

cipher[®]
data products, inc.

**Series 525 FloppyTape™
Cartridge Tape Drive
Product Description**

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SECTION 1

INTRODUCTION

1.1 SCOPE

This manual describes the electrical and mechanical characteristics of Cipher Data Products' 525 FloppyTape™ 1/4-inch cartridge tape drive. It contains the timing, electrical, and mechanical specifications for the 525, which is available with a data rate of 500 KHz with SA450 or SA850 interface, or a 250 KHz rate with a SA450 interface. It also recommends the formats and circuitry necessary to interface the 525 to a host controller.

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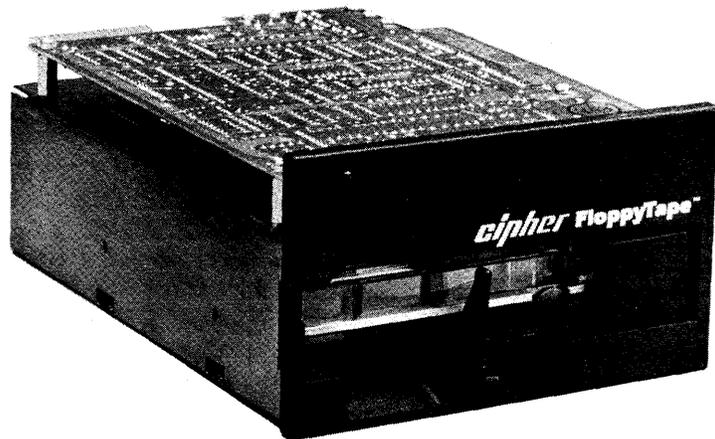


Figure 1-1. 525 FloppyTape Drive

1.2 TERMINOLOGY

The following new or, possibly, unfamiliar terms relate to FloppyTape technology:

- o **Sector** - smallest unit of addressable memory located within a segment.
- o **Segment** - a fixed length of tape that emulates a floppy disk track. Each segment is 26.55 inches, and has the capacity (unformatted) of 20.5 kilobytes. See Figure 1-2.
- o **Stream** - one of six physical bit serial tracks recorded on tape. Each stream contains 255 segments (0-254). See Figure 1-2.
- o **Index Pulse** - a signal sent to the host controller by the 525 to indicate the detection of an Index Mark. An Index pulse can be used by the host controller to initialize segment operations.
- o **Index Mark** - a portion of a stream in which the oxide is saturated in one direction. An Index Mark is used for the logical separation of segments. See Figure 1-2.
- o **Upstream** - a position on tape that is between the present location and the logical End of Stream (EOS). See Figure 1-2.
- o **Downstream** - a position on tape that is between the present location and the logical Beginning of Stream (BOS). See Figure 1-2.
- o **Host Controller** - the hardware required to interface the 525 to the host computer.

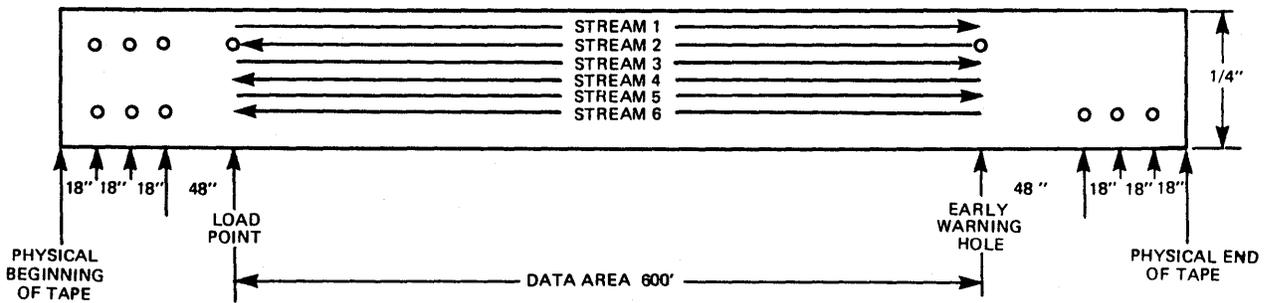
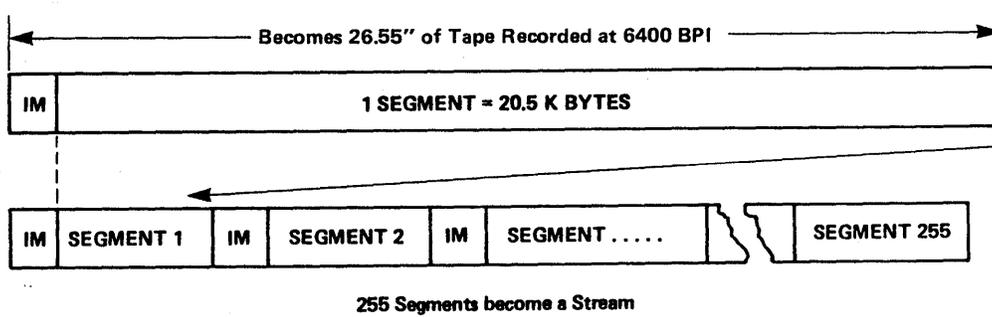
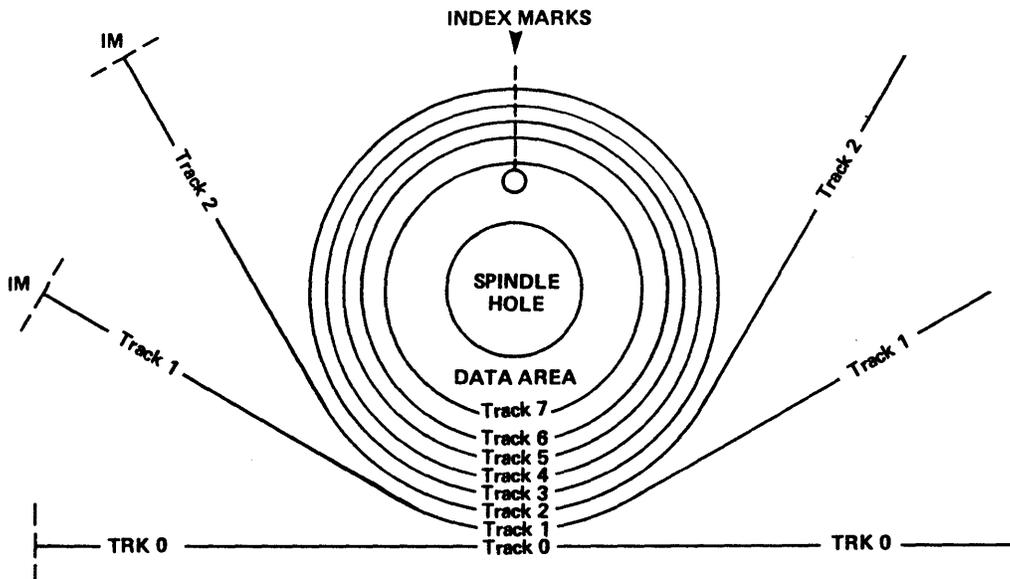


Figure 1-2. The Evolution of FloppyTape

1.3 GENERAL DESCRIPTION

The Cipher 525 FloppyTape cartridge tape drive is a low cost, computer data storage tape drive, employing the 3M DC600A or any other Cipher approved 1/4-inch cartridge tape media. The 525 emulates the industry standard SA850 or SA450 interface and responds to common floppy disk drive commands. Emulation of a floppy disk drive is accomplished by the FloppyTape's on-board Z8603 microprocessor. Data is recorded in a bit serial manner on each one of the six streams on the tape. Streams are selected by the host system via the four Drive Select and Side Select lines supported by the standard SA850 or SA450 bus. The host treats each stream as a logical disk surface. Prior to any stream access, the host system must select one of the six logical surfaces. Actual physical stream selection is accomplished by first having the Z8603 microprocessor interpret the Drive Select and Side Select lines, then positioning the Read/Write head on the selected stream. Each stream has an unformatted capacity of 5.2 megabytes.

Emulation of a floppy disk track is achieved by partitioning a stream into 26-inch segments. Segments are separated by DC saturated portions of tape referred to as Index Marks (IMs). Stream partitioning into segments by IMs is done by the Z8603 microprocessor during a stream format operation initiated by the host system. Following the format operation, the FloppyTape uses the IMs to generate the Index Pulse signal seen by the host on the interface. IMs are also used by the FloppyTape to count the 26-inch increments of tape, when a segment seek operation is initiated by the host system controller. The unformatted capacity of a segment is 20.5 Kbytes (approximately twice the capacity of an 8-inch floppy disk track). Segments are accessed by the host system using the floppy disk protocol step and direction lines from the floppy disk controller.

1.4 FEATURES

The main features of the 525 FloppyTape include:

- o Standard ANSI cartridge mounting
- o Precise head stepping
- o SA450 or SA850 floppy disk interfaces
- o Operable with existing floppy disk controller chips
- o No AC requirements
- o 5-1/4-inch form factor
- o High capacity storage (32 MB)
- o Soft sector type floppy disk format
- o Enclosed/removable media
- o Low maintenance

SECTION 2

SPECIFICATIONS & RELIABILITY

2.1 TAPE SPECIFICATIONS

Tape Speed/Transfer Rate:*	78 ips/500 Kbits/sec or 39 ips/250 Kbits/sec
Ramp Time:	350 ms
Tape Speed Variation	
Low Frequency:	Less than $\pm 2\%$
Instantaneous:	Less than $\pm 6\%$
Write Pre-compensation:	200 ns @ 500 Kbits/sec 250 ns @ 250 Kbits/sec
MFM Recording Density:	6,400 bpi nominal
Unformatted Capacity (MFM Recording)	
Segment:	26.55 inches = 20.5 Kbytes max.
Stream:	255 segments = 5.2 Mbytes
Cartridge:	6 streams = 31.3 Mbytes
Recording Tracks:	6
Recording Method:	NRZ
Interface Code	
Recommended:	Modified Frequency Modulation (MFM)
Available:	Frequency Modulation (FM)

2.1.1 Recording Times

78 ips (500 Kbits/sec)	0.333 sec/segment 93 sec/stream 558 sec/cartridge
39 ips (250 Kbits/sec)	0.666 sec/segment 186 sec/stream 1,116 sec/cartridge

2.1.2 Positioning

Method:	Multi-position stepper motor
---------	------------------------------

*Transfer rate is tape drive dependent.

2.2 RELIABILITY

2.2.1 Mean Time Between Failures (MTBF)

The MTBF for a drive is defined as follows:

$$\text{MTBF} = \frac{\text{Power-on Hours}}{\text{Number of Equipment Failures}}$$

Definitions

Failures caused by operator error, or an out-of-specification operation, are not counted as failures.

Product Workload is stated in terms of a unit duty cycle, and is defined as actual tape motion time divided by total power-on time.

Infant mortality failures which occur within the first 100 hours of power-on time after site installation are not considered in the MTBF calculations.

The sample size must be greater than 100 units for the purpose of MTBF calculation.

Production and design maturity improvements allow the MTBF rate to be achieved 18 months from start of production. In the interim the actual MTBF might be lower. The minimum MTBF for the 525 is:

Product Workload	MTBF (Hours)
20%	19,250
40%	9,625
60%	6,416
80%	4,813

2.2.2 Mean Time To Repair (MTTR)

MTTR is defined as the time for an adequately trained and competent serviceman to diagnose and correct a malfunction at the subassembly level.

The MTTR is expected to be 15 minutes.

2.2.3 Preventive Maintenance (PM)

The 525 requires no service call related PM. The hours of required operator PM are related to the product workload.

Product Workload	Hours of PM/100 Hours On
20%	0.1
40%	0.3
60%	0.4
80%	0.4

This preventive maintenance, at a minimum, involves cleaning the tape path, including the recording head and the drive roller surface.

2.3 DATA INTEGRITY

Errors attributed to operator mishandling of the tape cartridge, or errors on the cartridge which can be detected and flagged during formatting, are not included in determining error rates.

2.3.1 Media

Only cartridges from Cipher approved sources may be used, such as the 3M DC600A. Properly handled, the cartridge can be used for at least 5,000 full length passes. (BOT to EOT and back to BOT is considered 2 passes.)

2.3.2 Recoverable Read Errors

A recoverable error (soft error) is one which may be corrected by no more than 10 re-read attempts. Data patterns, tape position, and Read/Write head position do not affect data error rate performance.

The recoverable read error rate for the 525 is less than 1 in 10^9 bits.

2.3.3 Non-Recoverable Read Errors

A non-recoverable read error (hard error) is one which cannot be corrected by 10 re-read attempts. The non-recoverable read error rate for the 525 is less than 1 in 10^{11} bits.

2.3.4 Power Loss

Accidental loss of DC power will not result in any component failure.

SECTION 3

FUNCTIONAL CHARACTERISTICS

3.1 GENERAL DESCRIPTION

The 525 FloppyTape 1/4-inch cartridge tape drive consists of Read/Write electronics, control logic, tape drive mechanism, head positioning mechanism, and the Read/Write head. These components perform the following functions:

- o Interpret, generate, and emulate floppy disk drive control signals
- o Position the Read/Write head on the logically selected stream
- o Monitor and control tape speed
- o Read and Write data

Figure 3-1 is a block diagram of the 525 FloppyTape. The host system interfaces the 525 through the control and data signal bus. The control signals are interpreted, and appropriate action is initiated by the tape motion control logic.

Tape is transported across the Read/Write head in both directions by a direct-drive DC capstan motor. The built-in tachometer circuit provides feedback to the control electronics for constant motor speed adjustment.

A photo detector senses the Beginning Of Tape (BOT), the Early Warning (EW), and the End Of Tape (EOT) holes. The on-board microprocessor initiates subsequent control actions.

The Write protect circuitry guards against accidental alterations of recorded data inhibiting the Write electronics when the cartridge tumbler is in the "safe" position.

Figure 3-2 shows the physical locations of these components on the 525 chassis.

