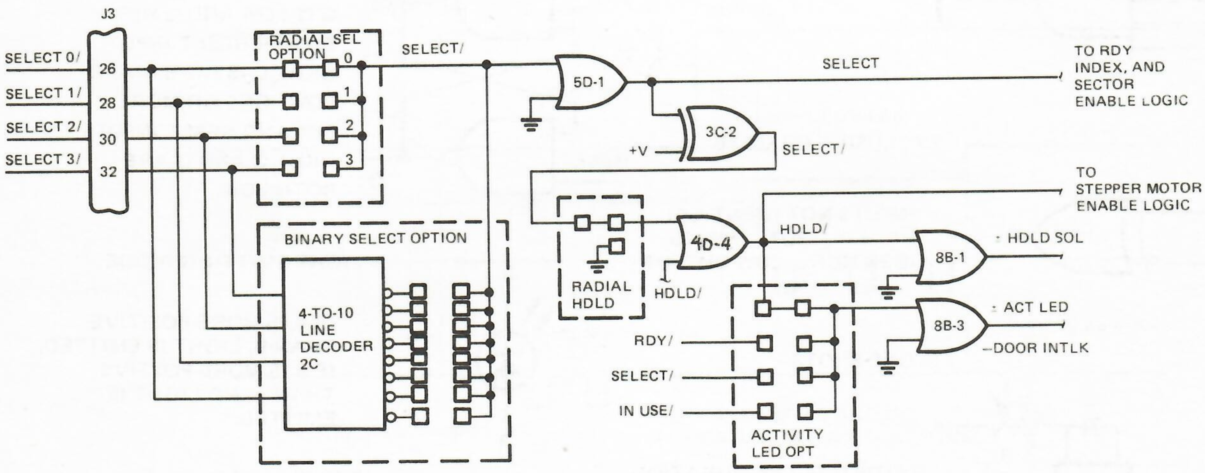


Figure 3-15. Select Logic

When SELECT/ is inactive, gate 5D-1 outputs a low SELECT signal to inhibit all ready, index, sector, write-protect, and track 00 logic. Exclusive-OR gate 3C-2 outputs a high SELECT/ to inhibit all head load and step logic.

As shipped from the factory, a jumper is installed between the "0" Radial Select pads, causing SELECT 0/ to drive 5D-1. This assigns physical address 0 to the disk drive. One of three different addresses can be assigned, SELECT 1/, SELECT 2/, or SELECT 3/, by installing the jumper 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.

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 2C, and eight sets of jumper pads (see Figure 3-15).

When SELECT 0/ is inactive, the decoder is inhibited and all outputs are high. When 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, SELECT 1/ through SELECT 3/, and decodes them to produce a low output decimal equivalent, corresponding to the desired address.

The jumper plug is connected between the pads to assign the independent physical address of the disk 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 flexible disk. If the Hard Sector option is installed, a 32-sector disk should be used. Index pulse detection logic is shown in Figure 3-16.

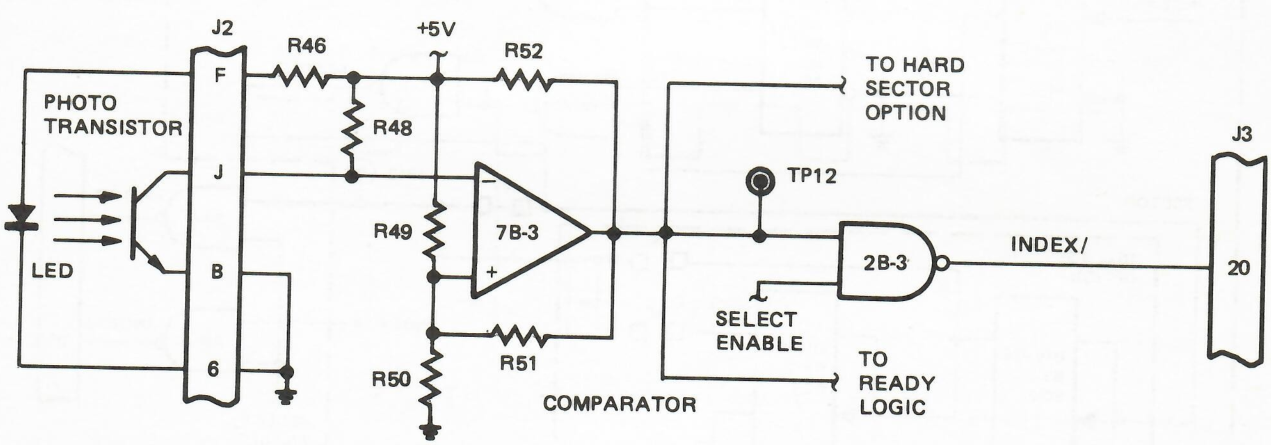


Figure 3-16. Index Detection Logic

The index detection logic is comprised of an LED and phototransistor, a comparator, and an output line driver. The negative input to comparator 7B-3 is driven by the output of the activated phototransistor. Resistor R46 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 R49, R50 and R51 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. The INDEX pulse is input to interface line driver 2B-3 and inverted to provide a low INDEX/ signal to the controller. Figure 3-17 shows index pulse timing.

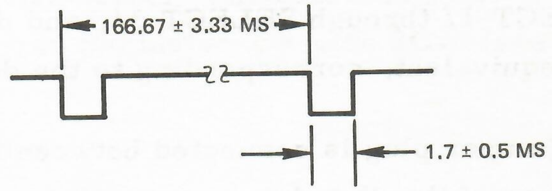


Figure 3-17. Index Timing

### Hard Sector (Option)

With the Hard Sector option installed, and by using a 32-sector flexible disk, the comparator provides 32 SECTOR pulses, equally spaced 5.24 milliseconds apart, during each disk revolution, plus an INDEX pulse that occurs half way between sector pulses 31 and 0. Refer to Figure 3-18.

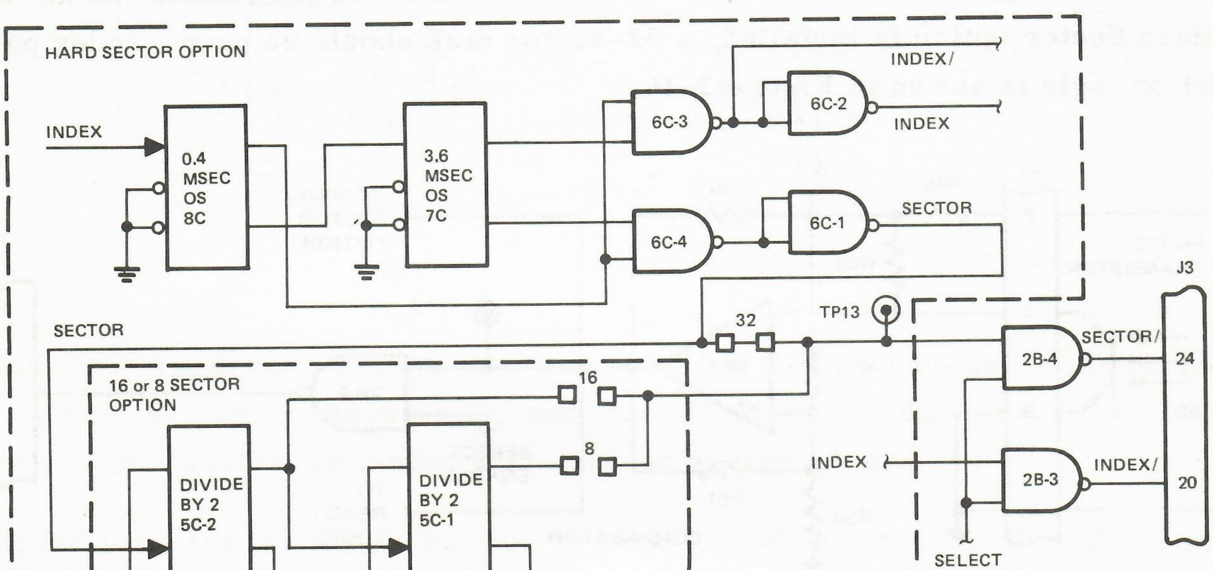


Figure 3-18. Hard Sector and 16/8 Sector Option Logic

The positive-going leading edge of the INDEX pulses from the comparator triggers one-shot 8C to produce a 0.4 millisecond pulse, and complement. The positive-going trailing edge of the complement (Q1), triggers one-shot 7C 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 7C can not be triggered.

The output of gate 6C-3 is INDEX/, which drives gate 6C-2 and resets flip-flop 5C-2 and 5C-1 of the 16 or 8 Sector divider logic. The INDEX output of gate 6C-2 is input to interface line driver 2B-3 and the Ready logic. Gate 6C-1 provides the SECTOR pulse input to interface line driver 2B-4 if the 32-sector jumper is installed.

The SECTOR output of gate 6C-1 also drives the clock input to the 16 or 8 Sector option, if it is installed. Divide-by-2 flip-flop 5C-2 produces 16 SECTOR pulses per disk revolution and, if the 16 sector jumper is installed, the pulses are sent to the controller by interface driver 2B-4. The outputs of 5C-2 also clock flip-flop 5C-1 to produce divide-by-8 SECTOR pulses to the controller, provided the jumper is installed between the 8 pads. Figure 3-19 shows INDEX/ and SECTOR/ timing.

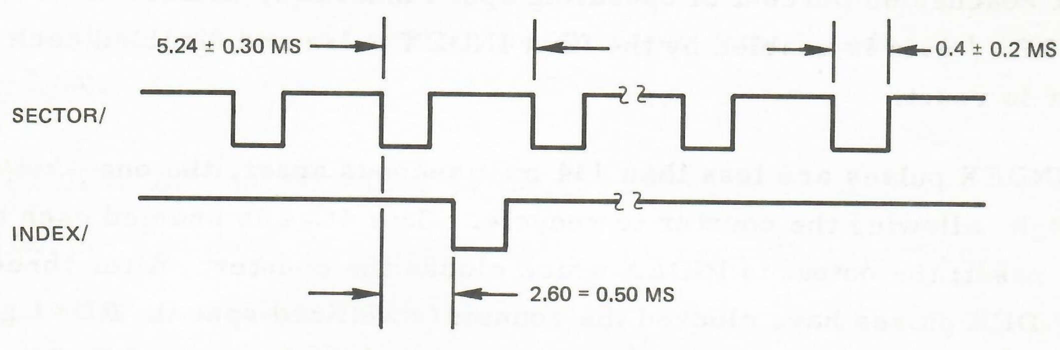


Figure 3-19. Index/Sector Timing

Ready

The ready logic is used to monitor the INDEX pulse for the rotational speed of the flexible 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 retriggerable one-shot 2A, whose nominal time is 434 milliseconds (see Figure 3-20).

