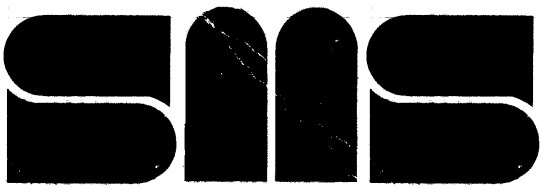

SCSI/SASI
INTELLIGENT DATA CONTROLLERS
OMTI 5000 SERIES
REFERENCE MANUAL
JANUARY 1985

Scientific Micro Systems, Inc.

PUBLICATION NO. 3001206

SCSI/SASI

INTELLIGENT DATA CONTROLLERS

REFERENCE MANUAL

(Preliminary)

Models:

OMTI 51ØØ Winchester only

OMTI 52ØØ Winchester & Floppy

OMTI 53ØØ Winchester & Tape

OMTI 54ØØ Winchester & Tape & Floppy

OMTI Products Division

SCIENTIFIC MICRO SYSTEMS, INC.
339 North Bernardo Avenue
Mountain View
CALIFORNIA 94043

TEL: /415-964-5700
TWX: 910-3379-6577

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ABBREVIATIONS/MNEMONICS

ACK	Acknowledge
ADDR	Address
AM	Address Mark
ANSI	American National Standard Institute
ATN	Attention
BSY	Busy
C/D	Control Data
CDB	Command Descriptor Block
CRC	Cyclic Redundancy Check
CYL	Cylinder
DB	Data Bit
DP	Data Parity
DRVR	Driver
ECC	Error Correcting Code
EOD	End of Data
EPROM	Eraseable Programmable Read Only Memory
FDC	Flexible Disk Controller
HD	Head
ID	Identification
I/O	Input/Output
LOG	Logical
LSB	Least Significant Bit
LSTTL	Low-Power Schottky Transistor-Transistor Logic
LUN	Logical Unit Number
MFM	Modified Frequency Modulation
MHz	Megahertz

ABBREVIATIONS/MNEMONICS (continued)

MSB	Most Significant Bit
MSG	Message
MTBF	Mean Time Between Failures
MTTR	Mean Time To Repair
ns	Nanosecond
NRZ	Non-Return to Zero
PHY	Physical
QIC-02	Quarter Inch Cartridge (Tape Interface)
RAM	Random Access Memory
RCVR	Receiver
REQ	Request
RST	Reset
SASI	Shugart Associates System Interface
SCSI	Small Computer System Interface
SEC	Sector
SEL	Select
TPI	Track Per Inch
TRK	Track
TTL	Transistor Transistor Logic
us	Microsecond
VCO	Voltage Control Oscillator
VLSI	Very Large Scale Integration
WSI	Equivalent to: Reduced Write Current
XCVR	Transceiver

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SECTION 1

INTRODUCTION

1.1 PURPOSE

This manual introduces the user to the OMTI 5000 Series Data Controllers. It provides information needed to install, configure, program, operate, and maintain 5000 Series data controller boards. The manual is designed as a reference source for OEM engineers, system integrators, and service and maintenance technicians.

1.2 GENERAL

The OMTI 5000 is a series of intelligent, multifunctional data controllers interfacing with the following drives:

- Winchester 3-1/2 inch, or 5-1/4 inch disk drives, ST506/412 compatible, 5MBit/sec data transfer rate;
- Flexible disk drives, either 5-1/4 inch, or 8 inch, with either 250 KBit, or 500KBit data transfer rate;
- QIC-02, 1/4 inch compatible Streaming Tape drive.

The 5000 Series Data Controllers use OMTI's advanced VLSI chip sets to provide state-of-the-art data management and data integrity. A single chip data separator circuit ensures data integrity with Winchester disk drives. Efficient error detection/correction is accomplished by a powerful, "computer generated," 32-bit error correction code polynomial.

The host interface is the industry-standard, 8-bit, parallel, bidirectional SASI/SCSI bus.

Each 5000 Series Data Controller is contained on a single PCB (5-1/4" form factor) which mounts directly to the disk drive, or to a chassis.

1.3 MODEL DESCRIPTION

The OMTI Series 5000 data controllers are designed to attach any ST506/412 type 3-1/2 inch, or 5-1/4 inch Winchester Disk drive, Flexible Disk drive, (5-1/4 inch, or 8 inch), or Streaming Tape drive to a variety of host computer systems, through the industry standard SASI (Shugart Associates System Interface), or SCSI (Small Computer System Interface). All models support up to four LUN's. Model numbers identify the combination of drives that can be supported. (W=Winchester, F=Flexible, T=Tape)

OMTI Model 5100 (2W). This model supports any combination of up to two 3-1/2 inch, or 5-1/4 inch Fixed, Fixed/Removable, or Removable Winchester disk drives. Each disk drive can have as many as 16 heads and 65,536 cylinders.

OMTI Models 5200 (2W + 2F). The 5200 model supports up to four drives, of which up to two may be 3-1/2 inch, or 5-1/4 inch Winchester Disk drives, and up to four any combination of industry-standard 5-1/4 or 8 inch Flexible Disk drives. The Flexible Disk drives can support a transfer rate of 250KBits or 500KBits, single or double density, and single or double sided drives with an industry-standard interface.

OMTI Model 5300 (2W + T). This model supports up to three drives, of which up to two may be 3-1/2 inch, or 5-1/4 inch Winchester Disk drives, and one QIC-02 Streaming Tape drive. The Streaming Tape drive can be any QIC-02 interface compatible 1/4 inch drive.

OMTI Model 5400 (2W + T + F). This model supports up to four drives, of which up to two may be 3-1/2 inch, or 5-1/4 inch Winchester Disk drives. The remaining two drives may be any combination of up to two flexible disk drives, or one Flexible Disk drive and one Streaming Tape drive. The Streaming Tape drive can be any QIC-02 interface compatible 1/4 inch drive.

NOTE: - All models handle the Winchester Disk drives similarly, with the same performance, same format, and same command set.
- The 5200 and 5400 models handle the Flexible Disk drives similarly, with the same performance, and the same command set.
- The 5300 and 5400 models handle the Streaming Tape drive similarly, with the same performance, and the same command set.
- Disks formatted and written by one controller model can be read, written, and reformatted by all the other models.
- Tape medias recorded by one model (5300 or 5400), can be updated and read by the other model (5400 or 5300).

1.4 FUNCTIONAL ORGANIZATION

1.4.1 Host Interface

The host interface is SASI, a subset of the proposed ANSC Small Computer System Interface (SCSI). This is a bi-directional bus interface that provides the host computer with device independence so that disk drives, tape drives, printers, communication devices, processor devices, and other devices can be added without requiring modifications to system hardware.

1.4.2 Microprocessor

The controller board contains an 8MHz ROMless Zilog Z8 Microcomputer. The Z8 provides a powerful instruction set, simplified system expansion off chip, and flexible serial and parallel I/O capabilities. It contains a 16-bit program counter and a separate 16-bit stack pointer. The Z8 has 128 internal registers. Sixty-four registers are used for drive status and drive parameters for up to four LUNs. The remaining registers are used for system status and command parameters.

1.4.3 Data Sequencer

Disk data function is handled by the OMTI 5050 Data Sequencer chip. The Sequencer manages the flow of block-level information between serial device interfaces and a memory controller. The OMTI 5050 handles SERDES (Serialize, Deserialize) functions to and from NRZ data, format operations, and ECC generation and checking.

