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SPECIFICATION for MODEL OMTI 20C-1 INTELLIGENT CONTROLLER for 5-1/4" WINCHESTER DISK DRIVES

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REVISION RECORD

DATE	REVISION
6/29/83	Created document on text editing system.
3/28/84	Add precompensation and cartridge support.

1.0 INTRODUCTION

The OMTI Model 20C-1 intelligent controller is a high performance low cost 5-1/4" winchester disk controller designed to attach any ST506 type 5-1/4" winchester disk drive to various host computer systems.

The OMTI Model 20C-1 intelligent controller will support up to two 5-1/4" fixed, removable, or fixed/removable winchester disk drives. The fixed disk drives may have up to 16 heads.

The host interface is OMTI's standard implementation of the industry standard SASI BUS.

GENERAL FEATURES

HOST INTERFACE	Plug compatable with all SASI Controllers.
INTEGRAL DATA SEPARATOR	Field proven data separator design
WRITE PRECOMPENSATION	The starting Write precompensation cylinder can be specified by the ASSIGN PARAMETERS command.
HOST BUS TRANSFER RATE	The maximum host bus transfer rate is 1.2 microseconds per byte.
ODD PARITY	Unless disabled, odd parity is generated and checked on data transfers.
SINGLE PCB	The Model 20C-1 is a single 5-3/4 X 8.0 inch printed circuit board.
PROGRAMMABLE DISK PARAMETERS	The parameters for FIXED, REMOVABLE and the FIXED/REMOVABLE disk drives can be passed to the controller with the ASSIGN PARAMETERS command.
SELECTABLE SECTOR SIZE	Winchester disk sector sizes of 256 or 512 bytes are jumper selectable.
COMMAND LINKING	Allows the host the ability to link commands together on an "if sucessful" basis.
MULTIPLE CONTROLLERS	Allows up to eight controllers to be attached to the host.

GENERAL FEATURES (cont.)

DATA SCAN COMMANDS	Up to 256 sectors can be searched for a specific data pattern.
MULTIPLE DRIVE TYPES SUPPORTED	The Model 20C-1 supports any combination of 5-1/4" Fixed, Removable, and Fixed/Removable disk drives.
OVERLAPPED SEEK	Allows multiple drives to be postioned simultaneously.
IMPLIED SEEK AND VERIFY	A seek command is implied in all data transfer commands. If the heads are not positioned on the correct cylinder, a seek is initiated and cylinder verification is performed
MULTIPLE SECTOR OPERATIONS	Up to 256 sectors can be transferred with a single command. Head and cylinder switching is accomplished automatically by the controller.
ERROR CORRECTION	A powerful "computer generated" 32 bit ECC polynomial is utilized. Unless disabled, automatic correction is accomplished transparent to the host computer.
ERROR RETRY	Error retry on seek or read errors is performed automatically unless disabled
DEFECTIVE TRACK PROCESSING	Automatic defective/alternate track processing is accomplished transparent to the host computer. The host assigns an alternate for a defective track.
SECTOR BUFFER	A sector buffer is provided to ensure that no data overruns will occur.
SECTOR INTERLEAVING	Programmable interleave capability optimizes host throughput. A track may be transferred in two revolutions of the disk.
ERROR LOGGING	All disk related errors are logged and logs may be sensed by the host.

2.0 SPECIFICATION SUMMARY

2.1 ENVIORNMENTAL LIMITS

	OPERATING	STORAGE
Temperature	0 to 55^C	-40 to 75^C
Relative Humidity	10% to 95%	10 % to 95 %
Max. wet bulb	30^C	noncondensing
Altitude	0-10000 Ft.	0-15000 Ft.

2.2 POWER REQUIREMENTS

Model 20C-1

+ 5 VDC +/- 5% at 2.8 Amps (max.)
+12 VDC +/-10% at .15 Amps (max.)

2.3 PHYSICAL PARAMETERS

	Model 20C-1
Width	5.75 inches (14.6 cm)
Length	8.0 inches (21.6 cm)
Heigth	0.75 inches (1.3 cm)
Weight	9.0 ozs (.25 kg)

3.0 SYSTEM CONFIGURATION

The OMTI Model 20C-1 intelligent controller will support up to two 5-1/4" winchester disk drives.

The host computer is interfaced to the controller by a 50 pin cable connected to J4 on the controller. The host interface cable should not exceed 20 feet (6 meters) in length. The recommended mating connector for J4 is the 3M ribbon connector P/N 3425-6000.

The winchester disk drives are interfaced to the controller via J1,J2, and J3.

J1 is a 34 pin socket type connector which connects all winchester disk drives in a daisy chain configuration. This cable carries control information for the disk drives. The maximum cable length should not exceed 20 feet (6 meters) or the drive manufacturer's limit, which ever is smallest.

J2 and J3 are 20 pin socket type connectors used to radially connect the winchester disk drive data lines to the controller. The maximum cable length should not exceed 20 feet (6 meters) or the drive manufacturer's limit, which ever is less.

The disk drives are attached as shown in APPENDIX B.

3.0 SYSTEM CONFIGURATION (cont.)

5-1/4" WINCHESTER DISK DRIVE INTERFACE

The following diagrams define the pin assignments for the various 5-1/4" winchester disk drives supported.

CONTROL CABLE (J1)

DRIVE TYPE			ST506	REMOVABLE-FIXED/REMOVABLE
GND	1	2	WSI/HEAD SELECT 3	CARTRIDGE CHANGE
	3	4	HEAD SELECT 2	
	5	6	WRITE GATE	
	7	8	SEEK COMPLETE	
	9	10	TRACK 000	
	11	12	WRITE FAULT	
	13	14	HEAD SELECT 0	
	15	16	RESERVED	SECTOR
	17	18	HEAD SELECT 1	
	19	20	INDEX	
	21	22	READY	
	23	24	STEP	
	25	26	DRIVE SELECT 1	
	27	28	DRIVE SELECT 2	
	29	30	DRIVE SELECT 3	
	31	32	DRIVE SELECT 4	
GND	33	34	DIRECTION SELECT	

DATA CABLE (J2 and J3)

DRIVE TYPE	ST506	REMOVABLE-FIXED/REMOVABLE
1	DRIVE SELECTED	
2	GROUND	
3	RESERVED	
4	GROUND	
5	RESERVED	WRITE PROTECTED
6	GROUND	
7	RESERVED	
8	GROUND	
9	RESERVED	CARTRIDGE CHANGED
10	RESERVED	
11	GROUND	
12	GROUND	
13	+MFM WRITE DATA	
14	-MFM WRITE DATA	
15	GROUND	
16	GROUND	
17	+MFM READ DATA	
18	-MFM READ DATA	
19	GROUND	
20	GROUND	

Power is applied to the controller via J7 which is a 4 pin AMP connector. The recommended mating connector P3, is an AMP P/N 1-480424-0 using AMP pins P/N 60617-4 or equivalent.

```
                    J7
         .....................
         . 1    2    3    4  .
           ................

  + 12VDC    +12VDC    +5VDC     +5VDC
               RTN       RTN
```

The OMTI Model 20C-1 allows the user to jumper select the WINCHESTER disk sector size. The ASSIGN DISK PARAMETERS command WILL NOT OVERRIDE the jumper. The jumper (W6 or JP 4) selections are:

SECTOR SIZE	open = 256 bytes per sector shorted = 512 bytes per sector
NOTE:	AS SHIPPED, SECTOR SIZE IS 512.

The OMTI Model 20C-1 allows the user to jumper select parity enabled or parity disabled. The jumper (W9) selections are:

PARITY OPTION	Pins 1 - 2 shorted = parity enabled. Pins 2 - 3 shorted = parity disabled.
NOTE:	AS SHIPPED, PARITY IS ENABLED.

**NOTE: SEE APPENDIX E FOR BOARD LAYOUT.

Upon power-on or any reset command the controller defaults to the following parameters.

WINCHESTER DISK DRIVES

STEP PULSE WIDTH = 9 microseconds	(HEX 09)
STEP PULSE PERIOD = 3.0 milliseconds	(HEX 3C)
STEP MODE = 0	(HEX 00)
NUMBER OF HEADS = 4	(HEX 03)
MAXIMUM CYLINDER ADDRESS HI = 0	(HEX 00)
MAXIMUM CYLINDER ADDRESS LO = 153	(HEX 98)
REDUCED WRITE CURRENT = 128	(HEX 80)
If 256 bytes per sector;	
SECTORS PER TRACK = 32	(HEX 1F)
If 512 bytes per sector;	
SECTORS PER TRACK = 17	(HEX 10)

4.0 OPERATIONAL CHARACTERISTICS

4.1 STANDARD 'SOFT SECTORED' TRACK FORMAT

The standard track format for soft sectored disk drives is either 32 sectors per track with each sector containing 256 bytes of user data or 17 sectors per track with each sector containing 512 bytes of user data. Each sector consists of two fields separated by gaps to allow updating and recovery of the data. The first field in the sector is the ID FIELD. This field contains four data bytes which uniquely identifies the sector. The four bytes are defined as follows:

1. CYLINDER ADDRESS HI
2. CYLINDER ADDRESS LO
3. HEAD ADDRESS
4. SECTOR ADDRESS

The second field contains the user data bytes.