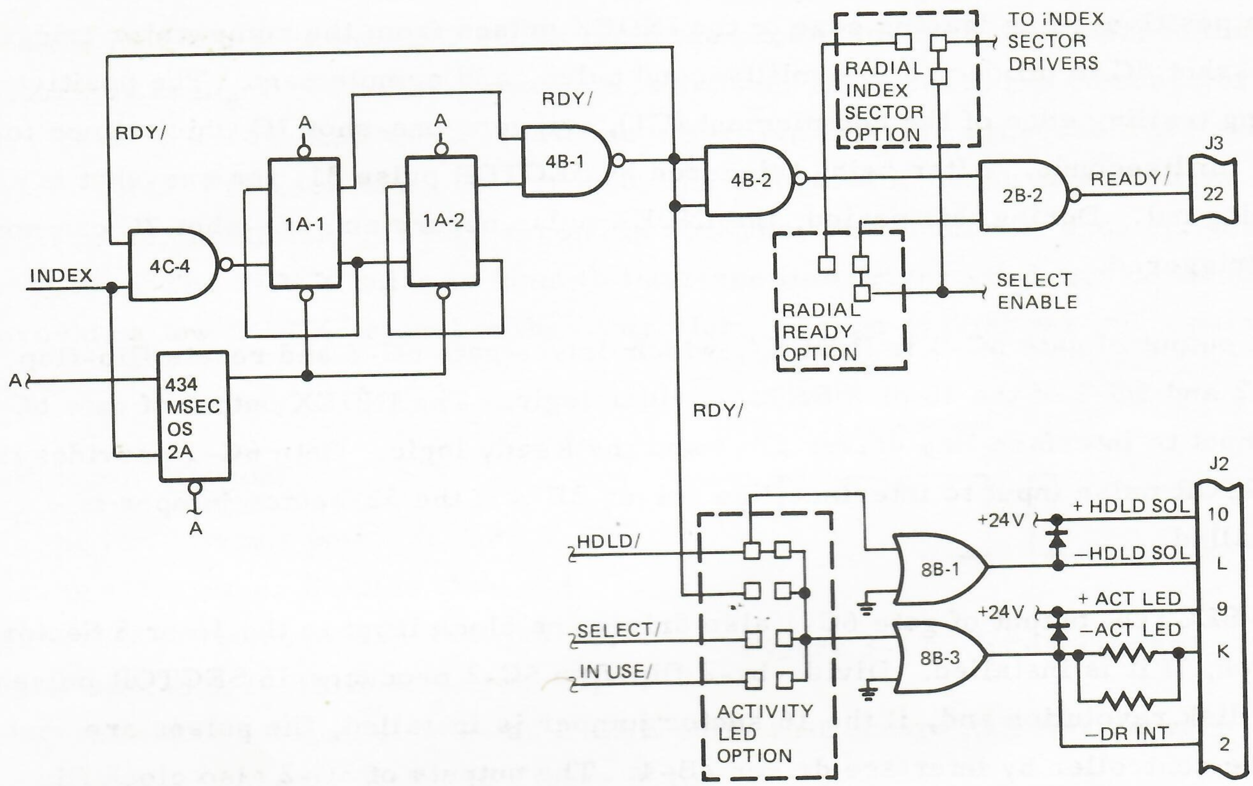


Figure 3-20. Ready Logic

When the input INDEX pulses are greater than 434 milliseconds apart, the disk has not yet reached 60 percent of operating speed and ready counter 1A-1 and 1A-2 is reset. RDY/ gate is enabled by the first INDEX pulse and disabled each time the counter is reset.

When the INDEX pulses are less than 434 milliseconds apart, the one-shot output remains high, allowing the counter to recycle. Gate 4C-4 is enabled each time the counter is reset; the output is INDEX which clocks the counter. After three consecutive INDEX pulses have clocked the counter (stabilized speed). RDY/ gate 4B-1 provides an active output to inhibit input gate 4C-4 and driving the READY output of gate 4B-2 high. The output of 4B-2 drives interface driver 2B-2, providing an active READY/ signal to the controller.

If the Radial Index/Sector option is connected, the SELECT signal is not required to enable the INDEX and SECTOR interface drivers. If the Radial Ready option is connected, the SELECT signal is not required to enable the 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. The Activity LED option can be connected to use the 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 interlock option.

### Activity Indicator

The activity indicator is an LED, mounted on the front panel bezel and is selectable to indicate one of four disk drive activities; HDLD/, RDY/, SELECT/, or IN USE/. Refer to Figure 3-20.

As supplied from the factory, a true HDLD/ command activates the LED. When HDLD/ is inactive, driver 8B-3 outputs a high and the LED remains off. When HDLD/ is active, 8B-3 outputs a low, the resistors supply bias current, and the LED is turned on.

In lieu of HDLD/, the activity LED can be turned on by any one of three different inputs (see Figure 3-20). The IN USE/ signal is a controller status input.

### Door Interlock

The door interlock 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 3-20.

## READ/WRITE HEAD POSITIONING LOGIC

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

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

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

### Head Load

The function of the head load logic is to accept the HDLD/ command from the controller and energize the head load solenoid. The energized solenoid exerts force against a pressure pad which gently forces the media against the read/write head. The head load logic is comprised of interface input and activity LED drivers required to enable the stepper motor drive logic, drive a solenoid, turn on the front panel activity indicator, and energize the door interlock (option) (see Figure 3-21).

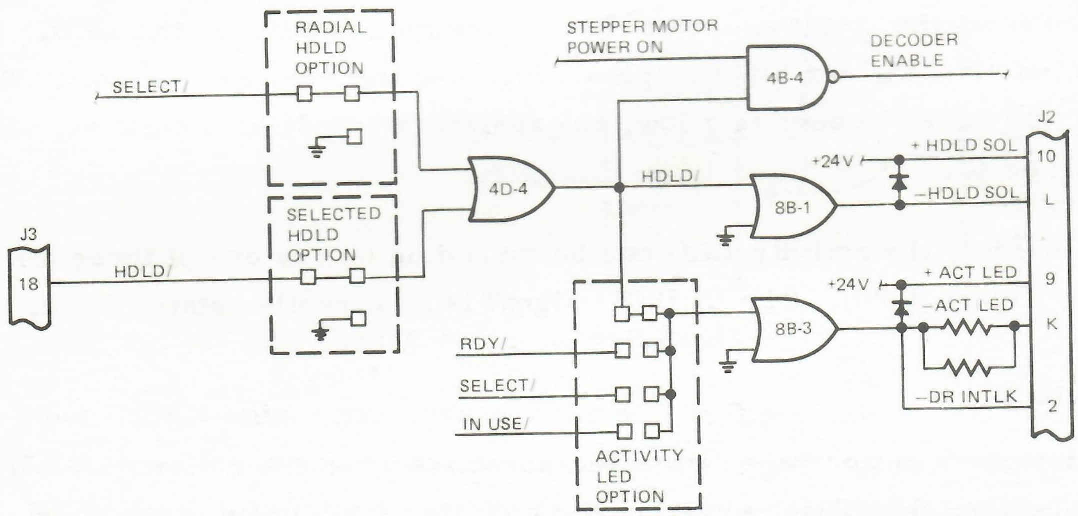


Figure 3-21. Head Load Logic

When SELECT/ is active and HDLD/ is not active, OR gate 4D-4 is inhibited and outputs a high. OR gate 8B-1 provides a high output and the solenoid is not energized. Gate 4B-4 is also inhibited, removing power from the stepper motor drive logic.

When both SELECT/ and HDLD/ are both active, gate 4D-4 is enabled and outputs a low to solenoid driver 8B-1 to energize the solenoid. Gate 4B-4 is also enabled and power is applied to the stepper motor at a rate established by the step logic.

### Track 00

The track 00 logic monitors the read/write head position and signals the controller when the head is at track 00. The logic comprises a single-pole, double-throw (SPDT) microswitch, a debounce latch, and drivers necessary to supply the signal to the controller (see Figure 3-22).

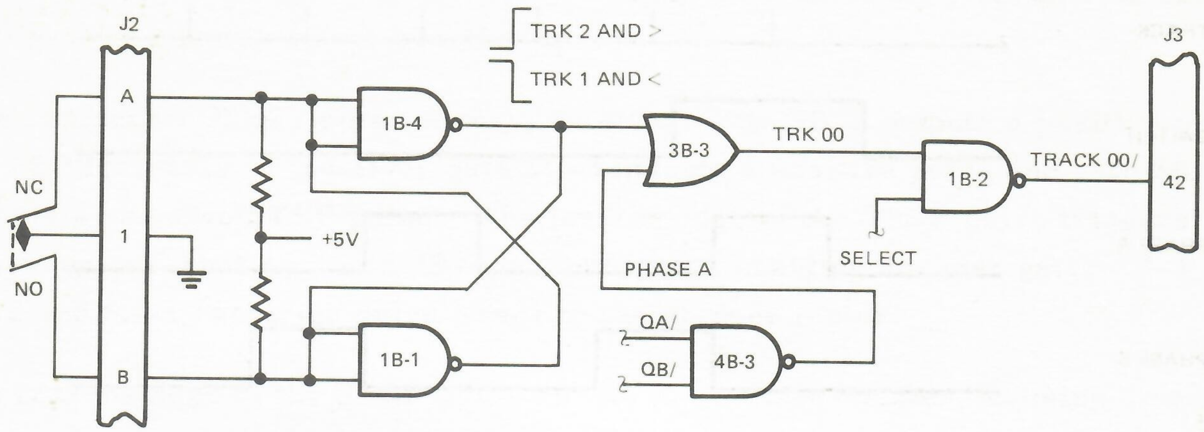


Figure 3-22. Track 00 Logic

The microswitch is mounted on the deck assembly and is activated by the movement of the read/write carriage. The outputs of the switch provide the set and reset inputs to the latch 1B-4 and 1B-1.