3.2 READ/WRITE & CONTROL ELECTRONICS

The Read/Write and control electronics are located on a single Printed Circuit Board (PCB). The PCB components include the following circuits:

- o Index Detector/Generator
- o Write Current Driver
- o Read Amplifier and Transition Detector
- o Write Protect Logic
- o Logical Drive/Stream Selection
- o Tape Speed/Capstan Control
- o Tape Hole Monitor

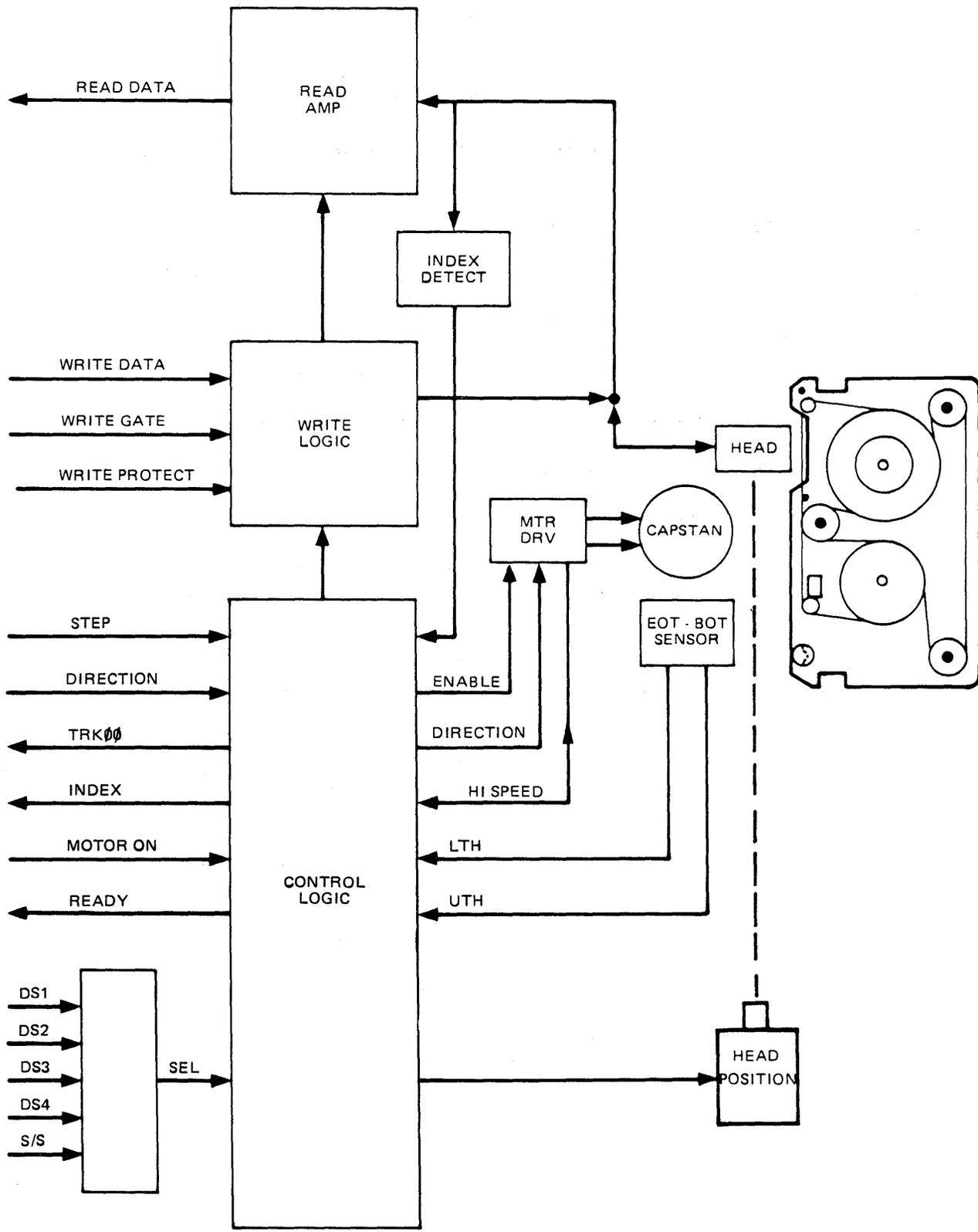


Figure 3-1. 525 Functional Block Diagram

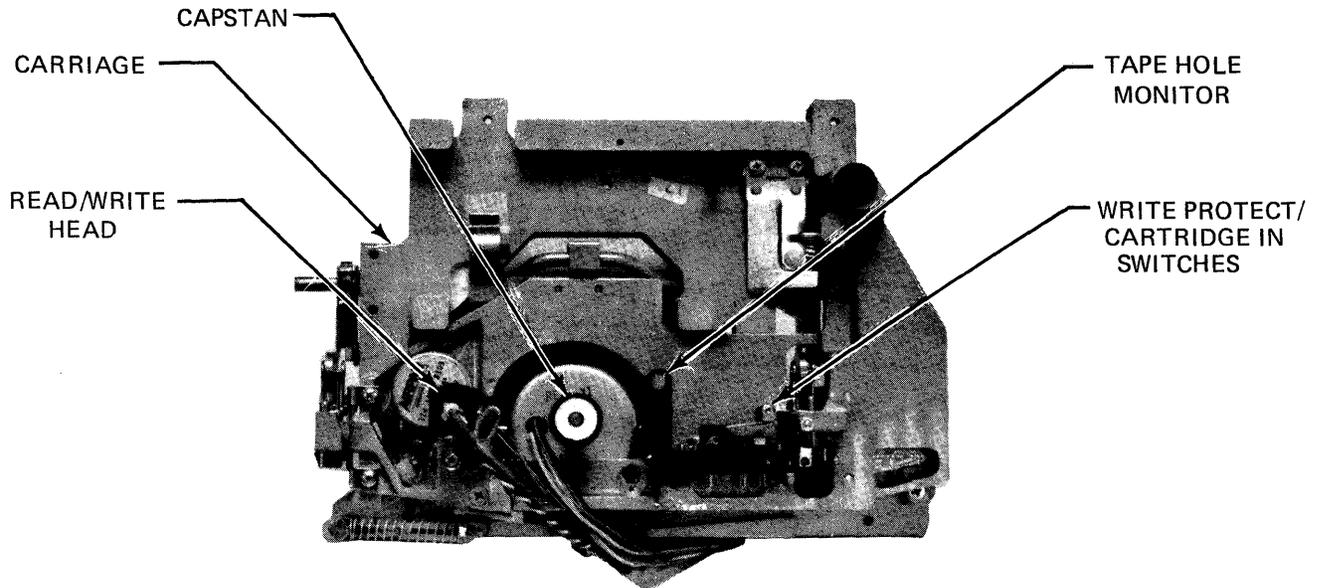


Figure 3-2. Component Location Layout

3.3 TAPE DRIVE MECHANISM

The tape drive capstan is driven by a three-phase, brushless DC motor. Feedback from the integral tachometer is utilized by the on-board microprocessor for accurate pulse-width modulation speed control.

Precise cartridge-to-head alignment is accomplished with a "floating" cartridge carriage assembly. Forces applied, similar to those recommended by ANSI 3.55-1977, locate the cartridge positively against the three registration pins and the datum surfaces of the deck plate. This configuration assures exact media positioning. A sliding contact pin opens the tape cartridge door to enable contact between the media and Read/Write head.

3.4 READ/WRITE HEAD POSITIONING MECHANISM

The Read/Write head is positively locked against the media by an upward turn of the cartridge lock lever. Stream access is performed by a multi-position four-phase head stepper motor. The head stepper motor is driven by the control logic in response to Drive/Side Select signals received from the host controller.

The stepper mechanism provides an approximate step size of one mil (0.001 inch) to position the head.

The 525 is designed with a single element, glass-bonded ferrite/ceramic head with tunnel erase.

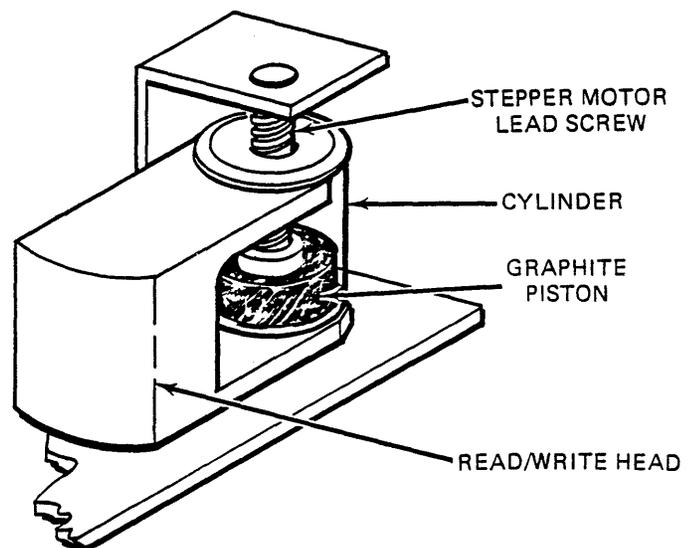


Figure 3-3. Read/Write Head Assembly

SECTION 4

FUNCTIONAL DESCRIPTION

4.1 POWER SEQUENCING

The DC voltage (+5V, +12V) can be applied in any sequence. However, in order to maintain data integrity during power-up, the Write Gate line must be held inactive, or the cartridge lock lever must be in the open position. On a power-up sequence, or the insertion of a new cartridge, the drive automatically performs a retention pass of the tape, leaving the medium positioned at Stream 1, Segment 0. (See Paragraph, 9.4.6)

4.2 STREAM SELECTION

Stream selection occurs as a function of the Drive and Side Select lines. These lines are used as inputs to a decode PROM. Through the use of three jumpers (W1, W2, W3), a total of seven possible stream configurations can be derived. (See Stream Selection Tables, Appendix A.)

When a new stream is selected and the Head Load or Motor On line asserted, the tape automatically moves to Segment 0 of that stream. If no Step pulses are received, the tape will position on the new stream at the same segment number as on the previous stream. Each time a new stream is selected, it is recommended that the host issue a recalibrate command to its controller to avoid tape device/controller confusion. (See Figures 4-1 and 4-2.)

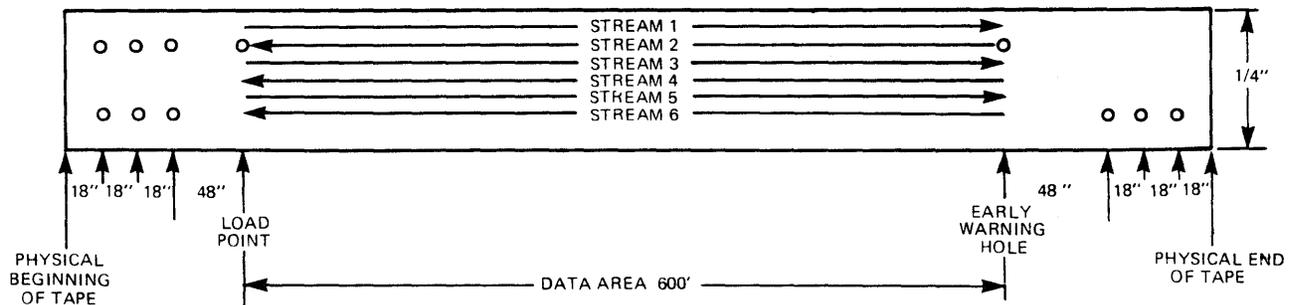
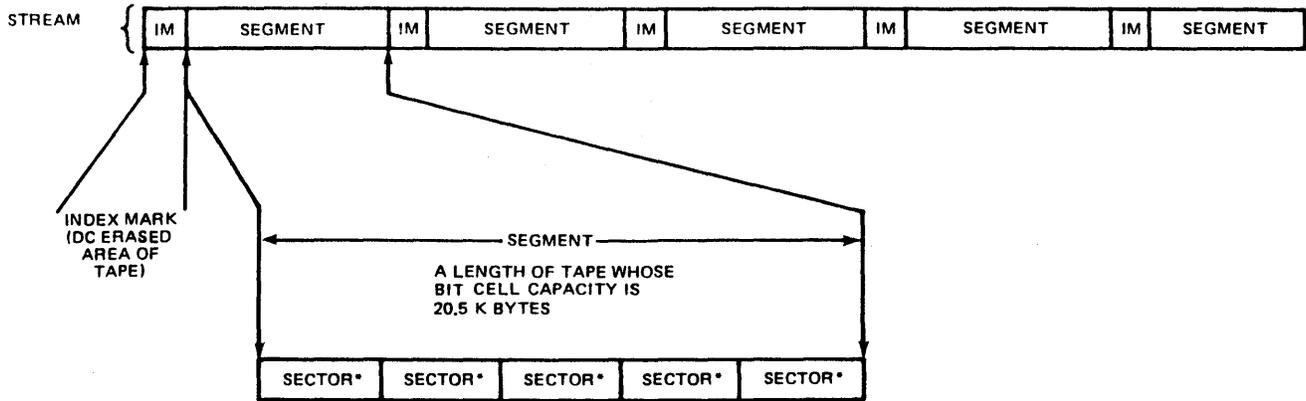


Figure 4-1. 525 Physical Tape Layout



NOTE* THE SOFT SECTORING OF A SEGMENT IS A FUNCTION OF THE HOST CONTROLLER

Figure 4-2. 525 Stream Partitioning Layout

4.3 HEAD LOAD/MOTOR ON

The Head Load line on the SA850 interface serves the same purpose as the Motor On line on the SA450 interface. This line must be asserted in order to Write or Read data. Following the assertion of the Head Load/Motor On line, a 400 ms nominal delay is introduced prior to any data operation to allow the medium to reach full operating speed.

If the Head Load/Motor On line is asserted and no Step pulses are issued by the host, the 525 always repositions to the last accessed segment. If, after four seconds, accessing has still not occurred, the host should deactivate the Head Load/Motor On line to avoid excessive wear of the medium.

4.4 SEGMENT ACCESSING

Segment accessing requires the host controller to perform the following steps:

- a. Select the desired stream
- b. Activate the Head Load/Motor On line
- c. Read the segment/sector address mark from the tape
- d. Compare the segment/sector address read from the tape to the target segment/sector address. If there is a mismatch, go to Step e. Otherwise go to Step f.
- e. Address mismatch: determine the direction of the target segment within the stream and activate the Direction line accordingly. Issue Step pulses equal to the offset difference between the actual and the target address.

With the Head Load/Motor On line still asserted and with an incoming stream of Step pulses, the 525 responds by moving the tape in the direction selected by the Direction line until the number of Index Marks passed is equal to the number of Step pulses received. At this point, the host should reenter this procedure at Step c. This process is repeated until a segment address mark compare occurs. (See Figure 4-3.)

- f. Address match: access the appropriate sector within the segment.