STANDARD 'SOFT SECTORED' TRACK FORMAT

```
.............................................................
.GAP 1  ID FIELD  GAP 2  DATA FIELD  GAP 3   16 / 31   GAP 4.
                                             SECTORS
.............................................................
...............1 sector..................
```

GAPS

INDEX GAP	=	11 bytes of 4E
GAP 1	=	12 bytes of 00
GAP 2	=	12 bytes of 00
GAP 3	=	15 bytes of 4E
GAP 4	=	325 bytes of 4E (256 bytes/sector)
	=	698 bytes of 4E (512 Bytes/sector)

ID FIELD

Byte #	1	A1
	2	FE
	3	Cylinder Hi
	4	Cylinder Lo
	5	Head and Flags
	6	Sector
	7-10	ECC
	11-12	00

	256 BYTE DATA FIELD		512 BYTE DATA FIELD	
Byte #	1	A1	1	A1
	2	F8	2	F8
	3-258	User data field	3-514	User data field
	259-262	ECC	515-518	ECC
	263-264	00	519-520	00

4.0 OPERATIONAL CHARACTERISTICS (cont.)

4.1 STANDARD SECTOR FORMAT (hard sectored drives)

The standard sector format for hard sectored disk drives consists of two fields separated by gaps to allow updating and recovery of the data. The number of sectors per track is determined by either the default jumpers or the ASSIGN PARAMETERS command. The first field in the sector is the ID FIELD. This field contains four data bytes which uniquely identifies the sector. The four bytes are defined as follows:

1. CYLINDER ADDRESS HI
2. CYLINDER ADDRESS LO
3. HEAD ADDRESS
4. SECTOR ADDRESS

The second field contains either 256 or 512 bytes of user data bytes.

STANDARD SECTOR FORMAT

```
.........................................
.GAP 1  ID FIELD  GAP 2  DATA FIELD  GAP 3.

.........................................
...............1 sector..................
```

GAPS

INDEX GAP	= 11 bytes of 4E
GAP 1	= 12 bytes of 00
GAP 2	= 12 bytes of 00
GAP 3	= 2 bytes of 4E

ID FIELD

Byte #	1	A1
	2	FE
	3	Cylinder Hi
	4	Cylinder Lo
	5	Head and Flags
	6	Sector
	7-10	ECC
	11-12	00

256 BYTE DATA FIELD

Byte #	1	A1
	2	F8
	3-258	User data field
	259-262	ECC
	263-264	00

512 BYTE DATA FIELD

1	A1
2	F8
3-514	User data field
515-518	ECC
519-520	00

4.2 DEFECTIVE TRACK FORMAT

If a track is found to be defective, the host can assign an alternate track for the defective track. When the controller encounters a defective track (for which an alternate track has been assigned) it will automatically access the assigned alternate track. The address of the alternate track is contained in the first three bytes of data field in all sectors of the defective track.The ID fields of the defective track contain a flag indicating that the track has been alternated. The ID fields of the alternate track are formatted with a flag indicating that the track has been assigned as an alternate track.

DEFECTIVE TRACK FORMAT

GAP 1	ID FIELD	GAP 2	DATA FIELD	GAP 3	16 / XX SECTORS	GAP 4

................1 sector...................

GAPS

INDEX GAP	= 11 bytes of 4E
GAP 1	= 12 bytes of 00
GAP 2	= 12 bytes of 00
GAP 3	= 15 bytes of 4E
GAP 4	= 325 bytes of 4E (256 bytes/sector)

ID FIELD

Byte #		
	1	A1
	2	FE
	3	Cylinder Hi
	4	Cylinder Lo
	5	Head and Flags
	6	Sector
	7-10	ECC
	11-12	00

256 BYTE DATA FIELD

Byte #		
	1	A1
	2	F8
	3-5	Log. Sec. Addr.
	6-9	ECC
	10-262	4E
	263-264	00

5.0 HOST BUS DEFINITION

The Model 20C-1 controller interface is the general purpose 8 bit bidirectional bus popularly known as the SASI BUS.

All commands are issued to the controller over the host bus using a predefined protocol. The host always initiates a command sequence by first selecting the controller. After the selection process the host then issues the appropriate command bytes.

Various checks are made on the command to ensure that drive limits, such as the number of tracks, are not exceeded. For data transfers, a sector buffer is provided to eliminate any possibility of data overruns. Upon command completion (either successfully or not), the controller will issue completion status to the host. Additional completion status information is provided through appropriate sense commands.

5.1 ELECTRICAL INTERFACE

All host computer interface signals are negative true. The signals are "ASSERTED" or active at 0 to 0.4 VDC and "DEASSERTED" or inactive at 2.5 to 5.25 VDC.

5.1.1 INTERFACE TERMINATION

All host computer interface lines are terminated with a 220/330 ohm resister network as shown in figure _. The host adapter should be terminated in a similar fashion.

The devices driving the controller inputs should be open collector devices capable of sinking at least 48 milliamps at a voltage level of less then 0.5 VDC (7438 or equivalent).

Devices receiving the controller outputs should be of the "SCHMITT" trigger type to improve noise immunity (74LS14, 74LS240 or equivalent). The host adapter should not load the bus with more than 1 standard TTL input per line.

5.1.2 SIGNAL INTERFACE

The host computer interface signals are as shown below.

GND	1	2	DATA BIT 0 (DB0)
	3	4	DATA BIT 1 (DB1)
	5	6	DATA BIT 2 (DB2)
	7	8	DATA BIT 3 (DB3)
	9	10	DATA BIT 4 (DB4)
	11	12	DATA BIT 5 (DB5)
	13	14	DATA BIT 6 (DB6)
	15	16	DATA BIT 7 (DB7)
	17	18	PARITY
	19	20	
	21	22	
	23	24	
	25	26	
	27	28	
	29	30	
	31	32	
	33	34	
	35	36	BUSY
	37	38	ACKNOWLEDGE
	39	40	RESET
	41	42	MESSAGE
	43	44	SELECT
	45	46	CONTROL / DATA
	47	48	REQUEST
GND	49	50	INPUT / OUTPUT

5.1.3 SIGNAL DESCRIPTION

RESET (-RST)

Assertion by the host causes the controller to cease all operations and return to the IDLE condition. This signal is normally used during a power up sequence. A RESET during a write operation would cause incorrect data to be written on the disk. The RESET pulse should be at least one microsecond wide.

SELECT (SEL)

Assertion by the host with the controller address bit (DBX) causes the controller to be selected. The SELECT line must be deasserted after the controller asserts the BUSY line.

BUSY (BSY)

Assertion by the controller indicates that the controller has control of the interface bus and cannot be interupted.

CONTROL / DATA (C/D)

Assertion by the controller indicates that command or status information is to be transferred on the data bus. Deassertion of this line indicates that data information is to be transferred on the data bus.

INPUT / OUTPUT (I/O)

Assertion by the controller indicates that information will be transferred to the host from the controller. Deassertion indicates that information will be transferred to the controller from the host.

REQUEST (REQ)

Assertion by the controller indicates that an 8 bit byte is to be transferred on the data bus. REQUEST is deasserted following assertion of the ACKNOWLEDGE line.

ACKNOWLEDGE (ACK)

Assertion by the host indicates data has been accepted by the host or that data is ready to be transferred from the host to the controller.

MESSAGE (MSG)

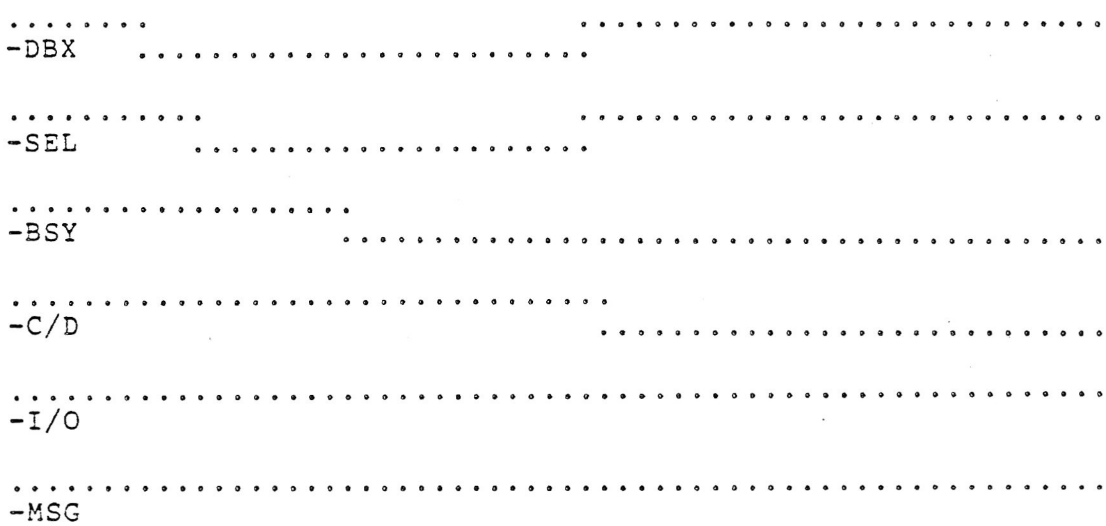
Assertion by the controller indicates that a status byte transfer has been accomplished. When MESSAGE is asserted, REQUEST will be asserted in order to transfer an 8 bit byte indicating the end of the operation. When the REQ/ACK handshake is complete the controller will deassert all interface signal lines and return to the IDLE state.

DATA BITS 0-7 (DB0-7)

The 8 bidirectional data lines are used to transfer 8 bit parallel data to / from to host computer. Bit 7 is the most significent bit.

5.1.4 SELECTION SEQUENCE

In order to gain the attention of the controller it is necessary to perform the following selection sequence: The host must first test BSY to determine if the controller is available. If BSY and all other I/O lines are deasserted, the host will assert one of the data lines (DBX = controller ID) and then assert SEL. The controller will then respond by asserting BSY. At this point the host must deassert SEL and DBX. The controller responds to SEL deasserted by asserting C/D. I/O remains deasserted throughout the selection sequence.



Parameter		min. (nS)	max. (nS)
ts	=	0	--
t(SaBa)	=	600	2000
t(SdCa)	=	1400	1800

ts = the time DBX must be valid prior to SELECT asserted.
t(SaBa) = The time from SEL asserted to BSY asserted.
t(SdCa) = the time from SEL deasserted to C/D asserted.