When the stepper motor drives the carriage out, the microswitch closes contacts as track 00 is approached. At track 1 or less, the output of 1B-4 is low to drive gate 3B-3. Gate 4B-3 provides a low output when phase A of the stepper motor direction control logic is energized. The output of 4B-3 also drives gate 3B-3 and SELECT enabled interface driver 1B-2, to send an active TRACK 00/ signal to the controller.

When the carriage drives the head beyond track 01, the output of gate 1B-4 goes high to inhibit gate 3B-3. The TRACK 00 signal goes high indicating to the controller that the read/write head is beyond track 00. Refer to Figure 3-23.

## 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 STEP/ command, and in a direction determined by the high or low state of the STEP IN/ command. The positioning logic comprises interface gates, a 3-state up-down counter, a counter-decoder, stepper motor drive logic and a stepper motor power-on one-shot.

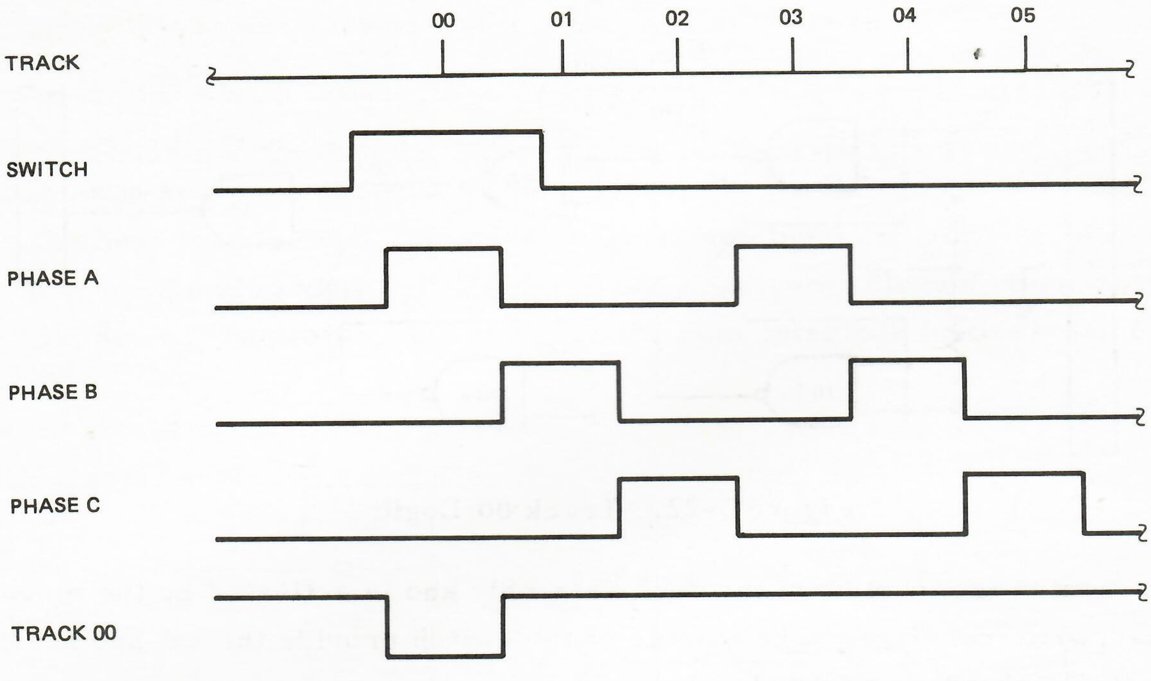


Figure 3-23. Track 00 Timing

## Interface Gating

When STEP IN/ is inactive, interface gate 3B-1 outputs a low, causing Exclusive-OR gates 3C-1 and 3C-4 to be inverters (see Figure 3-24). The high output of each inverter causes up-down counter 3A-1 and 3A-2 to start counting down. When

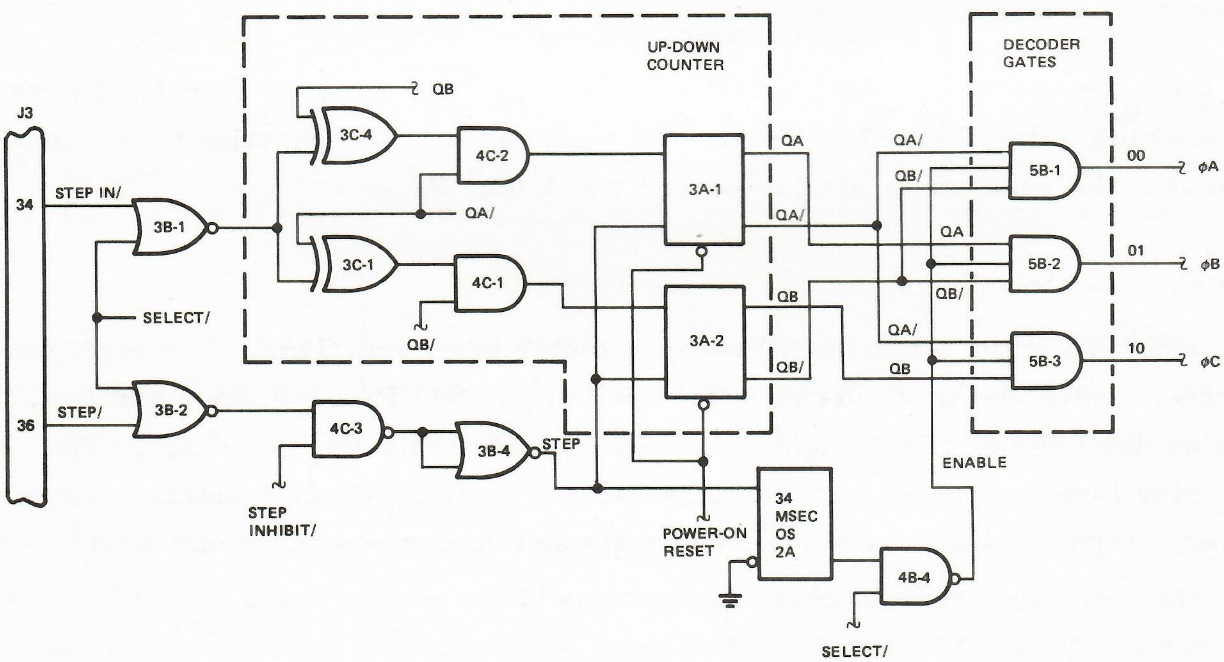


Figure 3-24. Stepper Motor Interface Gating Logic

STEP IN/ is active, gate 3B-1 outputs a high, Exclusive-OR gates non-invert, and the up-down counter starts counting up.

When an active STEP/ pulse occurs, interface gate 3B-2 outputs a positive pulse. If STEP INHIBIT/ is inactive, gate 4C-3 outputs a positive pulse and gate 3B-4 outputs a negative STEP pulse. The leading edge of the STEP pulse triggers power-on one-shot 2A, gate 4B-4 outputs a high enabling decoder gates 5B-1, 5B-2 and 5B-3, applying drive power to the stepper motor.

The trailing edge of the STEP pulse clocks the 3-state counter, causing a count-up or count-down as determined by the state of the STEP IN/ interface signal. Figure 3-25 shows the stepper motor timing.

## Up-Down Counter

The up-down counter is comprised of gates 3C-1, 3C-4, 4C-1 and 4C-2, and flip-flops 3A-1 and 3A-2 (Figure 3-24). When initial power is applied to the disk drive, the power-on reset logic resets the counter to a 00 state (phase A). If the counter is in the count-up mode, it will advance to state 01 (phase B) when a STEP pulse occurs. The next STEP pulse advances the counter to state 10 (phase C), and the next pulse advances the count to state 00 again. Subsequent pulses will continue the cycle until the STEP/ command becomes inactive.

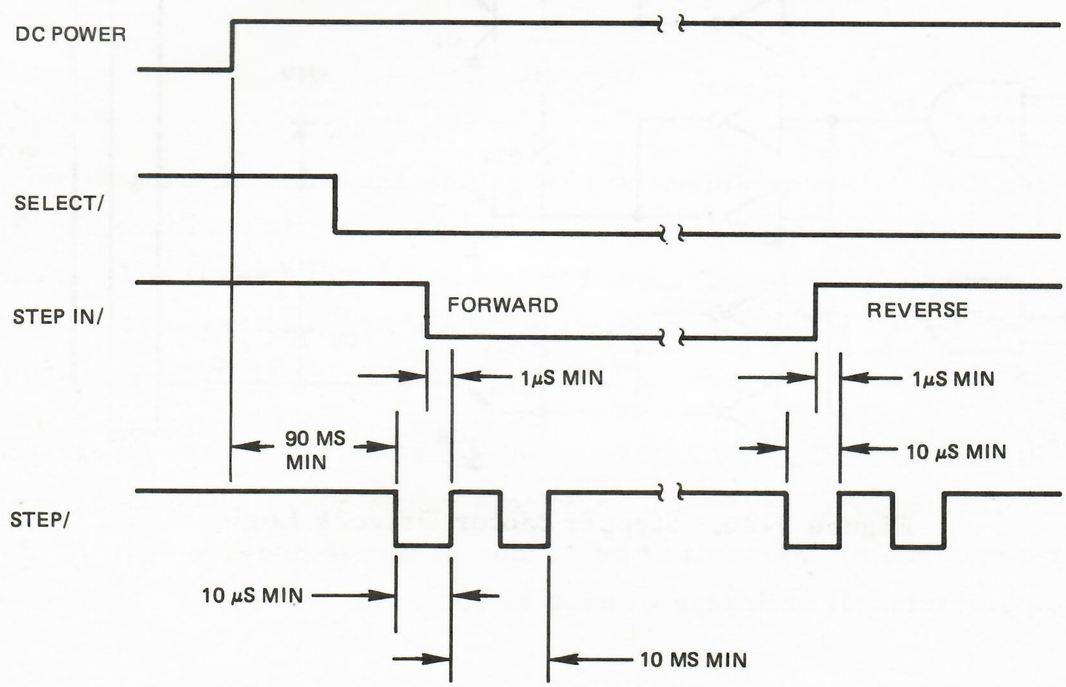


Figure 3-25. Stepper Motor Timing

If the counter is in the count-down mode, it will retard to state 01 on the next STEP pulse. Subsequent pulses will continue the count-down cycle until the STEP/ command becomes inactive.