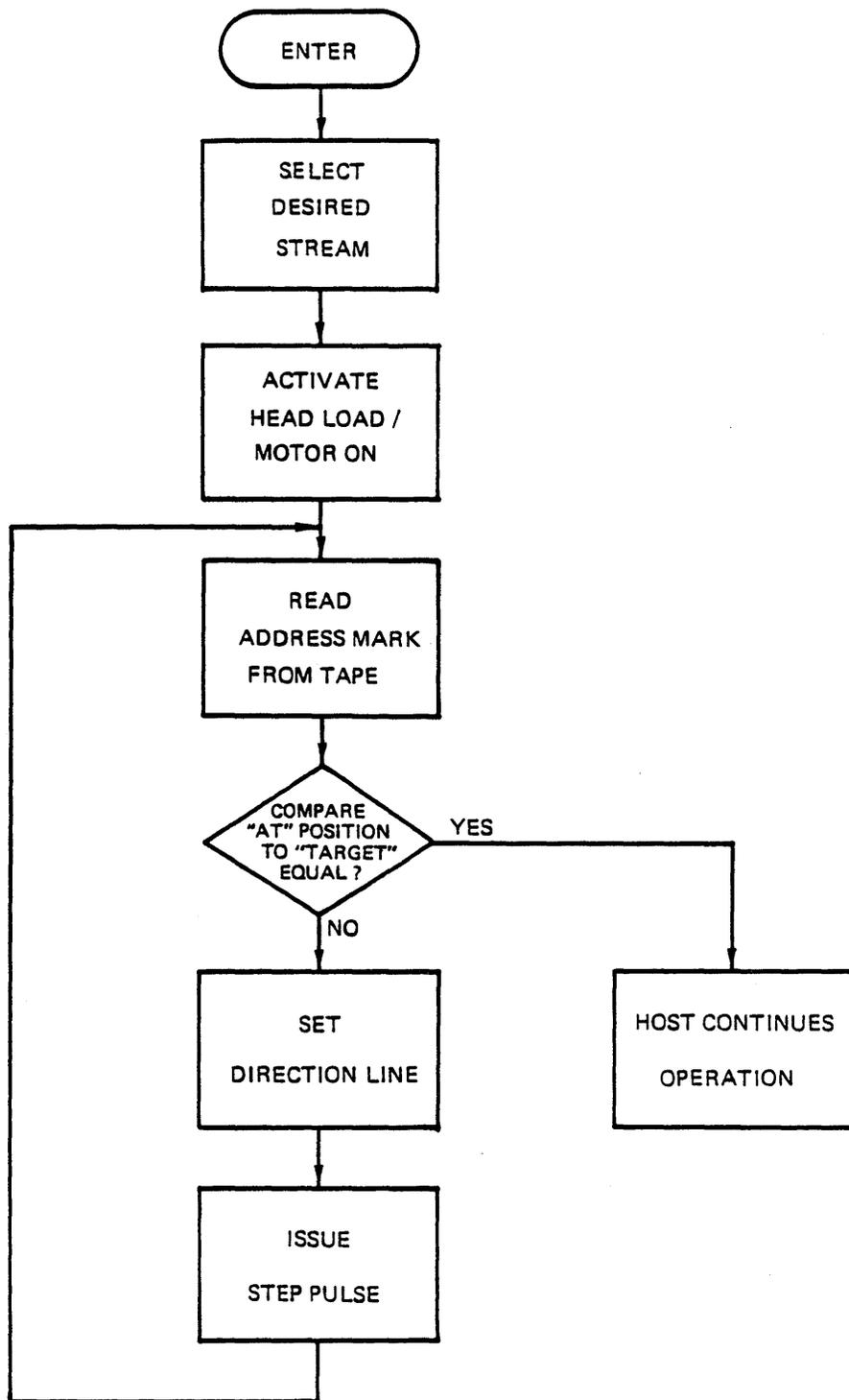


Figure 4-3. Stream Access Flowchart

4.5 STEP OUT/STEP IN

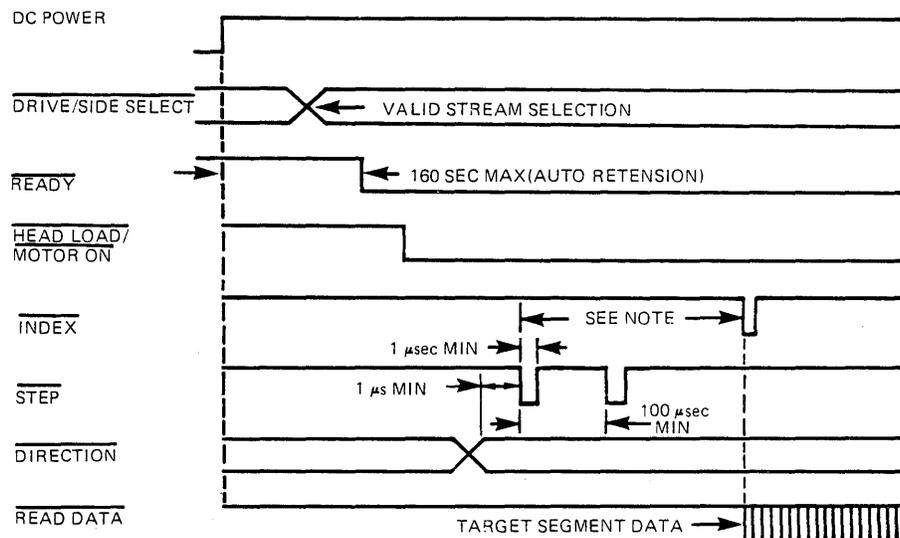
The Direction Select line is used to send a pulse which moves the tape to the next segment (step out), or the previous segment (step in).

Step Out

With the Direction Select line at a high logic level (+2.5V to +5.25V), a pulse on the Step line, in conjunction with Head Load or Motor On, moves the tape downstream to the next segment.

Step In

With the Direction Select line at a low logic level (0.0V to +0.8V), a pulse on the Step line in conjunction with the Head Load or Motor On, moves the tape upstream to the next segment. See Figure 4-4.



NOTE: Time to target segment is approximately equal to the number of Step pulses issued times 333 ms.

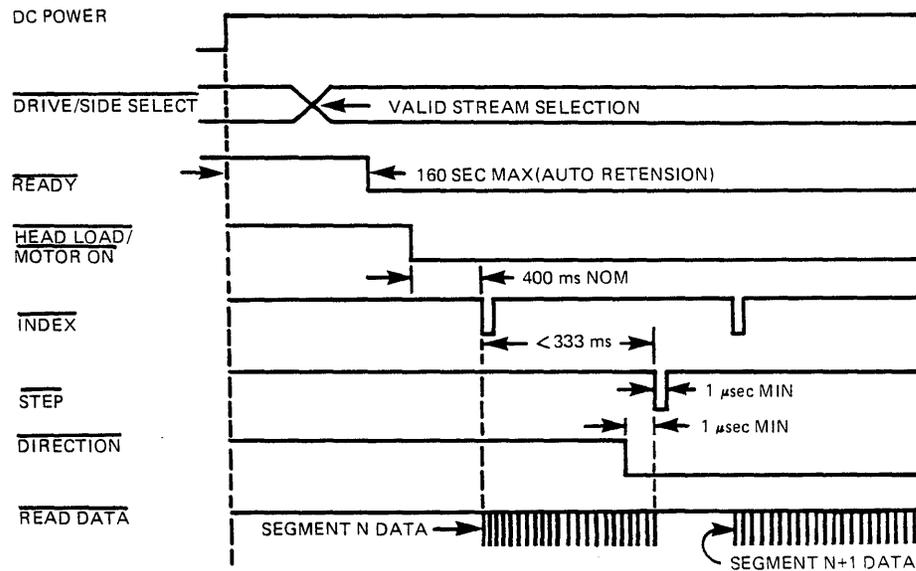
Figure 4-4. Random Segment Access Timing

4.6 READ OPERATION

Reading data from the 525 drive is accomplished by:

- Activating Drive Select to select the desired stream
- Activating the Head Load/Motor On line
- Deactivating the Write Gate line

Timing relationships are shown in Figure 4-5.



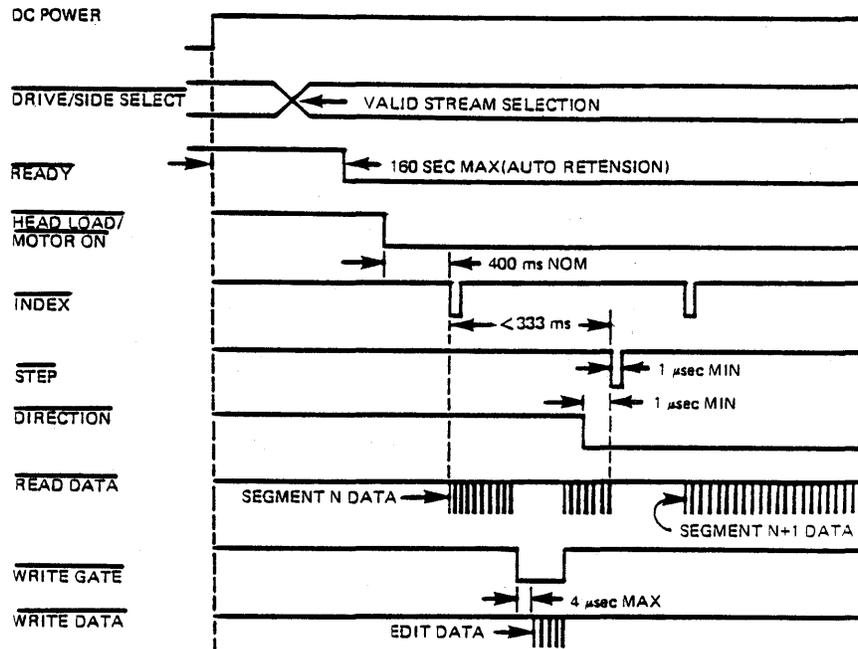
- NOTES:**
1. Timing is measured at the host.
 2. If no Step pulse is received, the 525 will not issue the second Index pulse until the unit completes repositioning on the same segment.

Figure 4-5. Read Timing

4.7 WRITE OPERATION

To Write data on the 525, the following steps are performed:

- a. Activate the Drive Select
- b. Activate the Head Load/Motor On line
- c. Activate the Write Gate line
- d. Pulse the Write Data line with the data to be written. The Write timing relationships are shown in Figure 4-6.



- NOTES:**
1. Timing is measured at the host.
 2. If no Step pulse is received, the 525 will not issue the second Index pulse until the unit completes repositioning on the same segment.

Figure 4-6. Write Timing

4.8 RECORDING FORMAT

The data format recorded on the cartridge tape is a function of the host system. The format should be designed around the user's application to take maximum advantage of the available storage capacity.

For detailed recording format information, refer to Section 9 and Appendix B.

SECTION 5

INTERFACE SIGNALS

5.1 DRIVE INTERFACE

The 525 requires two separate connections to the host controller: J1, the digital signal interface which provides control signals and data and J2 which provides DC power. Connector dimensions are detailed in Section 6.