5.1.5 COMMAND TRANSFER SEQUENCE

Following the selection sequence the controller will assert REQ. The host will then place the first byte of the device command field on the data bus. The host will then assert ACK. The controller will then respond by reading the byte on the data bus and then deassert REQ. The host must then deassert ACK to begin the next REQ / ACK handshake. The handshake continues until all bytes of the command have been transferred. SEL is deasserted and BSY is asserted throughout this sequence.

```
.................                                             ...
-C/D              ...........................................

.............................................................
-I/O

.............................................................
-MSG

.........................      .......      .......      ......
-REQ                     .......      .......      .......

............................      .......      .......      ...
-ACK                        .......      .......      .......

...........................     .........    .........    .....
-DATA BITS.................     .........    .........    .....
```

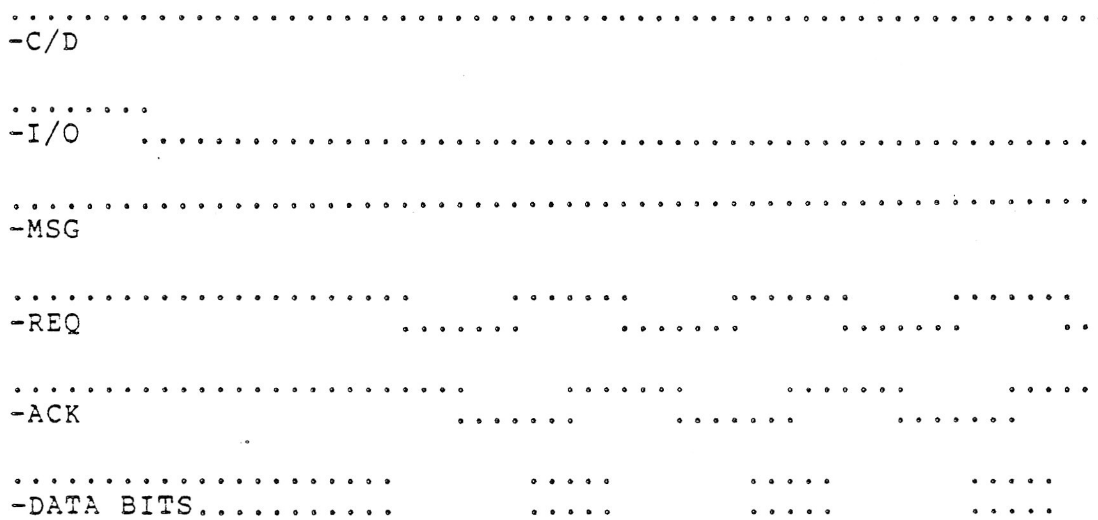
Parameter		min. (nS)	max. (nS)
ts	=	1	--
th	=	1	--
t(CaRa)	=	600	1000
t(RaRd)	=	600	--
t(RdRa)	=	600	--
t(RaAa)	=	0	--
t(AaRd)	=	600	800
t(RdAd)	=	0	--
t(AdRa)	=	600	800
t(RaRa)	=	1200	--

ts = the DATA setup time prior to asserting ACK.
th = the DATA hold time after REQ deassertion.
t(CaRa) = the time from C/D assertion to REQ assertion.
t(RaRd) = the time from REQ assertion to REQ deassertion.
t(RdRa) = the time from REQ deassertion to REQ assertion.
t(RaAa) = the time from REQ assertion to ACK assertion.
t(AaRd) = the time from ACK assertion to REQ deassertion.
t(RdAd) = the time from REQ deassertion to ACK deassertion.
t(AdRa) = the time from ACK deassertion to REQ assertion.
t(AdCd) = the time from ACK deassertion to C/D deassertion.
t(RaRa) = the minimum time between data bytes.

5.1.6 DATA TRANSFER SEQUENCE

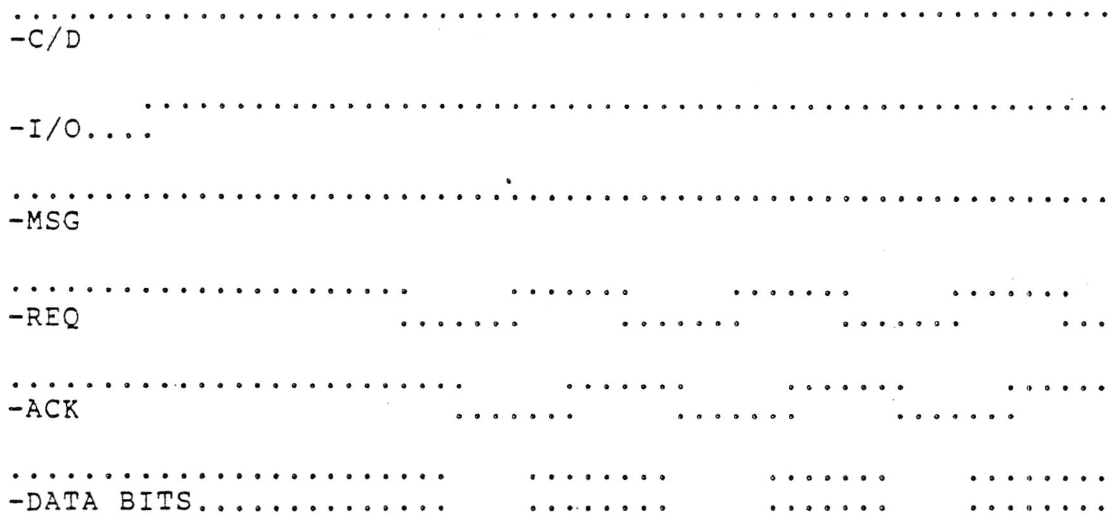
If the command sent to the controller involves a data transfer the controller will deassert the C/D line to indicate a data transfer. If the data transfer is from the controller to the host (read data) the I/O line will be asserted. If the data transfer is from the host to the controller (write data) the I/O line will be deasserted. The controller will then assert the REQ line to request a byte transfer. The host will then respond by transferring a byte across the data bus and then asserts ACK. This handshake continues until all data bytes have been transferred. SEL is deasserted and BSY is asserted throughout this sequence.

DATA TO THE HOST



Parameter		min. (nS)	max. (nS)
ts	=	100	--
th	=	100	--
t(IaRa)	=	600	1000
t(RaRd)	=	600	--
t(RdRa)	=	600	--
t(RaAa)	=	0	--
t(AaRd)	=	600	800
t(RdAd)	=	0	--
t(AdRa)	=	600	800
t(RaRa)	=	1200	--

DATA FROM HOST

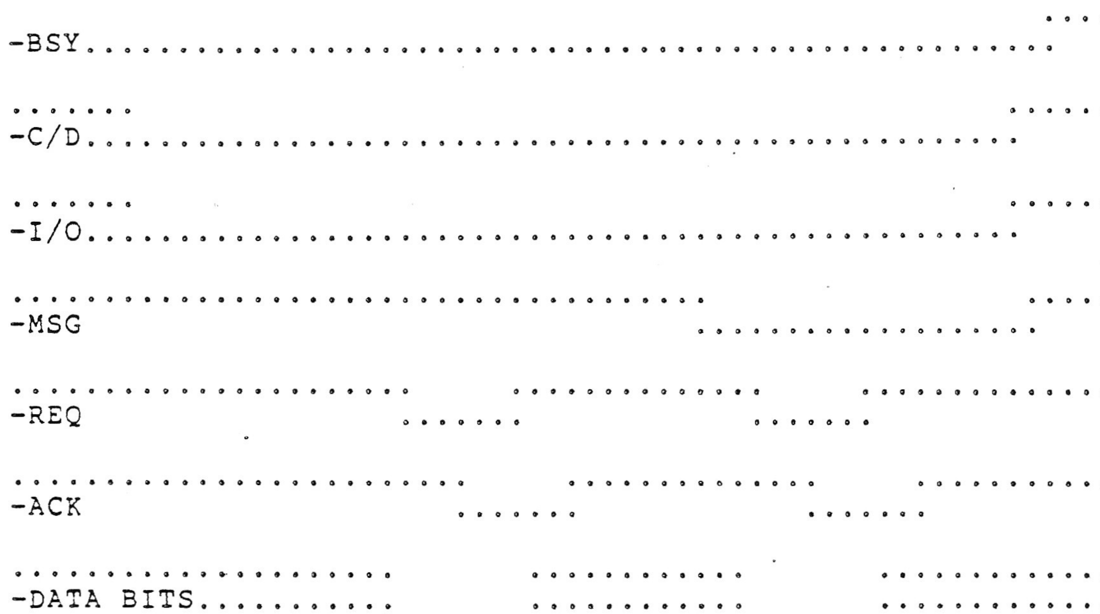


Parameter		min. (nS)	max. (nS)
ts	=	1	--
th	=	1	--
t(IdRa)	=	400	600
t(RaRd)	=	600	--
t(RdRa)	=	600	--
t(RaAa)	=	0	--
t(AaRd)	=	600	800
t(RdAd)	=	0	--
t(AdRa)	=	600	800
t(RaRa)	=	1200	--

ts = the DATA setup time prior to asserting ACK.
th = the DATA hold time after REQ deassertion.
t(IaRa) = the time from I/O assertion to REQ assertion.
t(IdRa) = the time from I/O deassertion to REQ assertion.
t(RaRd) = the time from REQ assertion to REQ deassertion.
t(RdRa) = the time from REQ deassertion to REQ assertion.
t(RaAa) = the time from REQ assertion to ACK assertion.
t(AaRd) = the time from ACK assertion to REQ deassertion.
t(RdAd) = the time from REQ deassertion to ACK deassertion.
t(AdRa) = the time from ACK deassertion to REQ assertion.
t(RaRa) = the minimum time between data bytes.

