SIEMENS

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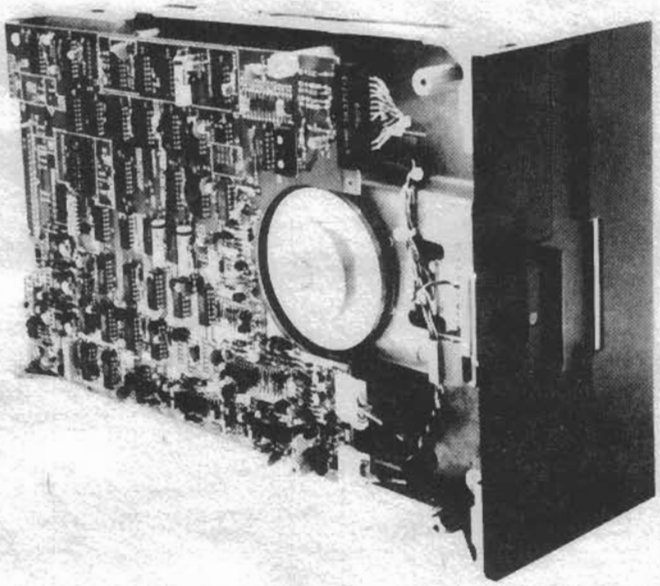
Floppy Disk Drive FDD 200-8

Technical Manual
Volume 1 Model 200-8



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Technical Manual
Volume 1 Made 2700

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INTRODUCTION

GENERAL

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

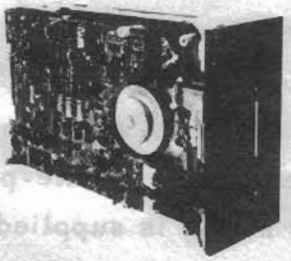


Figure 1-1. Model FDD 200-8N Floppy Disk Drive

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 single-density data, or 3.88 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

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 data 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 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 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 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.

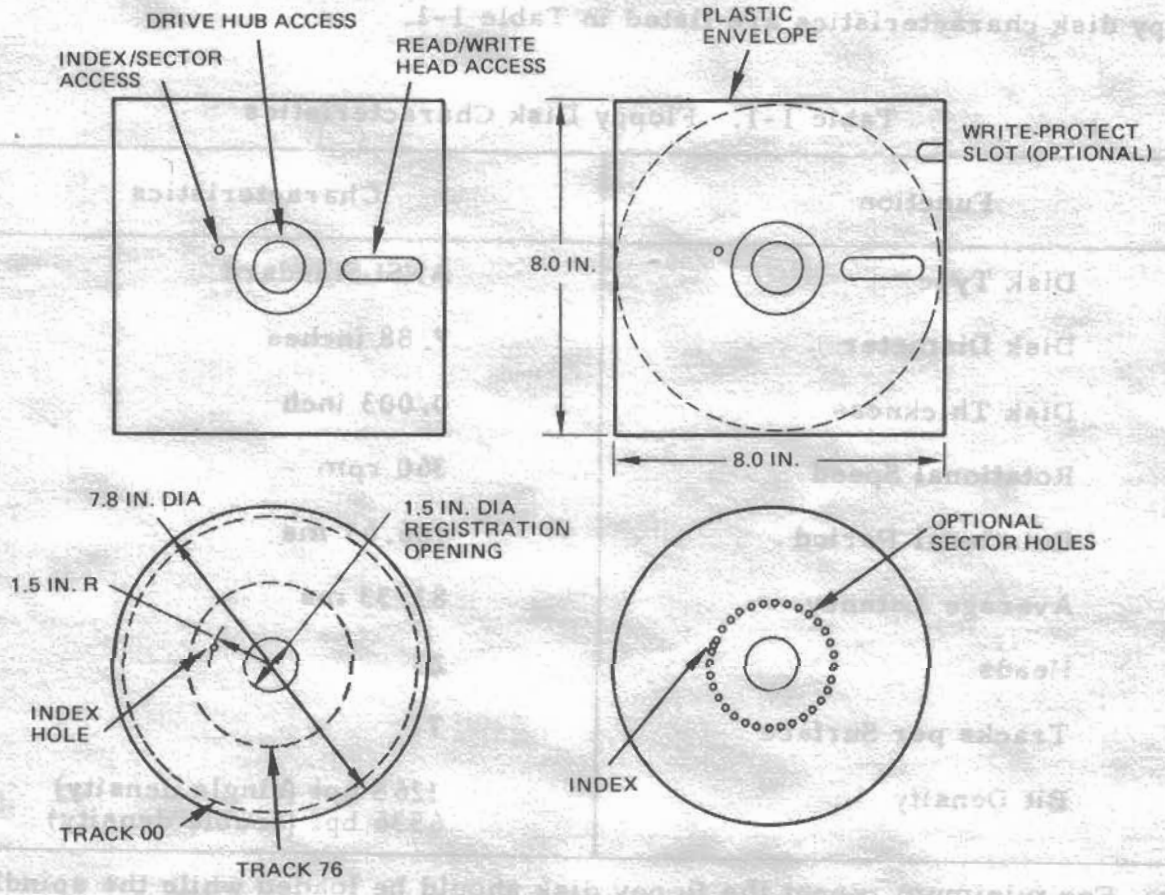


Figure 1-2. Floppy Disk and Protective Envelope

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, 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 meets the requirements of the following documents:

X3138/77-118	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

Function	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 a 4 microseconds wide (see Figure 1-3).

Track Format

The flexible disk contains 77 tracks. The first (outside) track is track 00, and the last (inside) track is 76. 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 guard band is established to protect the data from adjacent track crosstalk when reading.

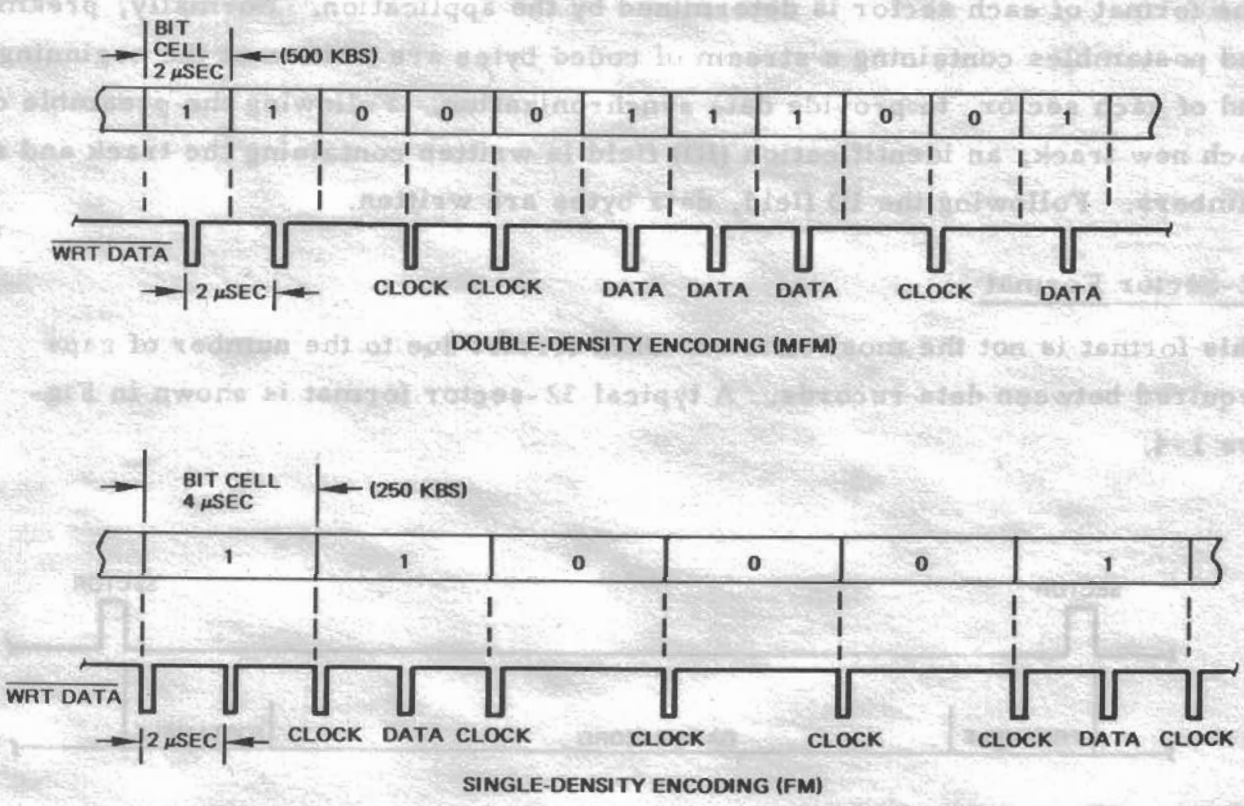


Figure 1-3. Single and Double Density Encoding

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 one 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 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.

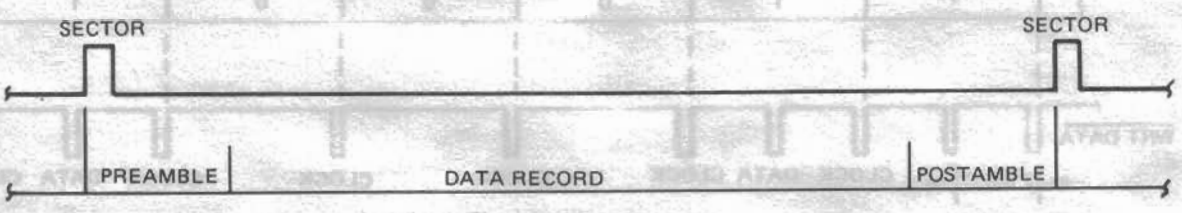


Figure 1-4. 32-Sector Format

IBM 3740 Format

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

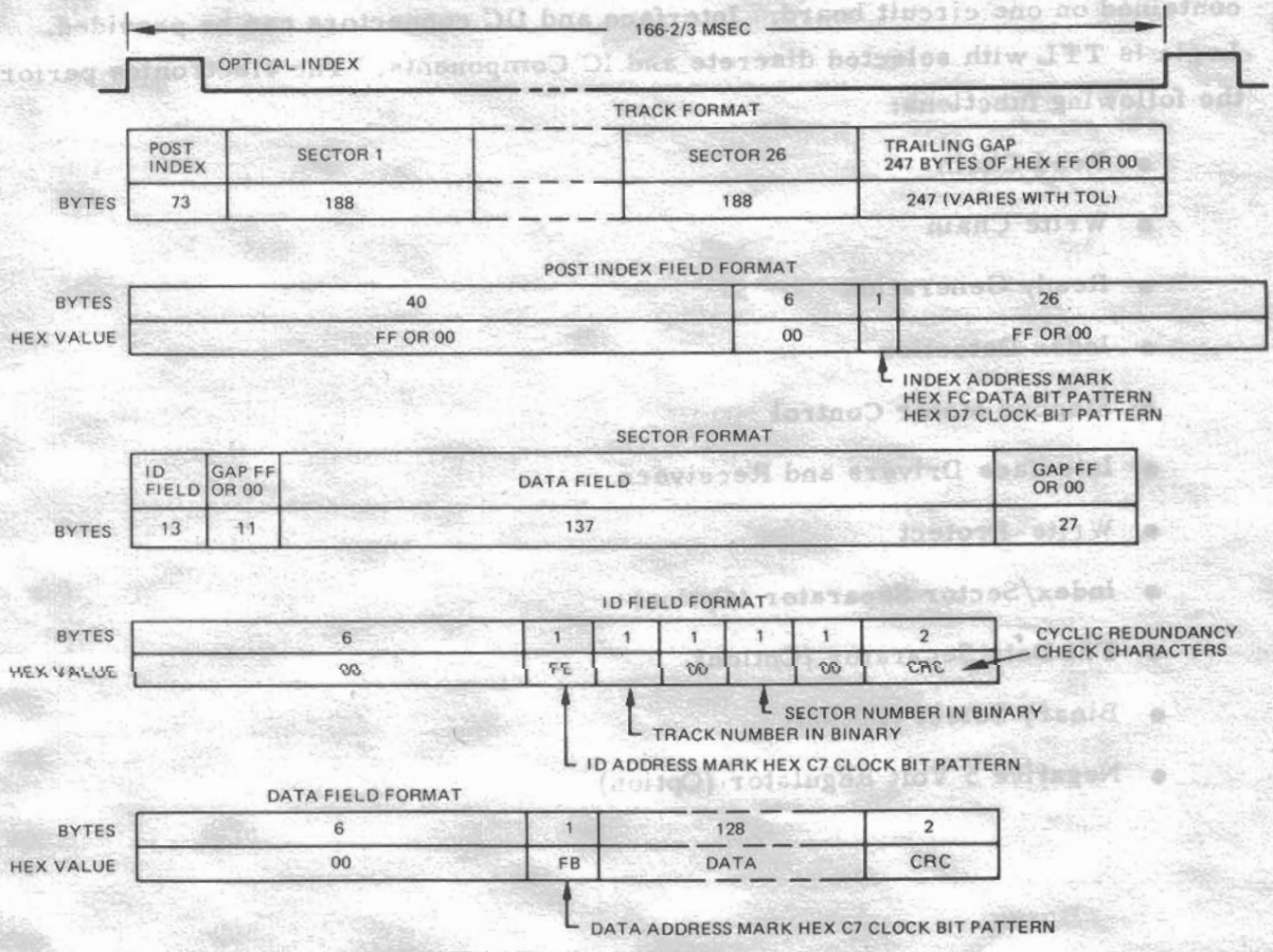


Figure 1-5. IBM 3740 Format

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
- Index Detection
- Stepper Motor Control
- Interface Drivers and Receivers
- Write-Protect
- Index/Sector Separator (Option)
- FM Data Separator (Option)
- Binary Select (Option)
- Negative 5 Volt Regulator (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 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 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.
- Optional 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 platten 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, 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.