1.4.4 Four-Channel Memory Controller

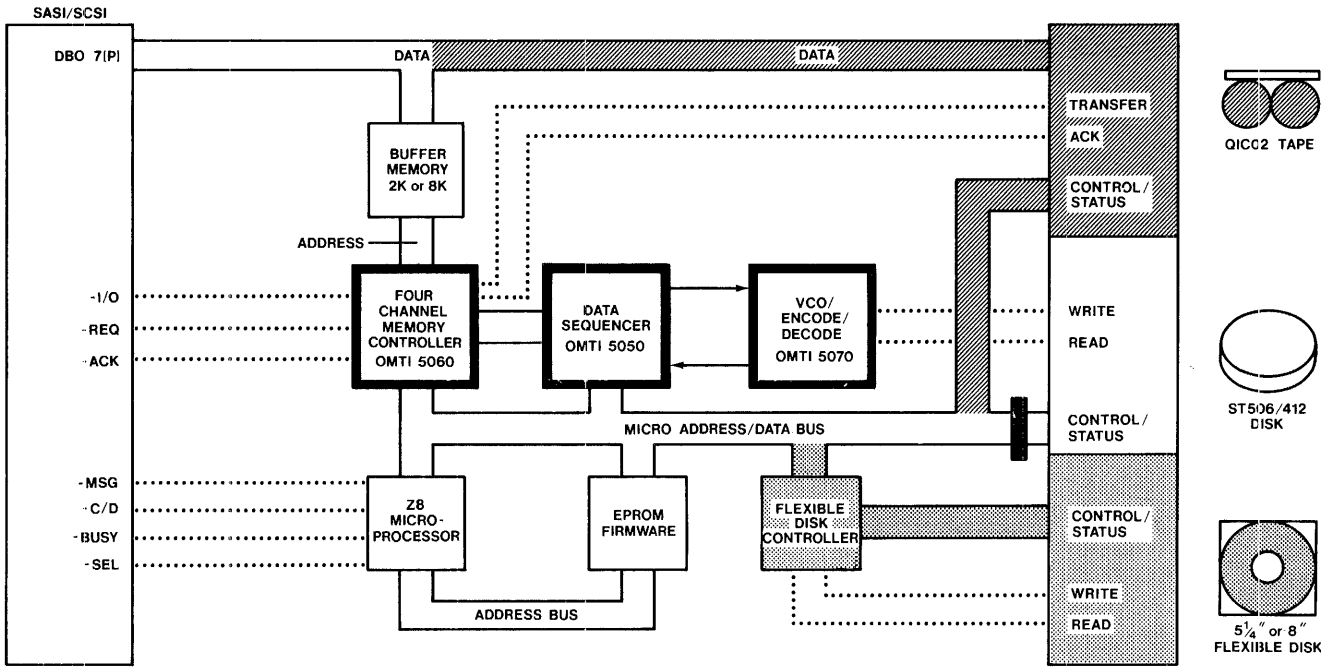
Data control functions are handled by the OMTI 5060 Four-Channel Memory Controller. The Memory Controller manages the flow of block-level information between buffer memory and host and/or byte-oriented peripheral interfaces.

1.4.5 VCO/Encode/Decode

These functions are handled by the OMTI 5070 VCO/Encode/Decode chip. This is a fifth-generation data separator that converts MFM serial data to NRZ data and clock translations.

1.4.6 Flexible Disk Controller

Flexible Disk control is provided by an LSI flexible disk controller chip (NEC 765), with control functions for interfacing a processor and flexible disk drives. It supports either IBM 3740 single density format or IBM System 34 double-density format, including double-side recording.



5000-SERIES BLOCK DIAGRAM

Figure 1-1. Functional Organization of OMTI 5000 Series Controllers

1.5 Buffering Scheme

The controllers include a static RAM data buffer, the size of which is dependent on the model. The 5100 and 5200 Model controllers use a 2 KBytes buffer. The 5300 and 5400 Models use a 8 KBytes buffer. The buffers are used only to store blocks of data; they are not used to store parameters. Buffer operations are independent of firmware constants and variables.

If the block size on disk is 1024 Bytes, the 2K buffer will hold up to two blocks; if the block size is 512 Bytes, the buffer will hold up to four blocks; if the block size is 256 Bytes, the buffer will hold eight blocks; if the block size is 128 Bytes, the buffer will hold up to 16 blocks. The buffer is used as a ring buffer, controlled by an OMTI VLSI chip, called "DMA buffer controller chip" (5060 Model). The chip includes four channels (ports). Each channel has its own separate address and byte count register. The channels operate simultaneously, allowing read and write operations to the buffer from various data paths at the same time.

Of these channels

- one is connected to the SASI/SCSI bus,
- one is dedicated to the "OMTI Sequencer chip" (5050 Model),
- one is connected to the Tape bus (valid for 5300 and 5400 Models),
- the fourth channel is dedicated to the Z8 Microprocessor for specific applications, such as load and read data for an alternate track, with the automatic handling of media defects.

EXAMPLE OF BUFFER USE:

The following case is a multi-block READ command from the disk:

- the first logical block, specified as starting block address in the SCSI command is read from the disk and written into the buffer, (controlled by the "Sequencer chip" channel of the 5060 chip).
- when the ECC is calculated, the data block is available for transfer to the host bus;
- The data block is then transferred asynchronously at the host memory speed (Handshake Timing).
- the next block on the disk is stored in the buffer (at the address, in the buffer, below the previous block), as soon as it is read, independently of the access from the host. Reading of data from the Disk, and sending data to the Host are independent, and take place at the same time.
- blocks are stored below each other in the buffer,

until the maximum address is reached; then the channel wraps around to the first address in the buffer (assuming that the first block has already been transferred to the Host).

- if the host is too slow to empty all data blocks stored in the buffer, from the disk, and another block is ready to be stored into the buffer, with no space available, an overrun situation occurs. In this case, the controller will stop reading from the disk, wait one or more revolutions, until the buffer is completely empty. This will occur only if the host transfer rate is much slower than the 5 MBits/sec rate, rate at which data is stored into the buffer, from the disk (this is unlikely to occur with the 8K buffer or with small block size; it is more likely to occur with the 2K buffer and 1024 bit block size).

BACKUP AND RESTORE IMPLEMENTATION:

The BACKUP and RESTORE commands use the buffer as described above. The host channel is replaced either by the Tape channel or by the "Sequencer chip" channel, depending on the command and its implicit data path direction.

COPY IMPLEMENTATION:

The COPY command uses the buffer differently. The whole buffer is used, 2K, or 8K, depending on the controller model. The COPY command involves the disks only (Winchester and/or flexible disks). Block sizes have to be identical on the source and the destination devices. Because the COPY command may involve flexible disk drives, the controller will read as much as possible before writing, rather than performing simultaneous operations.

When using the buffer, the controller considers the following parameters:

- number of sectors left to read on the track (limited to track boundary);
- number of sectors that the buffer will hold (depending on block count);
- total number of sectors left to transfer.

With the COPY command, only one "buffer chip" channel is used at a time.

1.6 SPECIFICATIONS

This section lists the specifications needed for proper use of the controller. Included are environmental and power requirements as well as mounting and dimensional characteristics. Where limits are specified, they should be adherred to in order to ensure proper operation of the controllers.

1.6.1 Physical Specifications

Width	- All:	5.75 inches	(14.6 cm)
Length	- OMTI 5100:	7.85 inches	(19.9 cm)
	- OMTI 5200:	8.00 inches	(21.6 cm)
	- OMTI 5300:	8.00 inches	(21.6 cm)
	- OMTI 5400:	8.00 inches	(21.6 cm)
Height	- All:	0.75 inches	(1.3 cm)
Weight	- All:	9.0 ozs	(0.25 kg)

See Figures 3-5 and 3-6 for mounting hole locations.

1.6.2 Environmental Specifications

	Operating	Storage
Temperature	0 to 50C	-40 to 75C
Relative Humidity	10% to 95%	10% to 95%
Max. Wet Bulb	30C	Noncondensing
Altitude	0-10000 ft	0-15000 ft

1.6.3 Power Requirements

The OMTI 5000 Series requires +5 V (±5%) power only. The maximum ripple and noise (P/P) is 100 mV. The maximum current drawn by each model is:

Model	Maximum Current
OMTI 5100	1.5 A
OMTI 5200	1.8 A
OMTI 5300	1.8 A
OMTI 5400	2.0 A

SECTION 2

STANDARD FEATURES

2.1 GENERAL

HOST INTERFACE	SCSI/SASI
MULTIFUNCTION	Support Winchester Disks + Flexible Disks + Streaming Tape. Up to 4 LUNs.
SCSI BUS TRANSFER RATE	Up to 1.5 MBytes per second in asynchronous mode. The maximum host bus transfer rate is 950 nanoseconds per byte.
SCSI BUS PARITY	Jumper selectable. Unless disabled, odd parity is generated and checked on all handshakes
COMPACT BOARD	The 5000 Series Controllers are single 5-3/4 X 8.0 inch printed circuit boards (ST506/412 form factor). All controllers use identical mounting holes (similar to OMTI 20 Series)
MULTIPLE CONTROLLERS	The SASI/SCSI bus allows up to eight controllers, in any combination, to be attached to the host. All devices are daisy-chain connected with a 50-pin cable. Each controller is selectable to be one of the eight devices with the Selection address of 0 to 7. Various OMTI 5000 Series controllers can be connected to the same SASI/SCSI bus.
COMMAND LINKING	Upon successful completion of a command, chaining of commands is allowed, and prevents the entering of a new Selection phase
ERROR RETRY	Error retry on SEEK or READ errors is performed automatically unless disabled.