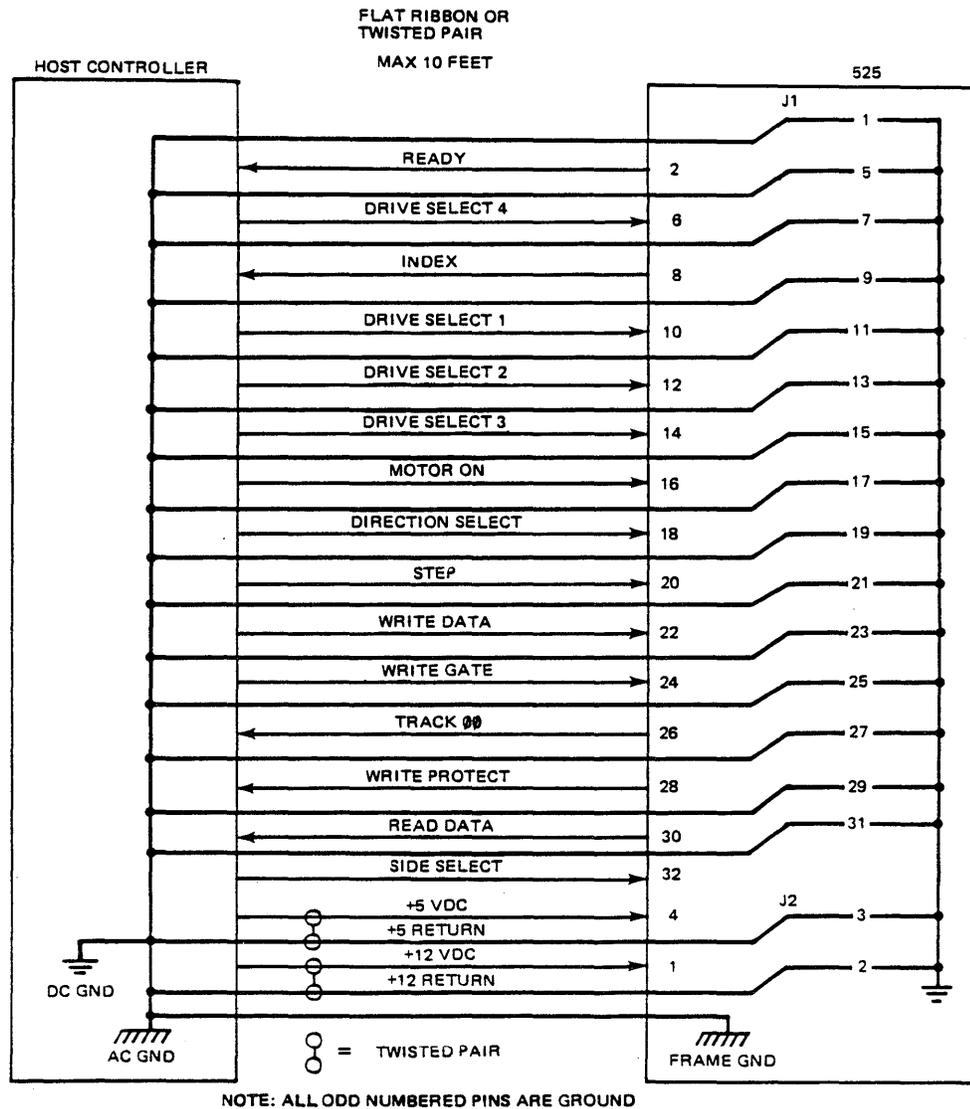


Figure 5-1. 525 Drive Interface - SA450

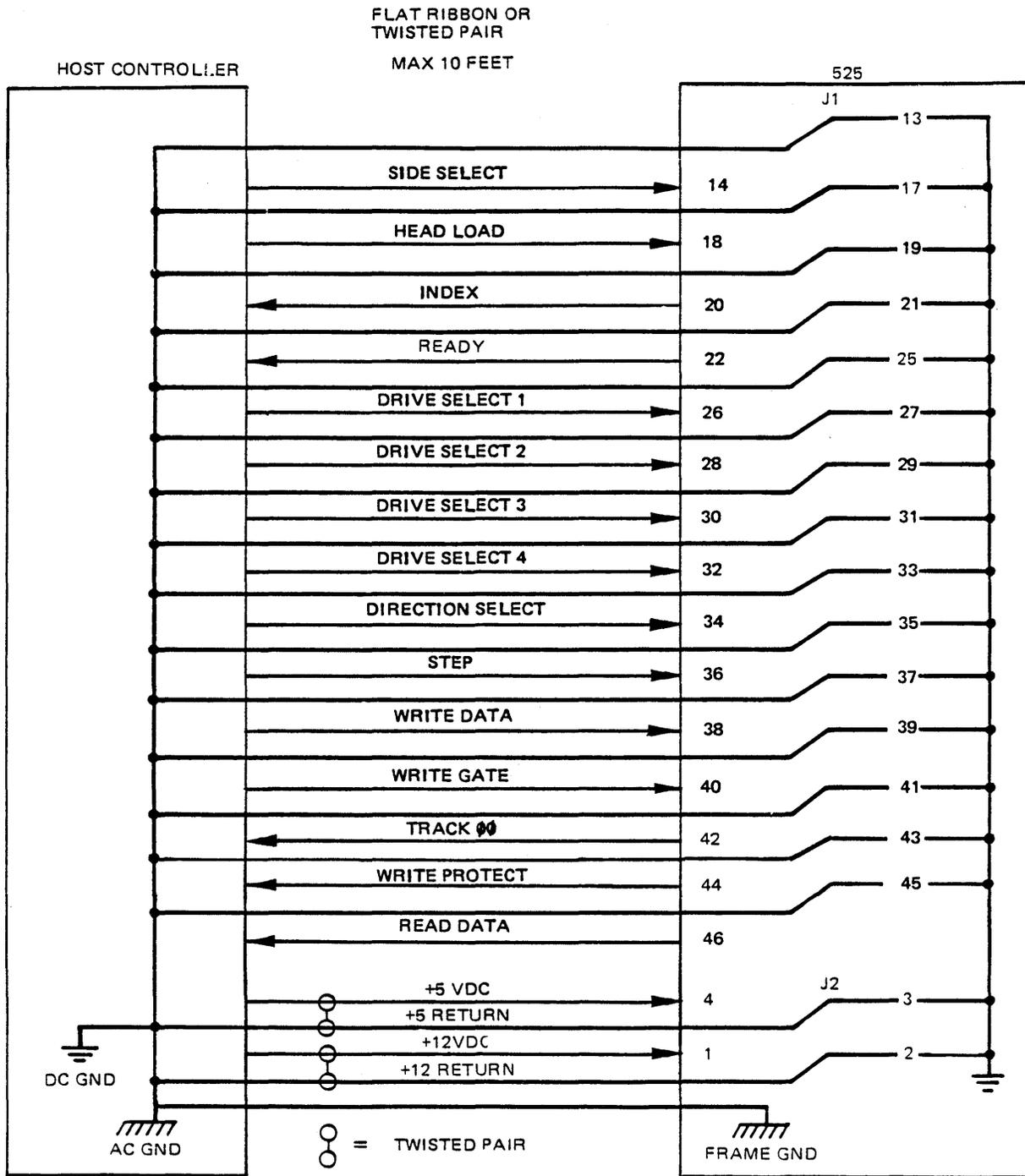


Figure 5-2. 525 Drive Interface - SA850

SA850 Pin #	SA450 Pin #	Name	I/O	Signal	Description
Input Control Signals					
26	10	DS 1	I	Drive Select 1	Stream selection with Side Select
28	12	DS 2	I	Drive Select 2	Stream selection with Side Select
30	14	DS 3	I	Drive Select 3	Stream selection with Side Select
32	6	DS 4	I	Drive Select 4	Stream selection with Side Select
14	32	SS	I	Side Select	Stream selection
34	18	DIRC	I	Direction Select	When low (true), in conjunction with Step pulse, causes tape to move toward Segment 254 of selected stream
36	20	STP	I	Step	When pulsed causes tape to move one segment per pulse in the direction selected by the Direction line
18		HLD	I	Head Load	Causes tape motion
	16	MTON	I	Motor On	Causes tape motion
40	24	WGT	I	Write Gate	Enables writing of data
Output Control Signals					
20	8	INDX	0	Index Pulse	Indicates beginning of a segment
42	26	TRK \emptyset	0	Track \emptyset	Indicates tape position is at, or going to, Segment \emptyset of selected stream
44	28	WPT	0	Write Protect	When low, indicates cartridge is Write protected
22	2	RDY	0	Ready	Indicates cartridge in, retension pass done
Data Line Signals					
38	22	WD	I	Write Data	Data to be written
46	30	RD	0	Read Data	Read data from tape

Figure 5-3. I/O Listing

5.2 INTERFACE SIGNAL LEVELS

True = Logical 0 = $V_{in} \pm 0.0$ to $+0.8V$

@ $I_{in} = 40$ ma (max)

False = Logical 1 = $V_{in} +2.5V$ to $5.25V$

@ $I_{in} = 0$ ma

Input Impedance = 150 ohms

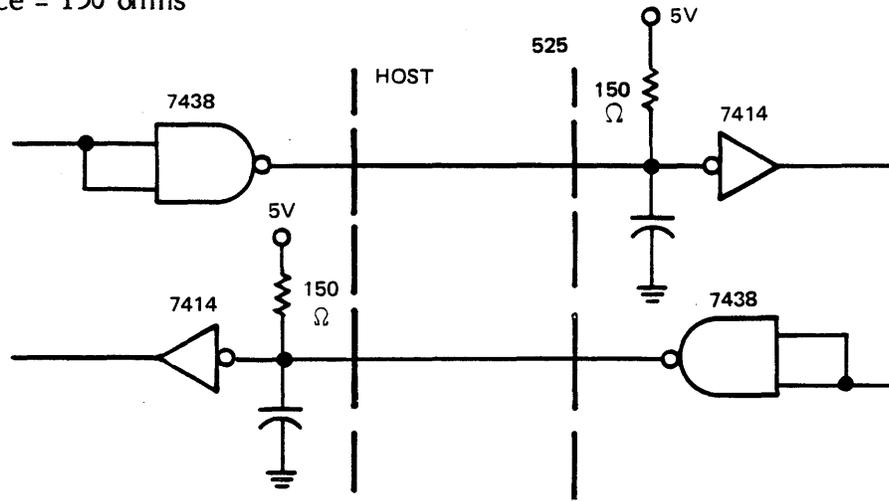


Figure 5-4. Interface Signal Driver/Receiver

5.3 INPUT CONTROL SIGNALS

Drive Select

The four Drive Select lines ($\overline{DS1}$ - $\overline{DS4}$), used with the Side Select (\overline{SS}) line, and the configuration jumpers W1, W2, W3, allow selection of one of six logical drives. When a particular drive is selected, the head moves to the appropriate stream and the microprocessor is enabled to scan and respond to other control signals.

Head Load/Motor On

When the Head Load (\overline{HLD}) or Motor On (\overline{MTON}) line, and Drive Select (\overline{DS}) lines are asserted by the host controller, the capstan on the selected drive is enabled and tape motion begins.

Direction Select

The Direction Select (\overline{DIRC}) line is used by the 525 to control the direction of tape movement. If this line is low, it causes the tape to move upstream. If it is high, it causes the tape to move downstream.

Step

A pulse on the Step line (\overline{STP}) causes the tape to move one segment from its current position in the direction controlled by the \overline{DIRC} line.

$\overline{DIRC} = 1$ Tape motion towards logical Segment 0.
 $\overline{DIRC} = 0$ Tape motion towards logical Segment 254.

Write Gate

The Write Gate (\overline{WGT}) line allows the host to disable the Step function and enable the Write drivers. A false (high) level on this line enables the Read output to the Read amplifier section so data may be read.

5.4 OUTPUT CONTROL SIGNALS

Track 00

A logic low level on the Track line ($\overline{TR00}$) indicates the 525 is at, or going to, the first segment (00) of the selected stream.

Index

A pulse on the Index (\overline{INDX}) line indicates that the drive is at the beginning of a segment in the selected stream. The segment time from Index Mark to Index Mark in a write format routine is 333 milliseconds.

Write Protect Signal

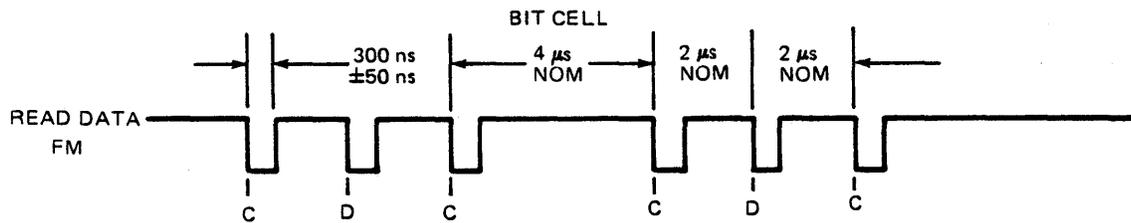
A low on the Write Protect (\overline{WPT}) line indicates that the safe tumbler on the cartridge has been manually set. The 525 Write circuits are also disabled under this condition.

5.5 DATA LINE SIGNALS

5.5.1 Read Data Signal

While reading, this line provides a 300 ns pulse for each flux transition detected on the tape.

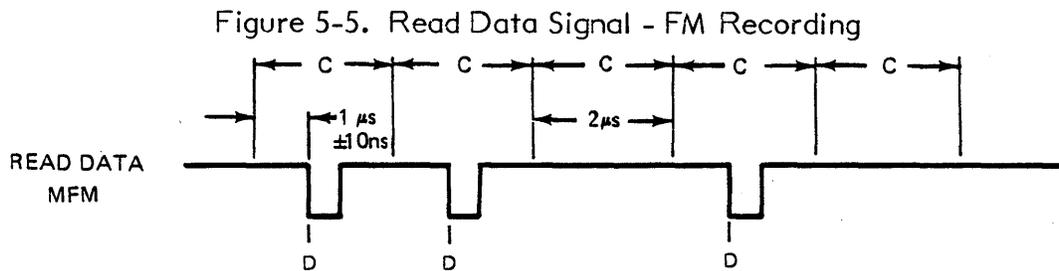
FM Recording



C = Clock Pulse = 300 ± 100 ns
Bit Cell Time = 4μ s

D = Data Pulse = 300 ± 50 ns

MFM Recording



D = Data Pulse = 300 ± 50 ns
Bit Cell Time = 2μ s

Figure 5-5. Read Data Signal - FM & MFM

SECTION 6

PHYSICAL INTERFACE CONNECTION

6.1 INTERFACE CONNECTOR LOCATIONS

Control and data signals are transferred between the host controller and the 525 via connector J1. J1 is a 50-pin connector on the SA850 interface unit, and a 34-pin connector on the SA450 interface drive. J2 is a 4-pin connector used to supply DC power.

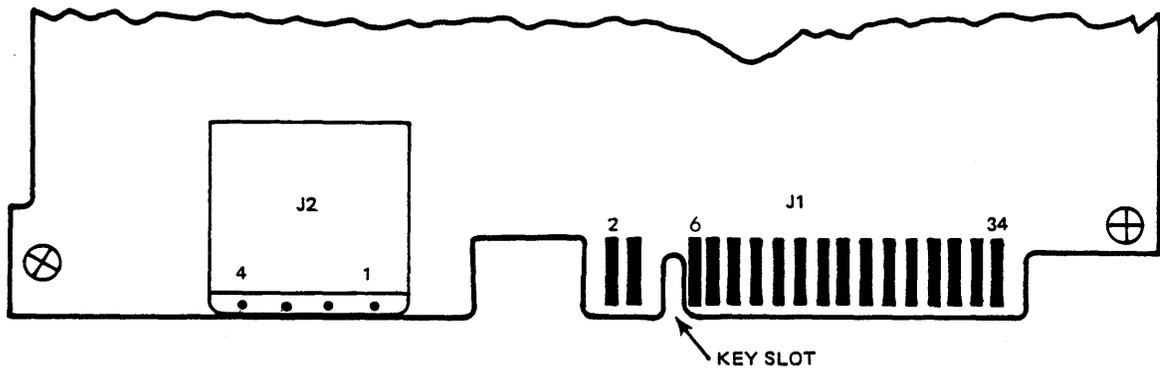


Figure 6-1. 525 Interface Connectors - SA450

6.2 SIGNAL CONNECTOR DIMENSIONS

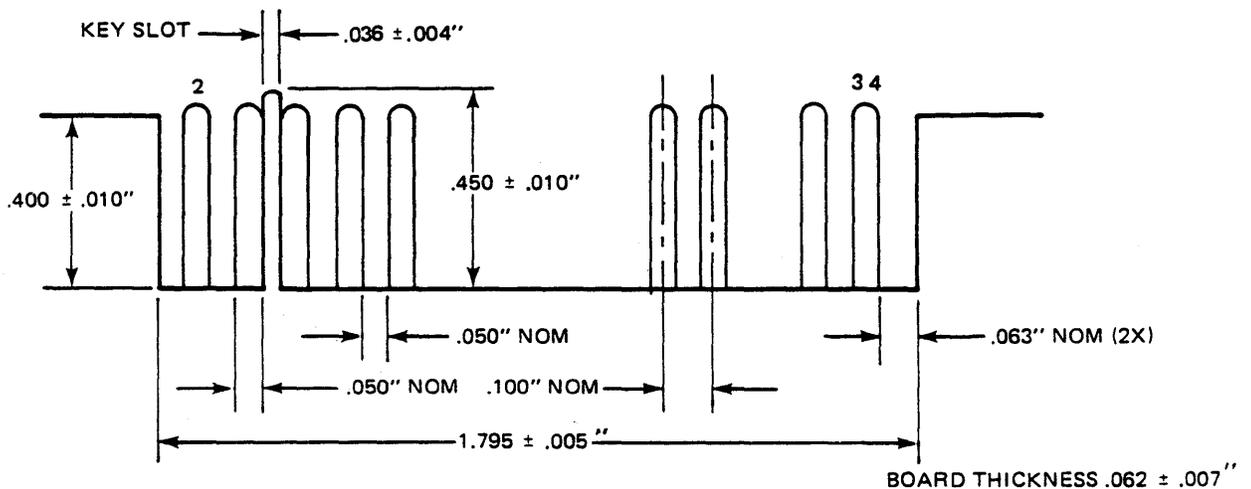


Figure 6-2. J1 Interface Connector Dimensions - SA450

SECTION 7

PHYSICAL CHARACTERISTICS

7.1 MECHANICAL DIMENSIONS

Width: 5.75 in. (146 mm)

Height: 3.25 in. (83 mm)

Depth: 8.00 in. (203 mm)

7.2 WEIGHT

Unit Weight: 4.0 lbs. (1.8 kg)

Shipping Weight: 7.0 lbs. (3.2 kg)

7.3 MOUNTING

The 525 can be mounted in the same space as a 5-1/4-inch floppy disk drive. The unit may be mounted horizontally or vertically. In the horizontal position, the PCB must be on top. In the vertical position, the PCB board should be on the right side while viewing the unit from the front.