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.

-5V Regulator

In the basic configuration, the controller must provide -5 volts, ±5 percent at 0.08 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 Head Load

In the basic configuration, the controller issues a $\overline{\text{HDLD}}$ command after the unit has been selected. When the AUTO HEAD 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 $\overline{\text{HDLD}}$ command, by installing jumpers 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 for the $\overline{\text{HDLD}}$ status signal, one of the following status signals:

- $\overline{\text{IN USE}}$ (signal from controller)
- $\overline{\text{SELECT}}$
- $\overline{\text{RDY}}$

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 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	6-8 milliseconds	6-8 milliseconds
Track 0 - Track 76	456 milliseconds	456 milliseconds
38-Track Move	226 milliseconds	226 milliseconds
Settling Time	24 milliseconds	24 milliseconds
Head Engage Time	25 milliseconds	25 milliseconds

Table 1-2. Principal Specifications (Continued)

Function	Characteristics	
	Single-Density	Double-Density
Data Transfer Rate	250 kilobits/sec	500 killobits/sec
Erase/Write Recovery Time	580 microseconds (req'd for read to stabilize after write completed)	580 microseconds (req'd 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	0.013 inch	
Tunnel Erase Width	0.006 inch (on either side of track)	
Spacing Between Tracks	0.02083 inch	
Track Centerline Radius	$2.029 + \frac{76 - N}{48}$ 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	120V ± 10% 60 Hz ± 0.5 Hz	
Optional	120V ± 10% 50 Hz ± 0.5 Hz 220V ± 10% 60 Hz ± 0.5 Hz 220V ± 10% 50 Hz ± 0.5 Hz	
Voltage Dropout	100%, 10 milliseconds once each 600 seconds	

Table 1-2. Principal Specifications (Continued)

Function	Characteristics	
Motor Current (Max)		
Start	1.0 ampere for 115 volts AC 0.6 amperes for 230 volts AC	
Run	0.5 amperes for 115 volts AC 0.3 amperes for 230 volts AC	
DC Input Power	+24 volts ± 5%, 1.6 amperes maximum + 5 volts ± 5%, 1.0 amperes maximum	
Minus Voltage Standard Optional	-5 Volts ± 5%, 0.08 amperes maximum -7 to -16 volts (with -5V Regulator enabled)	
Reliability MTBF MTTR	6000 hours (after initial 200 hours) Less than 20 minutes	
Read Errors Recoverable Non-recoverable (after 10 tries)	Less than 1 in 10^9 Less than 1 in 10^{12}	
	Operating	Non-Operating
Environmental		
Temperature	40° to 115°F (4° to 46°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	NA
Dimensions and Weight		
Dimensions	See Figure 1-6	
Weight	12.5 pounds	

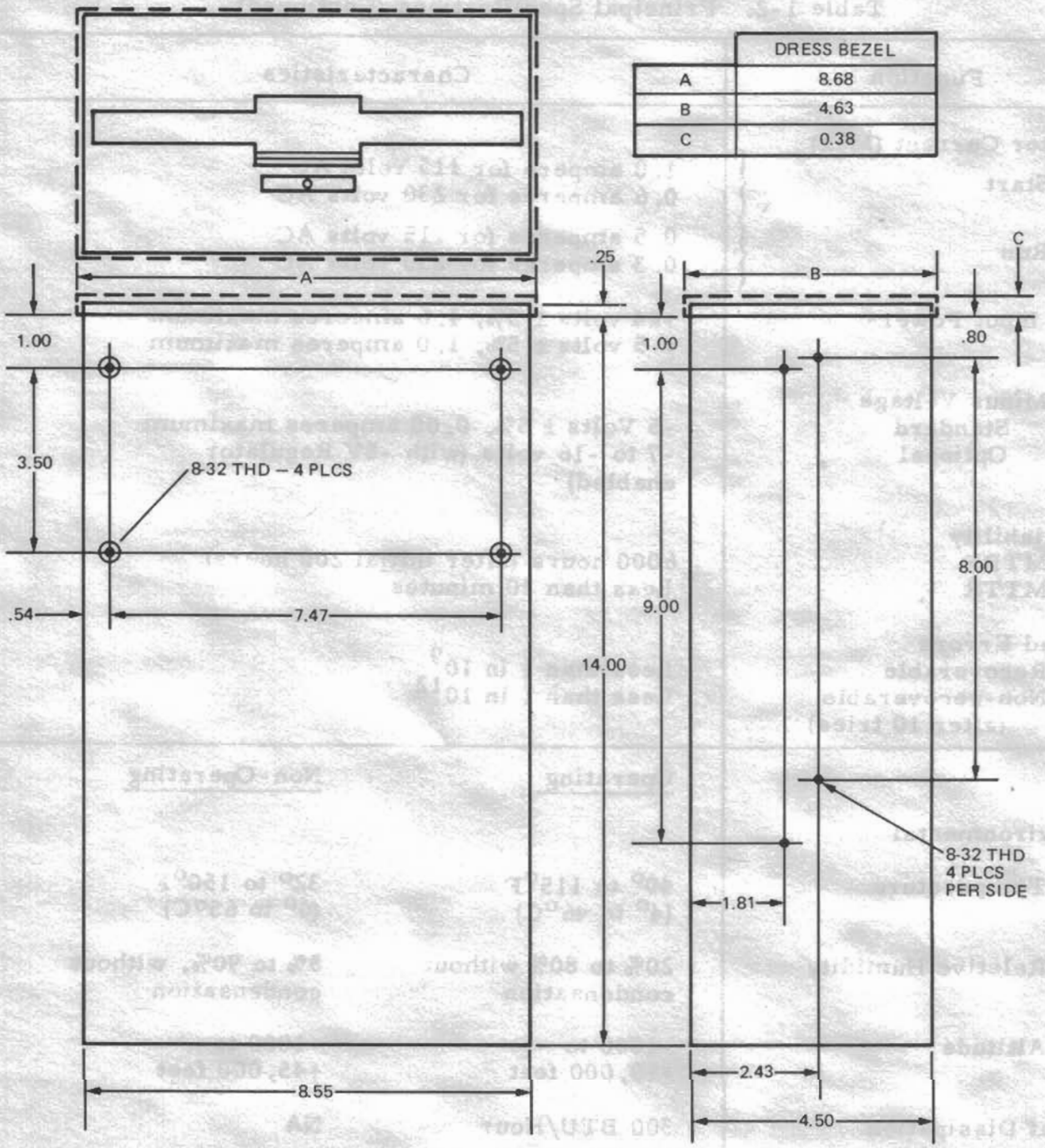


Figure 1-6. Physical Dimensions and Mounting Provisions

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.

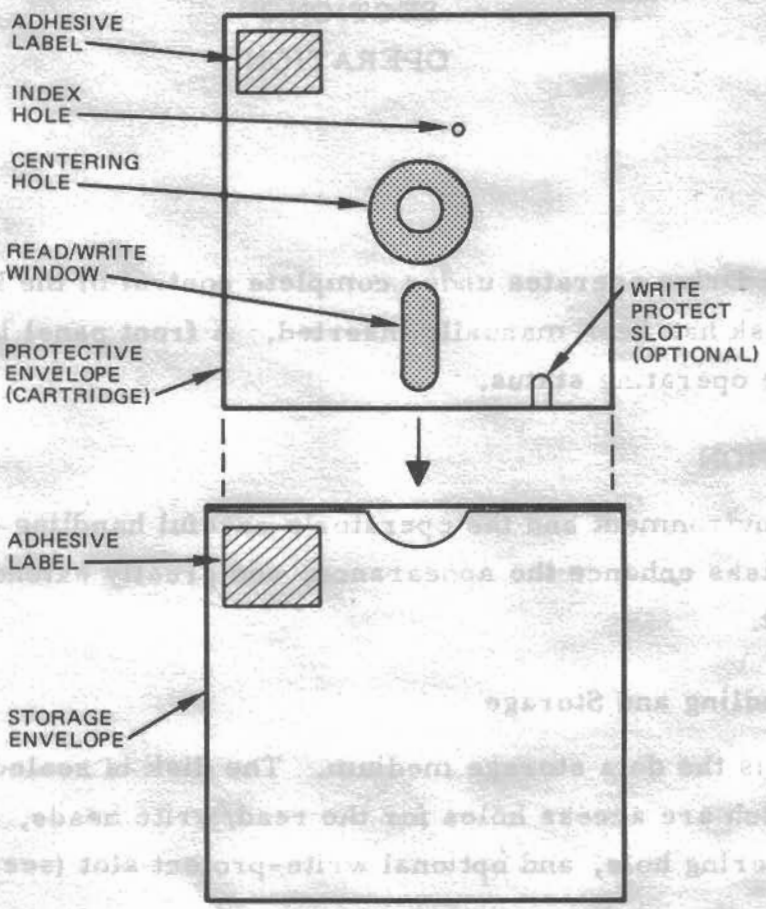


Figure 2-1. Floppy Disk and Storage Envelope

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.

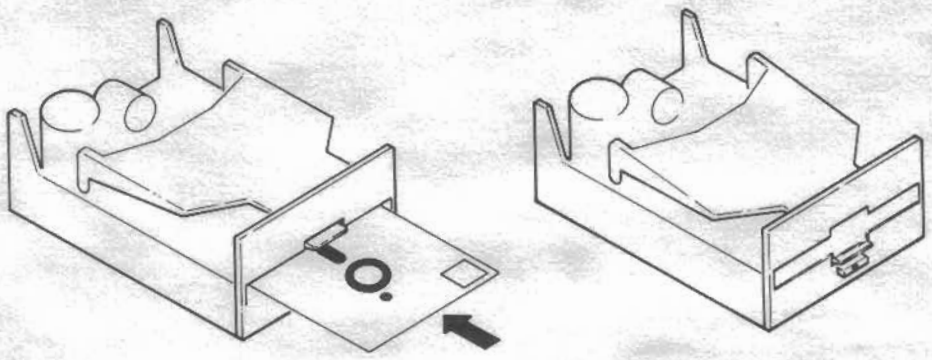


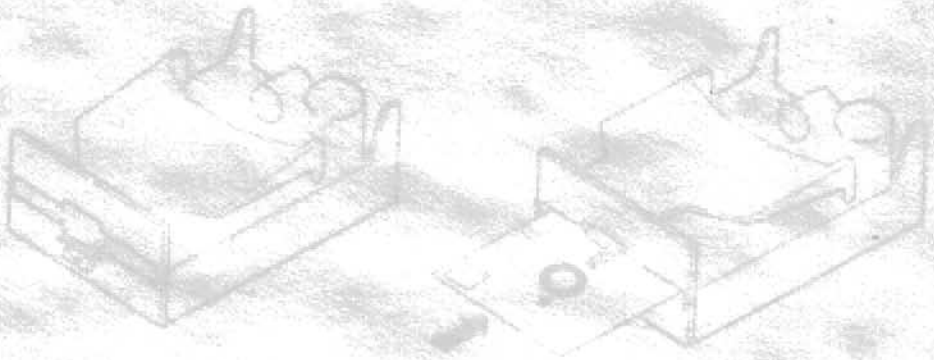
Figure 2-2. Floppy Disk Loading

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

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 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