5.1.7 STATUS AND MESSAGE TRANSFER SEQUENCE

Following a command or data transfer, the controller will initiate a status byte and completion message transfer. When a status byte is required, the controller will assert C/D and I/O. The controller will then assert REQ. The host must then accept the status byte on the data bus and assert ACK. The controller will then deassert REQ and the host deasserts ACK. Following the Status byte transfer, a completion message will be transferred to indicate operation complete. The controller will assert the MSG line, along with C/D and I/O, then assert REQ. The host accepts the completion message byte on the data bus and asserts ACK. The controller then responds by deasserting REQ and the host by deasserting ACK. At this point BSY and all other controller signal lines will be deasserted and the controller will return to an IDLE state. SEL remains deasserted throughout this sequence.



Parameter		min. (nS)	max. (nS)
ts	=	100	--
th	=	100	--
t(IaRa)	=	200	600
t(RaRd)	=	600	--
t(RdRa)	=	600	--
t(RaAa)	=	0	--
t(AaRd)	=	200	400
t(RdAd)	=	0	--
t(AdRa)	=	600	1000
t(AdMa)	=	600	1000
t(MaRa)	=	100	300
t(AdId)	=	300	1800
t(AdCd)	=	500	2200
t(AdMd)	=	100	2000
t(AdBd)	=	2000	2400
t(RaRa)	=	1200	--

ts = the DATA setup time prior to asserting REQ.
th = the DATA hold time after REQ deassertion.
t(IaRa) = the time from I/O assertion to REQ assertion.
t(RaRd) = the time from REQ assertion to REQ deassertion.
t(RdRa) = the time from REQ deassertion to REQ assertion.
t(RaAa) = the time from REQ assertion to ACK assertion.
t(AaRd) = the time from ACK assertion to REQ deassertion.
t(RdAd) = the time from REQ deassertion to ACK deassertion.
t(AdRa) = the time from ACK deassertion to REQ assertion.
t(AdMa) = the time from ACK deassertion to MSG assertion.
t(MaRa) = the time from MSG assertion to REQ assertion.
t(AdId) = the time from ACK deassertion to I/O deassertion.
t(AdCd) = the time from ACK deassertion to C/D deassertion.
t(AdMd) = the time from ACK deassertion to MSG deassertion.
t(AdBd) = the time from ACK deassertion to BSY deassertion.
t(RaRa) = the minimum time between data bytes.

6.0 DISK COMMAND SPECIFICATIONS

Following the controller selection sequence the controller will always request a Device Command Field (DCF) which is either 6 or 10 bytes in length. The first byte of the DCF must always contain the command. The remaining bytes specify the drive logical unit number (LUN), logical sector address, number of sectors to be transferred, and a control byte.

The controller will check all incoming DCF's validity and, unless disabled, will check both DCF's and data for odd parity. An error in the command structure will terminate the command and cause a status byte transfer to occur upon completion of the DCF transfer.

6.1 COMMAND FORMAT

	7	6	5	4	3	2	1	0
BYTE 1	COMMAND CODE							
BYTE 2	0	LUN		LOGICAL ADDR 2 (MS)				
BYTE 3	LOGICAL ADDR 1							
BYTE 4	LOGICAL ADDR 0 (LS)							
BYTE 5	NUMBER OF SECTORS/INTERLEAVE CODE							
BYTE 6	CONTROL FIELD							

LUN (byte 2 - bits 5, 6, and 7) is the LOGICAL UNIT NUMBER for the drive.

Drive Select 1 = LUN 0
Drive Select 2 = LUN 1
Drive Select 3 = LUN 2
Drive Select 4 = LUN 3

LOGICAL ADDRESS (byte 2 - bits 0 to 4, byte 3, and byte 4) is the LOGICAL SECTOR ADDRESS of the specified sector. Logical address 0 is the Least Significant byte (LS). Sectors start at cylinder 0 - head 0 - sector 0 and continue through cylinder 0 - head 1, cylinder 0 - head 2 etc. etc.. When the end of a cylinder is reached the next logical sector is located on cylinder 1 - head 0 - sector 0.

The logical address is computed using the following formula:

LOGICAL ADDRESS = (CYADR * HDCYL + HDADR) * SETRK + SEADR.

WHERE:
- CYADR = Cylinder address
- HDADR = Head address
- SEADR = Physical sector address
- HDCYL = number of heads per cylinder
- SETRK = number of sectors per track

The NUMBER OF SECTORS (byte 5) specifies the number of sectors to transfer per command. A value of 0 will result in a transfer of 256 sectors.

This byte also specifies the INTERLEAVE FACTOR for certain commands, ie. FORMAT DRIVE. An interleave factor of 0 will default to an interleave factor of 1. Interleave factors greater than one-half the number of sectors per track are invalid. An example of the interleave mechanism for a track with 32 sectors and an interleave factor of 10 is shown below:

Phy. Sec.	0	1	2	3	4	5	6	7	8	9	10
Log. Sec.	0	10	20	30	1	11	21	31	2	12	22
Phy. Sec.	11	12	13	14	15	16	17	18	19	20	21
Log. sec.	3	13	23	4	14	24	5	15	25	6	16
Phy. Sec.	22	23	24	25	26	27	28	29	30	31	
Log. Sec.	26	7	17	27	8	18	28	9	19	29	

CONTROL FIELD

```
            ..........................................
            .  7    6    5    4    3    2    1    0  .
  BYTE 6       X    X    0    0    0    0    0    X
               .    .                             .
               .    .    link command = 1..........
               .    ......disable error correction = 1
               ...........disable retry = 1
```

Should a valid DATA error occur with the RETRY bit of the CONTROL BYTE enabled the controller will attempt to read the sector up to four (4) times. If this attempt is unsuccessful the controller will recalibrate the drive and try to read again. After four unsuccessful "recalibrate / read" sequences the controller will report the error to the host.

Should a CORRECTABLE DATA ERROR occur with the ERROR CORRECTION bit enabled the controller will correct the data prior to transferring the data to the host.

If both the RETRY bit and the ERROR CORRECTION bit are enabled the retry sequence will be attempted prior to error correction. The RETRY bit and ERROR CORRECTION bit perform independent functions and may be used in any combination of the two.

If the LINK COMMAND bit of the CONTROL BYTE is enabled and the previous command was executed without an error, the controller will bypass the STATUS AND MESSAGE TRANSFER sequence as well as the SELECTION sequence and immediately request the next command. When used with the COPY command this function is very useful in copying fragmented files from one device to another.

COMPLETITION STATUS BYTE

At the normal termination of a command or following an fatal error, the controller will cause a status byte to be transferred from the controller to the host. Bit 0 will be set to 1 if a parity error is detected. Bit 1 will be set to 1 if the controller detects an error condition during command execution. Bits 5 and 6 represent the LUN of the device where the error occurred. If no error occurs bits 0 - 4 will be set to 0.

Following the transfer of the status byte, the MSG line will be asserted to indicate a completion message. This message consists of a single byte transfer with all bits set to 0.

COMPLETITION STATUS BYTE FORMAT

```
..........................................
. 7    6    5    4    3    2    1    0  .
. 0      LUN     0    0    X    X    X
          scan hit = 1.........    .    .
          error = 1................     .
          parity error = 1...............
```

Bit 0	Parity error
Bit 1	Error occurred during command execution
Bit 2	Scan hit
Bit 3-4	Spare (set to 0)
Bit 5-6	Logical unit number of the disk drive
Bit 7	Set to 0

6.2 TYPE 0 COMMANDS

SENSE STATUS (HEX 00) The device addressed by the LUN is selected and tested for ready. The completion status byte indicates the the state of the addressed device.

	7	6	5	4	3	2	1	0
BYTE 1	0	0	0	0	0	0	0	0
BYTE 2	0	LUN			NOT USED			
BYTE 3				NOT USED				
BYTE 4				NOT USED				
BYTE 5				NOT USED				
BYTE 6				CONTROL FIELD				

COMPLETION STATUS

7	6	5	4	3	2	1	0
0	LUN		0	0	0	X	X

0 = device ready (bit 1)
1 = parity error (bit 0)

RECALIBRATE (HEX 01) The drive specified by the LUN is stepped toward the outside track until either:

1. Track 0 flag is detected or
2. more steps have been issued than available tracks for the device type.

Since the recalibrate command must step and look for track 0, all steps are non-overlapped. (i.e. step, look for seek complete and track 0, repeat if no track 0.)

	7	6	5	4	3	2	1	0
BYTE 1	0	0	0	0	0	0	0	1
BYTE 2	0	LUN			NOT USED			
BYTE 3				NOT USED				
BYTE 4				NOT USED				
BYTE 5				NOT USED				
BYTE 6				CONTROL FIELD				

SEE TABLE 1.1 FOR VALID ERRORS

REQUEST SENSE (HEX 03) Following an error indication from the status byte, the host may perform this command to obtain more detailed information about the error. (Each unique command description contains a list of valid error codes)

	7	6	5	4	3	2	1	0
BYTE 1	0	0	0	0	0	0	1	1
BYTE 2	0	LUN			NOT USED			
BYTE 3				NOT USED				
BYTE 4				NOT USED				
BYTE 5				NOT USED				
BYTE 6				CONTROL FIELD				

The REQUEST SENSE command will transfer 4 bytes of error information to the host.

	7	6	5	4	3	2	1	0
BYTE 1				ERROR CODE				
BYTE 2	0	LUN		LOGICAL ADDR 2 (MS)				
BYTE 3				LOGICAL ADDR 1				
BYTE 4				LOGICAL ADDR 0 (LS)				

ERROR CODE FORMAT

7	6	5	4	3	2	1	0
X	0	TYPE			CODE		

.... Sector address valid = 1

ERROR TYPE bits 4 and 5 are decoded as follows:

Bits 5	4	
0	0	Drive errors
0	1	Data errors
1	0	Command errors
1	1	Misc. errors

REQUEST SENSE (cont.)