## Counter-Decoder

The decoder logic decodes the three states of the up-down counter and provides one active output to drive a single phase of the stepper motor (see Figure 3-24).

The counter-decoder logic is comprised of decoder gates 5B-1, 5B-2 and 5B-3. Each gate enables only one phase of the phase of the stepper motor drive logic. Gate 5B-1 enables phase A from a 00 count, gate 5B-2 enables phase B from an 01 count, and gate 5B-3 enables phase C from a 10 count. The gates are disabled if a power failure occurs or if the unit is deselected.

## Stepper Motor Drivers

The stepper motor is a 3-phase motor having three independent and identical drive circuits (see Figure 3-26).

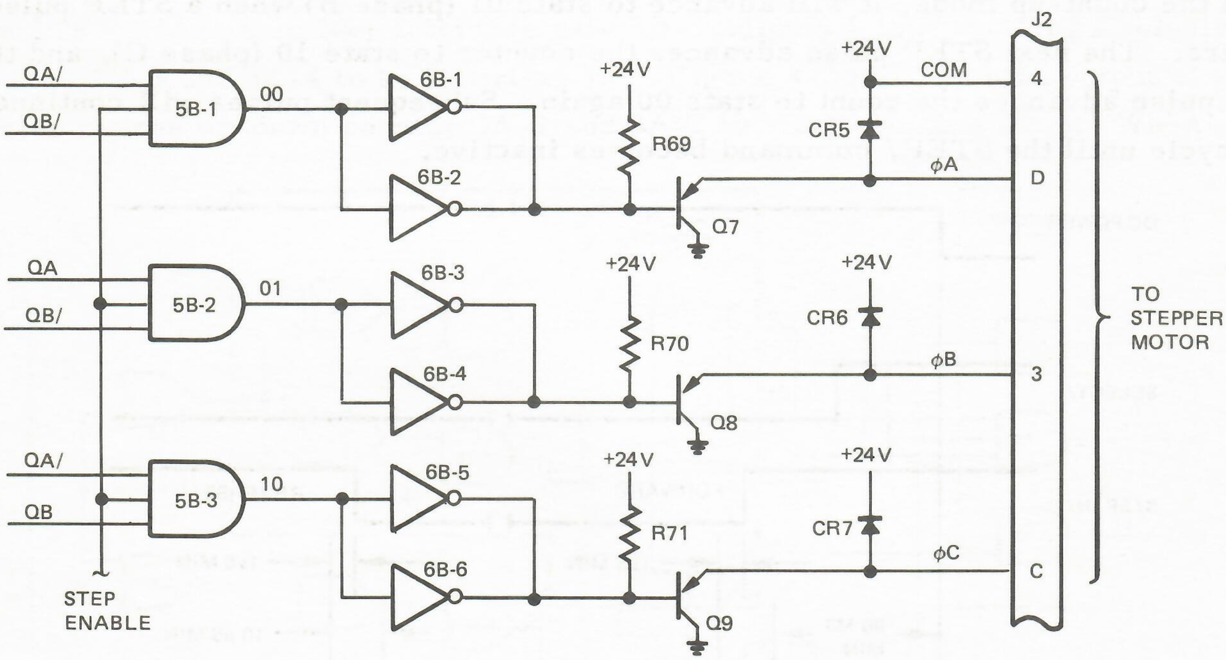


Figure 3-26. Stepper Motor Drivers Logic

Phase A drive logic is comprised of drivers 6B-1 and 6B-2, current limiting resistor R69, emitter-follower Q7, and isolation diode CR5. When decoder gate 5B-1 outputs a low (code 00 not detected), drivers 6B-1 and 6B-2 produce a high output, Q7 is cut off and phase A is not energized. When 5B-1 outputs a high (code 00 detected), drivers 6B-1 and 6B-2 produce a low output turning on Q7, and phase A is energized. When Q7 turns off, diode CR5 restricts the emitter of Q7 from going more positive than +24 volts. Each driver circuit is identical and operates in the same way to drive the stepper motor in the forward or reverse directions.

## Stepper Motor Power-On One-Shot

Power-on one-shot 2A is retriggerable, and times out after 34 milliseconds (see Figure 3-24). At each STEP pulse the one-shot fires, the decode gates are enabled and, for 34 milliseconds, drive power can be developed and applied to the stepper motor.

Enable gate 4B-4 OR's the output of 2A and SELECT enable gate 4D-4 (Figure 3-24), and provides a low output when the one-shot is not timing or when the read/write head is not loaded. Phase decode gates 5B-1, 5B-2, and 5B-3 are inhibited and drive power is removed from the stepper motor. When the one-shot is timing or when the head is loaded, the decode gates are enabled and power can be applied to the stepper motor.

## Stepper Motor

The stepper motor shaft changes 15 degrees of angular position with each 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. For every 15 degrees of shaft rotation, the read/write head is positioned precisely over a recording track on the flexible disk.

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 grooved lead screw is connected to the rotor (shaft) to position the head over one of 77 tracks. Track 00 is used to establish the starting point.

## READ/WRITE LOGIC

The read/write logic converts digital encoded serial data from the controller to analog flux patterns that are magnetically recorded (written) on the surface of a rotating flexible disk. The recorded data are sensed and decoded during a read operation and are restored to digital read data for the controller. A common read/write head is shared by switching 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 3-27 shows the write initiate timing.

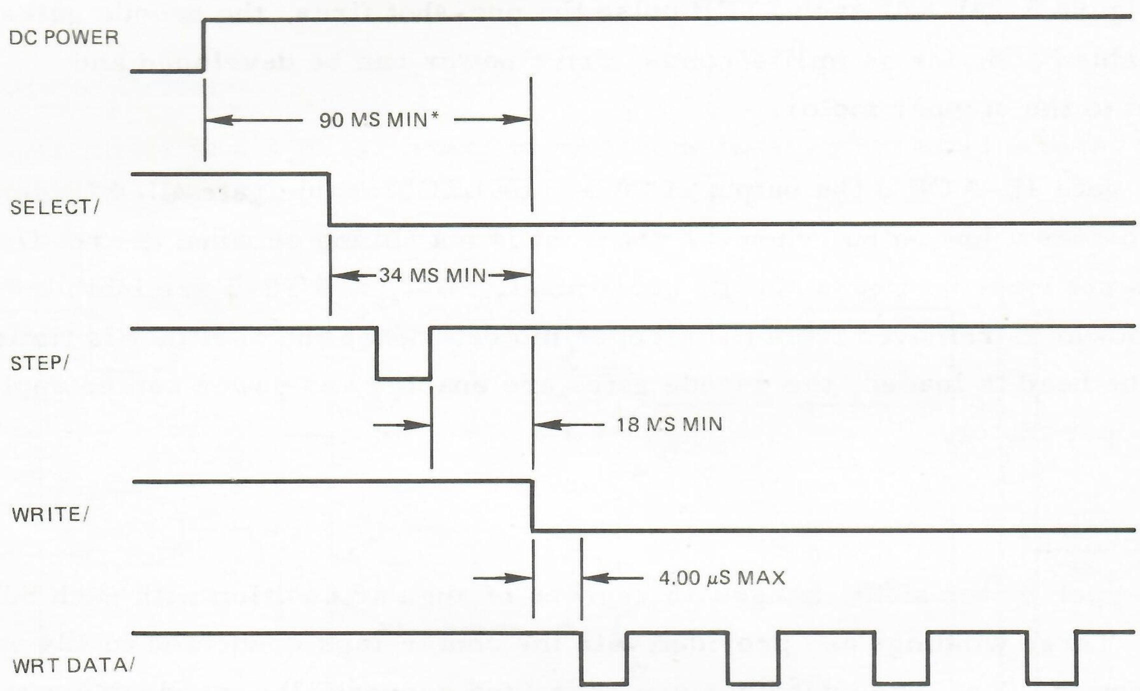


Figure 3-27. Write Initiate Timing

A write operation is initiated by the disk controller by activating the WRITE/, ERASE/, and 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 0.012 inch.

Write-Protect

When a flexible disk cartridge has a write-protect hole punched through it, the disk drive disregards any WRITE command and all write logic is disabled. When the hole is covered, normal read/write operations can be performed. The write-protect cartridge is used in conjunction with a light-sensing LED/phototransistor 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 7B-2 (see Figure 3-28).

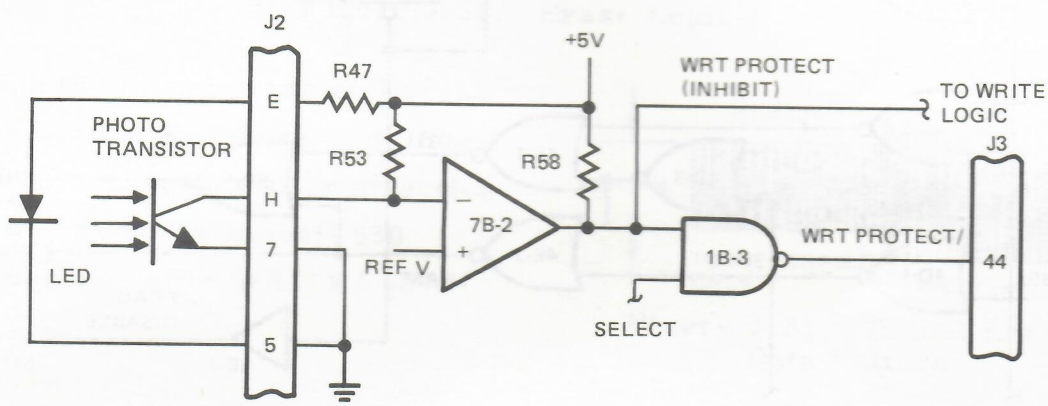


Figure 3-28. Write-Protect Logic

The output of comparator 7B-2 is high, providing an input to interface line driver 1B-3, and inhibiting write gate 4D-3.