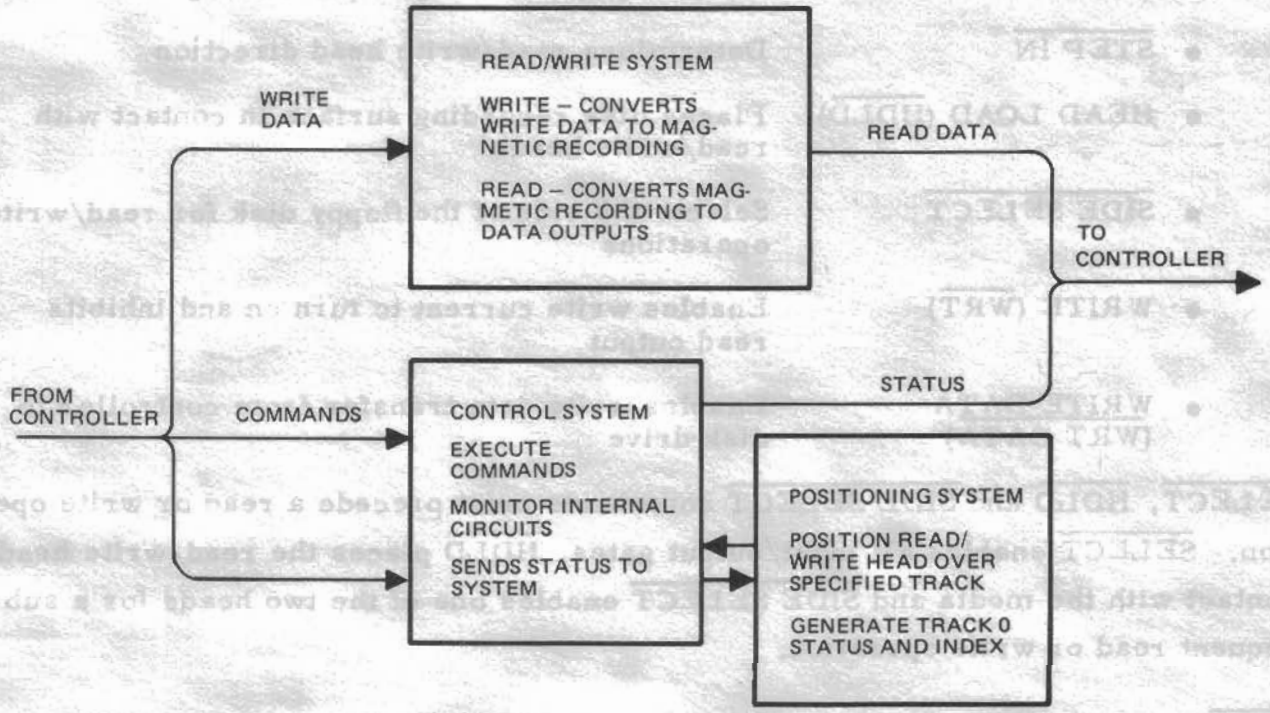


Figure 3-1. Floppy Disk Drive, Simplified Block Diagram

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 ($\overline{\text{HDLD}}$)	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 (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)
- $\overline{\text{TRACK 00}}$ — Read/write head positioned at track 00
- $\overline{\text{INDEX}}$ — Start of new track
- $\overline{\text{SECTOR}}$ — Start of new sector (if sector disk used)
- $\overline{\text{READY}}$ — Signifies disk drive is operational
- $\overline{\text{ILLEGAL PACK}}$ — Signals selection of the second side of a single-sided pack

$\overline{\text{READY}}$ and $\overline{\text{WRT PROTECT}}$ 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. 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 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 $\overline{\text{STEP}}$ 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 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 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 166 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 $\overline{\text{HDLD}}$ command is issued. 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 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 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.

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 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.

The disk drive comprises the following functional systems:

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

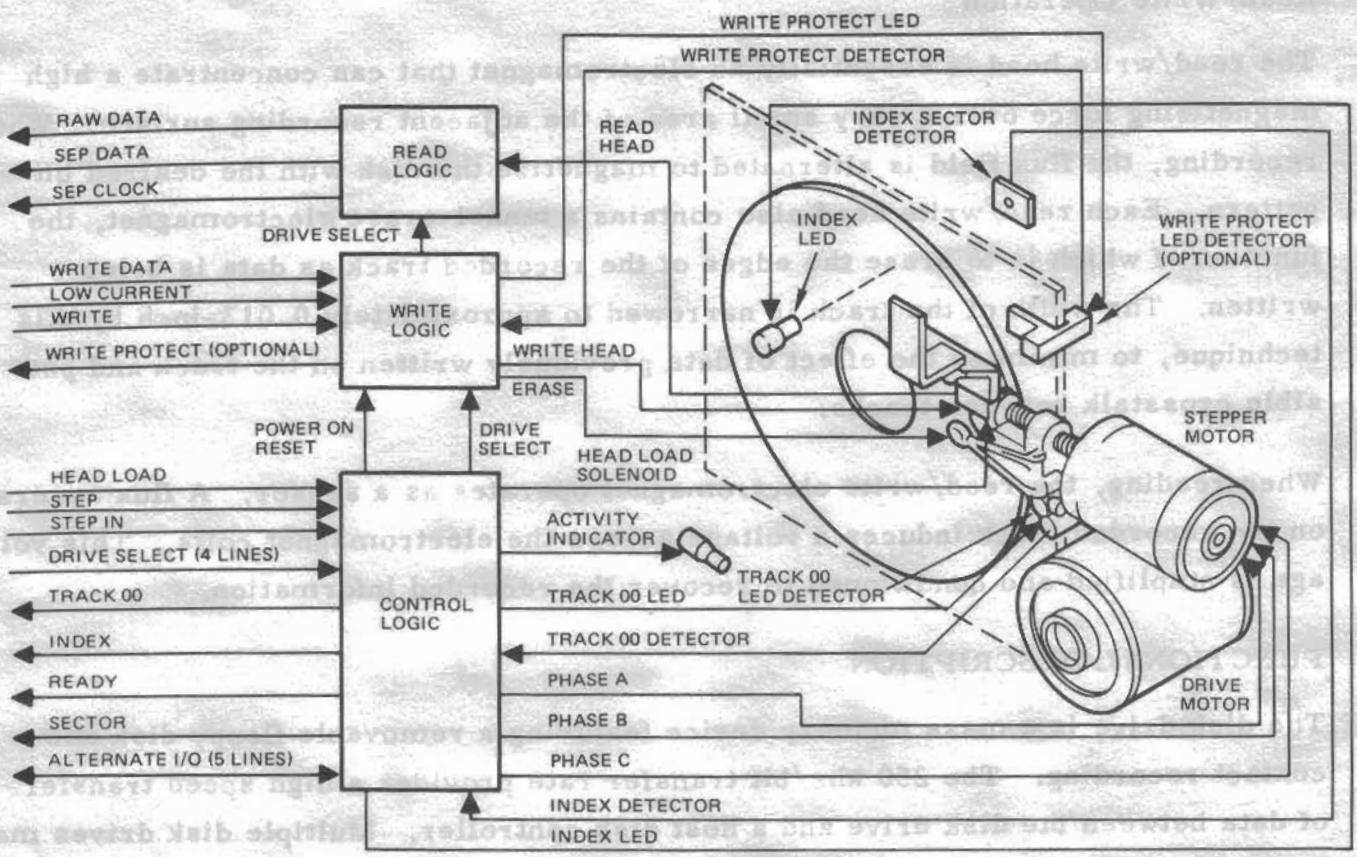


Figure 3-2. Detailed Functional Block Diagram

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 120 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 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.

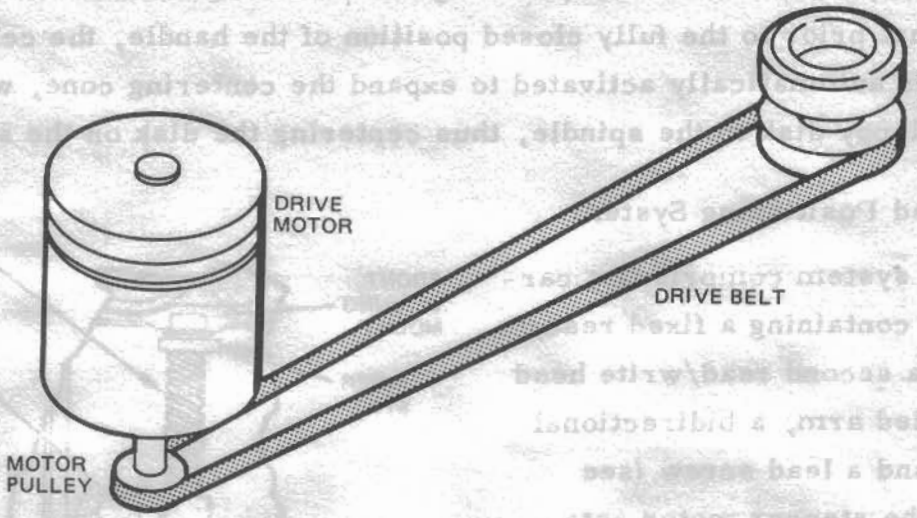


Figure 3-3. Spindle Drive System

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:

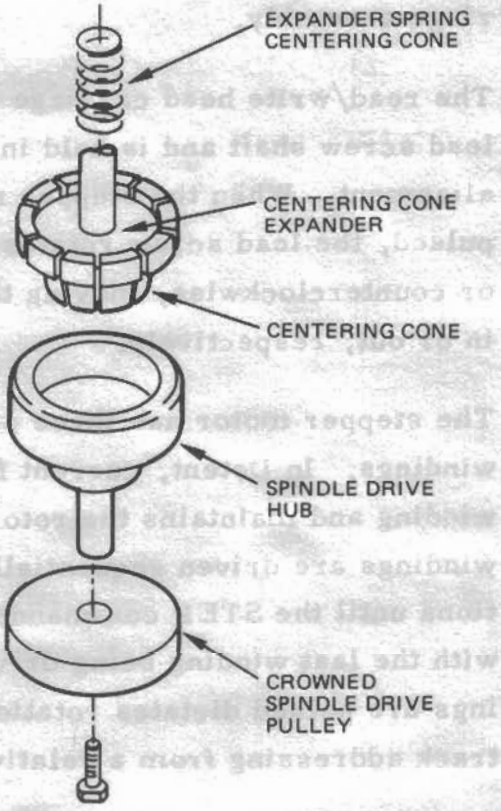


Figure 3-4. Spindle System

- 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 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.

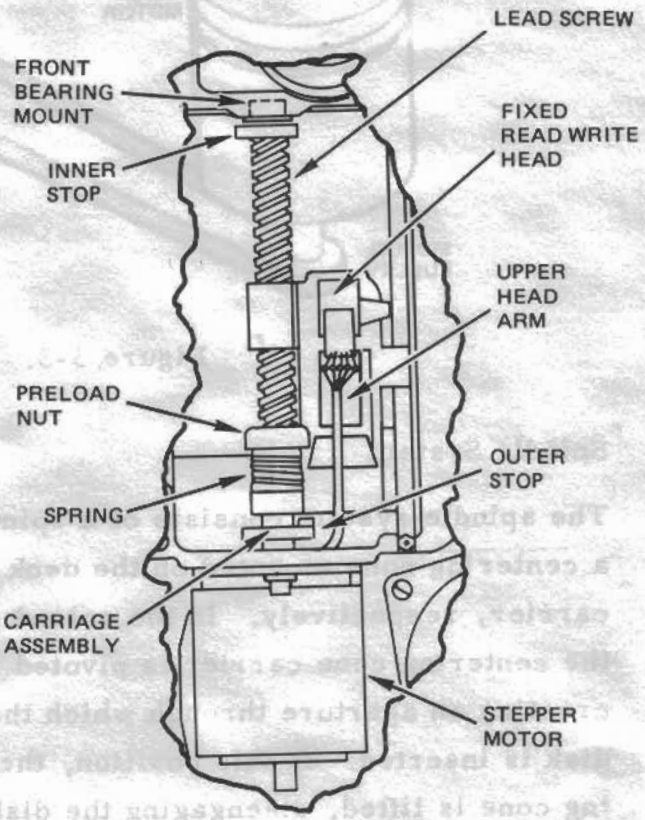


Figure 3-5. Read/Write Head Positioning System

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.