BUFFER TYPE	Ring Buffer (Wraps Around) with 4 Independent Ports
BUFFER SIZE	2KBytes on Models not Supporting Tape Drives (5100, 5200), and 8KBytes on Models Supporting Tape Drives (5300, 5400)
POWER	2 Amps Maximum (depending on model). Requires 5 Volts only.
LIMITED PART COUNT	Featuring OMTI VLSI Chips, supporting Winchesters and Tape

2.2 Winchester Disk Specific Features (All Models)

TRANSFER RATE	5 MBits/Sec
INTERFACE	ST506/412 Compatible
MULTIPLE DRIVE TYPES SUPPORTED	The 5000 Series Controllers support any combination of Fixed, Removable, or Fixed/Removable Winchester disk drives. The Removable Platter uses LUN 0 and the Fixed Platter uses LUN 1, or the Removable Platter uses LUN 2 and the Fixed Platter uses LUN 3. The Fixed/Removable drives occupy two LUNs.
CONSECUTIVE SECTOR TRANSFER	Can Transfer a Full Track in a Single Disk Revolution
MULTIPLE SECTOR BUFFER	Models 5100 and 5200 controllers include a 2 KByte buffer. Models 5300 & 5400 controllers include a 8 Kbyte buffer. A minimum of two 1024 Byte sectors, and a maximum of 32 256 Byte sectors may be stored in the buffer.
PROGRAMMABLE DISK PARAMETERS	The disk parameters for both the Fixed Disks and the Flexible Disks can be passed to the controller with the ASSIGN DISK PARAMETERS command.
SECTORING	Hard or Soft
NUMBER OF HEADS	Up To 16 Heads Supported

NUMBER OF CYLINDERS	Up To 65533 Cylinders Supported
SECTOR INTERLEAVING	One to One or Programmable
TRACK FORMAT	Compatible with the OMTI 20 Series
BLOCK OR SECTOR SIZE	Jumper Selectable, 128, 256, 512, or 1024 Bytes per Sector or Block
IMPLIED SEEK	Supported, with all Data Transfer Commands
LOGICAL BLOCK ADDRESSING	All Data Transfer Commands
AUTOMATIC HEAD OR CYLINDER SWITCHING	Supported
MULTI-BLOCK TRANSFER	Up To 256 Blocks per command (any block size listed above)
AUTOMATIC READ RETRIES	User Selectable
AUTOMATIC HANDLING OF MEDIA DEFECTS	Supported at Track Level with Alternate Track Assignment
OVERLAPPED SEEK	Allows multiple drives to be positioned simultaneously. While a seek is being performed on one drive, other operations can be performed on other LUNs.
ECC	For Header and Data Fields 32 Bits Error Correction Code. Polynomial - "Computer Generated" Code "x31+x24+x23+x20+ x17+x16+x13+x7+x0" Correction Capability - 5 Bits Detection Capability - 19 Bits
STEP RATE	Accepts a Minimum of 15 us
SECTORS PER TRACK	Programmable, Supported Through Assign Disk Parameters Command
COPY COMMAND	Betweem Disks (of any type) Uses the Internal Controller Buffer
FORMAT	Compatible with the OMTI 20 Series
COMMAND SET	Compatible with the OMTI 20 Series

2.3 Flexible Disk Drive Specific Features (Models 5200, and 5400)

8 Inch drive (500KBits)	An optional 34 Pin to 50 Pin Adapter Interface is needed to connect 8 Inch Flexible Drives to the Controllers (5200 and 5400) (Available from SMS)
3.5" or 5-1/4" (250KBits)	Supported
5-1/4" (500KBITS)	Models 5200 and 5400 Support the New Generation of Half Height, High Capacity, 5-1/4 Inch Flexible Disk Drives with the Same Transfer Rate as the 8 Inch (500 KBits) Drives
SECTOR SIZE	Programmable - 128, 256, 512, or 1024 Bytes per Sector
NUMBER OF SECTORS/TRACKS	Programmable. Complies to the Track and Sector Format. Gaps are Fixed (set by the Controller)
IBM FORMAT	Supported, 3740 SD, System 34 2SDD
IBM PC FORMAT	Supported
FLOPPY TAPE DRIVE	Supported by Model 5201 (see respective manual)
CRC	On Header and Data Fields

2.4 Tape Drive Specific Features (Models 5300 and 5400)

DRIVE TYPE	Streaming Tape Drives only
INTERFACE	QIC 02 - Intelligent 1/4 Inch Cartridge Interface
NUMBER OF DRIVES	One Drive is Supported
LUN	Addressed by LUN 3 only
QIC 02 PARITY	Supported - Jumper Selectable

BACKUP AND RESTORE	From and To Disk by Specific Commands (Host no involved)
READ MODES	Two Modes: Sequential and Direct
DISK DEFECTS HANDLING DURING BACKUP & RESTORE	Handled Through the Automatic Disk Media Defect Scheme. Only Valid Blocks Are Backed Up. Restore Does Not Access Defective Blocks.
STREAMING MODE	Continuously Maintained (eased by 8192 Bytes of Buffer in the controller).
CARTRIDGE LABELING	Allowed by WRITE and READ HEADER Commands
HEADER RECORD	An optional user defined header at the beginning of the cartridge allows cartridge identification while being transparent to BACKUP and RESTORE operations. Specific commands allow reading and writing of the header record.
DATA PATHS	Three Data Paths Available: Host To/From Tape, Host To/From Disk, Disk To/From Tape.
SPACING FORWARD	By Blocks, by File Marks, and To End of Data
TAPE RETENTION	Supported
ERASE TAPE	Supported
VERIFY MEDIA INTEGRITY	Supported

2.5 COMPATIBILITY WITH OMTI 20 SERIES CONTROLLERS

The OMTI 5000 Series Controllers conform to the same format as the 20 Series, with the same track architecture, and the same ECC. This allows disks formatted and written by one series to be read and updated by the other. The command sets are also compatible. Thus, the same software may be used for both. Only the timings are different. The 20 Series Controllers use a bit slice processor. The 5000 Series use a Z8 Microcomputer. In the 5000 Series, some Microprocessor cycle times create longer timings in some phases than the 20 Series. However, the 5000 Series Controllers offer higher performance in multi block transfers, by allowing consecutive sector transfers, which the 20 Series lack.

(Mounting hole locations on the 5000 Series are identical to those of the 20 Series. Connector locations are slightly different).

2.6 COMMAND SET SUMMARY

COMMAND	DRIVE TYPE	CODE (HEX)	LENGTH in BYTES	DATA BYTES(b) BLOCKS(B)	CONTROLLER MODEL(S)
		GROUP 0			
TEST UNIT READY	W,F,T	00	6	0	all
RECALIBRATE	W,F	01	6	0	all
REWIND	T	01	6	0	5300, 5400
RETENTION *	T	02	6	0	5300, 5400
REQUEST SENSE	W,F,T	03	6	4 or 12(b)	all
FORMAT UNIT	W,F	04	6	0	all
CHECK TRACK FORMAT	W	05	6	0	all
FORMAT TRACK	W,F	06	6	0	all
FORMAT BAD TRACK	W	07	6	0	all
READ	W,F	08	6	up to 256(B)	all
READ	T	08	6	up to 16M(B)	5300, 5400
WRITE	W,F	0A	6	up to 256(B)	all
WRITE	T	0A	6	up to 16M(B)	5300, 5400
SEEK	W,F	0B	6	0	all
ASSIGN ALTERNATE TRACK	W	0E	6	4(b)	all
WRITE FILE MARK	T	10	6	0	5300, 5400
SPACE FORWARD	T	11	6	0	5300, 5400
VERIFY **	T	13	6	0	5300, 5400
ERASE	T	19	6	0	5300, 5400
CHANGE CARTRIDGE	W	1B	6	0	all
		GROUP 1			
COPY	W,F	20	10	prog.(B)	all
BACKUP	T,W	22	10	prog.(B)	5300, 5400
RESTORE	T,W	23	10	prog.(B)	5300, 5400
BACKUP WITH HEADER	T,W	24	10	prog.(B)	5300, 5400
RESTORE CONTINUE	T,W	26	12	prog.(B)	5300, 5400
		GROUP 2			
RETENTION TAPE *	T	44	6	0	5300, 5400
VERIFY TAPE **	T	45	6	0	5300, 5400
READ SENSE	T	46	6	8(b)	5300, 5400
WRITE HEADER	T	48	6	512(b)	5300, 5400
READ HEADER	T	49	6	512(b)	5300, 5400
WRITE BLOCKS	T	4A	6	up to 256(B)	5300, 5400
READ BLOCKS	T	4B	6	up to 256(B)	5300, 5400

COMMAND SET SUMMARY (continued)

COMMAND	DRIVE TYPE	CODE (HEX)	LENGTH in BYTES	DATA BYTES(b) BLOCKS(B)	CONTROLLER MODEL(S)
		GROUP 6			
DEFINE FLEXIBLE DISK FORMAT	F	C0	6	10(b)	5200, 5400
ASSIGN DISK PARAMETERS	W,F	C2	6	10(b)	all
		GROUP 7			
RAM DIAGNOSTICS	D	E0	6	0	all
WRITE ECC	D	E1	6	0	all
READ ID	D	E2	6	0	all
READ DATA BUFFER	D	EC	6	one sector	all
WRITE DATA BUFFER	D	EF	6	one sector	all

*, ** Different code, but similar command execution

D=Diagnostics
W=Winchester
F=Flexible disk
T=Tape

all=5100, 5200, 5300, and 5400

SECTION 3

INSTALLATION

3.1 UNPACKING AND INSPECTION

Upon arrival of your OMTI controller board, you should immediately inspect it and its packaging for evidence of damage during transit. If the container shows signs of mishandling or damage, the carrier`s agent should be present during opening and unpacking.