When the disk cartridge write-protect hole is covered, or a non-write-protect cartridge is used, the phototransistor is inactive, and the negative input to comparator 7B-2 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 WRITE/ command followed by active WRT DATA/ and ERASE/ commands.

Write and Erase Gating

When WRITE/ is active, line receiver 4D-2 outputs a low to gate 4E-1. Enable gate 4D-3 outputs a low active signal provided the head is loaded (HDLD/) and a write-protect disk cartridge is not being used. The output produced by gate 4E-1 is high enabling WRITE flip-flop 5E-2, drivers 6E-4 and 6E-3, and inhibit gate 5D-4. Gate 5D-4 produces a low output to inhibit read circuit crossover detector 3F. The high input to driver 6E-3 switches the read/write select circuit to the write mode (see Figure 3-29).

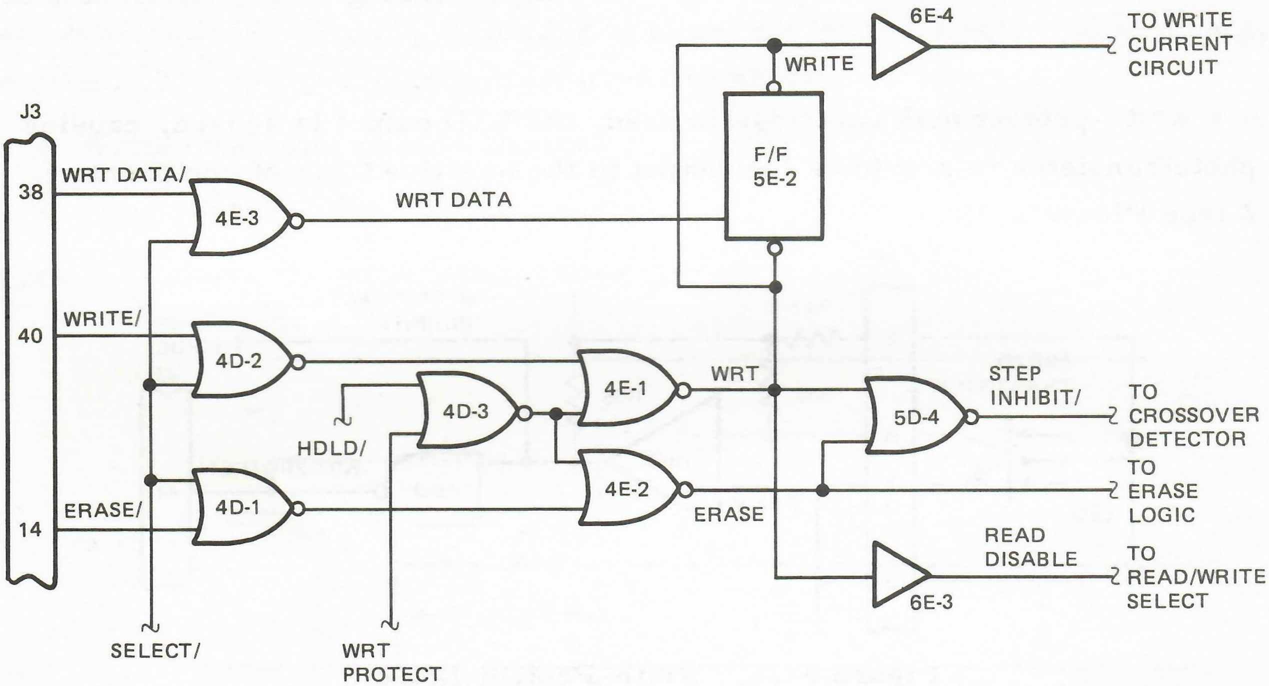


Figure 3-29. Write and Erase Gating Logic

When ERASE/ is active, line receiver 4D-1 produces a low output enabling erase gate 4E-2. Gate 4E-2 outputs a high which is inverted by gate 5D-3, enabling the erase logic. When ERASE/ is inactive, gate 4D-1 outputs a high to inhibit 4E-2. At this time, 4E-2 outputs a low which is inverted by 5D-3, inhibiting the erase logic.

## Erase Logic

The erase logic conprises gate 5D-3, driver 6E-1, resistors R40 through R43 and transistor Q4 (see Figure 3-30).

When ERASE/ is inactive, driver 6E-1 outputs a high and current source transistor Q4 is biased off. When ERASE/ is active, 6E-1 outputs a low turning Q4 on. With Q4 on +24 volts are developed across R40 and R41 causing erase current to

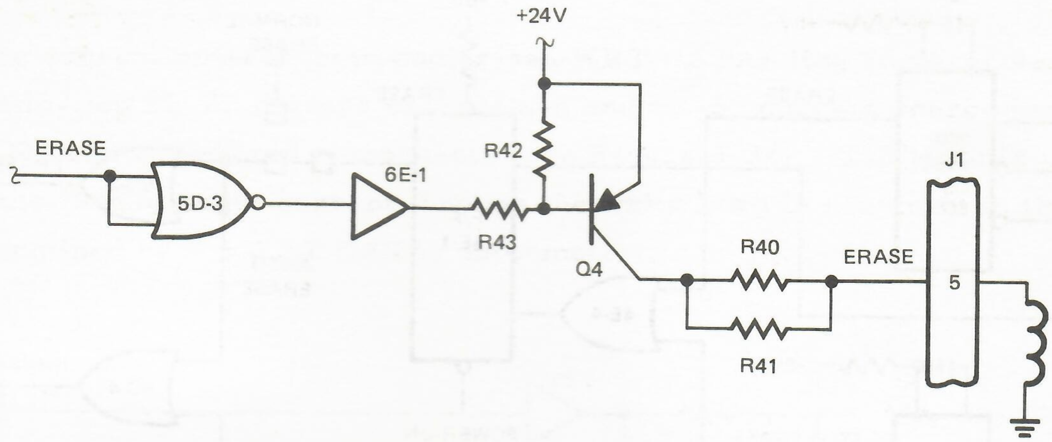


Figure 3-30. Erase Logic

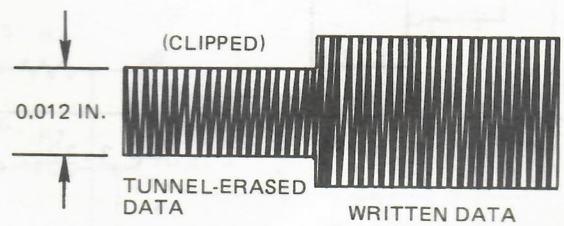


Figure 3-31. Tunnel Erase Data Pattern

flow through the tunnel erase coil of the read/write head. The current is turned on 200 ±10 microseconds after an active WRITE/, and remains on until 530 ±10 microseconds after WRITE/ goes inactive.

## Auto Erase (Option)

The Auto Erase option comprises monostable multivibrators (one-shots) 6D and 7D, capacitors C3, C4, C5 and C64, and resistors R10, R11 and R12 (see Figure 3-32). The purpose of the option is to provide the necessary turn-on delay between active WRITE/ and ERASE/ commands, and the turn-off delay after WRITE/ goes inactive. When this option is installed, it is not necessary for the controller to provide the ERASE/ command.

When WRITE/ goes active, WRT goes high to trigger one-shot 6D for a 200-microsecond time-out. The one-shot output is inverted by gate 4E-4 and the trailing edge clocks ERASE flip-flop 5E-1 on. The high output of 5E-1 is applied to ERASE gate 5D-3 and INHIBIT gate 5D-4. When WRITE/ goes inactive, WRT goes low to trigger one-shot 7D for a 530-microsecond time-out. The one-shot output is inverted by 4E-4 and its trailing edge clocks ERASE flip-flop 5E-1 to a false state, removing ERASE from gates 5D-3 and 5D-4.

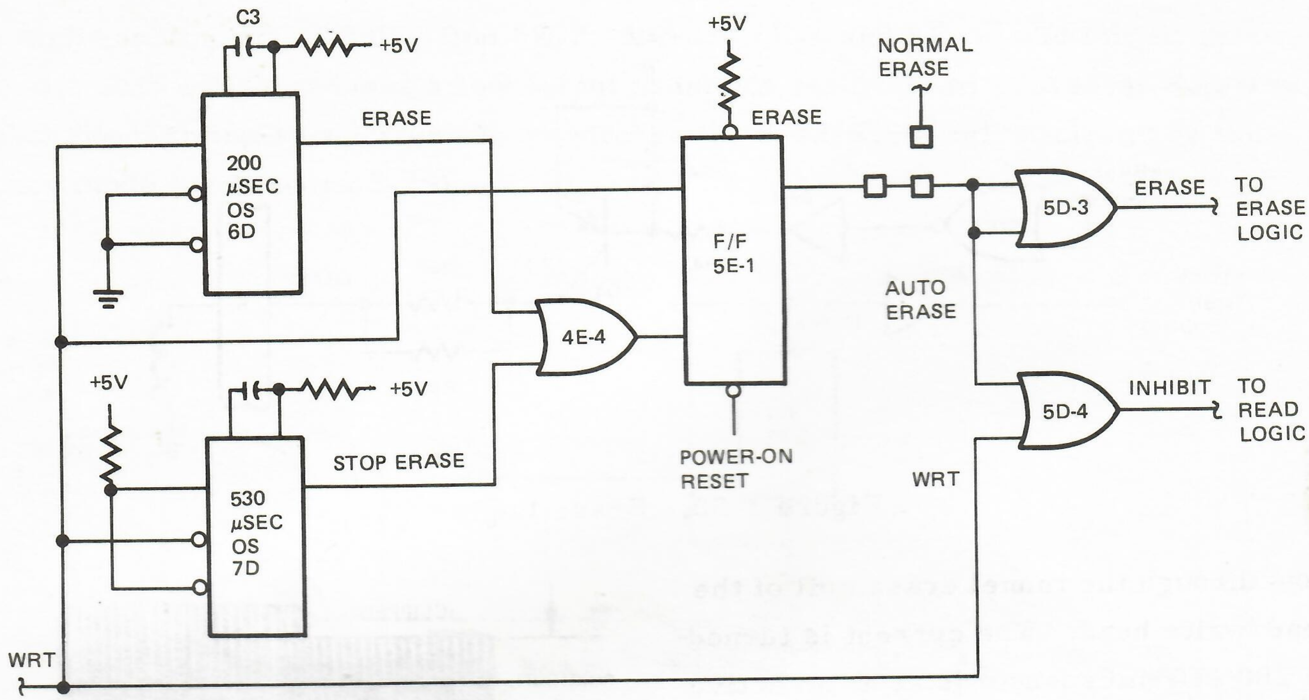


Figure 3-32. Auto Erase Logic

## DC Unsafe

The DC Unsafe logic comprises comparator amplifier 7B-4, transistor Q3, resistors R8, R9 and R59 through R61, and capacitor C58. 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 3-33).