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 HDLD 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

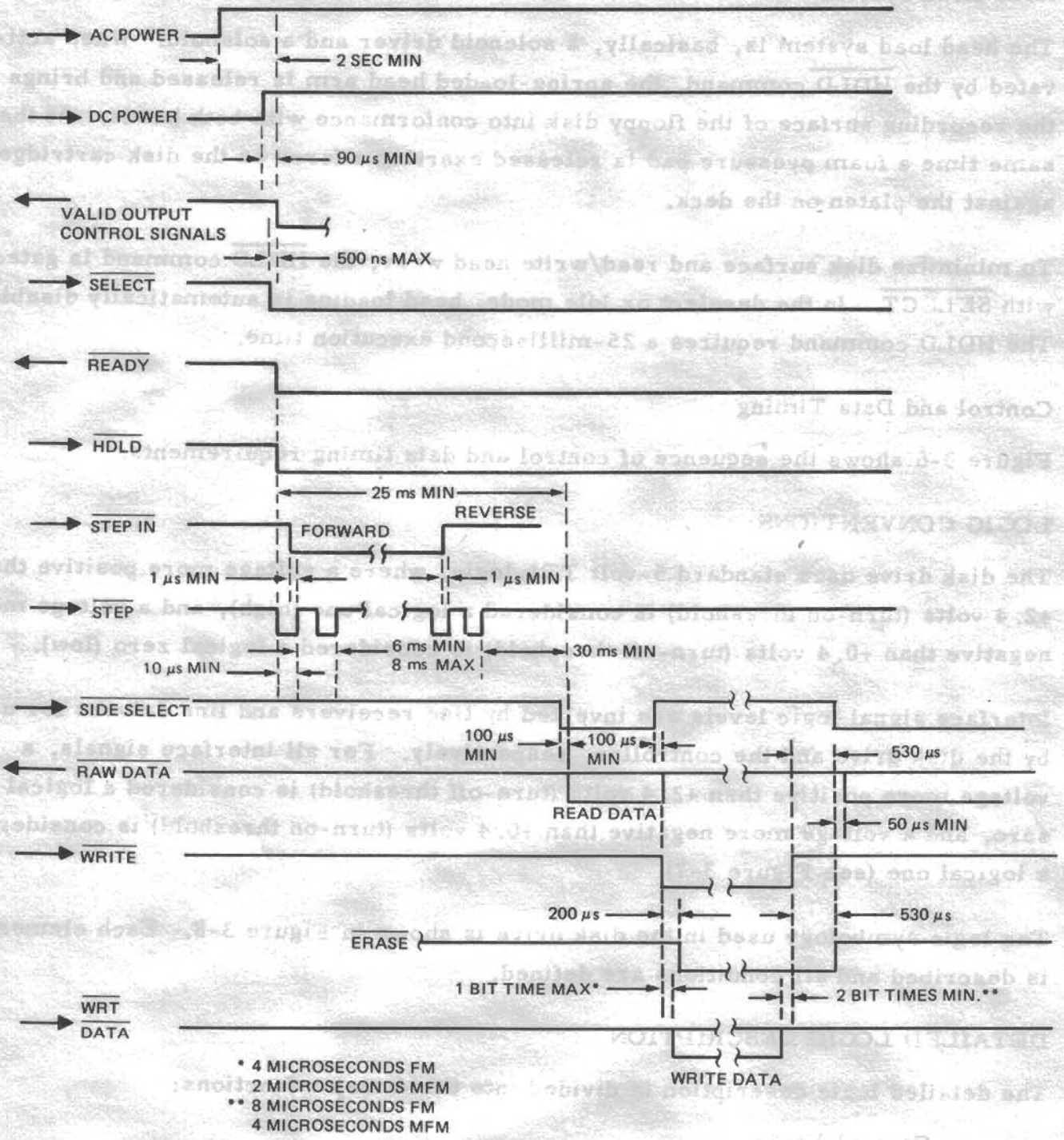


Figure 3-6. Control and Data Timing

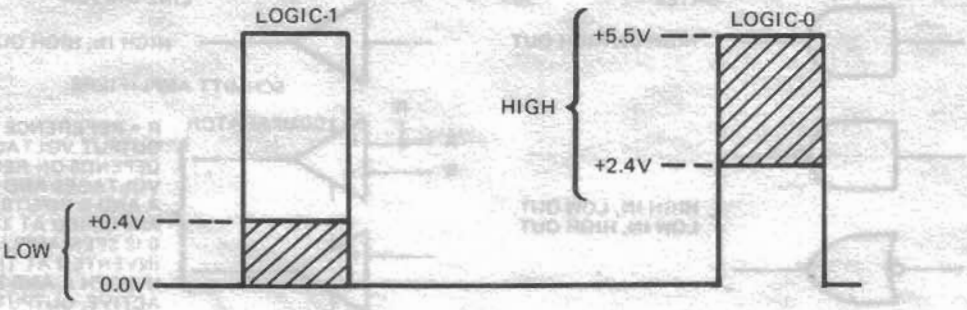


Figure 3-7. Interface Logic Levels

CONTROL LOGIC

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

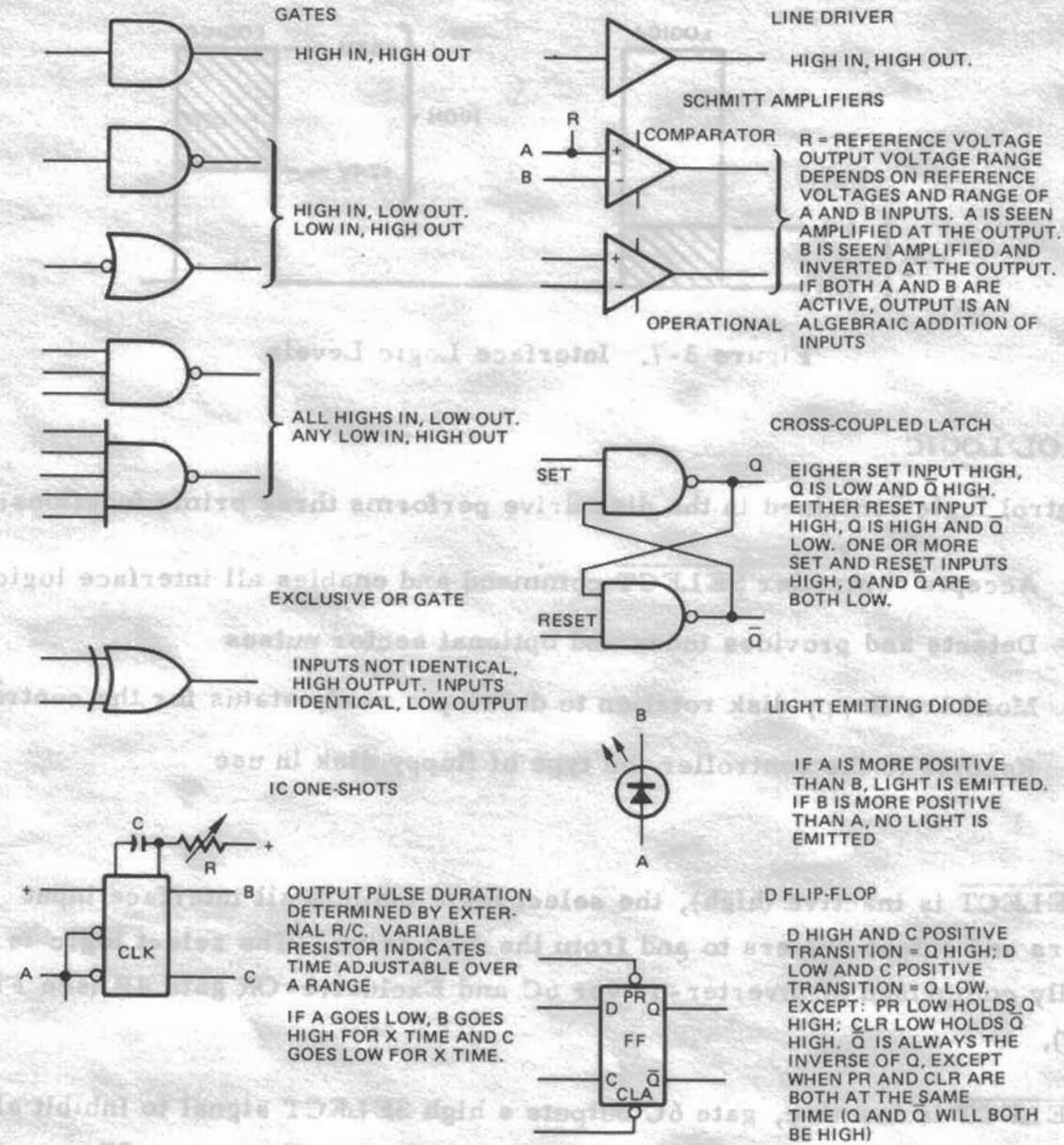
- Accepts controller $\overline{\text{SELECT}}$ command and enables all interface logic
- Detects and provides index and optional sector pulses
- Monitors floppy disk rotation to develop a ready status for the controller
- Reports to the controller the type of floppy disk in use

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 inverter-driver 6C and Exclusive-OR gate 4B (see Figure 3-9).

When $\overline{\text{SELECT}}$ is inactive, gate 6C outputs a high SELECT signal to inhibit all ready, index sector, write-protect, and track 00 logic. Exclusive-OR 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 $\overline{\text{SELECT 0}}$ to drive 6C. 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.



NOTE: LOCATION DESIGNATORS ON IC's, TRANSISTORS, AND CONNECTORS REFER TO THE FDD 110-8B. DESIGNATORS FOR THE FDD 110-8C ARE SHOWN IN PARANTHESES WHEN DIFFERENT FROM THE FDD 110-8B.

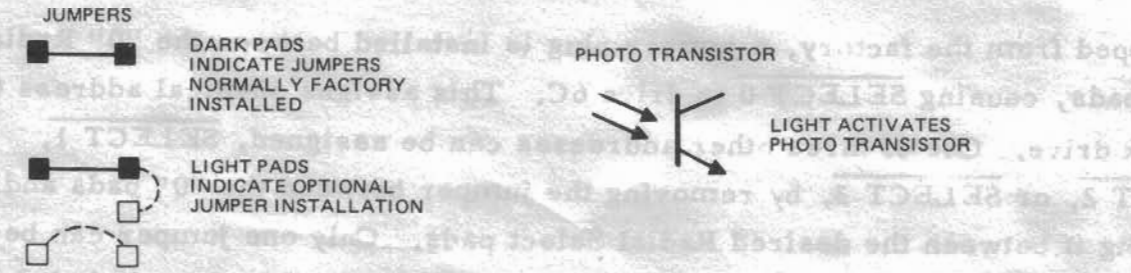


Figure 3-8. Logic Symbology

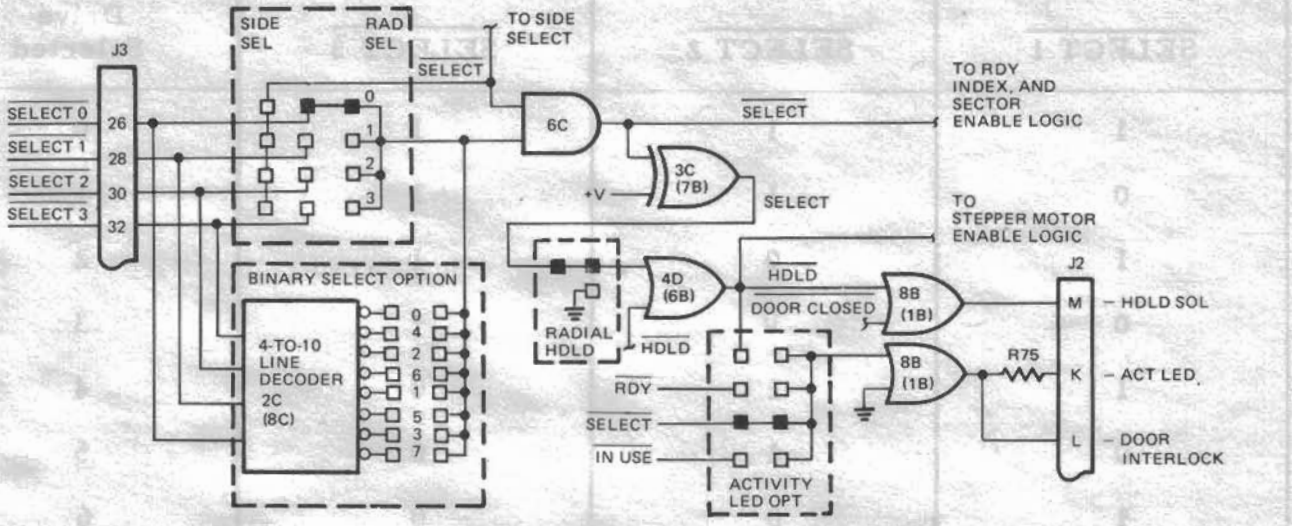


Figure 3-9. Select Logic

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 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.