Use your original Purchase Order to compare against the packing list. Verify that the actual contents of the package correspond with your purchase order and the packing list.

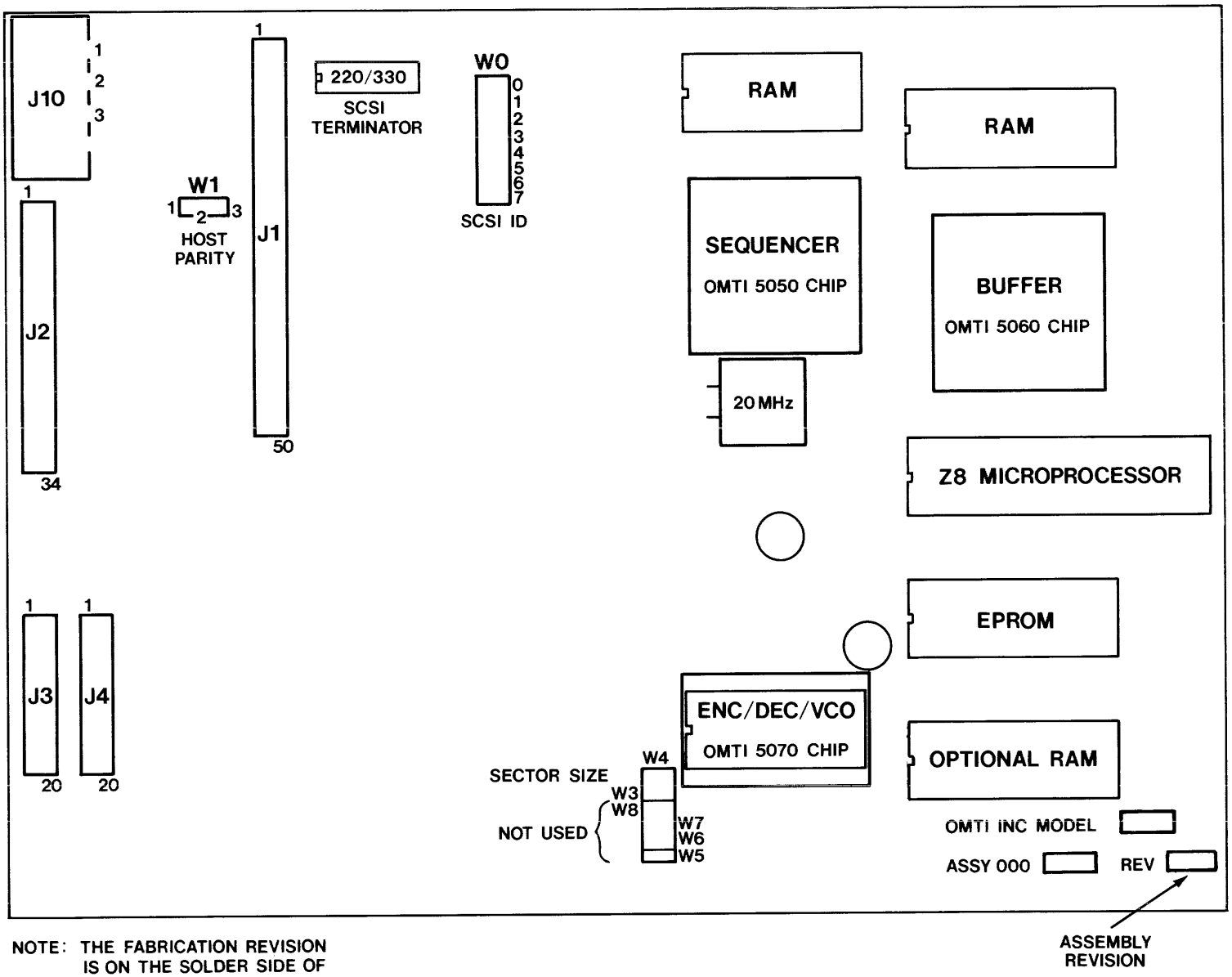
Inspect the controller board for visible damage such as scratches, loose components, or broken connectors. If there is damage, immediately notify your OMTI Products Division customer service representative.

The shipping container and packing material should be retained for examination (if it has been damaged), or for reuse when returning the controller board to the factory.

3.2 BOARD PREPARATION

Refer to Figures 3-1 and 3-2 for the appropriate board layout of your data controller. Connector and jumper locations are shown for each model in the 5000 Series. There are certain jumpers installed at the factory on your controller board. Use the table shown with each figure to ensure that these jumpers are still correctly in place.

It is also possible for you to install optional jumpers to tailor the functions of your controller board to the specific requirements of your system. Refer to Figure 3-1, 3-2, 3-3, or 3-4, as appropriate, for the location of the jumper connections on the controller board and then consult paragraph 4.3 for the various controller functions which are jumper selectable.



NOTE: THE FABRICATION REVISION IS ON THE SOLDER SIDE OF THE CONTROLLER

Figure 3-1. Model 5100 Connector and Jumper Locations

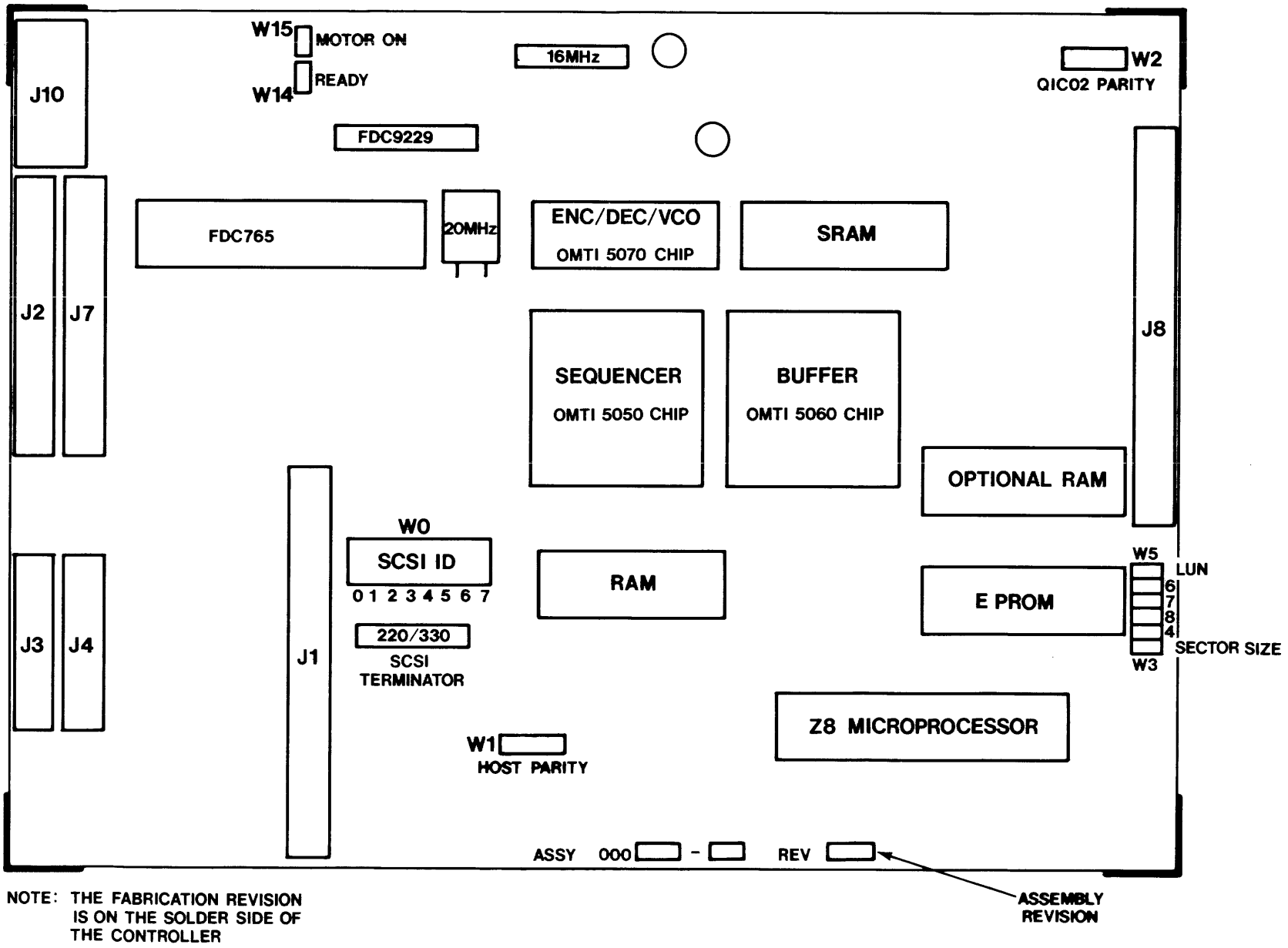


Figure 3-2. Model 5200/5300/5400 Connector and Jumper Locations

3.3 BOARD MOUNTING

Holes for mounting your controller board are dimensionally located in Figure 3-5 (Model 5100) and Figure 3-6 (Models 5200, 5300, and 5400). Four of these holes mate with the four mounting holes provided on ST506/412 Type drives. The controller may be mounted in a location other than on the disk drive itself. An important consideration it that air is allowed to freely pass by the board.