VALID DRIVE ERROR CODES

Bits 3 2 1 0	
0 0 0 0	No error
0 0 0 1	No index
0 0 1 0	No seek complete
0 0 1 1	Write fault
0 1 0 0	Drive not ready
0 1 0 1	Drive not selected
0 1 1 0	No track 0 on recalibrate
0 1 1 1	Multiple drives selected
1 0 0 0	Reserved
1 0 0 1	Disk Media Changed
1 0 1 0 thru 1 1 0 0	Reserved
1 1 0 1	Seek in progress
1 1 1 0	Reserved
1 1 1 1	Reserved

VALID DATA ERROR CODES

BITS 3 2 1 0	
0 0 0 0	ECC error in ID field
0 0 0 1	Uncorrectable error in data field
0 0 1 0	No ID address mark detected
0 0 1 1	No data address mark detected
0 1 0 0	No record found
0 1 0 1	Seek error
0 1 1 0	Reserved
0 1 1 1	Write protected
1 0 0 0	Correctable data error
1 0 0 1	Bad track flag set
1 0 1 0	Incorrect interleave code
1 0 1 1	Reserved
1 1 0 0	Unable to read alternate track data
1 1 0 1	Reserved
1 1 1 0	Illegal access to an alternate track
1 1 1 1	Reserved

REQUEST SENSE (cont.)

VALID COMMAND ERROR CODES

BITS 3 2 1 0	
0 0 0 0	Invalid command
0 0 0 1	Illegal sector address
0 0 1 0	Illegal function for drive type
0 0 1 1	Volume overflow
0 1 0 0 thru 1 1 1 1	Reserved

VALID MISC. ERROR CODES

BITS 3 2 1 0	
0 0 0 0	Ram error
0 0 0 1 thru 1 1 1 1	Reserved

FORMAT DRIVE (HEX 04) This command causes the specified LUN to be formatted using the interleave factor specified in byte 5. Formatting starts from track 0 of cylinder 0 and continues until all tracks have been written.Data fields are written with a HEX E5. Interleave factors of 0 and 1 are set to 1. Invalid interleave factors are those that are greater than one half the number of sectors per track. Track and cylinder overflow is handled automatically by the controller. NOTE: This command does not check data. For verification of format see CHECK TRACK FORMAT COMMAND.

	7	6	5	4	3	2	1	0
BYTE 1	0	0	0	0	0	1	0	0
BYTE 2	0	LUN			NOT USED			
BYTE 3	NOT USED							
BYTE 4	NOT USED							
BYTE 5	INTERLEAVE FACTOR							
BYTE 6	CONTROL FIELD							

CHECK TRACK FORMAT (HEX 05) The track specified by the logical sector address in bytes 2 - 4 is checked to see that its interleave scheme matchs that specified by the interleave factor in byte 5. The data field is also read to verify that a valid address mark exists and there are no ECC errors. Reading begins with the first sector after index.

	7	6	5	4	3	2	1	0
BYTE 1	0	0	0	0	0	1	0	1
BYTE 2	0	LUN		LOGICAL ADDR 2 (MS)				
BYTE 3	LOGICAL ADDR 1							
BYTE 4	LOGICAL ADDR 0 (LS)							
BYTE 5	INTERLEAVE FACTOR							
BYTE 6	CONTROL FIELD							

SEE TABLE 1.1 FOR VALID ERRORS

FORMAT TRACK (HEX 06) This command causes the track specified by the logical sector address in bytes 2 - 4 to be formatted using the interleave factor specified in byte 5. The track is written starting with index and all data fields are filled with a HEX E5. The first sector after index is always sector 0. The second sector is 0 plus the interleave factor. Interleave factors greater than one half the number of sectors per track are also invalid.

	7	6	5	4	3	2	1	0
BYTE 1	0	0	0	0	0	1	1	0
BYTE 2	0	LUN		LOGICAL ADDR 2 (MS)				
BYTE 3	LOGICAL ADDR 1							
BYTE 4	LOGICAL ADDR 0 (LS)							
BYTE 5	INTERLEAVE FACTOR							
BYTE 6	CONTROL FIELD							

FORMAT BAD TRACK (HEX 07) This command is identical to the format track command except that the defective track flag is set in the ID field.

	7	6	5	4	3	2	1	0
BYTE 1	0	0	0	0	0	1	1	1
BYTE 2	0	LUN		LOGICAL ADDR 2 (MS)				
BYTE 3	LOGICAL ADDR 1							
BYTE 4	LOGICAL ADDR 0 (LS)							
BYTE 5	INTERLEAVE FACTOR							
BYTE 6	CONTROL FIELD							

SEE TABLE 1.1 FOR VALID ERRORS

READ DATA (HEX 08) This command causes the number of sectors specified by byte 5 to be transferred to the host.The starting sector is specified by the logical sector address in bytes 2,3, and 4. Up to 256 sectors can be transferred with a single READ command.

	7	6	5	4	3	2	1	0
BYTE 1	0	0	0	0	1	0	0	0
BYTE 2	0	LUN		LOGICAL ADDR 2 (MS)				
BYTE 3	LOGICAL ADDR 1							
BYTE 4	LOGICAL ADDR 0 (LS)							
BYTE 5	SECTOR XFER COUNT							
BYTE 6	CONTROL FIELD							

WRITE DATA (HEX 0A) The number of sectors specified by byte 5 are written to the selected LUN beginning with the sector specified by the logical sector address in bytes 2,3, and 4.

	7	6	5	4	3	2	1	0
BYTE 1	0	0	0	0	1	0	1	0
BYTE 2	0	LUN		LOGICAL ADDR 2 (MS)				
BYTE 3	LOGICAL ADDR 1							
BYTE 4	LOGICAL ADDR 0 (LS)							
BYTE 5	SECTOR XFER COUNT							
BYTE 6	CONTROL FIELD							

SEEK (HEX 0B) This command causes the device addressed by the LUN to be physically positioned to the cylinder as defined by the logical sector address in bytes 2,3, and 4. The cylinder address is automatically computed by the controller.

No attempt to verify seek position is made until a read or write command is issued. Completion status is returned to the host immediately after receipt of the seek command without waiting for "seek complete" from the disk drive.

	7	6	5	4	3	2	1	0
BYTE 1	0	0	0	0	1	0	1	1
BYTE 2	0	LUN		LOGICAL ADDR 2 (MS)				
BYTE 3	LOGICAL ADDR 1							
BYTE 4	LOGICAL ADDR 0 (LS)							
BYTE 5	NOT USED							
BYTE 6	CONTROL FIELD							

SEE TABLE 1.1 FOR VALID ERRORS

ASSIGN ALTERNATE TRACK (HEX 0E) This command is used to assign an alternate track to the track specified in bytes 2 - 4, so that any future accesses to the sectors on the specified track cause the controller to automatically access those sectors on the alternate track. This command sets flags in the ID field and writes the alternate track address in all sectors on the specified track (See defective track format). The alternate track is then formatted with flags set to indicate that this track has been assigned as an alternate track. Future direct accesses to the alternate track will result in an error. The track can be assigned to one level only that is, an alternate track cannot have another alternate track assigned to it.

	7	6	5	4	3	2	1	0
BYTE 1	0	0	0	0	1	1	1	0
BYTE 2	0	LUN		LOGICAL ADDR 2 (MS)				
BYTE 3	LOGICAL ADDR 1							
BYTE 4	LOGICAL ADDR 0 (LS)							
BYTE 5	INTERLEAVE FACTOR							
BYTE 6	CONTROL FIELD							

The alternate track address is passed to the controller as data using the following format:

	7	6	5	4	3	2	1	0
BYTE 1	LOGICAL ADDR 2 (MS)							
BYTE 2	LOGICAL ADDR 1							
BYTE 3	LOGICAL ADDR 0 (LS)							
BYTE 4	0	0	0	0	0	0	0	0

NOTE: DATA WRITTEN ON THE SPECIFIED TRACK AS WELL AS THE ALTERNATE TRACK WILL BE DESTROYED.

SEE TABLE 1.1 FOR VALID ERRORS

6.2 TYPE 0 COMMANDS (cont.)

CHANGE CARTRIDGE (HEX 1B) This command causes the cartridge change line (J1 - PIN 2) to be asserted for a period of one (1) millisecond. There are no valid error codes for this command.

	7	6	5	4	3	2	1	0
BYTE 1	0	0	0	1	1	0	1	1
BYTE 2	0	LUN			NOT USED			
BYTE 3	NOT USED							
BYTE 4	NOT USED							
BYTE 5	NOT USED							
BYTE 6	NOT USED							

6.3 TYPE 1 COMMAND

COPY COMMAND (HEX 20) This command copies a specified number of records from a source LUN to a destination LUN. If either device reachs volume end prior to the sector count being exhausted, a volume overflow error is posted. Source and destination LUN's may be the same.

	7	6	5	4	3	2	1	0
BYTE 1	0	0	1	0	0	0	0	0
BYTE 2	0	SRC LUN		LOGICAL ADDR 2 (MS)				
BYTE 3	LOGICAL ADDR 1							
BYTE 4	LOGICAL ADDR 0 (LS)							
BYTE 5	SECTOR XFER COUNT							
BYTE 6	0	DST LUN		LOGICAL ADDR 2 (MS)				
BYTE 7	LOGICAL ADDR 1							
BYTE 8	LOGICAL ADDR 0 (LS)							
BYTE 9	NOT USED							
BYTE 10	CONTROL FIELD							

SEE TABLE 1.1 FOR VALID ERRORS

6.4 TYPE 2 COMMANDS

SCAN DATA COMMANDS - The controller supports three scan commands which allow the user to search successive data fields for a specific data pattern. The search argument is one sector in length. Any portion of the search argument not to be used as part of the sector search must be set to HEX FF. Once the controller has received the search argument, data is read from the drive and compared byte by byte (ie, byte 1 of the search argument is compared with byte 1 of the data, byte 2 with byte 2, etc, etc...). Bytes in the search argument equal to HEX FF are not compared. If the search is satisified the host is notified via the scan hit flag in the completion status byte (bit 2 = 1). The sector address with the " hit data " is then obtained by issuing a REQUEST SENSE command.