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)

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 1B is driven by the output of the activated phototransistor. For INDEX 0, resistor R5 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 R10, R11 and R28 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 ORed by gate 7D, conditioned by READY through gate 6B, and input to interface line driver 8B. Figure 3-11 shows index pulse timing.

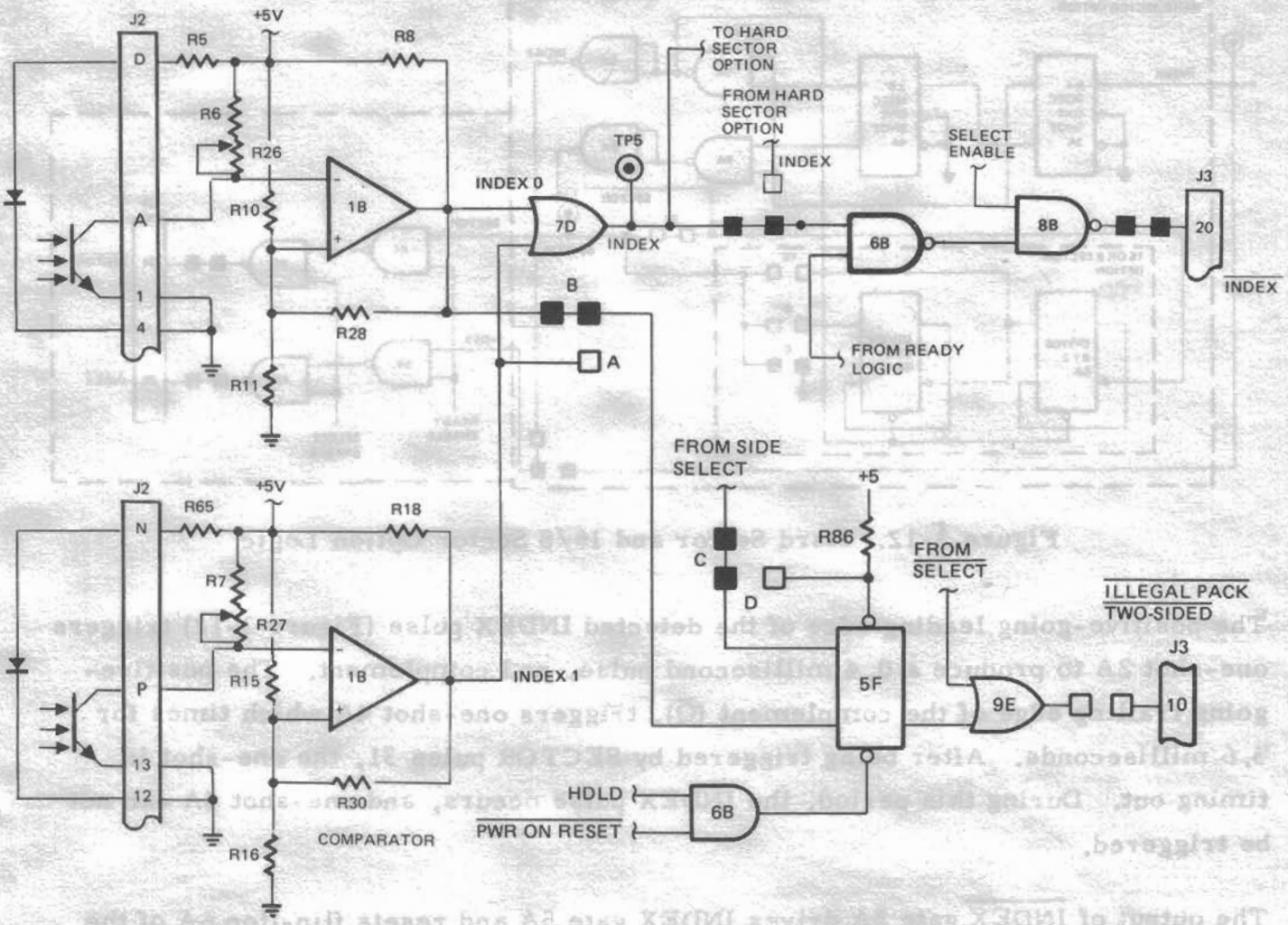


Figure 3-10. Index Detection Logic

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.

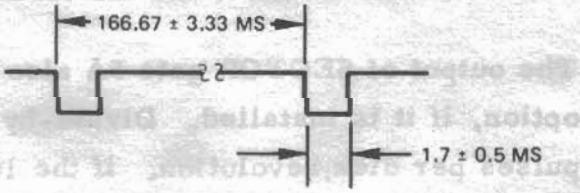


Figure 3-11. Index Timing

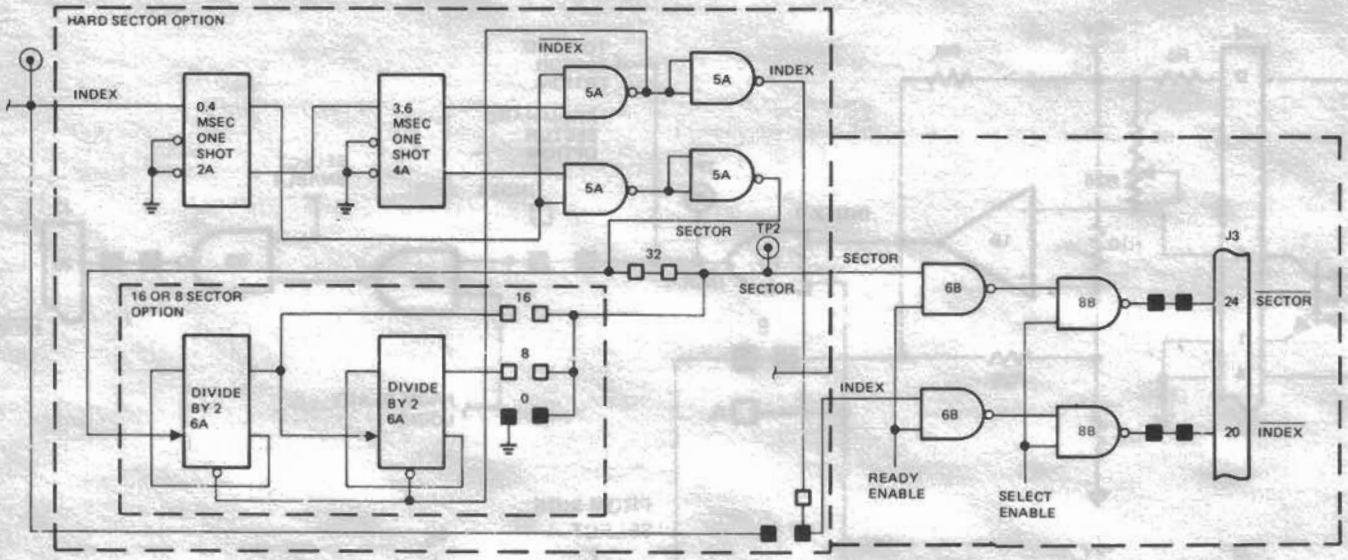


Figure 3-12. Hard Sector and 16/8 Sector Option Logic

The positive-going leading edge of the detected INDEX pulse (Figure 3-12) triggers one-shot 2A to produce a 0.4 millisecond pulse, and complement. The positive-going trailing edge of the complement ($\overline{Q}$), triggers one-shot 4A 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 4A can not be triggered.

The output of $\overline{\text{INDEX}}$ gate 5A drives INDEX gate 5A and resets flip-flop 6A of the 16 or 8 Sector divider logic. The output of INDEX gate 5A is input to READY ENABLE gate 6B and the Ready logic. SECTOR Gate 6C provides the SECTOR pulse inputs to gate 6B if the 32-sector jumper is installed. Drivers 8B gate $\overline{\text{INDEX}}$ and $\overline{\text{SECTOR}}$ to the interface.

The output of SECTOR gate 5A also drives the clock input to the 16 or 8 Sector option, if it is installed. Divide-by-2 flip-flop 6A 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 to the controller. Figure 3-13 shows $\overline{\text{INDEX}}$ and $\overline{\text{SECTOR}}$ timing.

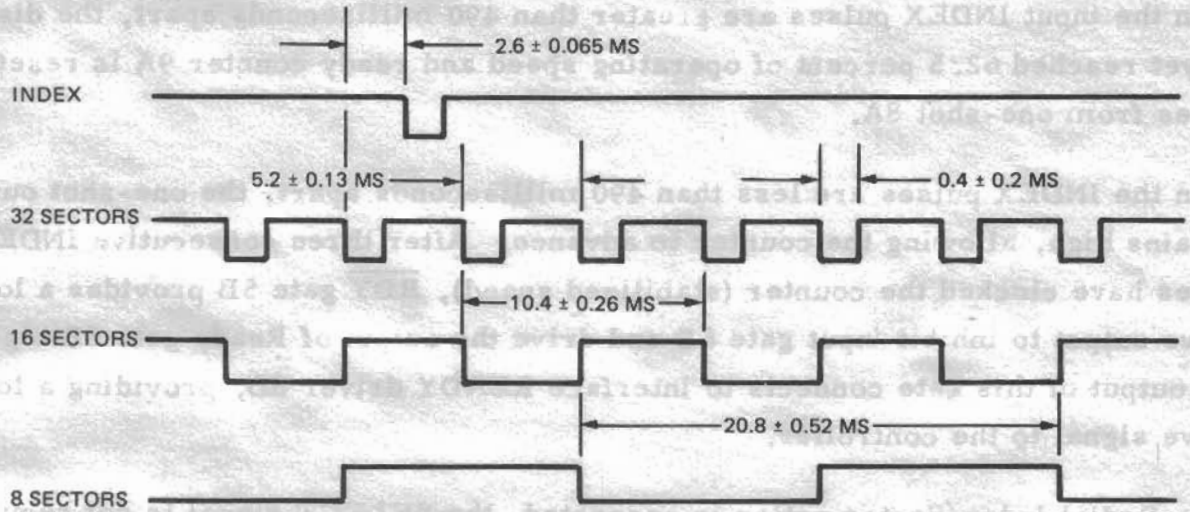


Figure 3-13. INDEX/SECTOR Timing

Ready

The Ready logic is used to monitor the INDEX pulse for the rotational speed of the 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 8A, whose nominal time is 490 milliseconds (see Figure 3-14).

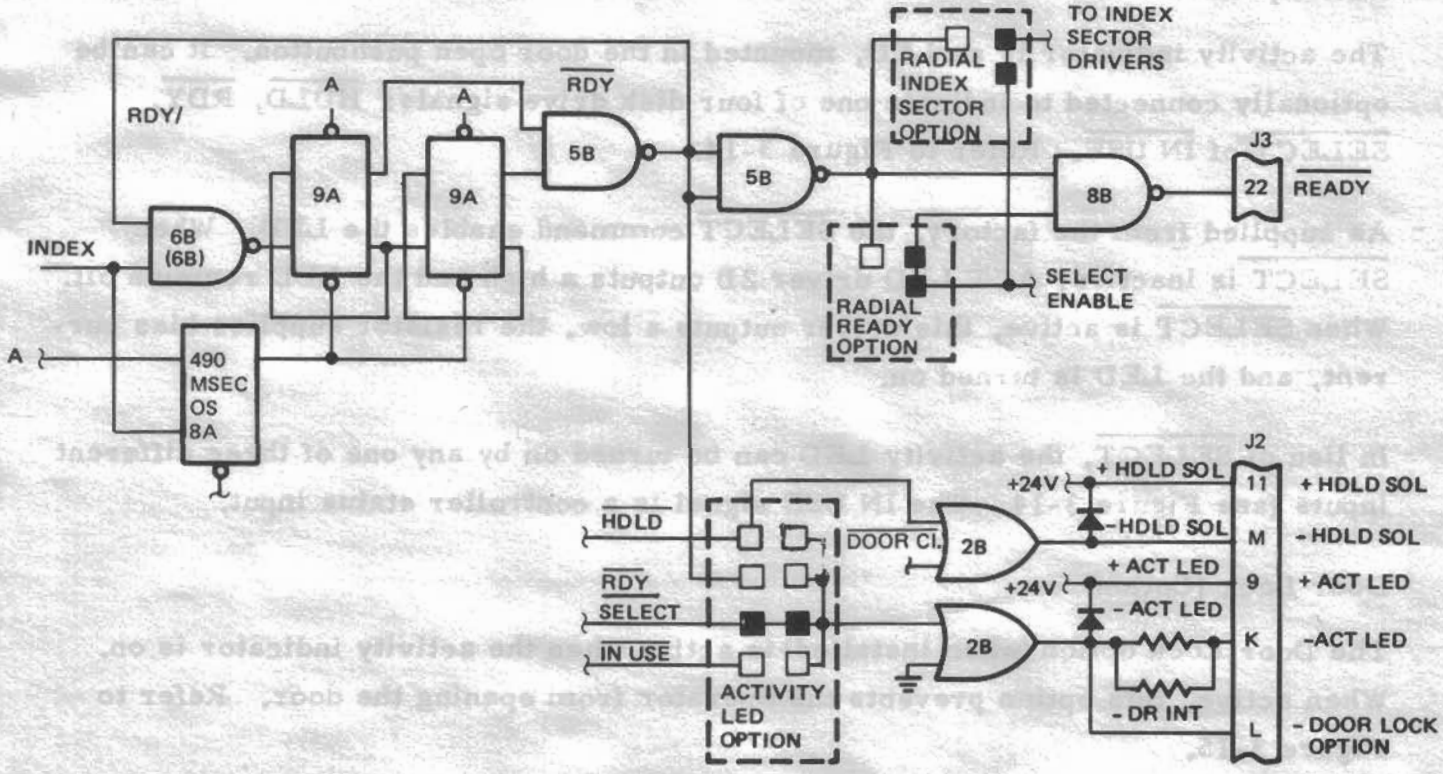


Figure 3-14. Ready Logic

When the input INDEX pulses are greater than 490 milliseconds apart, the disk has not yet reached 62.5 percent of operating speed and ready counter 9A is reset by pulses from one-shot 8A.