3.4 CABLE CONNECTIONS

After your board is mounted, the DC power cord and the cables to the disk drive and host computer must be connected. Refer to the appropriate Connector and Jumper Location drawing (Figure 3-1, and 3-2) for the location of connectors on your board. The System Configuration drawings (Figures 4-1 and 4-2) presented in the next section will also help in identifying the cable hookup for your particular system.

Pin 1 on all connectors is specified by a square solder pad, visible on the soldered side of the board.

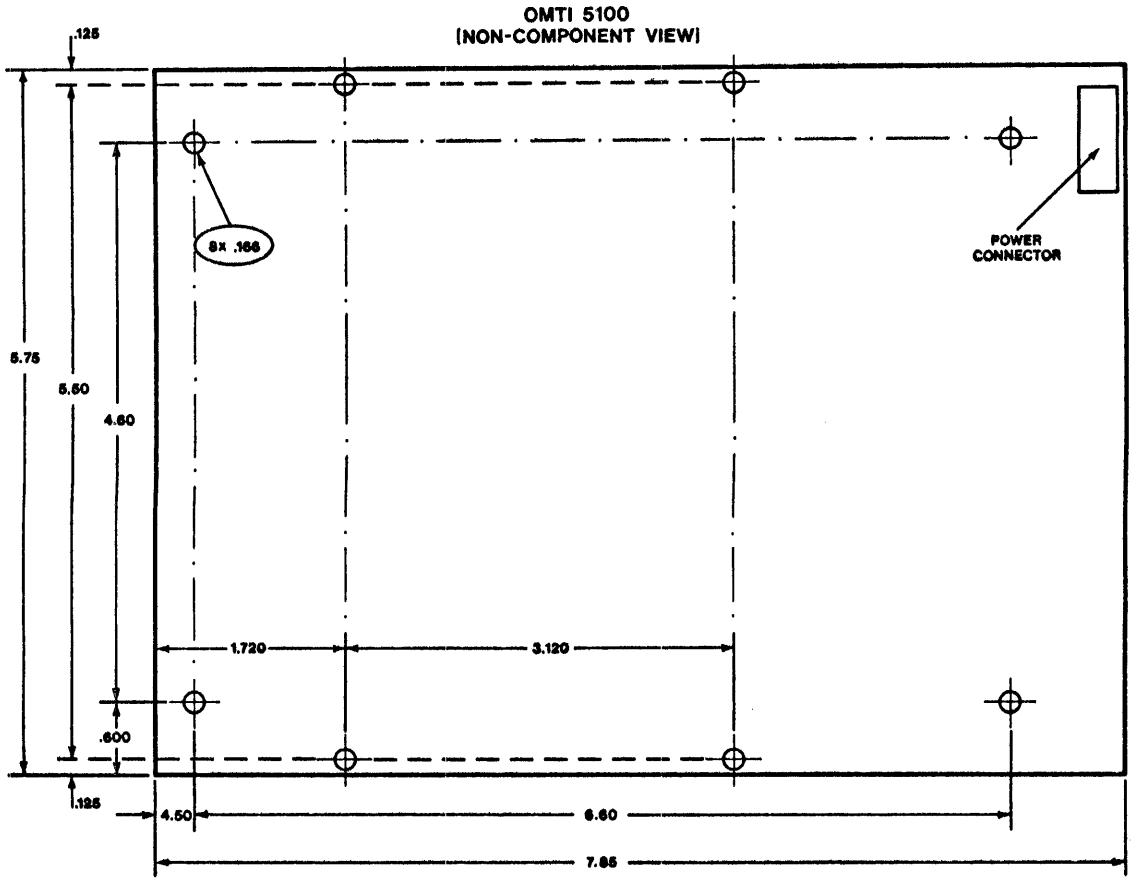


Figure 3-5. Model 5100 Mounting Hole Locations

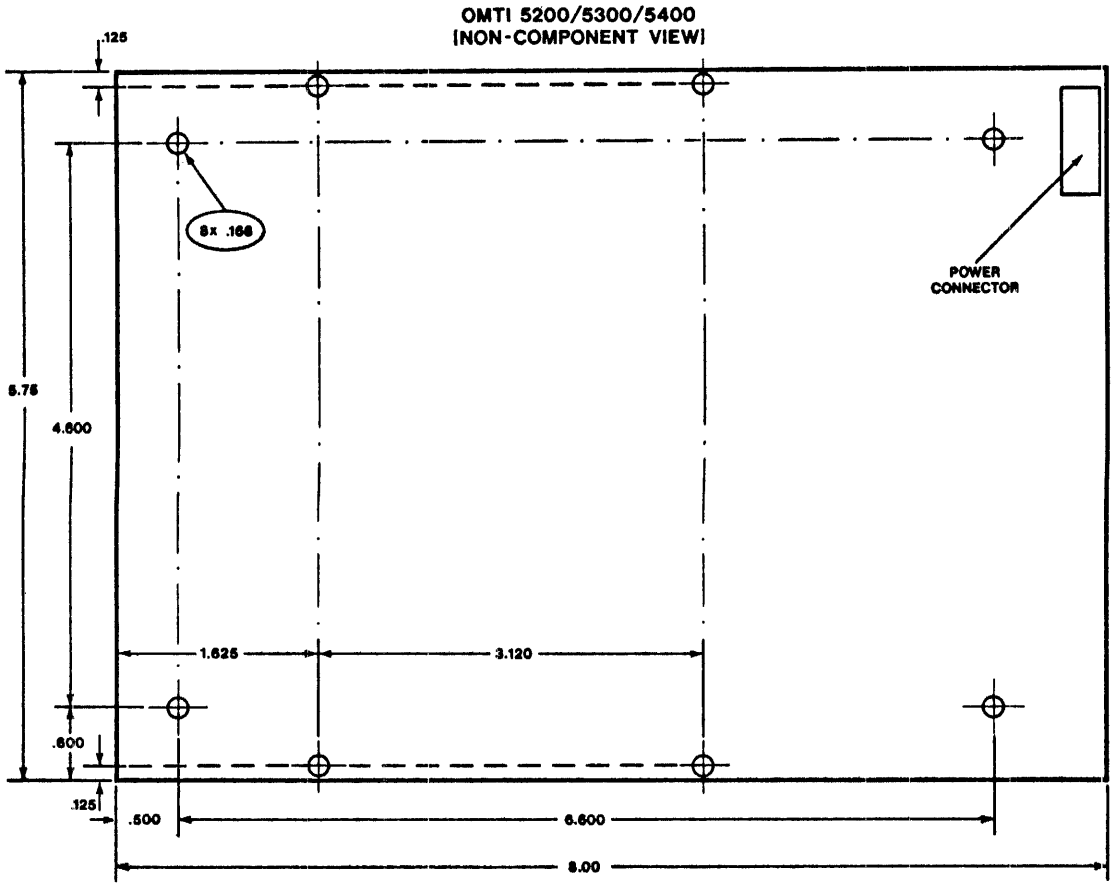


Figure 3-6. Model 5200/5300/5400 Mounting Hole Locations

SECTION 4

SYSTEM CONFIGURATION

4.1 GENERAL

The host computer is interfaced to the controllers by a 50-pin cable connected to J1 on the controller. The length of the host interface cable should not exceed 20 feet (6 meters), from the first to the last device (up to eight devices) on the bus. The recommended mating connector for J1 is the 3M ribbon connector.

The Winchester Disk drives are interfaced to the controller via J2, J3, and J4. J2 is a 34-pin header type which connects all Winchester Disk drives in a daisy-chain configuration. This cable carries the control signals . The maximum cable length should not exceed 20 feet (6 meters) or the drive manufacturer's limit, whichever is less. J3 and J4 are 20-pin header type connectors used to radially connect the disk drive data lines to the controller. The cable length should not exceed 20 feet (6 meters) or drive manufacturer's limit, whichever is less.

The Flexible Disk drives are interfaced to the controller via J7 which is a 34-pin header type connector. This cable carries data and control signals. The maximum cable length should not exceed 20 feet (6 meters) or the drive manufacturer's limit, whichever is less. The 8 inch Flexible Disk drives with a 50 pin connector must be connected to the 34-pin Controller connector, through an optional 34-pin to 50-pin adaptor.