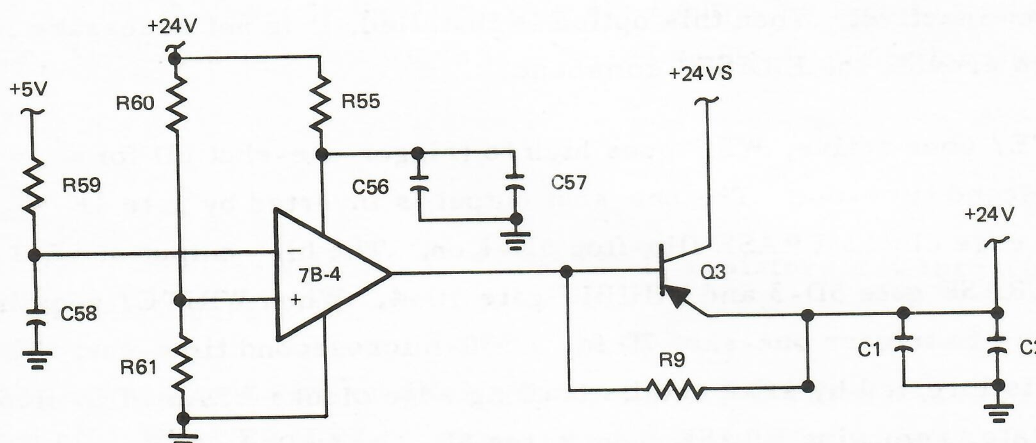


Figure 3-33. DC Unsafe Logic

## Write Current Control

The write current control logic comprises WRT DATA/ line receiver 4E-3, WRITE flip-flop 5E-2, drivers 6E-4, 6E-5 and 6E-6, current source transistors Q1 and Q2, and associated components (see Figure 3-34). The logic is used to control the flow of write current through the write head in response to the direction determined by the WRT DATA/ information.

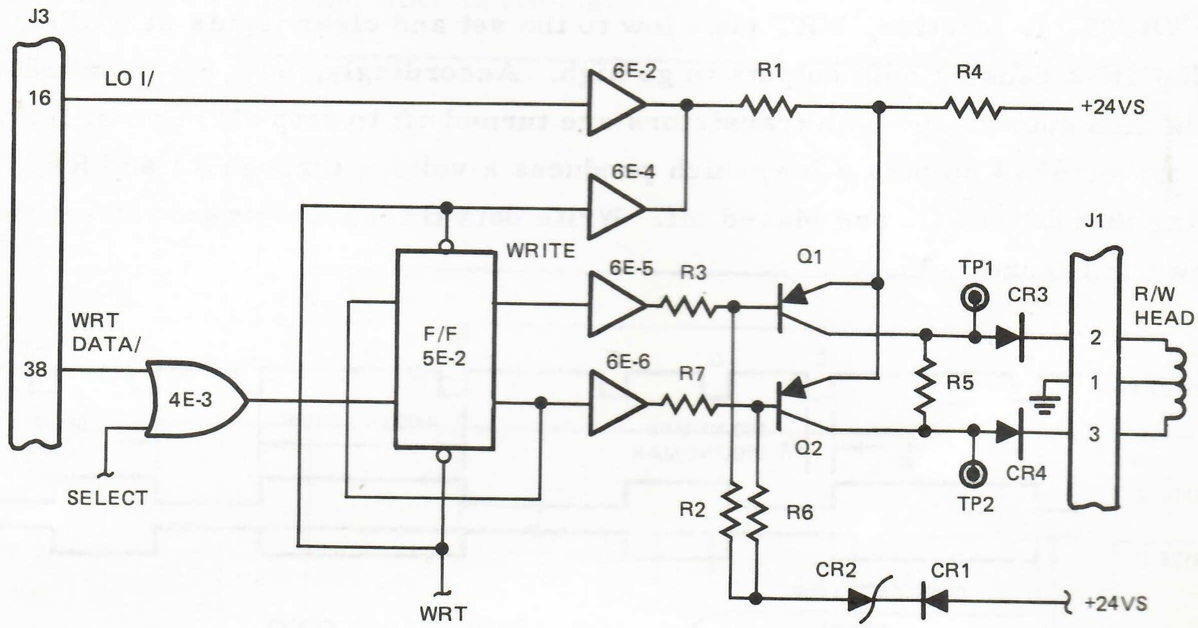


Figure 3-34. Write Current Control Logic

When the disk drive is not selected, write current flow is inhibited. When the drive is selected interface line driver 4E-3 is enabled and gates WRT DATA/ to WRITE flip-flop 5E-2. If the WRITE/ command is active, 5E-2 toggles to the false state and drives the output of driver 6E-5 low. Current flow through CR1, CR2, R2 and R3 cause Q1 to turn on. Driver 6E-6 outputs a high and Q2 is turned off. When flip-flop 5E-2 toggles to the true state, driver 6E-6 outputs a low, causing current flow through CR1, CR2, R6 and R7 to turn on Q2. Driver 6E-5 outputs a high and Q1 is turned off.

Transistors Q1 and Q2 are used as write driver switches and the source of write current to the write coil. The voltage developed at the emitters of Q1 and Q2 cause peak write current to flow through R4, the turned-on transistor, the series diode, and through one-half of the write coil in the read/write head.

Low Write Current Control

Driver 6E-2 and resistor R1 form a low write current circuit (see Figure 3-34). When LOI/ is inactive, 6E-2 outputs a high and current does not flow through R1. In this state, the level of write current is determined by R4. When the controller drives the LOI/ line active, 6E-2 outputs a low, causing current to flow through R1 which substantially reduces write current for inside tracks 43 through 76.

When WRITE/ is inactive, WRT goes low to the set and clear inputs of WRITE flip-flop 5E-2 causing both outputs to go high. Accordingly, both 6E-5 and 6E-6 provide high outputs and both transistors are turned off to stop all current flow. Also, driver 6E-4 outputs a low which produces a voltage through R1 and R4, ensuring that Q1 and Q2 are biased off. Write data timing and write current flow is shown in Figure 3-35.

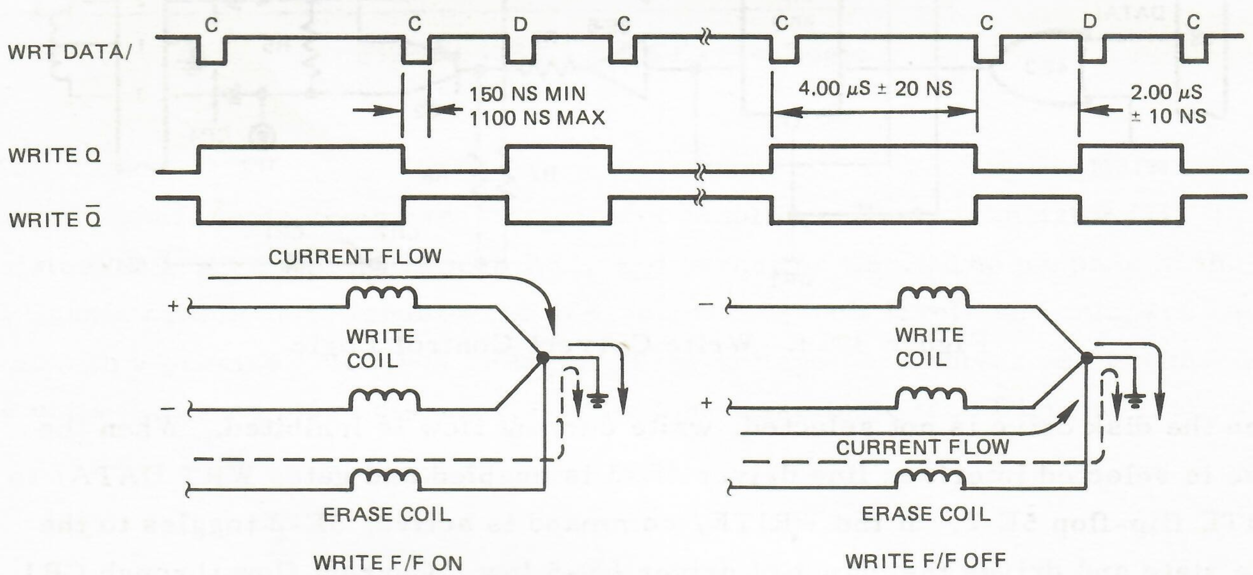


Figure 3-35. Write Current Timing

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 WRITE/ command becomes inactive. The controller activates an initial read operation by issuing the following commands:

- SELECT/ - Addresses the disk drive
- HDLD/ - Loads the read/write head
- WRITE/ - Providing a high (inactive) enable signal

Figure 3-36 shows the read initiate timing.