When the INDEX pulses are less than 490 milliseconds apart, the one-shot output remains high, allowing the counter to advance. After three consecutive INDEX pulses have clocked the counter (stabilized speed), $\overline{\text{RDY}}$ gate 5B provides a low active output to inhibit input gate 6B and drive the output of Ready gate 5B high. The output of this gate connects to interface READY driver 8B, providing a low active 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 $\overline{\text{READY}}$ interface driver. In both conditions, the disk drive need not be selected by the controller until the disk is up-to-speed and ready. 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.

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: $\overline{\text{HDLD}}$, $\overline{\text{RDY}}$, $\overline{\text{SELECT}}$ of $\overline{\text{IN USE}}$. Refer to Figure 3-14.

As supplied from the factory, the $\overline{\text{SELECT}}$ command enables the LED. When $\overline{\text{SELECT}}$ is inactive, ACT LED driver 2B outputs a high and the LED remains off. When $\overline{\text{SELECT}}$ is active, this 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 three different inputs (see Figure 3-14. The $\overline{\text{IN USE}}$ signal is a controller status input.

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.

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). If an Index 0 pulse is detected at the time that side select is active, flip-flop 5F will be set. A low active input from 5F and a low active $\overline{\text{SELECT}}$ on gate 9E generates the low active interface signal $\overline{\text{ILLEGAL PACK}}$. Flip-flop 5F remains set until HDLD or $\overline{\text{PWR ON RESET}}$ are made low on the input of gate 6B.

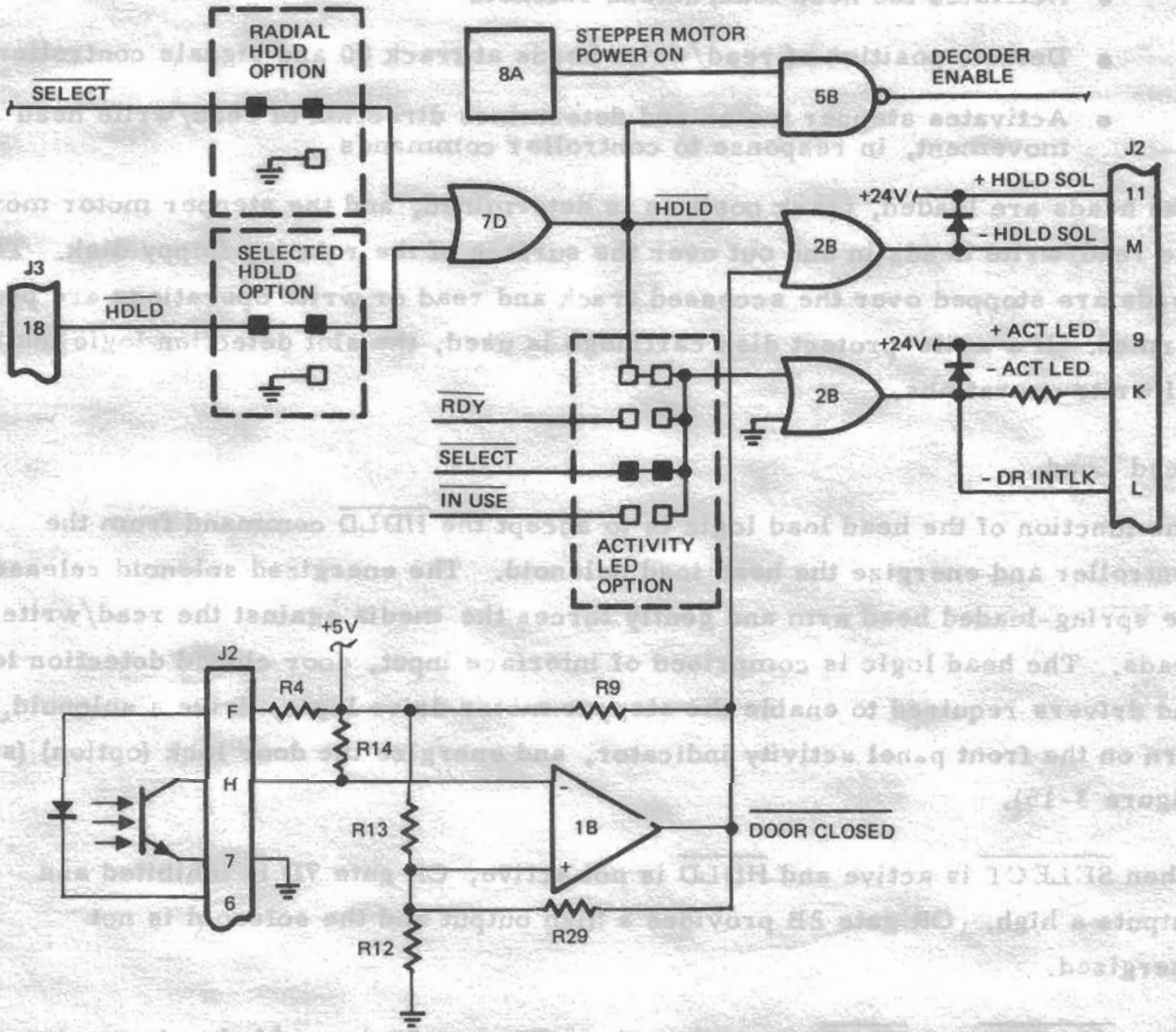


Figure 3-15. Head Load Logic

Two-Sided (Option)

The drive may optionally be configured to present $\overline{\text{TWO-SIDED}}$ on the interface instead of $\overline{\text{ILLEGAL PACK}}$. This signal will be active whenever a dual sided pack is installed in the disk drive. The D input of flip-flop 5F is jumpered to R86 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 heads are unloaded.

READ/WRITE HEAD POSITIONING LOGIC

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

- Activates the head load/unload solenoid
- Detects position of read/write heads at track 00 and signals controller
- 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).

When $\overline{\text{SELECT}}$ is active and $\overline{\text{HDLD}}$ is not active, OR gate 7D is inhibited and outputs a high. OR gate 2B provides a high output and the solenoid is not energized.

When $\overline{\text{SELECT}}$ and $\overline{\text{HDLD}}$ are both active, OR gate 7D is enabled and outputs a low to OR gate 2B.

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 1B will be low providing an enable to solenoid driver 2B.

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 2C is low enabling NOR gate 3B (see Figure 3-16).

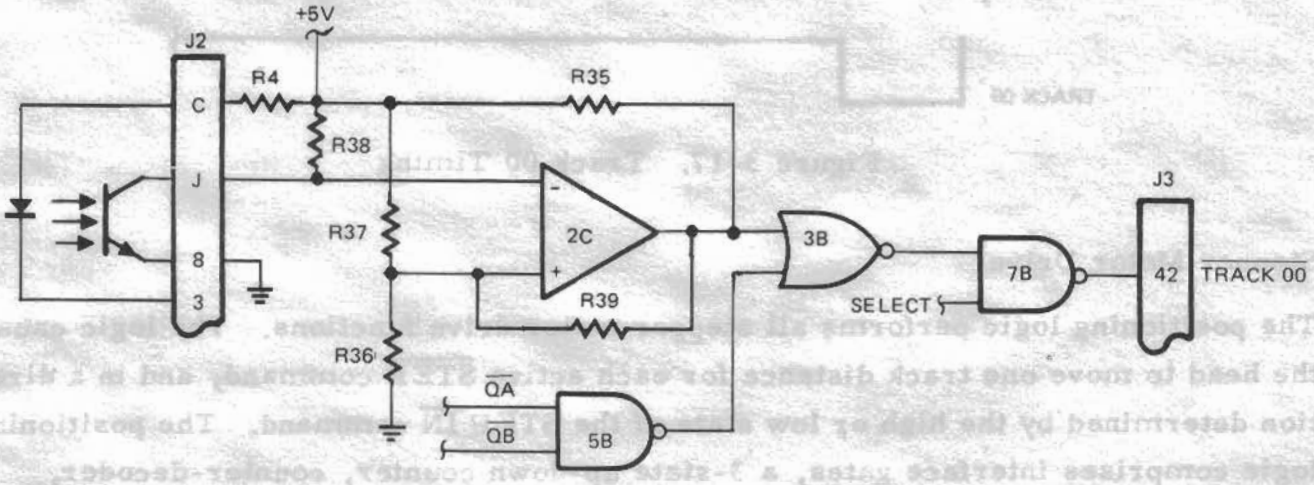


Figure 3-16. Track 00 Logic

Phase A of the stepper motor control is decoded by NAND gate 5B providing a low active enable for the Track 00 detection logic at the other input of NOR gate 3B. The high output of NOR gate 3B enables gate 7B to send an active low $\overline{\text{TRACK 00}}$ signal to the host controller.

When phase A goes low, the output of gate 5B goes high, inhibiting NOR gate 3B. The TRACK 00 signal goes high indicating the read/write head is beyond track 00. Refer to timing diagram Figure 3-17.

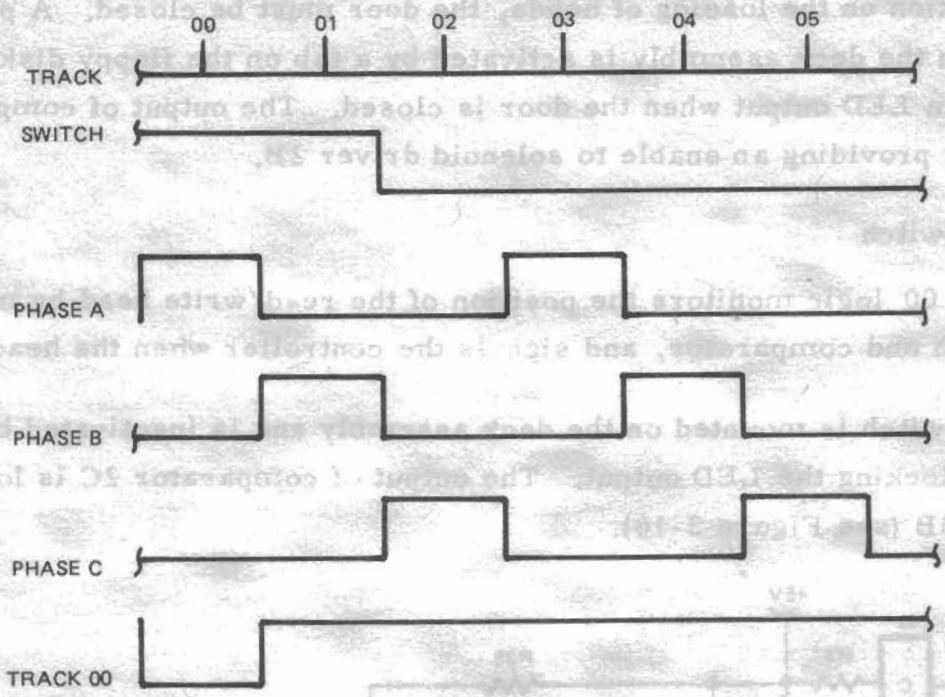


Figure 3-17. Track 00 Timing

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, a 3-state up-down counter, counter-decoder, stepper motor drive logic and a stepper motor power-on one-shot.