CAUTION: Do not mount the 525 upright (cartridge slot facing up).

Four base holes and two holes on each side are provided for mounting. The holes are tapped for 6-32 screws. See Figure 7.1 for mounting hole locations. Screws used for mounting must penetrate the mounting surface by at least 0.125 inches (3.2 mm), but no more than 0.22 inches (5.6 mm). The mounting surface thickness is 0.047 inches (1.2 mm).

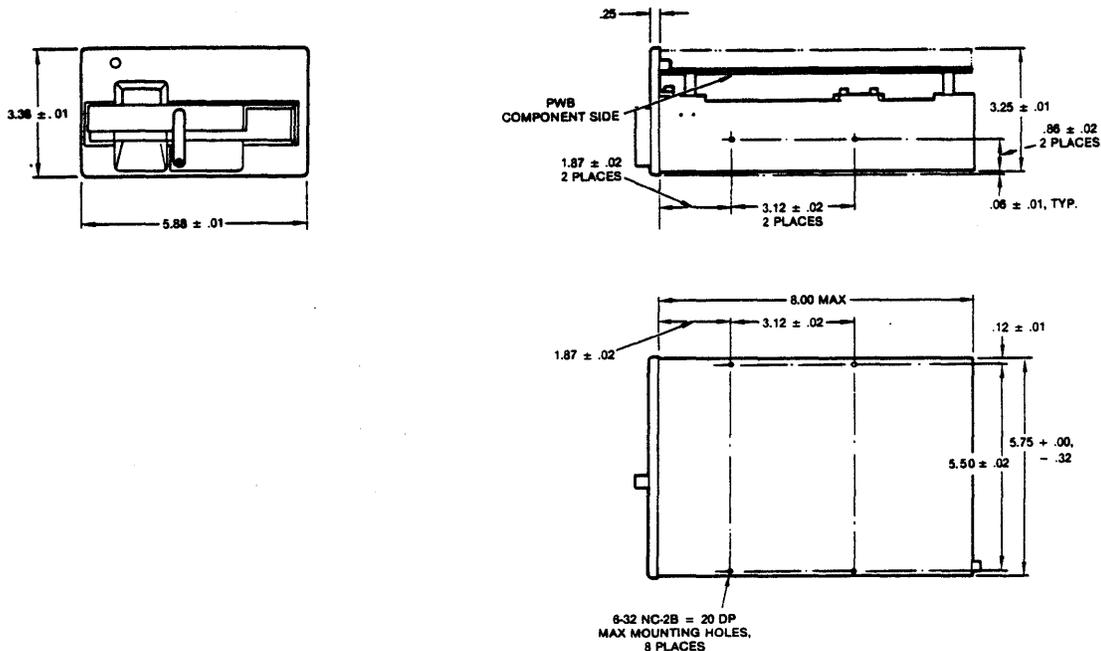


Figure 7-1. 525 Dimensions

SECTION 8

ENVIRONMENTAL CHARACTERISTICS/POWER REQUIREMENTS

8.1 TEMPERATURE

Operational:	5 to 45°C, measured at cartridge base (max. gradient of 1°C per minute)
Non-Operational:	-30 to 60°C
Temperature Cycling:	No condensation shall result

8.2 HUMIDITY

Operational:	20 to 80% relative humidity*
Non-Operational:	1 to 90% relative humidity*

*Wet bulb temperature 26° max., non-condensing

8.3 ALTITUDE

Operational:	Sea level to 10,000 ft (3,000 m)
Non-Operational:	Same as Operational
Shipping:	Sea level to 49,000 ft (15,000 m)

8.4 VIBRATION

Equipment Operational:	The unit shall withstand a peak acceleration of 0.3g for the frequency range of 5-500 Hz along each orthogonal axis.
Equipment Non-Operational:	The unit shall withstand a peak acceleration of 0.3g for the frequency range of 5-500 Hz along each orthogonal axis.

8.5 SHOCK

The equipment in a non-operational status shall not suffer damage or fail to operate according to specifications, when subjected to a 30g shock.

8.6 AIR QUALITY

The unit will function in a normal office environment, i.e., up to 60 milligrams of 5-micron diameter dust particles per 100 cubic feet of air.

8.7 ACOUSTICAL NOISE

Standby: Inaudible

Steady Tape Motion: Less than 55 dba at a distance of 3.3 feet (1 m)

8.8 DC POWER

+5V $\pm 5\%$, 0.8A max., 50 mV max. ripple (peak to peak)

+12V $\pm 5\%$, 1.8A nominal, 2.5A surge max. during cartridge acceleration (350 ms duration). 100 mV max. ripple (peak to peak).

Source Impedance: 50 milliohms max.

8.9 HEAT DISSIPATION

25.6 Watts operational: 87 BTU/hr

35.0 Watts surge (250 ms duration): 119 BTU/hr

8.10 COOLING

Dependent on individual mounting and type of operation, 15 cf/min fan recommended for most applications.

SECTION 9
APPLICATION NOTES

9.1 GENERAL

This Section addresses hardware and software considerations for integrating the 525 into a host computer system. The information supplied is based on formatter designs utilizing controller chips as outlined in Appendix B.

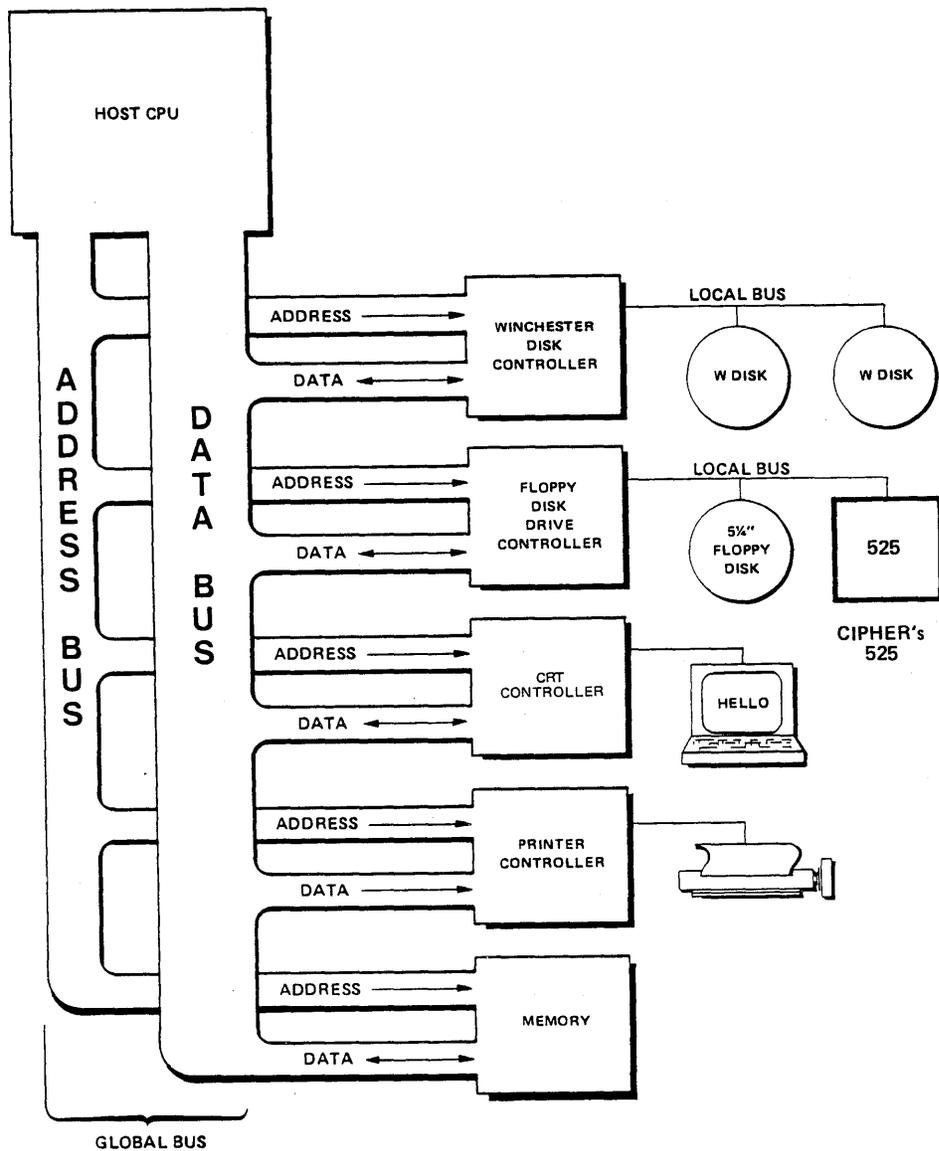


Figure 9-1. Typical Host System (Block Diagram)

9.2 HARDWARE CONSIDERATIONS

The mounting, interfacing, and operation of the 525 emulates a standard floppy disk drive. Figure 9-2 illustrates the interfacing of a 525 to a typical host controller. Figure 9-3 is an example of a controller interface schematic for the 525.