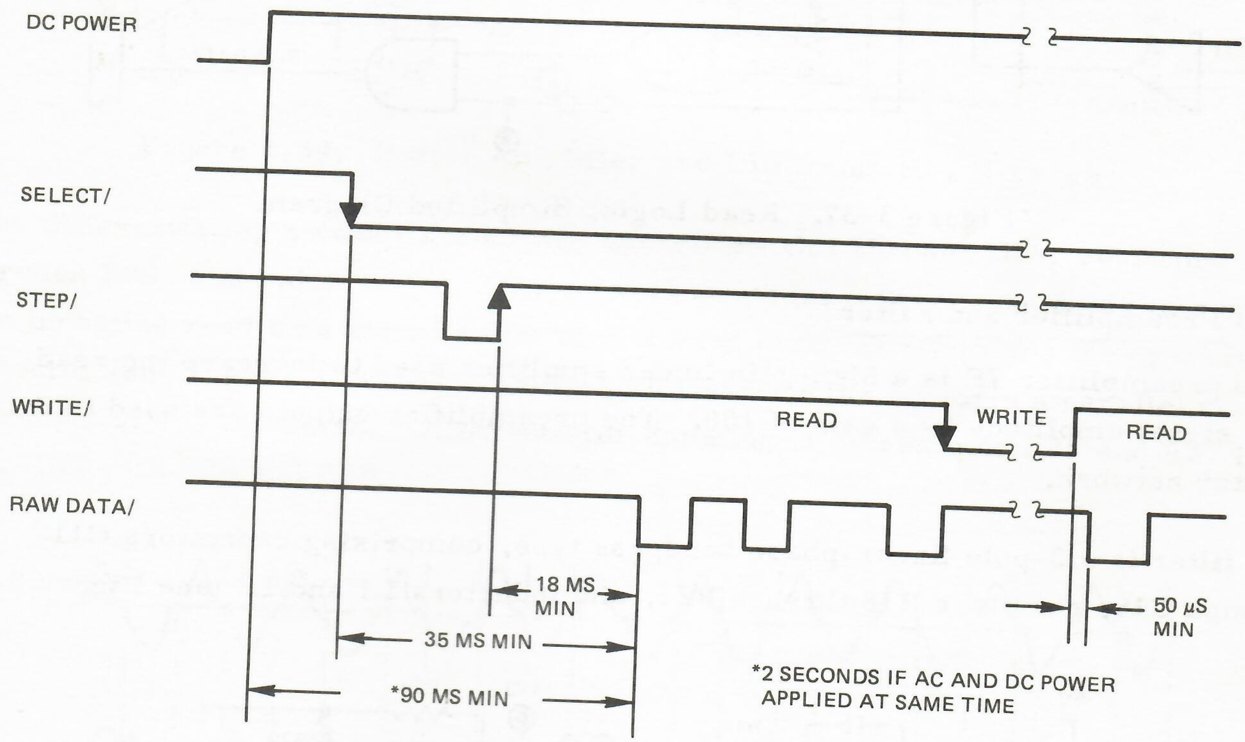


Figure 3-36. Read Initiate Timing

## Read/Write Select

The read/write select circuit comprises MOS FET's Q5 and Q6, resistor R13, and WRT driver 6E-3. The source inputs to Q5 and Q6 are connected to the read coils of the read/write head. The output drains are connected to the inputs of preamplifier 7F. When the disk drive is operating in the Write mode, the output of WRT driver 6E-3 is high. Both Q5 and Q6 are in the off state to isolate the read coil from the preamplifier. Read damping is determined by R14 and R15 in parallel with R76 (see Figure 3-37).

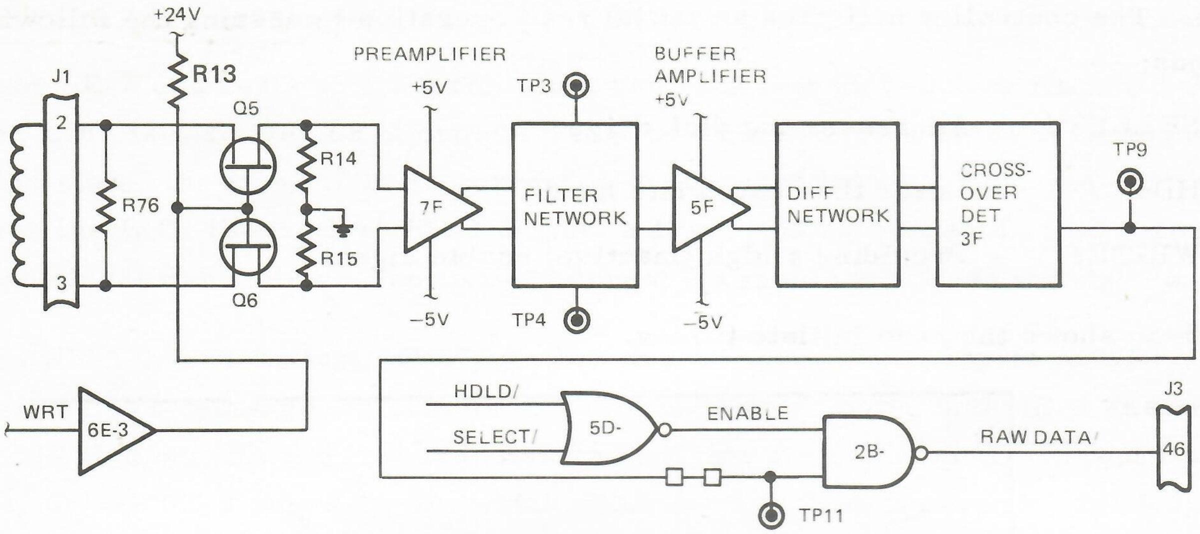


Figure 3-37. Read Logic, Simplified Diagram

## Read Preamplifier and Filter

Read preamplifier 7F is a high-gain linear amplifier used to increase the read data signal amplitude by a gain of 100. The preamplifier outputs are used to drive a filter network.

The filter is a 3-pole linear-phase bandpass type, comprising capacitors C11 through C16, resistors R18 through R23, and inductors L1 and L2 (see Figure 3-38).

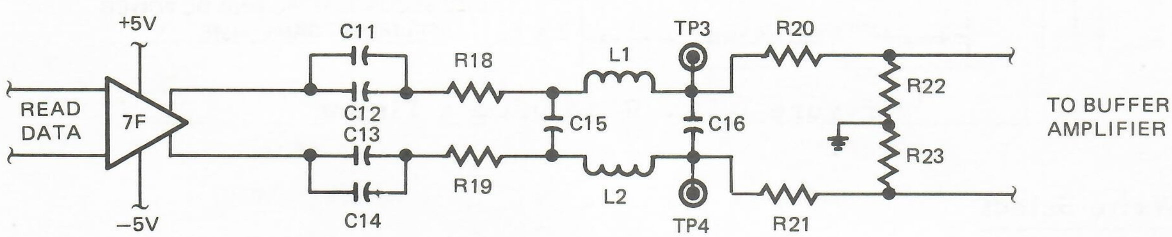


Figure 3-38. Read Preamplifier and Filter Circuit

The filter has a -3 dB bandwidth of 800 kilohertz that drives buffer amplifier 5F. Resistors R20 through R23 divide the output voltage to constrain the buffer amplifier within its linear range.

## Buffer Amplifier and Differentiating Network

Buffer amplifier 5F has a nominal gain of 10 and isolates the read data filter from the differentiator network (see Figure 3-39).

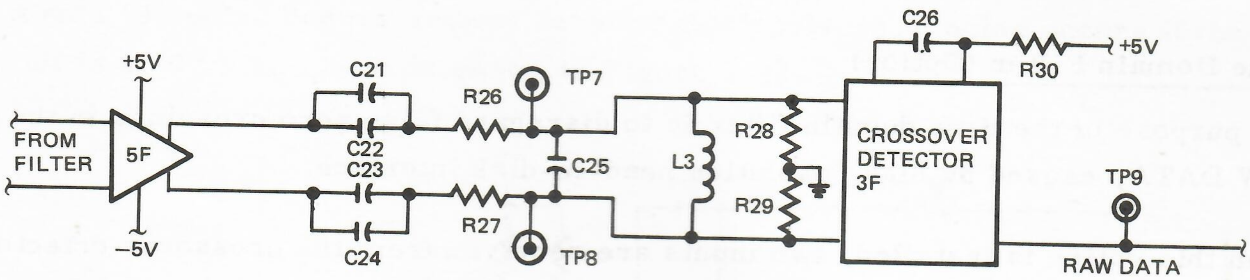


Figure 3-39. Buffer Amplifier and Differentiating Network

The differentiating network comprises capacitors C21 through C25, resistors R26 through R29, and inductor L3. The network provides a 90-degree delay to convert the incoming read data signal peaks to distorted zero crossings for the crossover detector (see Figure 3-40). Capacitor C25 and inductor L3 form a parallel circuit, resonant at 750 kilohertz. Differentiator damping is by resistor R26 and R27 in parallel with R28 and R29.

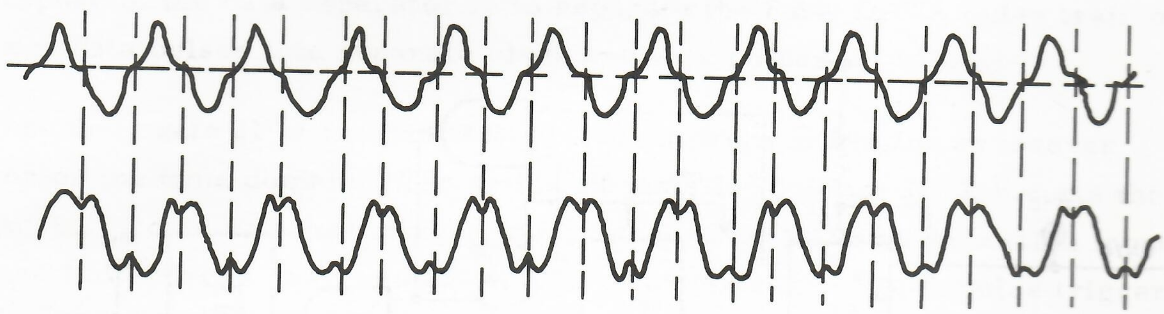

Figure 3-40. Read Data Waveforms

## Crossover Detector

The crossover detector comprises comparator and bidirectional one-shot 3F, capacitor C26 and resistor R30. The comparator is driven by the analog output of the differentiator and provides a RAW DATA pulse for each zero crossing.