Interface Gating

When an active $\overline{\text{STEP}}$ pulse occurs interface $\overline{\text{STEP}}$ gate 6D outputs a positive pulse driving gate 6C. If it has been enabled by an inactive $\overline{\text{STEP INHIBIT}}$, gate 6C outputs an active high signal driving OR gate 3B, which outputs a negative step pulse (see Figure 3-18).

The trailing edge of this step pulse triggers the 28-millisecond one-shot 8A causing gate 5B to output a high enabling Decoder gate 7E to apply drive power to the stepper motor.

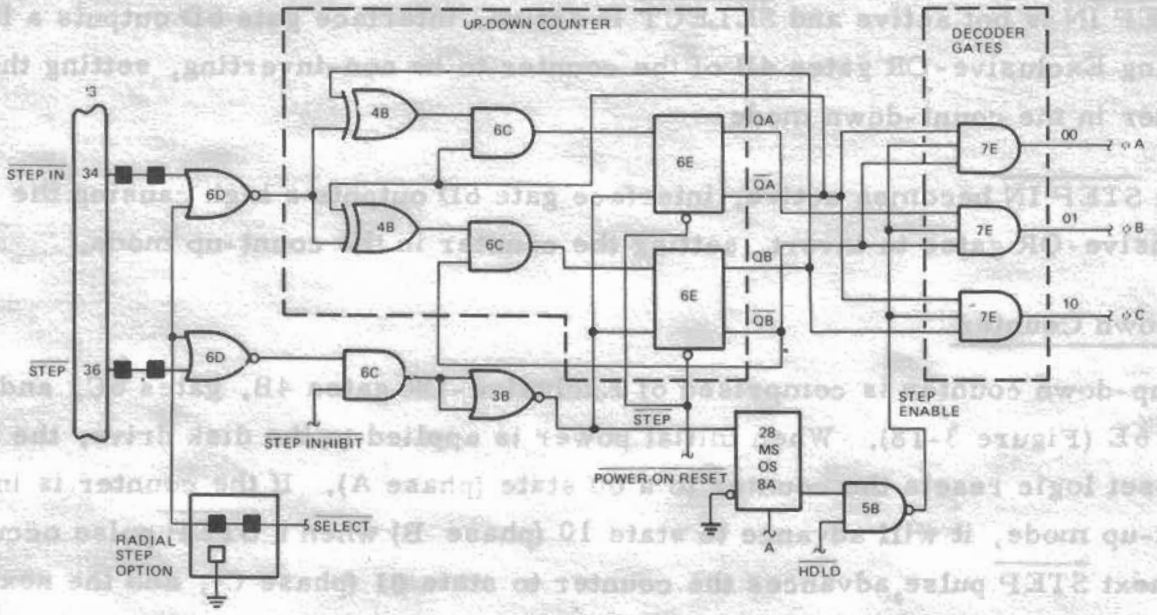


Figure 3-18. Stepper Motor Interface Gating Logic

The trailing edge of the step pulse clocks the 3-state counter, causing a count-up or count-down as determined by the $\overline{\text{STEP IN}}$ interface signal. Refer to Figure 3-19 for stepper monitoring.

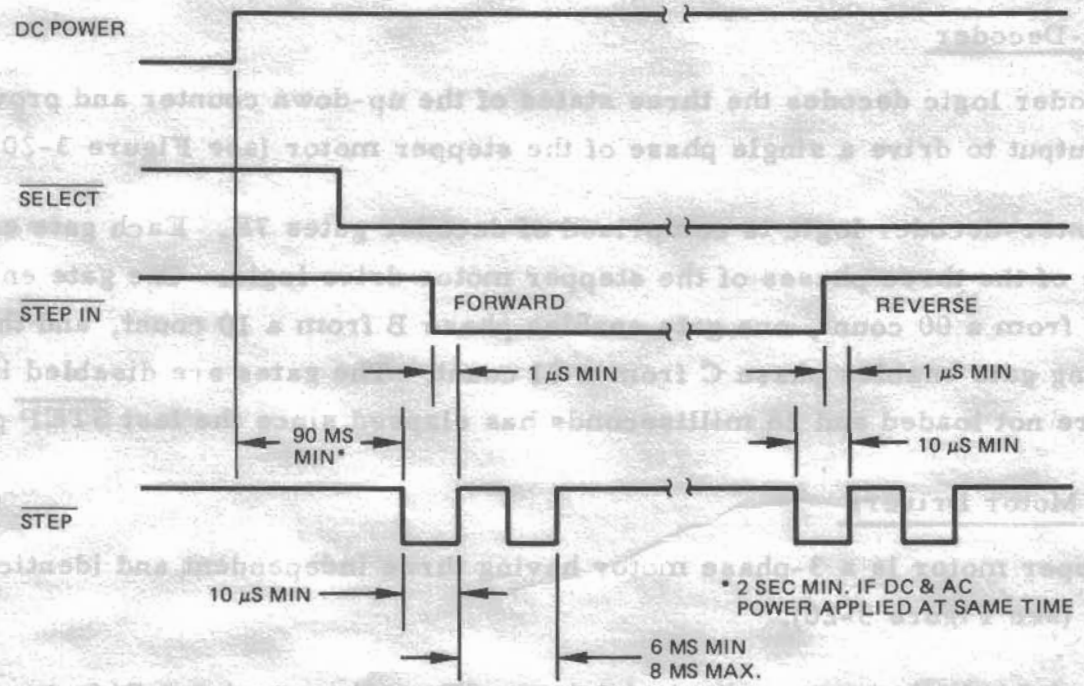


Figure 3-19. Stepper Motor Timing

If $\overline{\text{STEP IN}}$ is not active and $\overline{\text{SELECT}}$ is active, interface gate 6D outputs a low causing Exclusive-OR gates 4B of the counter to be non-inverting, setting the counter in the count-down mode.

When $\overline{\text{STEP IN}}$ becomes active, interface gate 6D outputs a high causing the Exclusive-OR gates to invert, setting the counter in the count-up mode.

Up-Down Counter

The up-down counter is comprised of Exclusive-OR gates 4B, gates 6C, and flip-flops 6E (Figure 3-18). 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 10 (phase B) when a $\overline{\text{STEP}}$ pulse occurs. The next $\overline{\text{STEP}}$ pulse advances the counter to state 01 (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.

If the counter is in the count-down mode, it will decrement to state 01 on the next $\overline{\text{STEP}}$ pulse. Subsequent pulses will continue the count-down cycle until the $\overline{\text{STEP}}$ 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 3-20).

The counter-decoder logic is comprised of decoder gates 7E. Each gate enables only one of the three phases of the stepper motor drive logic. One gate enables phase A from a 00 count, one gate enables phase B from a 10 count, and the remaining gate enables phase C from a 01 count. The gates are disabled if the heads are not loaded and 28 milliseconds has elapsed since the last $\overline{\text{STEP}}$ pulse.

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 8E, pull up resistor R69, transistor Q5, and flyback diode CR4. When the decoder gate outputs a low (code 00 not

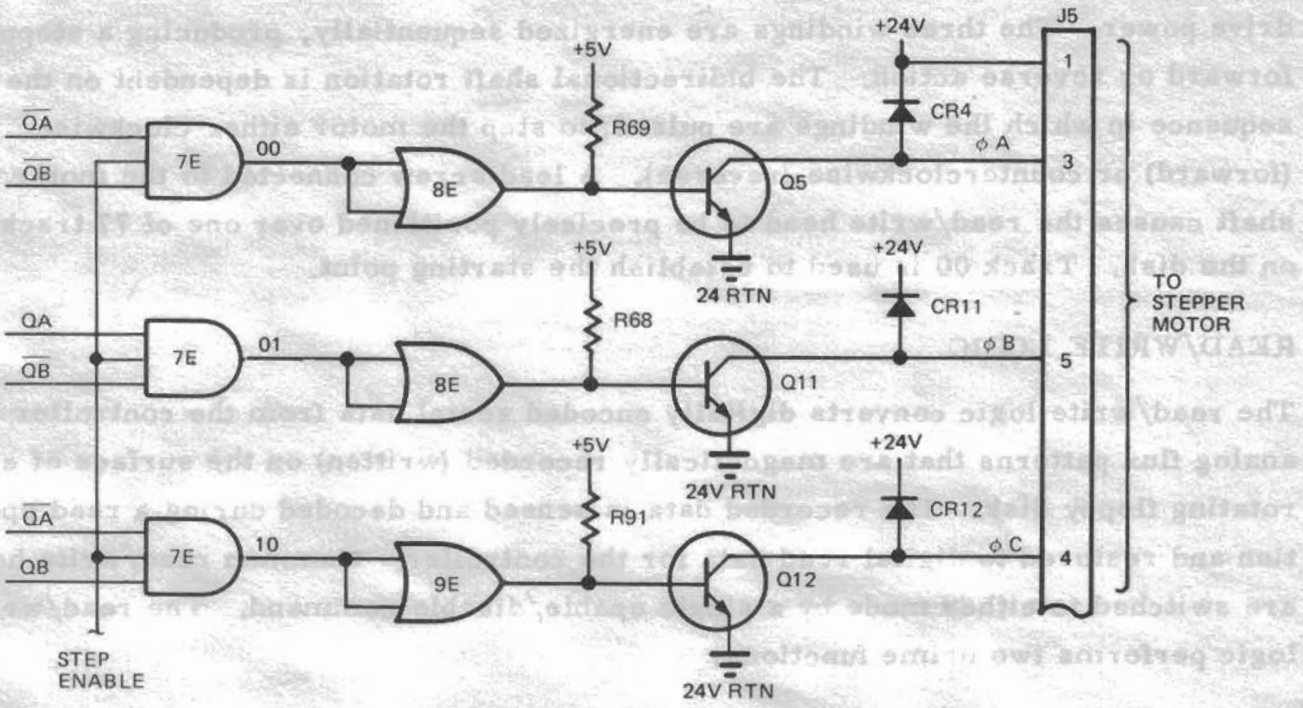


Figure 3-20. Stepper Motor Drivers Logic

detected), the drivers produce a low output, Q7 is cut off and phase A is not energized. When the 7E gate outputs a high (code 00 detected), the drivers produce a high output turning on Q5, and phase A is energized. When Q5 turns off, diode CR4 restricts the emitter of Q5 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 Power-On One-Shot

Power on one-shot 8A is retriggerable, and times out after 28 milliseconds (see Figure 3-18). At each STEP pulse the one-shot fires, the decode gates are enabled and, for 28 milliseconds, drive power is applied to the stepper motor. Enable gate 5B OR's the output of 8A and Headload Enable gate 5B (Figure 3-15), and provides a low output when the one-shot is not timing or when the read/write head is not loaded. As a result, when the one-shot is timing, or when the head is loaded, the decode gates are enabled and power is applied to 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.

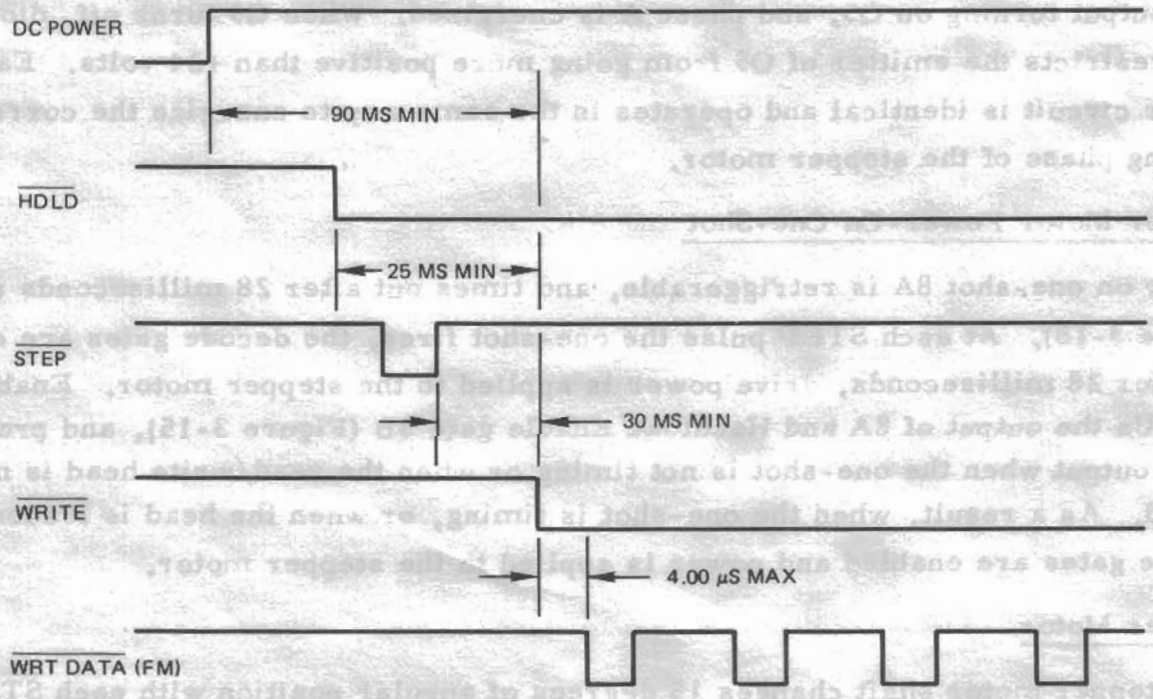


Figure 3-21. Write Initiate Timing

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.