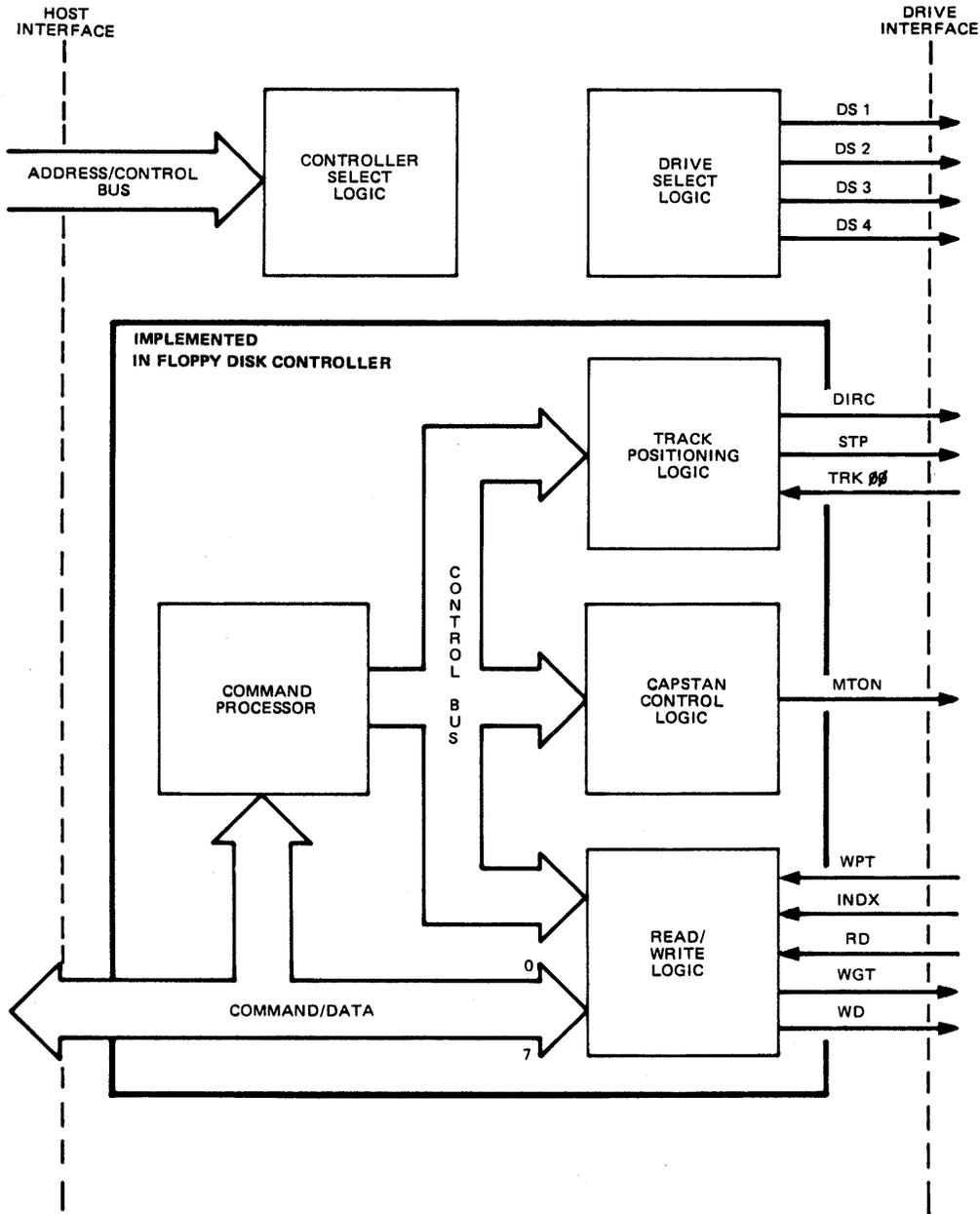


Figure 9-2. Typical Floppy Disk Host Controller

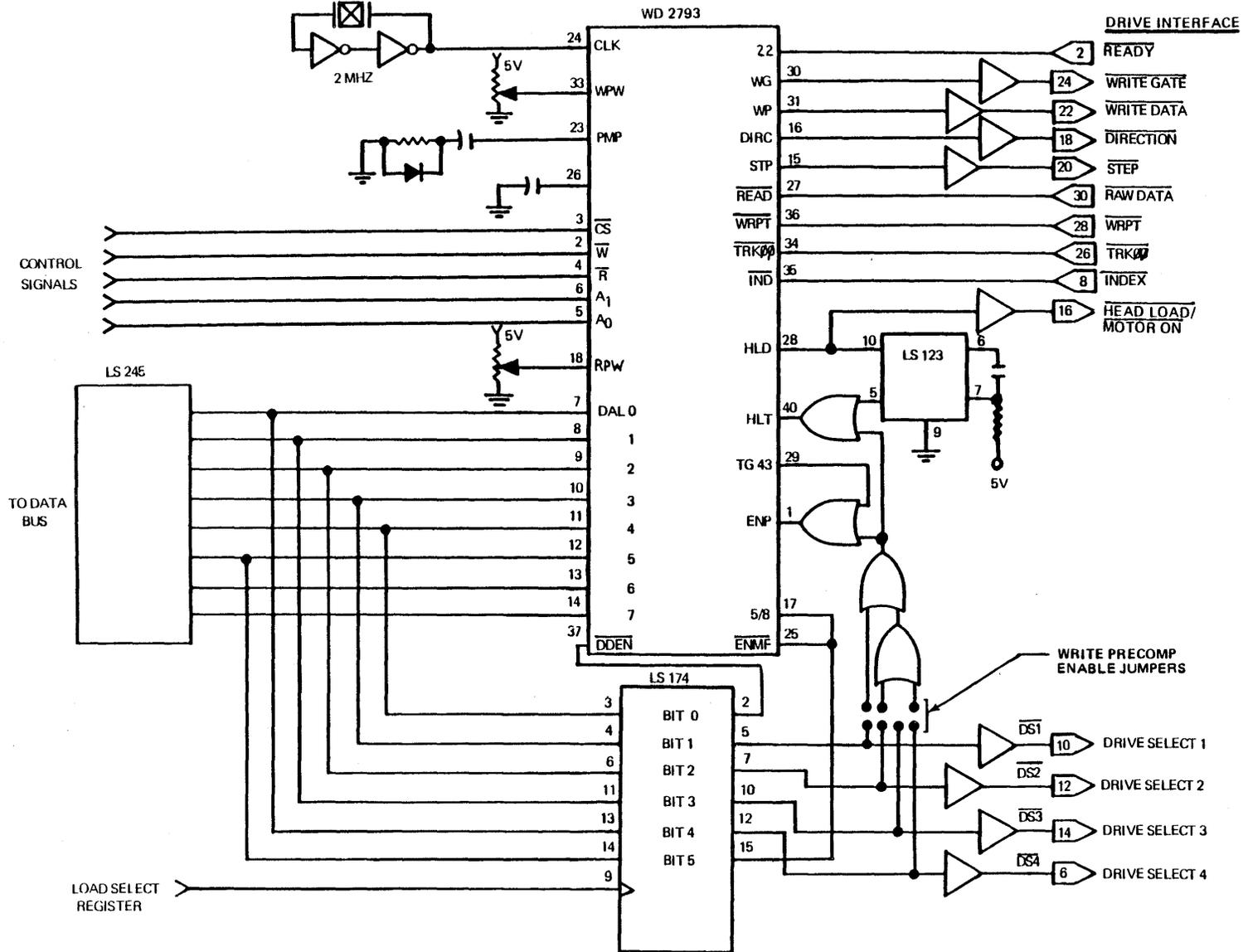


Figure 9-3. 525 Controller Example - SA450

9.3 ENCODING TECHNIQUES

The recording format on the tape cartridge is strictly a function of the host system. Data may be recorded, using either Frequency Modulation (FM) or Modified Frequency Modulation (MFM) encoding. MFM encoding is recommended, due to its more efficient utilization of tape storage capacity.

A "bit cell" is an abstract term referring to the nominal amount of time used to partition a bit-wide stream into component time-based values. Generation of the X-axis (reference clock) is the function of the host system controller. Without superimposing the X-axis, the value of the bit stream at a given time is impossible to determine. Figure 9-4 compares FM and MFM recording of a bit stream with a value of 01011001.

9.3.1 Single Density (FM)

Frequency Modulation (FM) is a self-clocking encoding scheme used to record bit serial data on magnetic media. Bit cell clocking is achieved by first writing a one bit flux reversal to define the leading edge of the cell. If the data value of the cell is a one, a second flux reversal will occur approximately midway through the bit cell. If it is a zero, there will be no further flux reversals until the leading edge of the next bit cell. The bit cell time for single density is four microseconds. The pulse width for a one bit (either clock or data) is 300 ns. See Figure 9-4.

9.3.2 Double Density (MFM)

Modified Frequency Modulation (MFM) is a bit serial encoding scheme used to record data on magnetic media. Unlike FM, MFM does not provide clocking pulses to create a cell. In MFM, the data window (bit cell) generation requires the host system floppy disk controller to derive a reference clock from the incoming data bit stream that can be used to define bit cell boundaries. The nominal bit cell time for MFM is two microseconds. See Figure 9-4.

When using MFM, a write precompensation of 200 nanoseconds should be used by the floppy disk controller.

9.4 SOFTWARE CONSIDERATIONS

The following paragraphs address device driver software parameters and applications in order to optimize data throughput and storage capacity for the 525.

9.4.1 Drive Selection

To utilize all six data streams of the 525, the host controller should use a binary device (drive) selection on the drive interface bus.

Use of a Radial Select mode, with Side Select, would limit the host system to selecting eight logical disk surfaces (i.e., one double-sided floppy disk drive and one 525).

9.4.2 Addressable Tracks (Segments)

Software drivers for the 525 should allow a track value of 255 to utilize all segments within a stream.

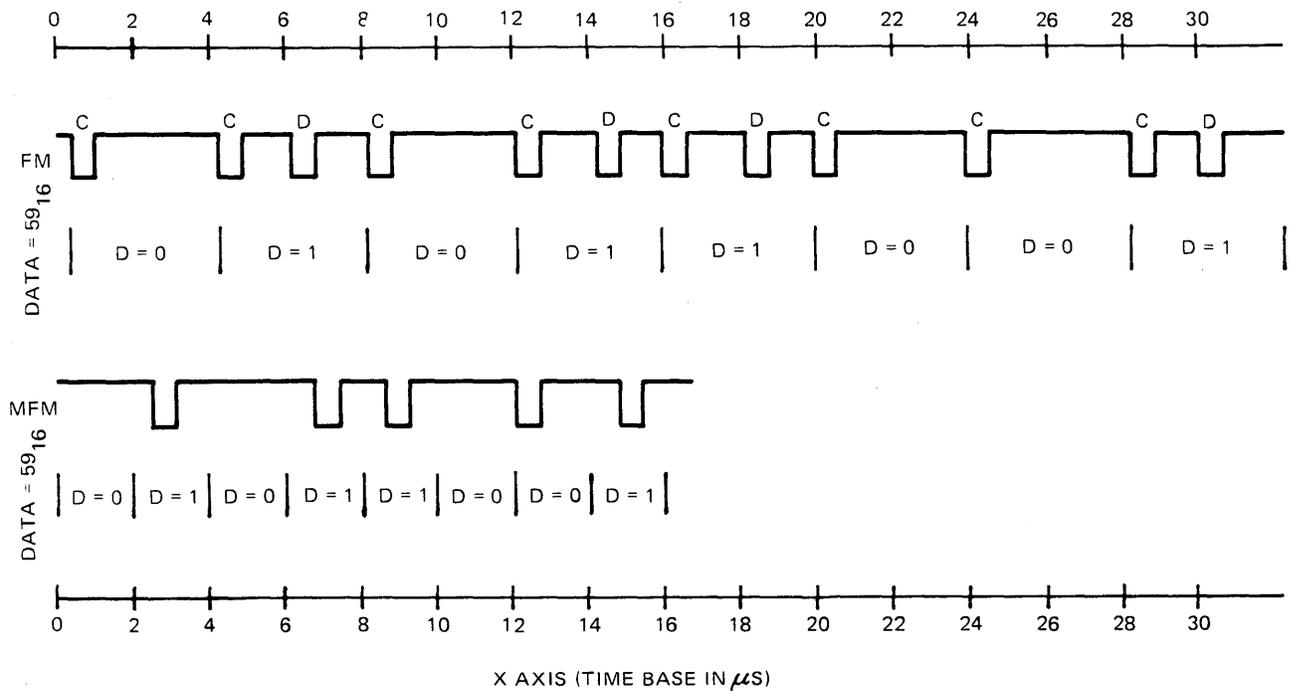


Figure 9-4. FM vs. MFM Recording

9.4.3 Number Of Sectors

Software drivers for the 525 must utilize the appropriate number of sectors per segment. (See Paragraph 9.5.)

9.4.4 Stream Formatting

The operating system should format streams in consecutive pairs to reduce the time required for the verification pass. When Stream 2 is formatted after Stream 1, the controller can then start the verification pass for Stream 1 and then Stream 2. This way serpentine recording will not cause the loss of time required to recalibrate to Segment 00. Another way to accomplish the same result is to format all six streams prior to the start of the verification pass.

9.4.5 I/O Buffering & Sector Interleaving

Multiple sector accessing should always be performed in a contiguous mode to avoid repositioning within segments. Therefore, there should be no sector interleaving.

Although sector interleaving is often used by systems integrators, it does lengthen the interblock time between sectors that is required by certain Disk Operating Systems (DOS) to relocate data. Another performance penalty occurs when the rate at which the DOS can accept data is exceeded, causing the system to wait one full disk rotation before being able to retrieve the data written in the next consecutive sector. A similar penalty can occur when using the 525. It is caused by a host system not being able to sustain a data rate of 49.1 Kbytes/sec with 512 byte sectors. The time required for each

reposition is 1.7 seconds. Disk users facing this problem address the issue by interleaving sectors by the same factor. However, sector interleaving on tape would force the 525 to perform constant repositions.

Fine tuning of the 525 to an Operating System can be accomplished by increasing the minimum gap size between sectors to achieve the correct Interblock Time. Using gap characters to compensate for the required Operating System Interblock Time eliminates the time penalty of a segment reposition at the expense of the users data capacity.

Adding one byte to the Inter-Record Gap (IRG) G3 (see Figure 9-5) increases this time by 16 us. Because the maximum available number of bytes per segment is 20,455 bytes, an increase of G3 could result in a smaller number of sectors per segment. Refer to Paragraph 9.5.1 for details.

9.4.6 Retension Pass

Tapes that have set idle, transported, handled excessively, or have been involved in more than 50 start/stop operations, should have a retension pass to ensure proper operation. Failure to do so may result in data error rates that are unacceptable. The 525 performs this function automatically when a tape is loaded into the device. The pass lasts for approximately 90 seconds. ~~Future 525s (January 1985) will have a short auto-retension pass built into the unit. This pass will also take place during a tape load, but will last for approximately 30 seconds.~~

Full retension passes can be performed under program control by seeking to segment 255 and followed by a return Seek to segment 0. Full retension is a function of host software and should be performed when soft errors increase to an unacceptable level due to excessive start/stop operations or repositions.

9.5 FORMATTING

9.5.1 Format Description

In order to ensure interchangeability between drives and proper operation over the entire operating temperature range, it is required to have preambles and postambles (gaps) attached to each sector. The use of the standard IBM System 34 format and MFM encoding is recommended. Formats deviating from the IBM standard must still comply with the minimum gap requirements specified for the IBM System 34 format. (See Figure 9-5.)

The formula for the maximum number of sectors per segment for a given sector size is:

$$\text{Sectors Per Segment} = \frac{\text{SL} - \text{IP}}{\text{DF} + \text{OL} + \text{IGL}}$$

SL = Segment length (fixed) = 20,455 bytes

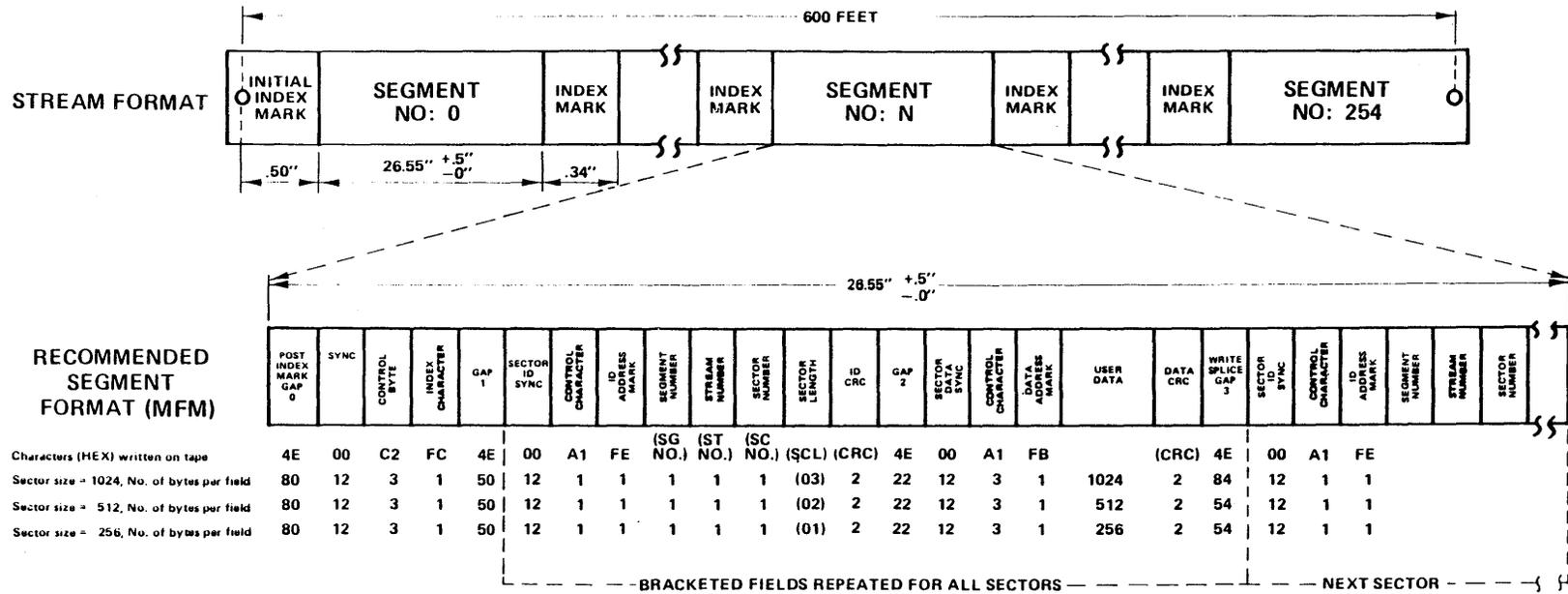
IP = Index Postamble = 146 bytes (IBM format)

DF = Data Field = 256 or 512 or 1,024 bytes

OL = Overhead Length = 62 bytes (IBM format)

IGL = Inter-record Gap Length G3 = 54 bytes for 256/512 byte Data Fields
84 bytes for 1,024 byte Data Fields

Sector Length	Sectors/Segment	Capacity/Stream	Total Formatted Capacity
256 bytes	54	3.5 Mbytes	21.15 Mbytes
512 bytes	32	4.2 Mbytes	25.07 Mbytes
1,024 bytes	17	4.4 Mbytes	26.63 Mbytes



FORMATTED CAPACITIES

SECTOR SIZE	SECTOR/SEGMENT	USER BYTES/SEGMENT	DATA YIELD PER STREAM	TOTAL DATA YIELD
1024 Bytes	17	17,408 Bytes	4.4 M Bytes	26.63 M Bytes
512 Bytes	32	16,384 Bytes	4.2 M Bytes	25.07 M Bytes
256 Bytes	54	13,824 Bytes	3.5 M Bytes	21.15 M Bytes

Figure 9-5. IBM System 34 Format Example

It is important to use controllers offering maximum versatility. Some floppy disk controllers allow only 15 sectors of 512 bytes each to be formatted per segment. Others may not allow all 255 segments to be addressed. Limitations to these parameters would significantly impact capacity and performance of a system.