SCAN EQUAL (HEX 40) The argument sent by the host is compared with the data from the disk starting with the logical sector specified and continuing until an equal data field is found or the sector count is exhausted. "Don't care" positions are indicated by a HEX FF in the search argument. If the sector count is exhausted without finding a "hit" then the completion status byte will contain only the LUN.

	7	6	5	4	3	2	1	0
BYTE 1	0	1	0	0	0	0	0	0
BYTE 2	0	LUN		LOGICAL ADDR 2 (MS)				
BYTE 3	LOGICAL ADDR 1							
BYTE 4	LOGICAL ADDR 0 (LS)							
BYTE 5	SECTOR XFER COUNT							
BYTE 6	CONTROL FIELD							

SEE TABLE 1.1 FOR VALID ERRORS

SCAN HIGH OR EQUAL (HEX 41) This command operates the same as the SCAN EQUAL command except the hit can be made on any data that is algebraically greater than or equal to the argument.

	7	6	5	4	3	2	1	0
BYTE 1	0	1	0	0	0	0	0	1
BYTE 2	0	LUN		LOGICAL ADDR 2 (MS)				
BYTE 3	LOGICAL ADDR 1							
BYTE 4	LOGICAL ADDR 0 (LS)							
BYTE 5	SECTOR XFER COUNT							
BYTE 6	CONTROL FIELD							

SCAN LOW OR EQUAL (HEX 42) This command operates the same as the SCAN EQUAL command except the hit can be made on any data that is algebraically less than or equal to the argument.

	7	6	5	4	3	2	1	0
BYTE 1	0	1	0	0	0	0	1	0
BYTE 2	0	LUN		LOGICAL ADDR 2 (MS)				
BYTE 3	LOGICAL ADDR 1							
BYTE 4	LOGICAL ADDR 0 (LS)							
BYTE 5	SECTOR XFER COUNT							
BYTE 6	CONTROL FIELD							

SEE TABLE 1.1 FOR VALID ERRORS

6.5 TYPE 6 COMMANDS

ASSIGN DISK PARAMETERS (HEX C2) This command allows the host to setup rigid disk variable parameters for the specified LUN. The FIXED, REMOVABLE, or FIXED/REMOVABLE disk drive variables are step pulse width, step period, step mode, maximum head address, maximum cylinder address, write reduced current cylinder address, write precompensation cylinder address and the number of sectors per track. There are no valid error codes for this command.

	7	6	5	4	3	2	1	0
BYTE 1	1	1	0	0	0	0	1	0
BYTE 2	0	LUN		0	0	0	0	0
BYTE 3	NOT USED							
BYTE 4	NOT USED							
BYTE 5	NOT USED							
BYTE 6	NOT USED							

When defining rigid disk parameters the following 10 bytes of disk parameters are passed as data:

	7	6	5	4	3	2	1	0
BYTE 1	STEP PULSE WIDTH							
BYTE 2	STEP PERIOD							
BYTE 3	STEP MODE							
BYTE 4	NUMBER OF HEADS (-1)							
BYTE 5	CYLINDER ADDR HI							
BYTE 6	CYLINDER ADDR LO (-1)							
BYTE 7	WSI / WRITE PRECOMPENSATION CYLINDER							
BYTE 8	0	0	X	X	X	0	Y	Y
BYTE 9	SECTORS PER TRACK (-1)							
BYTE 10	RESERVED							

DEFINITION OF BYTES

BYTE 1

STEP PULSE WIDTH - The length of time the step pulse is asserted. The value of this byte specifies the width of the step pulse in 1 microsecond increments.

BYTE 2

STEP PERIOD - The length of time between two step pulses. A ZERO value is equal to 3.5 microseconds between two step pulses. A NON-ZERO value specifies the time in 50 microsecond increments.

BYTE 3

STEP MODE - This byte is set to zero (buffered or normal mode).

BYTE 4

NUMBER OF HEADS - The value of this byte specifies the number of heads on the disk drive. The maximum number of heads is 16. Any value greater than 8 causes the REDUCED WRITE CURRENT (WSI) function to be disabled. Write precompensation is not effected.

BYTES 5-6

MAXIMUM CYLINDER ADDRESS - These 2 bytes specify the maximum number of cylinders on the disk drive. The maximum number of cylinders is 65K.

BYTE 7

WSI/WRITE PRECOMPENSATION CYLINDER ADDRESS - This byte specifies the cylinder address where (WSI) and PRECOMPENSATION is first applied. Reduced write current is applied to all cylinders greater than or equal to the value of the byte. Write precompensation is applied to all cylinders greater than or equal to the 10 bit value (byte 7 and bits 0-1 of byte 8). A value of 0 in byte 7 means the reduced write current function is disabled. A 10 bit value of 0 (byte 7 and bits 0-1 of byte 8) means that the write precompensation function is disabled.

EXAMPLES :

BYTE 8		BYTE 7							
9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	0	0	0

NO WSI OR PRECOMPENSATION

BYTE 8		BYTE 7							
9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	0	1	1	1	1

WSI AND PRECOMPENSATION STARTS AT 00F (HEX)

BYTE 8		BYTE 7							
9	8	7	6	5	4	3	2	1	0
0	1	0	0	0	0	0	0	0	0

PRECOMPENSATION STARTS AT 100 (HEX)

BYTE 8

BITS 0 and 1 of BYTE 8 specify the high order cylinder address at which Write precompensation is to start.

BITS 4 and 5 of BYTE 8 specify whether the device is a FIXED, REMOVABLE, or FIXED/REMOVABLE winchester disk drive. BIT 3 of BYTE 8 specifies whether the device is a HARD or SOFT SECTORED disk drive (SOFT SECTORED = 0, HARD SECTORED = 1). If bit 5 is a 1 the REDUCED WRITE CURRENT (WSI) function is disabled.

BYTE 8:

BIT 5	BIT 4	
0	0	= FIXED DISK DRIVE
1	0	= FIXED / REMOVABLE DISK DRIVE
1	1	= REMOVABLE DISK DRIVE

BYTE 9

SECTORS PER TRACK - This byte selects the number of sectors per track. A zero value is interpreted as either 17 or 32 sectors per track dependent upon the position of the SECTOR SIZE jumper (W6).

BYTE 10

RESERVED

NOTE: A FIXED/REMOVABLE disk drive (ie. DMA SYS/MEMOREX 410) must have two LUN's assigned. One for the removable disk and one for the fixed disk. (LUN 0 = removable and LUN 1 = fixed).

6.6 TYPE 7 COMMANDS

RAM DIAGNOSTIC (HEX E0) This command performs a pattern test on the sector buffer.

	7	6	5	4	3	2	1	0
BYTE 1	1	1	1	0	0	0	0	0
BYTE 2	NOT USED							
BYTE 3	NOT USED							
BYTE 4	NOT USED							
BYTE 5	NOT USED							
BYTE 6	CONTROL FIELD							

WRITE ECC (HEX E1) This command displaces data on the disk to allow testing of the ECC logic. This command requests the number of data bytes, as determined by the sector size, plus four (4) ECC bytes.

	7	6	5	4	3	2	1	0
BYTE 1	1	1	1	0	0	0	0	1
BYTE 2	0	LUN		LOGICAL ADDR 2 (MS)				
BYTE 3	LOGICAL ADDR 1							
BYTE 4	LOGICAL ADDR 0 (LS)							
BYTE 5	NOT USED							
BYTE 6	CONTROL FIELD							

A data pattern which will NOT result in an ECC error is as follows:

	256 BYTE SECTORS		512 BYTE SECTORS	
Byte #	0-255	6C	0-511	6C
	256	3C	512	77
	257	FD	513	FB
	258	1E	514	4C
	259	B4	515	DC

SEE TABLE 1.1 FOR VALID ERRORS

READ IDENTIFIER (HEX E2) The ID field of the sector specified by the logical sector address is transferred to the host. Only 1 sector is processed. The data length will be 4 bytes.

	7	6	5	4	3	2	1	0
BYTE 1	1	1	1	0	0	0	1	0
BYTE 2	0	LUN		LOGICAL ADDR 2 (MS)				
BYTE 3	LOGICAL ADDR 1							
BYTE 4	LOGICAL ADDR 0 (LS)							
BYTE 5	NOT USED							
BYTE 6	CONTROL FIELD							

The format of these four data bytes is as follows:

	7	6	5	4	3	2	1	0
BYTE 1	HIGH CYLINDER NUMBER							
BYTE 2	LOW CYLINDER NUMBER							
BYTE 3	HEAD/FLAGS							
BYTE 4	PHYSICAL SECTOR NUMBER							

The HEAD/FLAGS byte bit assignments are as follows:

Bit #		
	0	= Head 1
	1	= Head 2
	2	= Head 4
	3	= 0
	4	= 0
	5	= Alternate track flag
	6	= Bad track with Alternate assigned
	7	= Bad track

SEE TABLE 1.1 FOR VALID ERRORS

REQUEST LOGOUT (HEX E6) The four bytes of error log area are transferred to the host. The log area is set to zero upon completion of the transfer. There are no valid error codes for this command.