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 1B (see Figure 3-22).

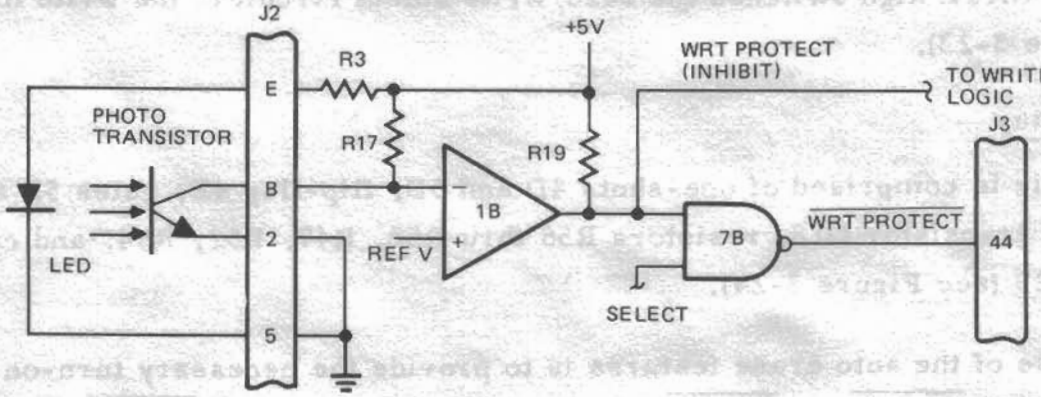


Figure 3-22. Write Protect Logic

The output of comparator 1B is high, providing an input to interface line driver 7B, and inhibiting write gate 7D (see Figure 3-23).

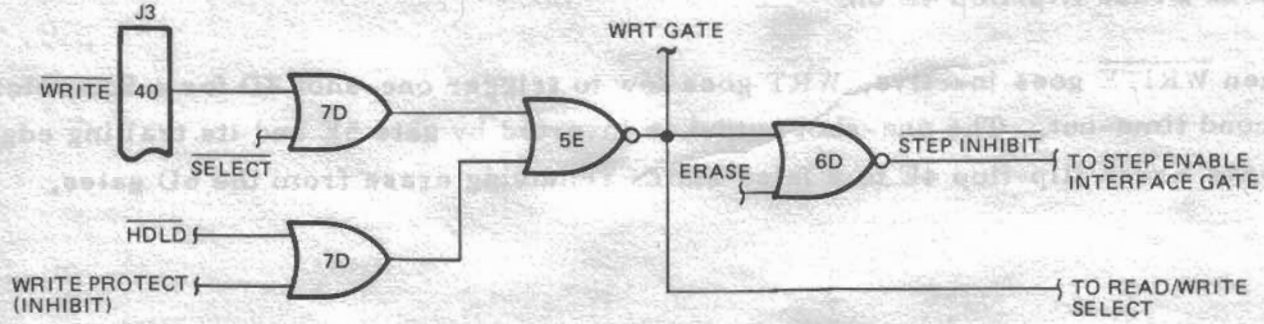


Figure 3-23. Write and Erase Gating Logic

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 1B 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, line receiver 7D outputs a low to gate 5E. Enable gate 7D outputs a low active signal provided the head is loaded ($\overline{\text{HDLD}}$) and the write-protect circuit does not sense a write-protected disk cartridge. The output produced by gate 5E is high, enabling Write flip-flop 4E, and 3E drivers and enable gate 6D. Gate 6D produces a low output to disable the step enable interface gate 6C. WRT GATE high switches the read/write select circuit to the write mode (see Figure 3-23).

Erase Logic

Erase Logic is comprised of one-shots 4D and 5D, flip-flop 4E, gates 5E and 6D, driver 3E, transistor Q18, resistors R56 thru R58, R47, R52, R54, and capacitors C28 and C29 (see Figure 3-24).

The purpose of the auto erase features 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 $\overline{\text{WRITE}}$ goes active, WRT goes high to trigger one-shot 5D for a 200-microsecond time-out. The one-shot output is inverted by gate 5E and the trailing edge clocks Erase flip-flop 4E on.

When $\overline{\text{WRITE}}$ goes inactive, WRT goes low to trigger one-shot 4D for a 530-microsecond time-out. The one-shot output is inverted by gate 5E and its trailing edge clocks Erase flip-flop 4E to a false state, removing erase from the 6D gates.

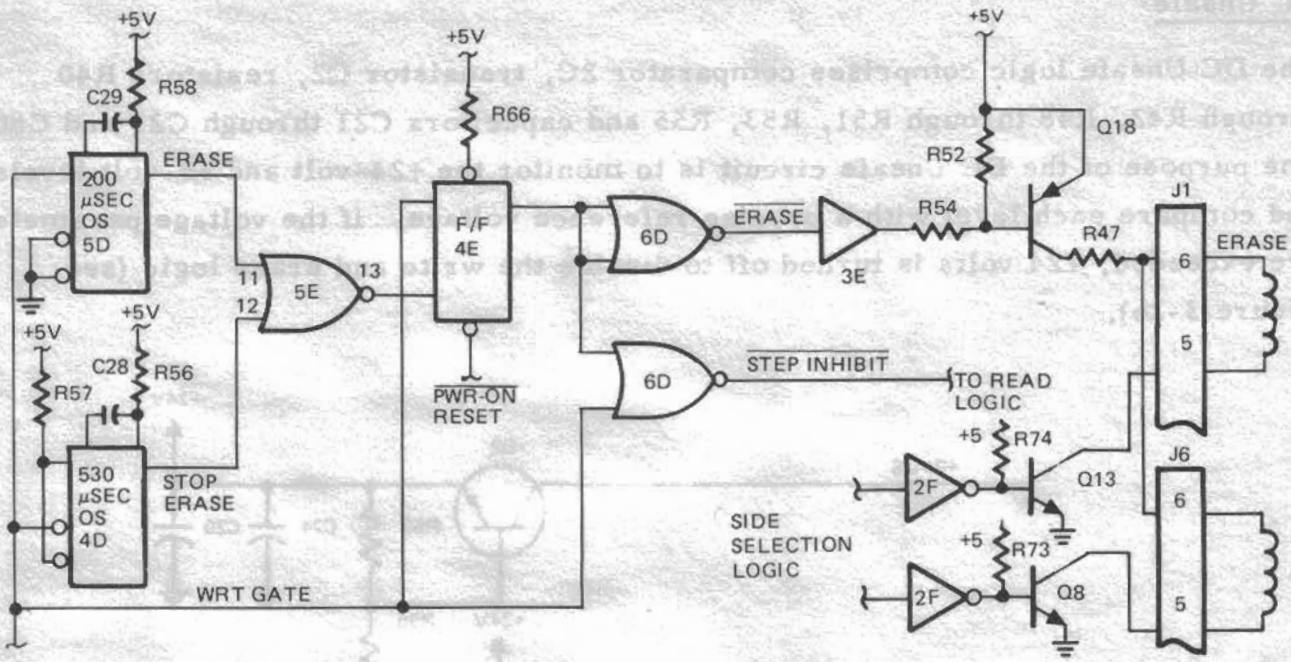


Figure 3-24. Erase Logic

When $\overline{\text{ERASE}}$ is inactive, driver 3E outputs a high to bias current source transistor Q18 off. When $\overline{\text{ERASE}}$ is active, 3E outputs a low turning Q18 on. With Q18 on, +5 volts is developed across R47 causing erase current to flow through the tunnel erase coil of the read/write head enabled by the side selection logic. The 2F gates and transistors Q8 and Q13 provide a ground to the erase coil of one head, as determined by interface line $\overline{\text{SIDE SELECT}}$.

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

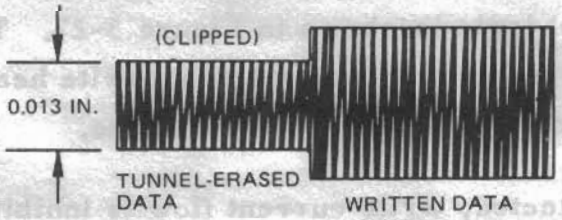


Figure 3-25. Tunnel-Erase Data Pattern

DC Unsafe

The DC Unsafe logic comprises comparator 2C, transistor Q2, resistors R40 through R42, R48 through R51, R53, R55 and capacitors C21 through C25 and C86. 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).

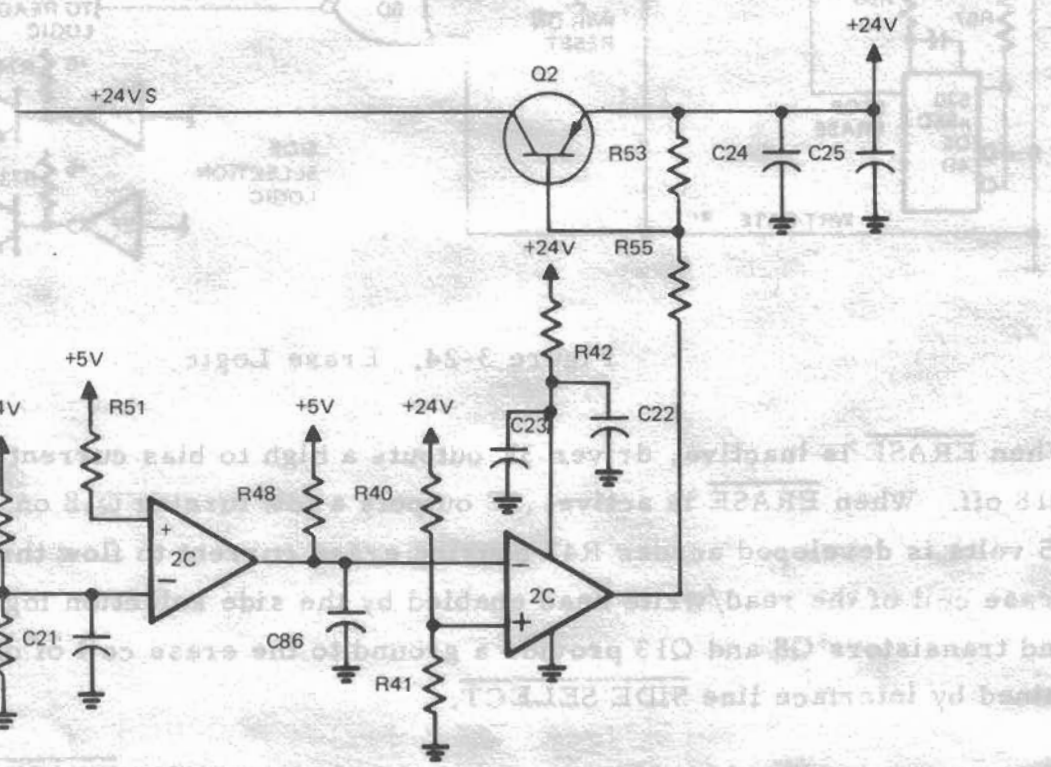


Figure 3-26. DC Unsafe Logic

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 determined by the $\overline{\text{WRT DATA}}$ interface line.

When the drive is not selected, write current flow is inhibited. When the drive is selected, interface line receiver 5E is enabled and gates $\overline{\text{WRT DATA}}$ to write flip-flop 4E. If the $\overline{\text{WRITE}}$ command is active, the flip-flop is enabled and the output