9.5.2 Data Integrity

The 525 is a streaming device that has the ability to re-write individual sectors. Host operations should be designed to run this device in a streaming mode as much as possible.

System operations designed strictly for a start/stop operation will cause heat build up within the cartridge and the tape device. This heat has to be removed through external cooling (fan(s)). Failure to do so will lead to a rise in temperature that may exceed 45° at the cartridge base, and loss of data could result.

To ensure data integrity, the following steps should be taken by the host system:

1. Format each stream with the selected sector scheme. An all-ones pattern should be written in the user data field to test all bit cells within the user data area.
2. Run a verification pass against each formatted stream to test for dropout events which result in CRC errors. Any sector with CRC errors should be flagged in the Volume Table Of Contents (VTOC) to indicate a defective sector. This prevents future use of defective sectors.

Each of the above passes takes approximately 90 seconds per stream to complete.

9.5.3 Format Operation

The 525 appears as a soft sectored floppy disk drive to the Floppy Disk Controller (FDC). Consequently, the format to be recorded is determined by the FDC. During formatting, the FDC scans for an Index pulse on the drive interface. When detected, the FDC is to start writing the track format, beginning with the Index postamble gap, and followed by the required numbers of sectors, including IDs. After the last sector, the FDC resumes writing the fill field (Index preamble gap) until another Index pulse occurs. Upon detection of the Index pulse, the FDC must stop the Write operation. The fill field allows the open loop writing process to be consistent with speed variations, and therefore Index timing, of the 525. The minimum time between Index pulses, while formatting, is 327 ms. Upon completion of the formatting operation, a verification pass should be run against each stream. (See Figures 9-6, 9-7 and 9-8.)

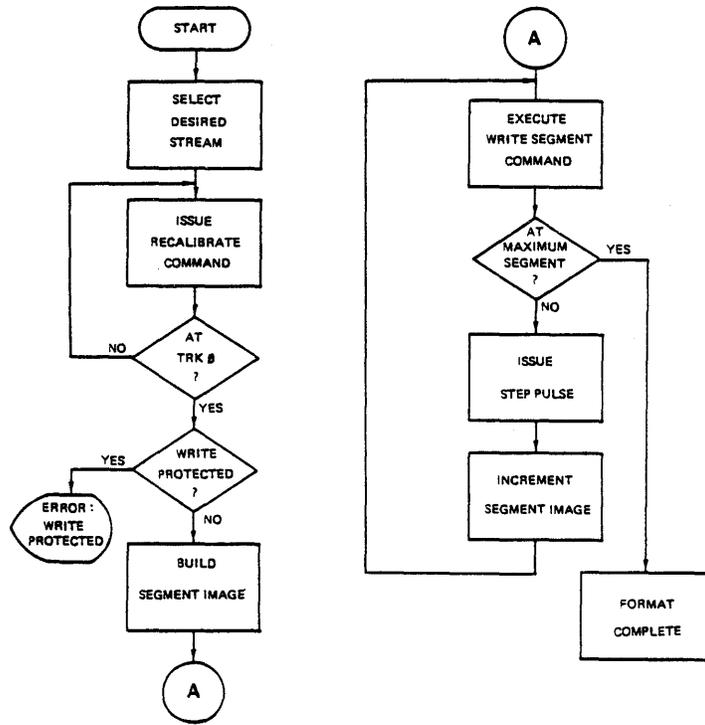


Figure 9-6. Format Flowchart

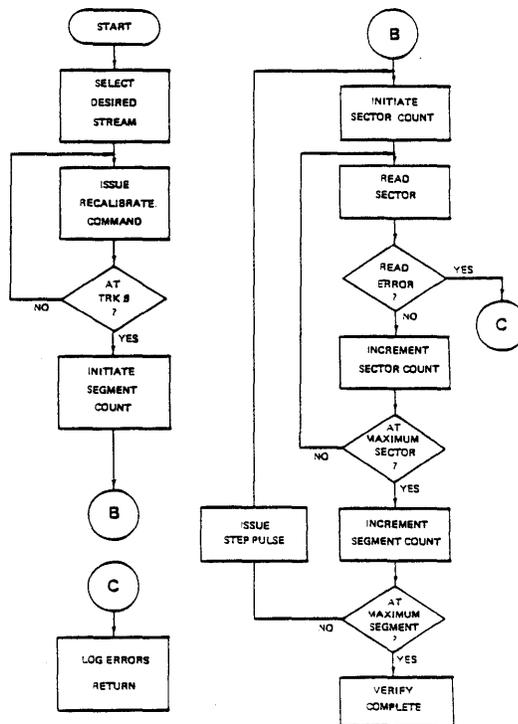
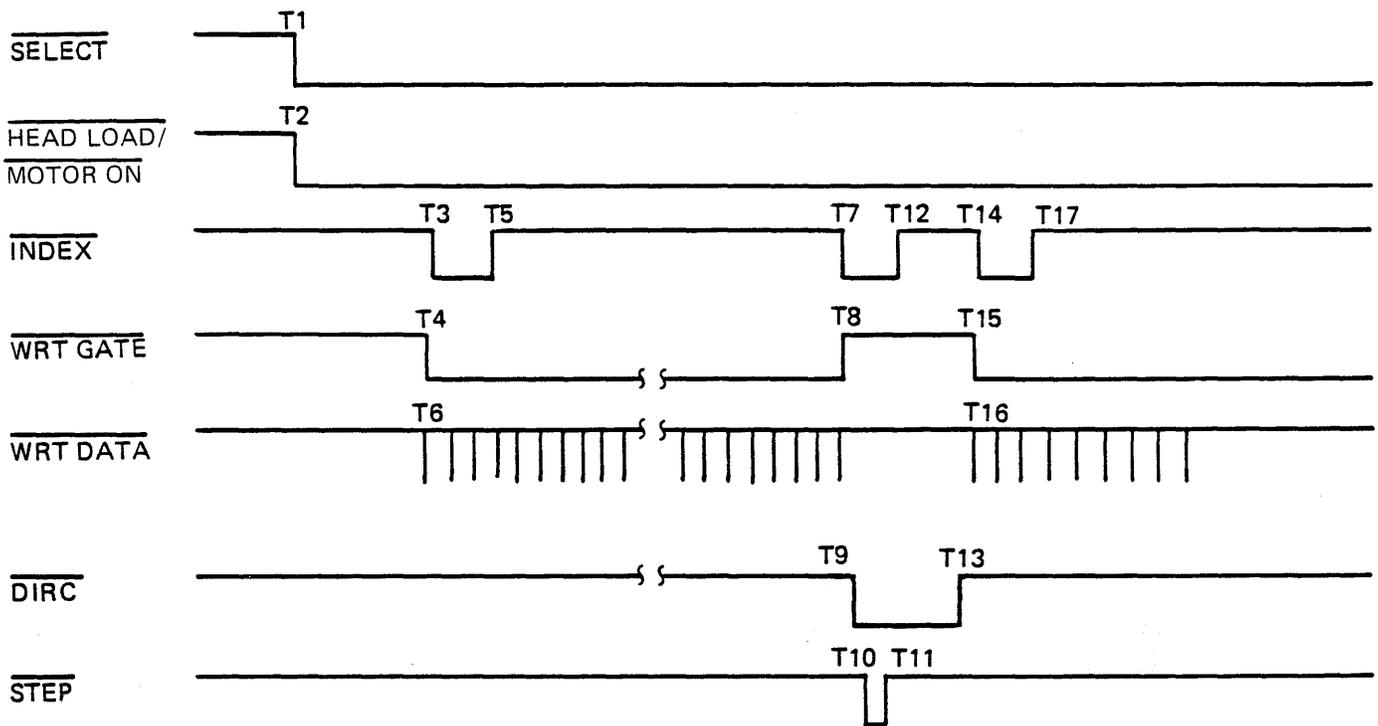


Figure 9-7. Verification Pass Flowchart



- $T_1 \rightarrow T_2$ Select to HLD/MTON ≥ 0 .
- $T_2 \rightarrow T_3$ HLD/MTON to INDEX > 350 ms.
- $T_3 \rightarrow T_4$ INDEX to WRT GATE < 125 μ s.
- $T_4 \rightarrow T_6$ WRT GATE to WRT DATA < 4 μ s.
- $T_3 \rightarrow T_5$ INDEX Width = 1.7 ms min.
- $T_3 \rightarrow T_7$ Segment Boundaries = 327 ms min.
- $T_7 \rightarrow T_8$ INDEX to WRT GATE ≥ 0 .
- $T_7 \rightarrow T_9$ INDEX to DIRC ≥ 0 .
- $T_9 \rightarrow T_{10}$ DIRC to STEP ≥ 1 μ s.
- $T_{10} \rightarrow T_{11}$ STEP Width = 1 μ s min.
- $T_{11} \rightarrow T_{13}$ STEP false to DIRC = 10 μ s min.
- $T_{11} \rightarrow T_{14}$ STEP false to INDEX = 100 μ s min.
- $T_7 \rightarrow T_{14}$ Inter-Segment Gap = 6 ms min. max.

Figure 9-8. Stream Format Timing

9.6 ACCESS TIMING

9.6.1 Stream To Stream

To achieve optimum positioning accuracy, the Read/Write head positioner is always returned to home position prior to positioning to a new stream.

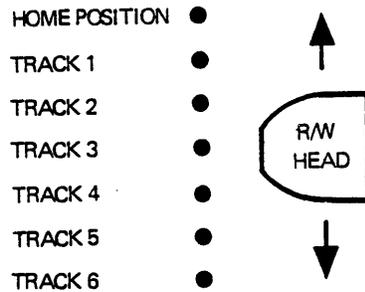


Figure 9-9. Head Positioning

Each step requires 200 ms.

Example: Position from Track 1 to Track 3 = ~~2~~ x 200 = ~~400~~ ms.
 Track 1 to ~~Home Position~~ Track 2 = 200ms, ~~Home Position~~ Track 2 to Track 3 = ~~200~~ms

9.6.2 Segment To Segment

Access time from a segment to a contiguous segment is 344 ms. (Index Mark to Index Mark).

Access time from a segment to a non-contiguous segment is calculated by determining the offset number of segments between the "at" segment and the "target" segment and multiplying by 0.344 seconds. This technique is illustrated in the following examples and Figures 9-10 and 9-11.

A. Upstream Segment Accessing

Target Segment 166

At Segment 150

Offset 16

Access Time = (16) x (0.344) = 5.5 seconds

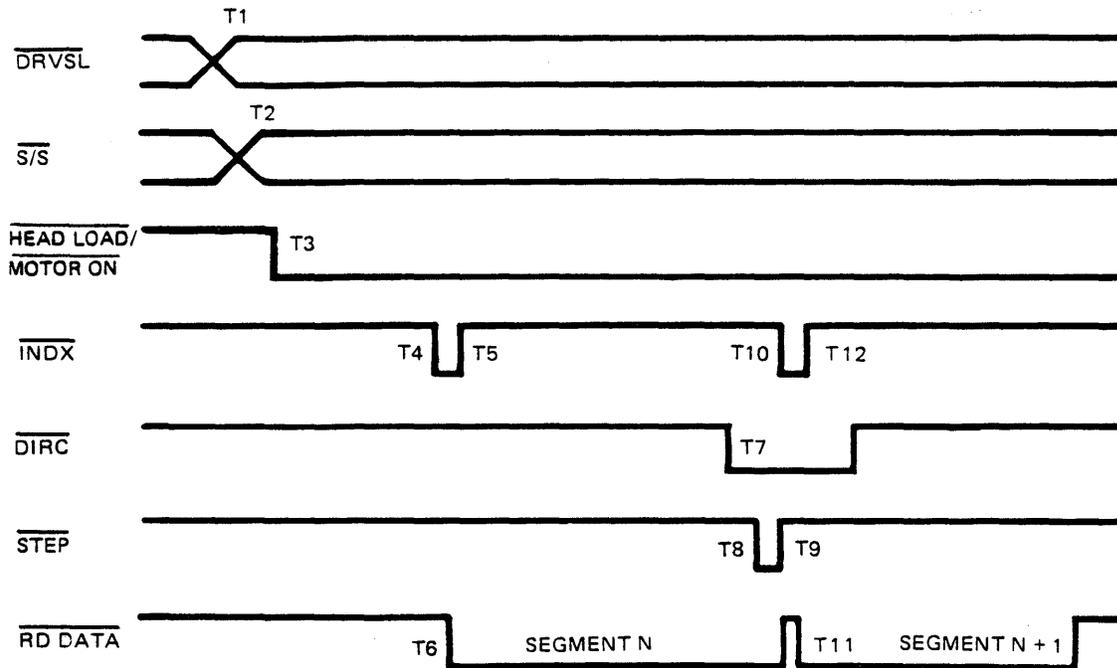
B. Downstream Segment Accessing

At Segment 64

Target Segment 58

Offset Number 6

Access Time = (6) x (0.344) + 1.2 (ramp time) = 3.26 seconds



T₁ - Host asserts DRVSL lines.