When the Time Domain Filter option is not installed, the pulse width is nominally 200 nanoseconds, as determined by R30 and C26. When the Time Domain Filter option is installed, the pulse width is determined by R30 and C26, C27 and is nominally 1,000 nonoseconds.

Time Domain Filter (Option)

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

When this option is installed, two inputs are received from the crossover detector. The 0 input to flip-flop 3E-2 is from the comparator, and the clock input is from the one-shot. The trailing edge of the one-shot clocks the flip-flop to the state dictated by the comparator and is delayed 1,000 nonoseconds. Flip-flop 3E-1, gates 2E-3, 2E-4, 2E-1, resistors R32, R33, and capacitors C28, C29 form a bidirectional one-shot, the output of which is a positive pulse for each transition produced by 3E-2. The positive edge of each pulse triggers one-shot 1E to output a 200 nanosecond pulse for interface driver 2B-1 and the Data Separator option (if installed for single-density recording). The time domain filter logic is shown in Figure 3-41.

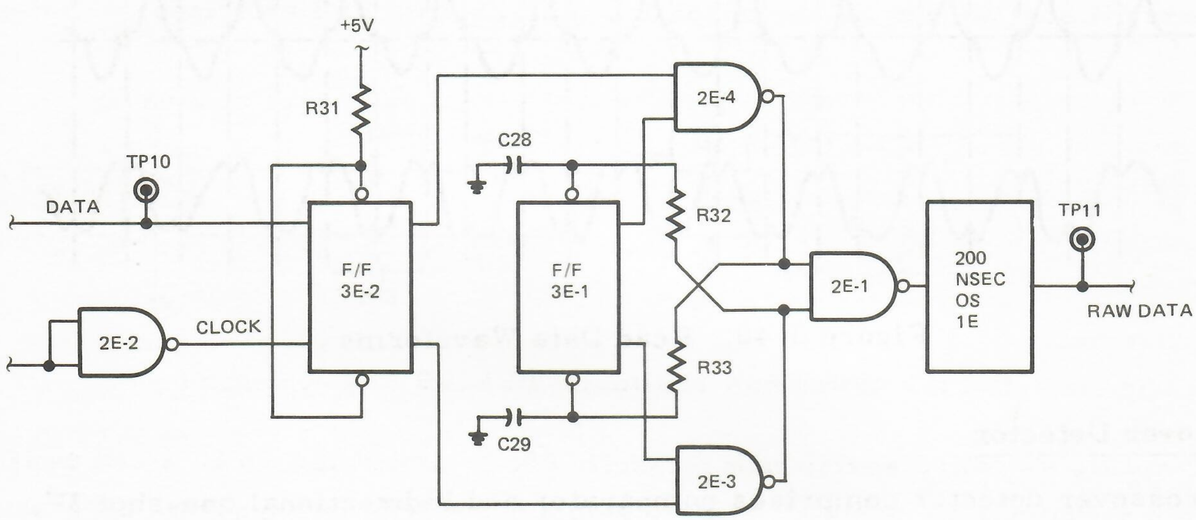


Figure 3-41. Time Domain Filter (Option) Logic

## Data Separator (Option)

The Data Separator option is usable only when the disk drive is used for single-density recording. Frequency modulated (FM) encoding is the method and is defined as being a pulse train wherein a clock pulse occurs every 4 microseconds and a data "1" pulse occurs midway between clock pulses; no pulse occurs if the data bit is a "0". The logic is shown in Figure 3-42.

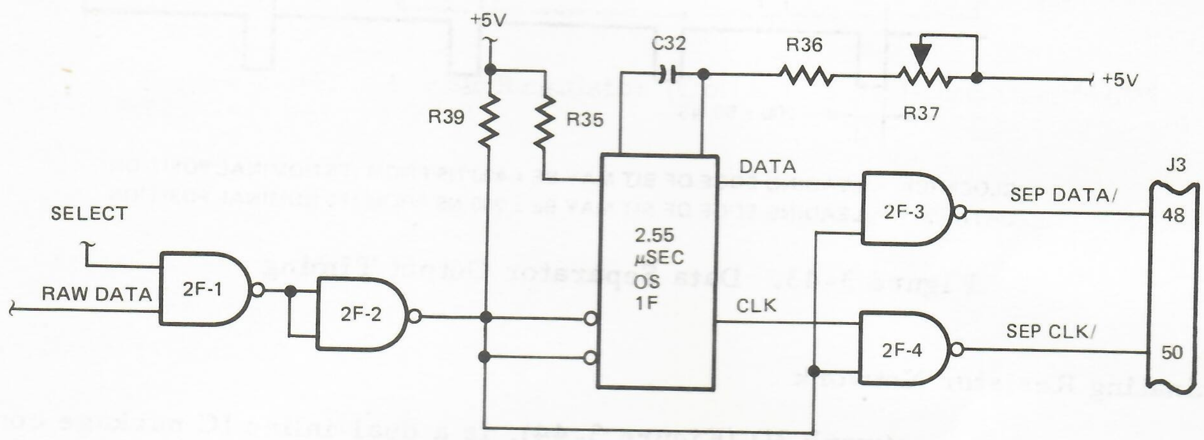


Figure 3-42. Data Separator (Option) Simplified Logic

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, gate 2F-1 inverts the pulse train from either the crossover detector or the time domain filter option (if installed). Gate 2F-2 inverts the input again, providing a low trigger input to one-shot 1F, and the enable input to interface line drivers 2F-3 and 2F-4. The trailing edge of each pulse triggers the one-shot to time for 2.55 microseconds. Therefore, since the time between a clock pulse and a data "1" pulse is 2 microseconds the pulse that triggered the one-shot is output as the SEP CLK/ pulse and the next pulse is the SEP DATA/ pulse. Potentiometer R37 is provided to vary the time delay. Figure 3-43 shows the data separator output timing.

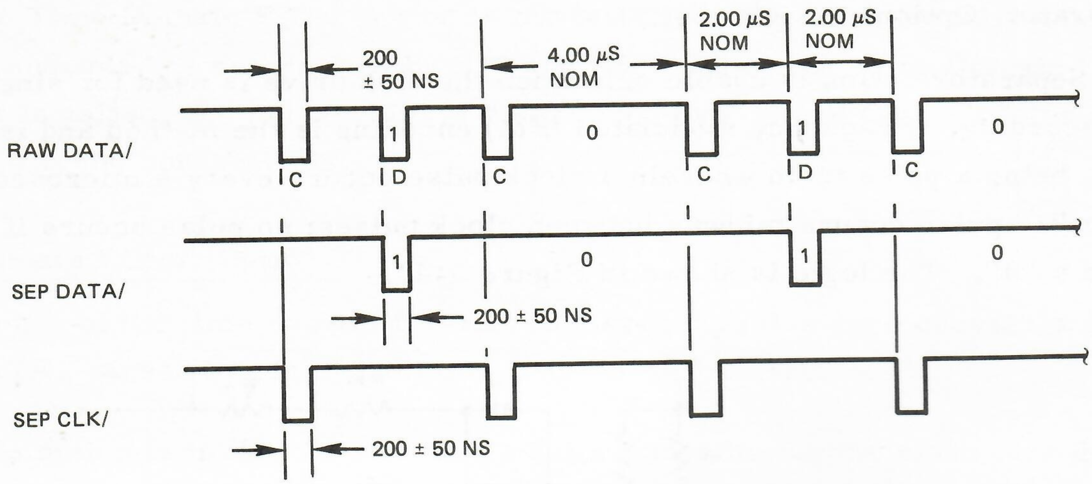


Figure 3-43. Data Separator Output Timing

## Terminating Resistor Network

Terminating resistor network 3D (Figure 3-44), 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.

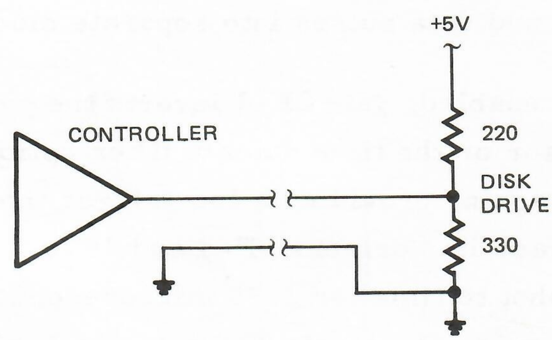


Figure 3-44. Terminating Resistor Network

## -5 Volt Regulator (Option)

The disk drive logic operates from -5.0 volt ±5%, supplied from the host controller. If the voltage is not available, the Negative Voltage Regulator option must be installed (see Figure 3-45).

When this option is installed the controller can supply an unregulated input from -7 volts to -16 volts. Regulator A1 provides a -5 volts output, regulated to ±5 percent.

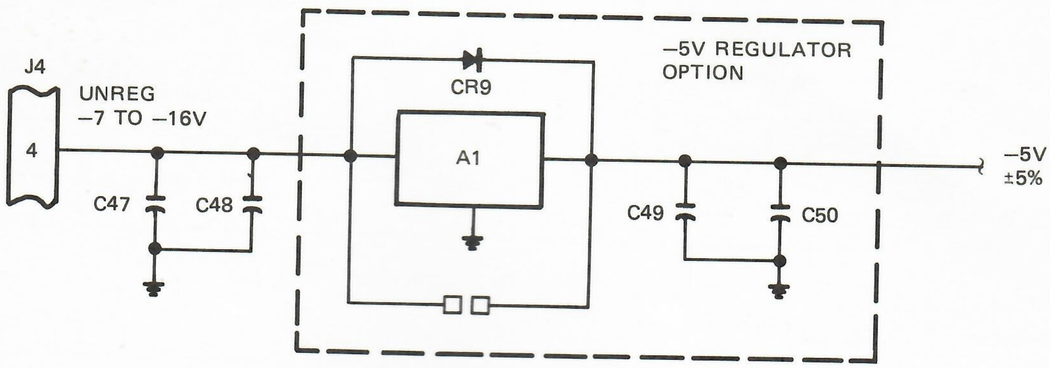


Figure 3-45. -5 Volt Regulator (Option), Simplified Diagram