	7	6	5	4	3	2	1	0
BYTE 1	1	1	1	0	0	1	1	0
BYTE 2	0	LUN			NOT USED			
BYTE 3	NOT USED							
BYTE 4	NOT USED							
BYTE 5	NOT USED							
BYTE 6	CONTROL FIELD							

The format of these four data bytes is as follows:

	7	6	5	4	3	2	1	0
BYTE 1	RETRY COUNT HIGH							
BYTE 2	RETRY COUNT LOW							
BYTE 3	PERMANENT ERROR COUNT HI							
BYTE 4	PERMANENT ERROR COUNT LO							

RETRY COUNT - If retries are enabled, the retry count is incremented each time a disk access results in an error.

PERMANENT ERROR COUNT - After eight retries the error is deemed permanent.

The following errors are logged:

1. ECC error in the ID field
2. Uncorrectable error in the data field
3. No ID address mark detected
4. No data address mark detected
5. No record found
6. Seek error

READ DATA BUFFER (HEX EC) The controller data buffer is transferred to the host as if a single sector read had occurred. The LUN can be any number since no device participates however, the number of bytes returned is determined by the sector size of the specified LUN. The host can use this command following a WRITE DATA BUFFER command to verify READ / WRITE sequences without drive participation or, on a permanent ECC error in the data field, to obtain the bad record. There are no valid error codes for this command.

	7	6	5	4	3	2	1	0
BYTE 1	1	1	1	0	1	1	0	0
BYTE 2	0	LUN		NOT USED				
BYTE 3	NOT USED							
BYTE 4	NOT USED							
BYTE 5	NOT USED							
BYTE 6	CONTROL FIELD							

WRITE DATA BUFFER (HEX EF) This command causes data to be written from the host to the controller data buffer. The LUN can be any number since no device participates however, the number of bytes written is determined by the sector size of the specified LUN. The host can use this command preceding a READ BUFFER command to verify a READ / WRITE sequence without device participation. There are no valid error codes for this command.

	7	6	5	4	3	2	1	0
BYTE 1	1	1	1	0	1	1	1	1
BYTE 2	0	LUN		NOT USED				
BYTE 3	NOT USED							
BYTE 4	NOT USED							
BYTE 5	NOT USED							
BYTE 6	CONTROL FIELD							

APPENDIX A

20C-1 COMMAND SUMMARY

COMMAND	OP CODE (HEX)
SENSE STATUS	00
RECALIBRATE	01
REQUEST SENSE	03
FORMAT DRIVE	04
CHECK TRACK FORMAT	05
FORMAT TRACK	06
FORMAT BAD TRACK	07
READ DATA	08
WRITE DATA	0A
SEEK	0B
CHANGE CARTRIDGE	1B
COPY	20
SCAN EQUAL	40
SCAN EQUAL OR HIGH	41
SCAN EQUAL OR LOW	42
ASSIGN DISK PARAMETERS	C2
RAM DIAGNOSTICS	E0
WRITE ECC	E1
READ ID	E2
REQUEST LOGOUT	E6
READ DATA BUFFER	EC
WRITE DATA BUFFER	EF

APPENDIX B

20C-1 ERROR CODE SUMMARY

ERROR	ERROR CODE (HEX)
NO ERROR	00
NO INDEX	01
NO SEEK COMPLETE	02
WRITE FAULT	03
DRIVE NOT READY	04
DRIVE NOT SELECTED	05
NO TRACK 0 FOUND	06
MULTIPLE DRIVES SELECTED	07
SEEK IN PROGRESS	0D
INVALID COMMAND	20
ILLEGAL PARAMETER	21
VOLUME OVERFLOW	23
RAM ERROR	30
ECC ERROR IN ID FIELD	90
ECC ERROR IN DATA FIELD	91
NO ADDRESS MARK IN ID FIELD	92
NO ADDRESS MARK IN DATA FIELD	93
NO RECORD FOUND	94
SEEK ERROR	95
CORRECTABLE ECC ERROR	98
BAD TRACK FLAG SET	99
CHECK TRACK FORMAT ERROR	9A
UNABLE TO READ ALT TRK DATA	9C
ILLEGAL DIRECT ACCESS TO ALT TRK	9E

TABLE 1.1 ERROR CODES vs. COMMANDS (1 of 3)

ERROR CODES \ COMMANDS		TEST	REZERO	SENSE	FORMAT	CHK. TRK	FMT. TRK	FMT. BAD	READ
		00	01	03	04	05	06	07	08
NO ERROR	00				ALL				
NO INDEX	01				X	X	X	X	
NO SEEK COMPLETE	02		X		X	X	X	X	X
WRITE FAULT	03				X		X	X	
DRIVE NOT READY	04	X	X		X	X	X	X	X
DRIVE NOT SELECTED	05	X	X		X	X	X	X	X
NO TRK 0 FOUND	06		X		X	X			
MULT DR. SELECTED	07	X	X		X	X	X	X	X
CART. CHANGED	09	X	X		X	X	X	X	X
SEEK IN PROGRESS	0D	X							
ID ECC ERROR	10					X			X
UNCORR. DATA ERROR	11					X			X
ID AM NOT FOUND	12					X			X
DATA AM NOT FOUND	13					X			X
RECORD NOT FOUND	14								X
SEEK ERROR	15					X			X
WRITE PROTECTED	17				X		X	X	
CORR. DATA ERROR	18					X			X
BAD TRK FLAG SET	19					X			X
CHECK TRK FMT ERROR	1A					X			
CANT READ ALT TRK	1C					X			X
ILL. ACC. TO ALT TRK	1E								X
INVALID COMMAND	20								
ILLEGAL PARAMETER	21					X	X	X	X
ILLEGAL FUNCTION	22					X		X	
VOLUME OVERFLOW	23					X			X
RAM ERROR	30				X		X	X	

TABLE 1.1 ERROR CODES vs. COMMANDS (2 of 3)

ERROR CODES \ COMMANDS		WRITE	SEEK	ASS.ALT	COPY	SCAN.HI	SCAN.LO	SCAN.EQ	DEF.FLO
		0A	0B	0E	20	40	41	42	C0
NO ERROR	00				ALL				
NO INDEX	01			X					
NO SEEK COMPLETE	02	X	X	X	X	X	X	X	
WRITE FAULT	03	X		X	X				
DRIVE NOT READY	04	X	X	X	X	X	X	X	
DRIVE NOT SELECTED	05	X	X	X	X	X	X	X	
NO TRK 0 FOUND	06	X			X	X	X	X	
MULT DR. SELECTED	07	X	X	X	X	X	X	X	
CART. CHANGED	09	X	X	X	X	X	X	X	
SEEK IN PROGRESS	0D								
ID ECC ERROR	10	X			X	X	X	X	
UNCORR. DATA ERROR	11				X	X	X	X	
ID AM NOT FOUND	12	X			X	X	X	X	
DATA AM NOT FOUND	13				X	X	X	X	
RECORD NOT FOUND	14	X			X	X	X	X	
SEEK ERROR	15	X			X	X	X	X	
WRITE PROTECTED	17	X		X	X				
CORR. DATA ERROR	18				X	X	X	X	
BAD TRK FLAG SET	19	X			X	X	X	X	
CHECK TRK FMT ERROR	1A								
CANT READ ALT TRK	1C	X			X	X	X	X	
ILL. ACC. TO ALT TRK	1E	X			X	X	X	X	
INVALID COMMAND	20								
ILLEGAL PARAMETER	21	X	X	X	X	X	X	X	
ILLEGAL FUNCTION	22			X		X	X	X	X
VOLUME OVERFLOW	23	X			X	X	X	X	
RAM ERROR	30			X					

TABLE 1.1 ERROR CODES vs. COMMANDS (3 of 3)

ERROR CODES \ COMMANDS		ASS.PAR	WR.ECC	READ.ID	REQ.LOG	RD.BUFF	WR.BUFF
		C2	E1	E2	E6	EC	EF
NO ERROR	00				ALL		
NO INDEX	01						
NO SEEK COMPLETE	02		X	X			
WRITE FAULT	03		X				
DRIVE NOT READY	04		X	X			
DRIVE NOT SELECTED	05		X	X			
NO TRK 0 FOUND	06		X	X			
MULT DR. SELECTED	07		X	X			
CART. CHANGED	09		X	X			
SEEK IN PROGRESS	0D						
ID ECC ERROR	10		X	X			
UNCORR. DATA ERROR	11						
ID AM NOT FOUND	12		X	X			
DATA AM NOT FOUND	13						
RECORD NOT FOUND	14		X	X			
SEEK ERROR	15		X	X			
WRITE PROTECTED	17		X				
CORR. DATA ERROR	18						
BAD TRK FLAG SET	19		X				
CHECK TRK FMT ERROR	1A						
CANT READ ALT TRK	1C		X	X			
ILL. ACC. TO ALT TRK	1E		X				
INVALID COMMAND	20						
ILLEGAL PARAMETER	21		X	X			
ILLEGAL FUNCTION	22		X				
VOLUME OVERFLOW	23		X				
RAM ERROR	30						