T₂ - Host asserts S/S line.

T₃ - Host asserts HLD/MTO line.

T₄ - 525 asserts INDX, T₃ → T₄ = 400 ms min.

T₅ - 525 de-asserts INDX, T₄ → T₅ = 1.7 ms min.

T₆ - 525 begins to supply raw data, T₄ → T₆ < 2 μs.

T₇ - Host sets DIRC line in preparation for a Step In command, T₅ → T₇ < 338 ms.

T₈ - Host sets STEP line, T₇ → T₈ > 1.0 μs and T₅ → T₉ < 338 ms.

T₉ - Host resets STEP T₈ → T₉ > 1 μs.

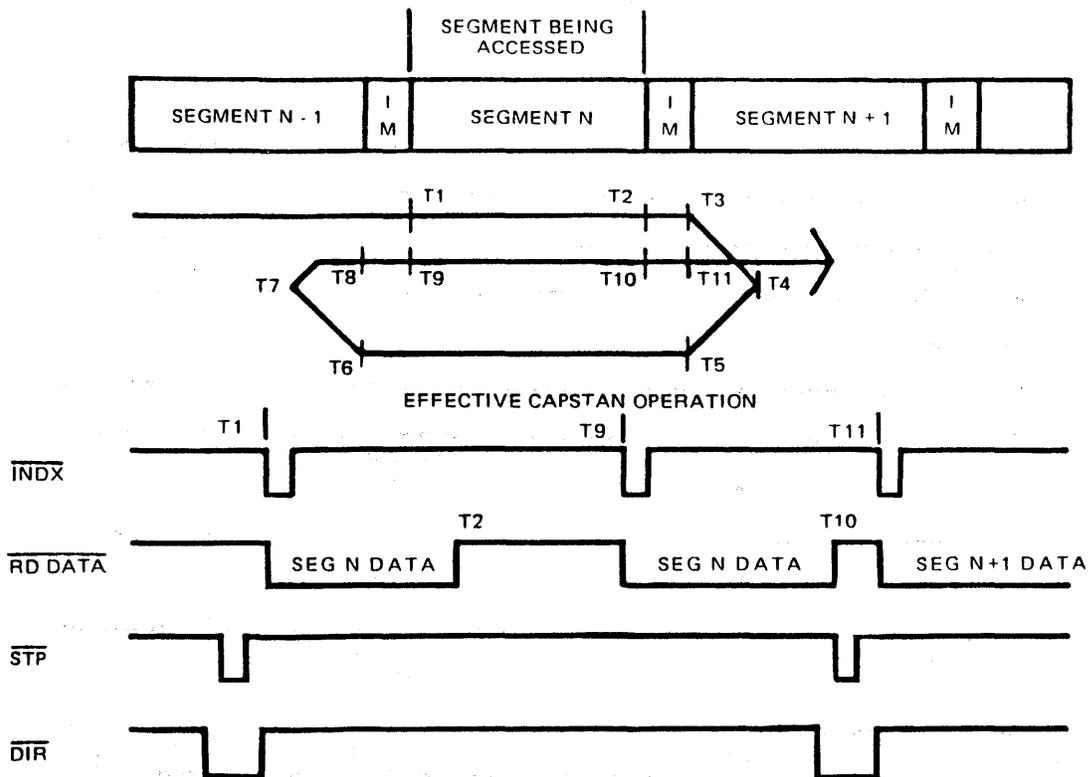
T₁₀ - 525 asserts INDX, T₄ → T₁₀ = 338 ms.

T₁₁ - Same as T₆.

T₁₂ - 525 resets INDX, T₁₀ → T₁₂ = 1.7 ms min.

Figure 9-10. Contiguous Segment-to-Segment Timing

9.6.3 Read Reposition



- T₁ - 525 generates INDX pulse (begins valid Read Data time).
- T₂ - Conclusion of valid RD time, T₁ → T₂ < 340 ms.
(To keep the 525 streaming, the host must send a STP pulse within T₁ → T₃ = 344 ms.)
- T₃ - No Step pulse sent by host, 525 drive motor begins to ramp down, T₂ → T₃ = 6 ms.
- T₄ - Tape motion halts T₃ → T₄ = 300 ms. Tape motion starts in reverse.
- T₅ - Tape motion in reverse at full speed, T₄ → T₅ = approximately 350 ms (Ramp-up time).
- T₆ - 525 runs reverse, T₅ → T₆ = 350 ms.
- T₇ - 525 starts ramp-down, T₆ → T₇ = approximately 300 ms.
- T₈ - Tape motion at Read speed, T₇ → T₈ = approximately 350 ms.
- T₉ - 525 generates INDX pulse (same as T₁).
- T₁₀ - Same as T₂.
- T₁₁ - Same as T₁.

Figure 9-11. Read Reposition Timing

APPENDIX A
CONFIGURATION TABLES

A.1 JUMPER OPTIONS

Jumpers W1 through W10 are used to configure the 525 as follows:

- W1 - Stream selection jumper
- W2 - Stream selection jumper
- W3 - Stream selection jumper
- W4 - In Use LED on when logical drive selected
- W5 - In Use LED on when logical drive selected and Head Load line true and drive ready
- W8 - When in, allows host generated signal to light front panel LED to indicate drive in use
- W9 - Service aids configuration jumper
- W10 - Service aids configuration jumper

A.2 STREAM SELECTION TABLES

Stream Selection is provided by the four Drive Select (DS 1-4) lines together with the Side Select line, as determined by the configuration of jumpers W1, W2 and W3.

Option 1. Binary Select Using DS2 - DS4

W1 - In		W2 - In		W3 - In	Yields
DS1	DS2	DS3	DS4	Side Select	
H	L	H	H	H	Stream 1
H	H	L	H	H	Stream 2
H	L	L	H	H	Stream 3
H	H	H	L	H	Stream 4
H	L	H	L	H	Stream 5
H	H	L	L	H	Stream 6

Option 2. Binary Select Using DS1 - DS3

W1 - Out		W2 - In		W3 - In	Yields
DS1	DS2	DS3	DS4	Side Select	
L	H	H	H	H	Stream 1
H	L	H	H	H	Stream 2
L	L	H	H	H	Stream 3
H	H	L	H	H	Stream 4
L	H	L	H	H	Stream 5
H	L	L	H	H	Stream 6

Option 3. Radial Select Using DS2 - DS4 And Side Select

W1 - In	W2 - Out		W3 - In	Yields	
DS1	DS2	DS3	DS4	Side Select	
H	L	H	H	H	Stream 1
H	L	H	H	L	Stream 2
H	H	L	H	H	Stream 3
H	H	L	H	L	Stream 4
H	H	H	L	H	Stream 5
H	H	H	L	L	Stream 6

Option 4. Radial Select Using DS1 - DS3 And Side Select

W1 - Out		W2 - Out		W3 - In	Yields
DS1	DS2	DS3	DS4	Side Select	
L	H	H	H	H	Stream 1
L	H	H	H	L	Stream 2
H	L	H	H	H	Stream 3
H	L	H	H	L	Stream 4
H	H	L	H	H	Stream 5
H	H	L	H	L	Stream 6

Option 5. Binary Select Using DS1 - DS2 And Side Select

W1 - In		W2 - In		W3 - Out	Yields
DS1	DS2	DS3	DS4	Side Select	
L	H	H	H	H	Stream 1
L	H	H	H	L	Stream 2
H	L	H	H	H	Stream 3
H	L	H	H	L	Stream 4
L	L	H	H	H	Stream 5
L	L	H	H	L	Stream 6

Option 6. Binary Select Using DS2 - DS3 And Side Select

W1 - Out		W2 - In		W3 - Out	Yields
DS1	DS2	DS3	DS4	Side Select	
H	L	H	H	H	Stream 1
H	L	H	H	L	Stream 2
H	H	L	H	H	Stream 3
H	H	L	H	L	Stream 4
H	L	L	H	H	Stream 5
H	L	L	H	L	Stream 6

Option 7. Binary Select Using DS3 - DS4 And Side Select

W1 - In		W2 - Out		W3 - Out	Yields
DS1	DS2	DS3	DS4	Side Select	
H	H	L	H	H	Stream 1
H	H	L	H	L	Stream 2
H	H	H	L	H	Stream 3
H	H	H	L	L	Stream 4
H	H	L	L	H	Stream 5
H	H	L	L	L	Stream 6

A.3 SERVICE AIDS

The on-board microprocessor can be utilized to perform basic service aid routines with the 525. The service aids are initiated by applying ground jumpers W9 and W10.

A.3.1 Continuous Forward/Reverse

With jumper W9 installed, inserting a cartridge causes the drive to do a normal retension pass and then start a continuous forward/reverse cycling between BOT and EOT. Head position is changed at the end of each pass to equalize wear. This function is terminated by removing the jumper and the cartridge.

A.3.2 Stream Positioning - All Streams

With jumper W10 installed, inserting a cartridge causes the head to move to the home position. Then the head moves alternately between the home position and each stream position, first decrementing, then incrementing, with a one second delay at each position. The function is terminated by removing the jumper and the cartridge.

A.3.3 Stream Positioning - Stream 0 & 4

With jumper W10 installed, inserting a cartridge starts the routine outlined in Paragraph A.3.2. **Subsequent** insertion of W9 modifies the routine as follows: The head will alternate between the home position and Stream 4 only. The head will remain two seconds at Stream 4, but turnaround without delay at the home position. Removal of W10 causes the head to remain at Stream 4 until W10 is replaced. The function is terminated by removing the jumpers and the cartridge.

A.3.4 Cyclic Tape Motion

With jumpers W9 and W10 installed, inserting a cartridge causes the drive to do a normal retension pass and then start a cyclic run forward motion for approximately 500 milliseconds (ms), then run in reverse for approximately 125 ms. This cycle continues until EOT is reached. Then, the drive does a high speed reverse to BOT and starts the cycle over. This function is terminated by removing the jumpers and the cartridge.

APPENDIX B

OPERATING PARAMETER CONSIDERATIONS

Integration of the 525 into a host floppy disk control system requires consideration of several specific operating parameters. Parameter changes indicated in this Appendix reflect the use of either Western Digital 179X, 279X, or NEC 765 controller chips by the host system.

B.1 TIME OUTS

Two types of time outs may require adjustment for the 525.

The first time out is sometimes referred to as the "dead man" timer. This timer is used by the host system to test for a catastrophic device failure. Common implementation of this timer is to start its count when the drive is first accessed, and halt it with the Index pulse returned by the drive. Because this timer is external to both types of controller chips, it may become a software consideration for the host system. The nominal time for the 525 to generate an Index pulse is 1.7 seconds from the time that the motion signal (Motor On or Head Load) is asserted. Any system time out shorter than 1.7 seconds should be adjusted to reflect this parameter.

The second type of time outs are those internal to a specific floppy disk controller chip. These time outs are either specified as part of commands (WD), or as part of a Specify Command (NEC), used to set up the controller prior to an operation.

Type	NEC 765	WD179X	WD279X
Head Load	2 ms	0 ms	0 ms
Step Rate	1 ms	3 ms	3 ms
Head Seek	N/A	Null Seek*	Null Seek*

- * The WD controller chips keep the head loaded for 15 "revolutions" (15 Index pulses) after the last command. To avoid constant repositioning during this time, a Null Seek command should be issued at the completion of all tape movement operations. This is accomplished by Seeking the current segment with the HLD bit turned off in the Seek command.

B.2 READ AFTER WRITE

The normal Read-After-Write operation for a floppy disk drive must be modified to achieve optimum performance with the 525. Read verification following a format pass should be performed in a streaming mode. System integrators should modify their format routine to format adjacent streams in pairs (i.e., 1 + 2, 3 + 4, 5 + 6) to eliminate the dead time caused by recalibrating to logical Track 00 (Segment 0). The read verification following the format pass should be performed in the same manner.

B.3 REINSTRUCT TIMING

The most critical timing for the 525 is in the format operation. Following the termination of a Write track operation by an Index pulse from the 525, the host controller has six milliseconds in which to give the drive a Step pulse to avoid a reposition. It is recommended that when the controller completes the Write Track command, the host system should immediately initiate a Step command. Following the Step command the host should then up-date the "Track Image Buffer" (Western Digital) or the "Track Sector List" (NEC 765) in preparation for the next segment format operation. To ensure streaming operations when editing sectors or segments following formatting, the host system must perform all Step In or Step Out type functions with the HLD bit turned on and the Verify bit (WD only) turned off.

B.4 SECTORS/SEGMENT COUNTS

In order to utilize the full capacity of the 525, the following parameters in the device driver software and format routine should be modified:

- o Number of Segments/Stream (equivalent to Tracks/FD surface)
- o Number of Sectors/Segment (equivalent to Sectors/FD track)

The following table is based on MFM encoding and an IBM System 34 type compatible format. The Bytes/Sector column lists the standard sector sizes used for floppy disks. The Sectors/Segment column reflects the maximum number of sectors that may be recorded reliably within a segment. The Segments/Stream columns state the maximum segment count that the floppy disk controller chip can support.

Bytes/ Sector	Sectors/ Segment	Segments/ Stream (WD)	Segments/ Stream (NEC)
256	54	252*	255
512	32	252*	255
1024	17	252*	255

*WD controller chips use the following hexadecimal numbers as control bytes for initialization purposes: F5 (245 dec), F6 (246 dec), F7 (247 dec). They are, therefore, unusable as valid segments for data storage.

B.5. STREAM (DRIVE) SELECTION

Adjacent streams run in opposite directions, allowing integrators to utilize the advantages of serpentine recording. The 525 has three configuration jumpers (W1, W2, W3) that facilitate the mapping of the six streams to the Drive Select and Side Select lines. (See Appendix A for configuration tables.) Two configurations allow for a radial selection of stream pairs with the Side Select choosing the required stream. In this mode, the 525 most closely resembles three double-sided disk drives. However, the head of the 525 is not at the same position in relation to Track 00 as it would be on a floppy disk. That is, if a double-sided floppy disk head is stepped to Track 23, both heads (side A and side B) would be over the same physical position except on opposite sides of the floppy disk media. This is not true for the 525.



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