The QIC-02 interface compatible Streaming Tape drives are connected to the controller by a 50-pin cable connected to J8 on the controller. This cable should not exceed 20 feet (6 meters) in length. The recommended mating connector for J8 is a 3M ribbon connector.

Typical system configurations for the OMTI 5000 Series are presented in block diagram form in Figures 4-1 through 4-2.

The recommended part numbers for the connectors are as follows:

J1 and J8 - AMP P/N 86916-1
J2 and J7 - AMP P/N 88373-3
J3 and J4 - AMP P/N 86904-1

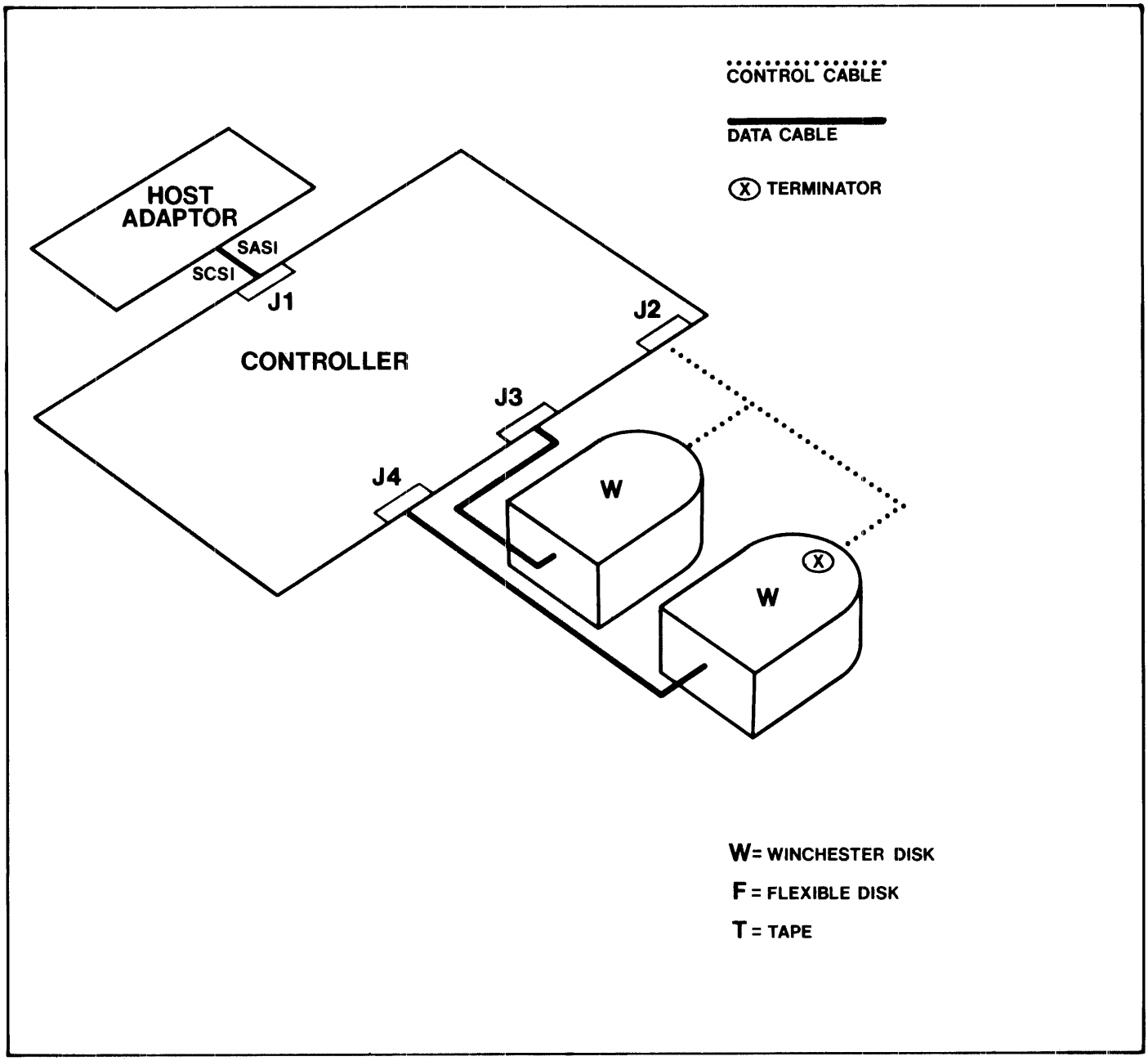


Figure 4-1. Model 5100 System Configuration

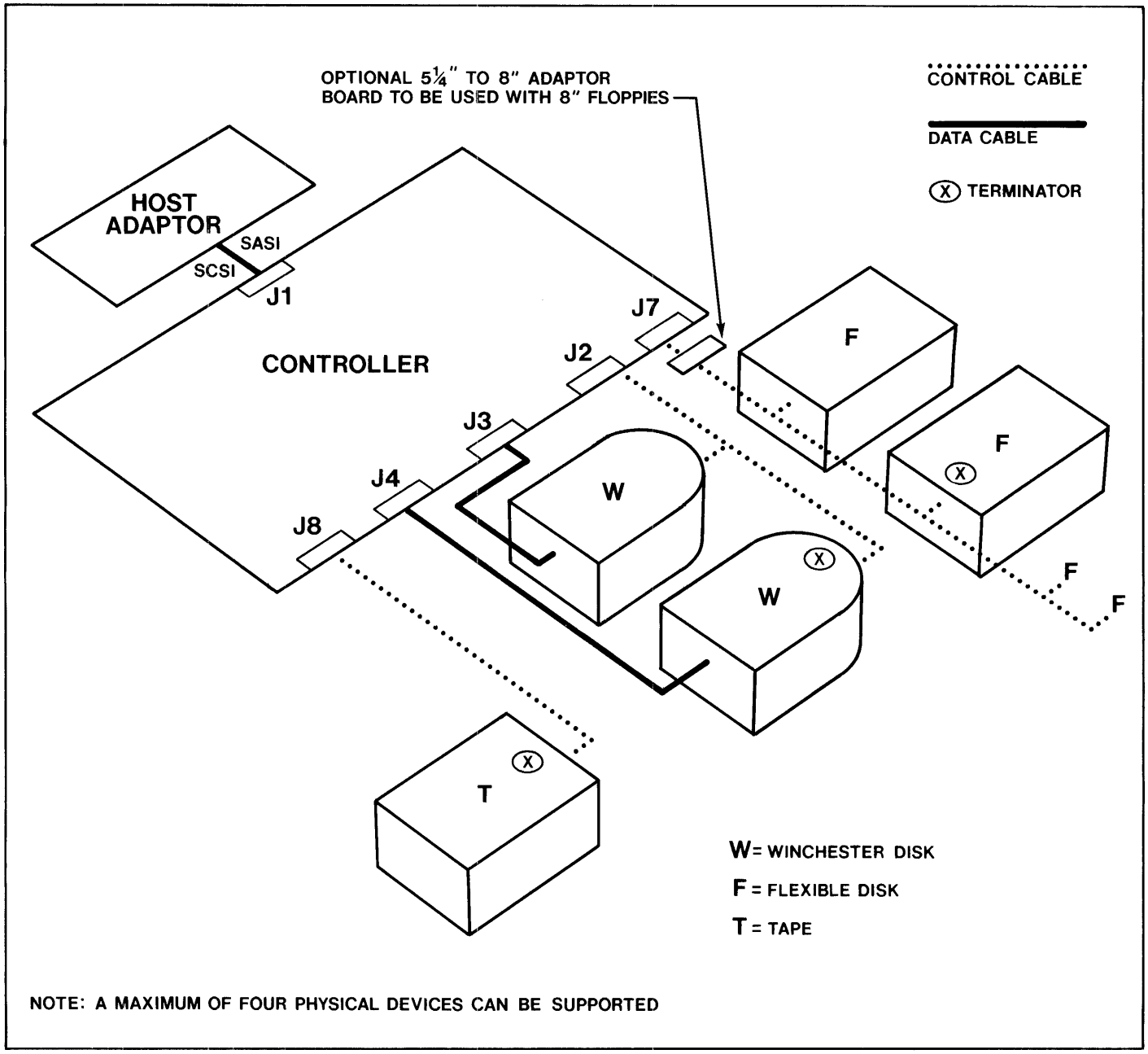


Figure 4-2. Model 5200/5300/5400 System Configuration

4.2 PIN ASSIGNMENTS

4.2.1 WINCHESTER DISK DRIVE INTERFACE

The following tables define the pin assignments for the various Winchester disk drives supported.