INTERLEAVE FACTOR

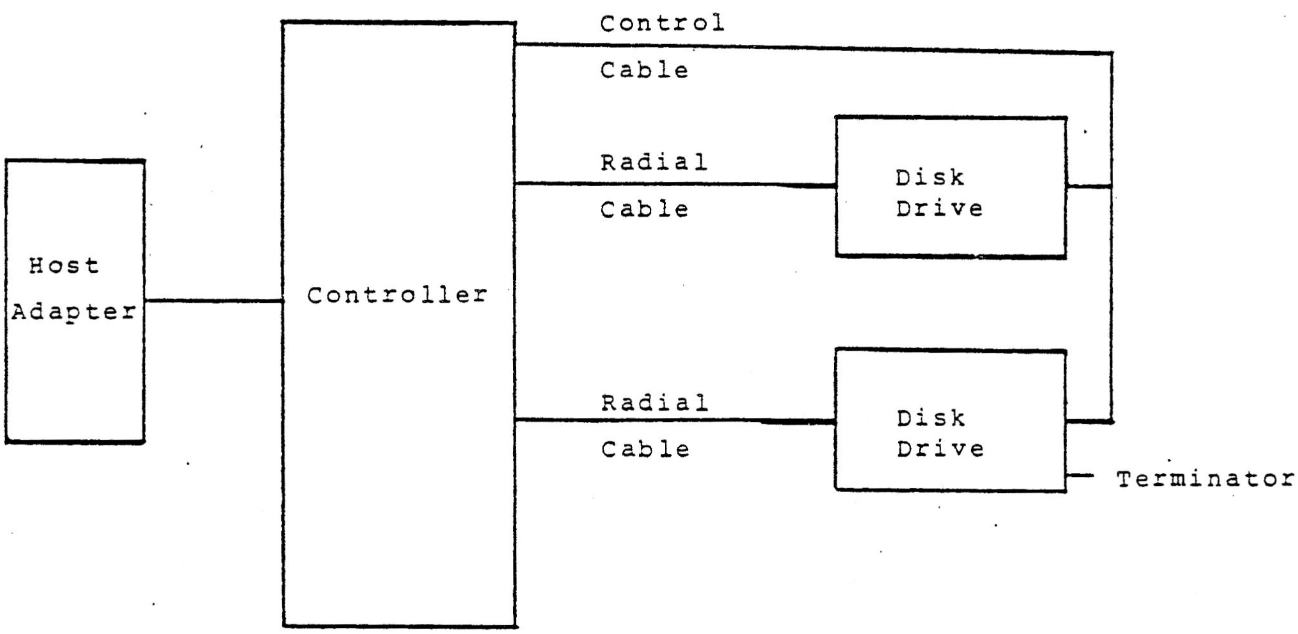
LOGICAL SECTOR NUMBERS

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
2	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	1
3	3	6	9	12	15	18	21	24	27	30	1	1	1	1	1	17
4	4	8	12	16	20	24	28	1	1	1	12	13	14	15	16	2
5	5	10	15	20	25	30	1	9	10	11	23	25	27	29	31	18
6	6	12	18	24	30	1	8	17	19	21	2	2	2	2	2	3
7	7	14	21	28	1	7	15	25	28	31	13	14	15	16	17	19
P 8	8	16	24	1	6	13	22	2	2	2	24	26	28	30	3	4
H 9	9	18	27	5	11	19	29	10	11	12	3	3	3	3	18	20
Y 10	10	20	30	9	16	25	2	18	20	22	14	15	16	17	4	5
S 11	11	22	1	13	21	31	9	26	29	3	25	27	29	31	19	21
I 12	12	24	4	17	26	2	16	3	3	13	4	4	4	4	5	6
C 13	13	26	7	21	31	8	23	11	12	23	15	16	17	18	20	22
A 14	14	28	10	25	2	14	30	19	21	4	26	28	30	5	6	7
L 15	15	30	13	29	7	20	3	27	30	14	5	5	5	19	21	23
16	16	1	16	2	12	26	10	4	4	24	16	17	18	6	7	8
S 17	17	3	19	6	17	3	17	12	13	5	27	29	31	20	22	24
E 18	18	5	22	10	22	9	24	20	22	15	6	6	6	7	8	9
C 19	19	7	25	14	27	15	31	28	31	25	17	18	19	21	23	25
T 20	20	9	28	18	3	21	4	5	5	6	28	30	7	8	9	10
O 21	21	11	31	22	8	27	11	13	14	16	7	7	20	22	24	26
R 22	22	13	2	26	13	4	18	21	23	26	18	19	8	9	10	11
23	23	15	5	30	18	10	25	29	6	7	29	31	21	23	25	27
24	24	17	8	3	23	16	5	6	15	17	8	8	9	10	11	12
25	25	19	11	7	28	22	12	14	24	27	19	20	22	24	26	28
26	26	21	14	11	4	28	19	22	7	8	30	9	10	11	12	13
27	27	23	17	15	9	5	26	30	16	18	9	21	23	25	27	29
28	28	25	20	19	14	11	6	7	25	28	20	10	11	12	13	14
29	29	27	23	23	19	17	13	15	8	9	31	22	24	26	28	30
30	30	29	26	27	24	23	20	23	17	19	10	11	12	13	14	15
31	31	31	29	31	29	29	27	31	26	29	21	23	25	27	29	31

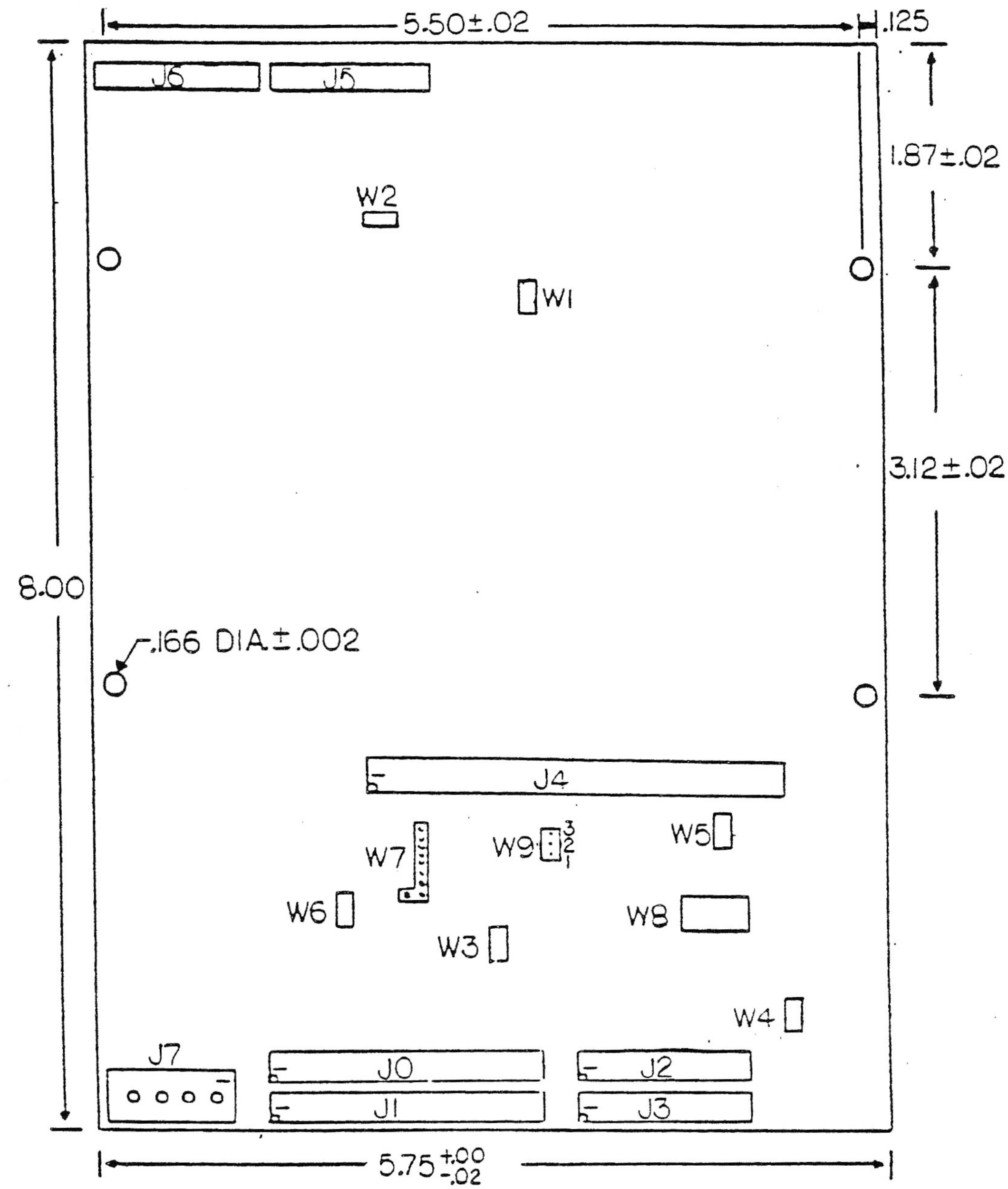
HOW TO USE THIS TABLE: As indicated in the above table, the interleave factor determines the order in which the controller assigns logical sector numbers to the physical sectors on the disk. This factor is normally chosen so as to minimize the number of disk rotations required to read or write an entire track, and can be determined by comparing the time required for one sector to be read or written (exclusive of seek time) to the time required by the operating system to process one sector of data.

Example: Consider a system in which the time required by the operating system to process a sector of data is 4 times that required by the disk to access a sector. In such a system, after the operating system has received and processed sector 0, the next sector that the disk will access is physical sector #4. From the table, interleave factors of 8, 9 and 10 will assign the next logical sector (#1) to the next physical sector (#4). After processing these data, the operating system will be ready for logical sector #2, while the disk will be ready to access physical sector #8. Again, interleave factors of 8, 9 and 10 will satisfy this situation. Continuing this analysis through one disk revolution will show that only an interleave factor of 8 will minimize the amount of time the disk has to wait to be able to access the next logical record.

APPENDIX D


Control
Cable
Radial
Cable
Disk
Drive
Host
Adapter
Controller
Radial
Cable
Disk
Drive
Terminator

APPENDIX E



CONNECTORS	JUMPERS
J0 - NO CONNECT	W1-OPEN OMTI TEST
J1 - CONTROL CABLE	W2-JUMPERED OMTI TEST
J2 - DATA CABLE	W3-NO CONNECT
J3 - DATA CABLE	W4-JUMPERED OMTI TEST
J4 - HOST INTERFACE CABLE	W5-OPEN OMTI TEST
J5 - OMTI TEST	W6-SECTOR
J6 - OMTI TEST	W7-CONTROLLER ADDRESS
J7 - POWER	W8-NO CONNECT
	W9-PARITY

APPENDIX F