WINCHESTER DISK CONTROL SIGNAL CONNECTOR (J2)

DRIVE TYPE		FIXED	REMOVABLE & FIXED/REMOVABLE
GND	1 2	HEAD SELECT 3/WSI	Change Cartridge
	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 Pulse
	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	

WINCHESTER DISK DATA SIGNAL CONNECTOR (J3 & J4)

DRIVE TYPE	FIXED	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	

4.2.2 FLEXIBLE DISK DRIVE INTERFACE (5-1/4 inch)

The following tables define the pin assignments for the 5-1/4" flexible disk drives.

FLEXIBLE DISK CONTROL SIGNAL CONNECTOR (J7)

GND	1	2	(OPEN)
	3	4	(OPEN)
	5	6	DRIVE SELECT 4
	7	8	INDEX
	9	10	DRIVE SELECT 1
	11	12	DRIVE SELECT 2
	13	14	DRIVE SELECT 3
	15	16	MOTOR ON
	17	18	DIRECTION SELECT
	19	20	STEP
	21	22	WRITE DATA
	23	24	WRITE GATE
	25	26	TRACK 00
	27	28	WRITE PROTECT
	29	30	READ DATA
	31	32	SIDE SELECT
GND	33	34	DRIVE STATUS

An optional 34-pin to-50 pin adaptor board connects the 8 inch Flexible Disk drive to the Controller connector, J7.

Optional adaptor board (Paddle board) connections

34-pin conn.	50-pin conn.	Signal Name
1	1	GROUND
2	-	-
3	-	-
4	-	-
5	-	-
6	32	DRIVE SELECT 4
7	-	-
8	20	INDEX
9	-	-
10	26	DRIVE SELECT 1
11	-	-
12	28	DRIVE SELECT 2
13	-	-
14	30	DRIVE SELECT 3
15	-	-
16	-	-
17	-	-
18	34	DIRECTION SELECT
19	-	-
20	36	STEP
21	-	-
22	38	WRITE DATA
23	-	-
24	40	WRITE GATE
25	-	-
26	42	TRACK 00
27	-	-
28	44	WRITE PROTECT
29	-	-
30	46	READ DATA
31	-	-
32	14	SIDE SELECT
33	-	-
34	22	DRIVE STATUS

4.2.3 POWER CONNECTOR

Power is applied to the controller via J10 which is a 4-pin Amp connector. The recommended mating connector, P10, is an Amp P/N 1-480424-0 using Amp pins, P/N 60617-4, or equivalent.

J10 POWER CONNECTOR

NC	PIN 1
NC	PIN 2
+ 5 RTN	PIN 3
+ 5 VDC	PIN 4

NOTE:

Pin 1 is not connected to + 12VDC as in the OMTI 20 series controllers.

Pin 2 is not connected to ground as in the OMTI 20 Series controllers.

4.2.4 QIC-02 1/4 INCH CARTRIDGE STREAMING TAPE INTERFACE

The following tables define the pin assignments for QIC-02 1/4 inch Cartridge Streaming Tape drive.

TAPE DRIVE CONNECTOR (J8)

GND	1	2	NOT USED
	3	4	NOT USED
	5	6	NOT USED
	7	8	NOT USED
	9	10	-PARITY
	11	12	-DATA BIT 7
	13	14	-DATA BIT 6
	15	16	-DATA BIT 5
	17	18	-DATA BIT 4
	19	20	-DATA BIT 3
	21	22	-DATA BIT 2
	23	24	-DATA BIT 1
	25	26	-DATA BIT 0
	27	28	-ON LINE
	29	30	-REQUEST
	31	32	-RESET
	33	34	-TRANSFER
	35	36	-ACKNOWLEDGE
	37	38	-READY
	39	40	-EXCEPTION
	41	42	-DIRECTION
	43	44	NOT USED
	45	46	NOT USED
	47	48	NOT USED
GND	49	50	NOT USED

4.3 JUMPER ALLOCATION

The OMTI 5000 Series Controllers allow the user to select various controller functions. These functions are as listed below:

(W0) SCSI CONTROLLER ID. Defines the SCSI device priority. ID 7 is the highest priority in a multi controller configuration.

```
*  0 SHORTED ID = 0
   1 SHORTED ID = 1
   2 SHORTED ID = 2
   3 SHORTED ID = 3
   4 SHORTED ID = 4
   5 SHORTED ID = 5
   6 SHORTED ID = 6
   7 SHORTED ID = 7
```

(W1) HOST PARITY

```
*  PINS 1 - 2 JUMPERED = PARITY ENABLED
   PINS 2 - 3 JUMPERED = PARITY DISABLED
```

(W2) QIC-02 PARITY(5300 & 5400 only)

```
*  PINS 1 - 2 JUMPERED = PARITY ENABLED
   PINS 2 - 3 JUMPERED = PARITY DISABLED
```

(W3 & W4) WINCHESTER DISK SECTOR SIZE

	W3	W4		
	Open	Open	=	128 BYTES PER SECTOR
*	Shorted	Open	=	256 BYTES PER SECTOR
	Open	Shorted	=	512 BYTES PER SECTOR
	Shorted	Shorted	=	1024 BYTES PER SECTOR

(W5 - W8) LUN ASSIGNMENT. W5 through W8 allows the ability to jumper select the default LUN assignment for Winchester, Flexible Disk drives, and Tape drive.

(W9) NOT ON BOARD

(10 - W11) RESERVED

(W12 - W13) NOT ON BOARD

* As shipped.

Refer to the LUN Assignment table below for jumper selections for the models 5200, 5300 and 5400. (The Model 5100 jumpers are not analyzed.)

LOGICAL UNIT NUMBER (LUN) ASSIGNMENT

Jumpers (W5, W6, W7, W8)

LUN	JUMPER	OPEN	SHORTED	MODEL
0	W5	* Winchester	Flexible	5400
		* Winchester	Reserved	5300
		* Winchester	Flexible	5200
1	W6	* Winchester	Flexible	5400
		* Winchester	Reserved	5300
		* Winchester	Flexible	5200
2	W7	Winchester	* Flexible	5400
		Winchester	* Reserved	5300
		Winchester	* Flexible	5200
3	W8	* Tape	Flexible	5400
		* Tape	Winchester	5300
		* Winchester	Flexible	5200

* As shipped.

Note: The ASSIGN DISK PARAMETERS command (C2 Hex), if issued, may override these jumper allocations. Tape, however, remains LUN 3.

Number and Type of Drives supported

	Model 5100	Model 5200	Model 5300	Model 5400
Number of drives	2 max	4 max	3 max	4 max
Number of LUNs	4	4	4	4
Winchesters	up to 2	up to 2	up to 2	up to 2
Flexible disks	0	up to 4	0	up to 4
Tape	0	0	1	1

Note: A Fixed/Removable Winchester occupies two LUNs. Connecting such a drive, limits the number of remaining LUNs from four to two, and limits the number of other drives that may be connected as well.

(W14) Motor On Override (5200 and 5400 only)

Installed: The Motor On signal will always be asserted. This overrides bit 6 of byte 09 in the ASSIGN FLEXIBLE DISK PARAMETERS command.

Removed: The Motor On signal is asserted or deasserted according to bit 6 of byte 09 in the ASSIGN FLEXIBLE DISK PARAMETERS command.

(W15) READY OVERRIDE (5200 and 5400 only)

Installed: The Flexible drive is considered to always be ready. This jumper must be in place for Flexible drives that do not support a READY signal.

Removed: This jumper should not be in place for drives supporting a drive READY signal.

4.4 DEFAULT PARAMETERS

4.4.1 WINCHESTER DISK DRIVES

Upon power-on or any Reset operation, the controller defaults to the following parameters.

The Hex values refer to the parameter list of the ASSIGN DISK PARAMETER command.

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 (MSB) = 0	(HEX 00)
MAXIMUM CYLINDER ADDRESS (LSB) = 153	(HEX 98)
REDUCED WRITE CURRENT = 128	(HEX 80)

Block Size	Numbers of Sectors Per track	Code Hex
128	55	36
256	32	1F
512	17	10
1024	9	08

4.4.2 FLEXIBLE DISK DRIVES

Upon power-on or any Reset operation, the controller defaults to the following parameters.

The Hex values refer to the parameter list of the ASSIGN DISK PARAMETER command.

Model 5200 Default Values

STEP PULSE WIDTH = 2 MICROSECONDS	(HEX 02)
STEP PULSE INTERVAL = 7 MILLISECONDS	(HEX 07)
MAXIMUM CYLINDER ADDRESS = 80 CYLINDERS	(HEX 4F)
HEAD SETTLING DELAY = 22 MILLISECONDS	(HEX 16)
HEAD SELECT DELAY = 205 MICROSECONDS	(HEX CD)
DRIVE SELECT DELAY = 0 MILLISECONDS	(HEX 00)
WRITE GATE DELAY = 1.1 MILLISECONDS	(HEX 0B)
FLEXIBLE DRIVE	(HEX 80)
FLEXIBLE DISK TYPE	(HEX 00)
START WRITE PRECOMPENSATION	(HEX 00)

The default track format is as follows:
(side 0, cylinder 0 = FM recording, 16 sectors per track, 128 bytes per sector; all other tracks = MFM recording, 16 sectors per track, 256 bytes per sector.) This is the same as code 06 of the DEFINE FLEXIBLE DISK FORMAT Command.

SECTION 5

TRACK AND SECTOR FORMAT

5.1 WINCHESTER DISK TRACK FORMAT

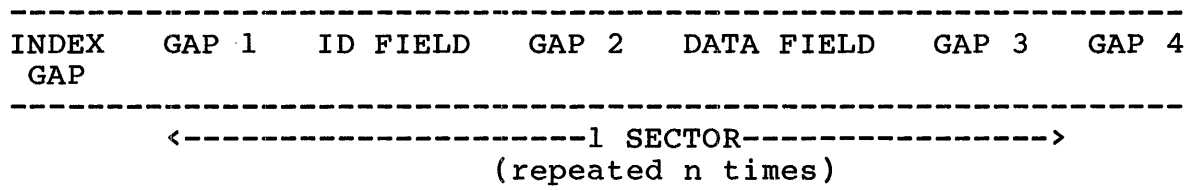
5.1.1 Track Format

The standard track format for the Hard and Soft sectored Winchester Disk drives is as below. The track is organized into numbered segments of data, called sectors. The beginning of each sector is defined by a prewritten identification (ID) field, registered during Format operation, which contains four bytes identified as follows:

BYTE 1. Cylinder Address (MSB)
BYTE 2. Cylinder Address (LSB)
BYTE 3. Head Address
BYTE 4. Sector Address

The second field contains the user data bytes, selectable as 128, 256, 512, or 1024 Bytes per sector.

STANDARD WINCHESTER DISK SECTOR FORMAT



The nominal Winchester Disk capacity is 10,416 Bytes. The minimum track capacity is 10,103 Bytes (based on a three percent speed variation). The method of encoding used is modified frequency modulation (MFM).

5.1.2 Sector ID Field

BYTE	1	A1 Address Mark (Drop Clock Bit)
	2	FE Address Mark
	3	Cylinder (MSB)
	4	Cylinder (LSB)
	5	Head and Flags
	6	Sector
	7-10	ECC
	11-12	00

5.1.3 Sector Data Field

128 BYTE DATA FIELD		
BYTE	1	A1*
	2	F8
	3-130	User Data Field
	131-134	ECC
	135-136	00

256 BYTE DATA FIELD		
	1	A1*
	2	F8
	3-258	User Data Field
	259-262	ECC
	263-264	00

512 BYTE DATA FIELD		
BYTE	1	A1*
	2	F8
	3-514	User Data Field
	515-518	ECC
	519-520	00

1024 BYTE DATA FIELD		
	1	A1*
	2	F8
	3-1026	User Data Field
	1027-1030	ECC
	1031-1032	00

* = Drop Clock Bit

5.1.4 Winchester Soft Sectored Gaps

INDEX GAP	= 11 BYTES of 4E	Head Switching Recovery Period
GAP 1	= 12 BYTES of 00	Sync for ID Field
GAP 2	= 12 BYTES of 00	Write Update Splice and Sync for Data Field
GAP 3	= 14 BYTES of 4E	Speed Tolerance at Sector Level
GAP 4	= xxx BYTES of the Speed Tolerance for the Track	
	= 340 BYTES of 4E (128 BYTES/SECTOR)	
	= 325 BYTES of 4E (256 BYTES/SECTOR)	
	= 698 BYTES of 4E (512 BYTES/SECTOR)	
	= 667 BYTES OF 4E (1024 BYTES/SECTOR)	

5.1.5 Winchester Hard Sectored Gaps

GAP 1	= 12	BYTES of 00
GAP 2	= 12	BYTES of 00
GAP 3	= 2	BYTES of 4E
GAP 4	= x	BYTES of 4E until next Sector Pulse

5.1.6 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 the 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.

5.2 FLEXIBLE DISK TRACK FORMAT

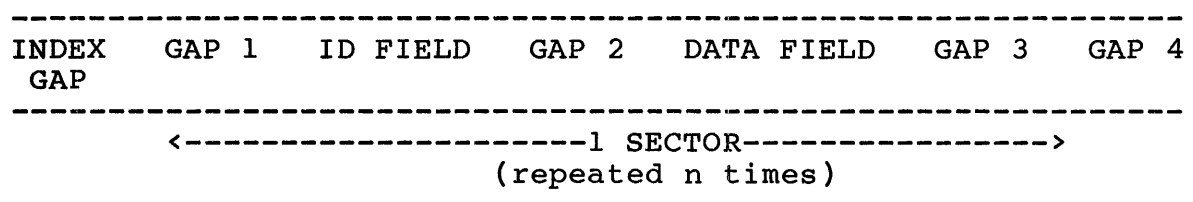
5.2.1 Track Format

The standard track format for Flexible Disk drives is as below. The track is organized into numbered segments of data, called sectors.

The beginning of each sector is defined by a prewritten identification (ID) field, registered during Format operation, which contains four bytes.

The second field contains the user data bytes, selectable as 128, 256, 512, or 1024 Bytes per sector.

STANDARD FLEXIBLE DISK TRACK FORMAT



Flexible Disk drives are either in 250 KBit or 500 KBit format.

5.2.2 Sector ID Field

```
BYTE  1   Number of Cylinders - 00-FE
      2   Number of Sides     - 00=Side 0; 01=Side 1
      3   Number of Sectors   - (See below)
      4   Sector Size
```

BYTE 3 - Number of Sectors:

250 KBit Format	500 KBit Format
01-10 at 128 Byte/Sec	01-1A at 128 Byte/Sec
01-10 at 256	01-1A at 256
01-09 at 512	01-10 at 512
01-04 at 1024	01-08 at 1024

Default Number of Sectors for 250 KBit Format are 8 (01-08), however, a 9 Sector Format (01-09) is possible.

Default Number of Sectors for 500 KBit Format are 15 (01-0F), however, a 16 Sector Format (01-10) is possible.

5.2.3 Sector Data Field

128 BYTE DATA FIELD		256 BYTE DATA FIELD	
BYTE 1-3	Address Mark	1-3	Address Mark
4	FB	4	FB
5-134	User Data Field	5-262	User Data Field
135-136	CRC	263-264	CRC

512 BYTE DATA FIELD		1024 BYTE DATA FIELD	
BYTE 1-3	Address Mark	1-3	Address Mark
4	FB	4	FB
5-518	User Data Field	5-1030	User Data Field
519-520	CRC	1030-1032	CRC

5.2.4 Spacing Between Sectors

250 KBit Format	500 KBit Format
25 Bytes at 128 Byte/Sec	27 Bytes at 128 Byte/Sec
50 Bytes at 256	54 Bytes at 255
50 Bytes at 512	54 Bytes at 512
240 Bytes at 1024	116 Bytes at 1024

SECTION 6

HOST BUS DEFINITION

6.1 GENERAL

The 5000 Series host-controller interface is the general purpose 8-bit bidirectional bus known as the SCSI/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 controller accepts selection, it takes control of the bus and requests the appropriate command bytes.

For data transfers, a multiple sector buffer is provided to eliminate any possibility of data overruns. Upon command completion (either successful or not), the controller will issue completion status to the host. Sense Status information is provided through the REQUEST SENSE command.

6.2 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.

6.3 INTERFACE TERMINATION

As shipped, all assigned interface signal lines are terminated with a 220/330 ohm resistor network, which can be removed. The first and last device (Host or Controller) on the daisy-chain SCSI bus should be terminated. The devices in between should have the terminators removed. For instance, if the Controller is in the middle of the string, remove its terminators. 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 than 0.5 VDC (7438 or equivalent).

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

6.4 SIGNAL INTERFACE

The host computer interface signals are as shown below. All signals are low true.

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	DATA PARITY(DBP)
	19	20	OPEN
	21	22	OPEN
	23	24	OPEN
	25	26	OPEN
	27	28	OPEN
	29	30	OPEN
	31	32	OPEN
	33	34	OPEN
	35	36	BUSY (BSY)
	37	38	ACKNOWLEDGE (ACK)
	39	40	RESET (RST)
	41	42	MESSAGE (MSG)
	43	44	SELECT (SEL)
	45	46	CONTROL / DATA (C/D)
	47	48	REQUEST (REQ)
GND	49	50	INPUT / OUTPUT (I/O)

6.5 SIGNAL DEFINITION

RESET (RST)

"OR Tied" signal asserted 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 twenty-five microsecond wide.

SELECT (SEL)

Asserted by the host, along with a single controller address bit (0 through 7), causes the appropriate controller to be selected. The SELECT line must be deasserted by the host after the controller asserts the BUSY line.

BUSY (BSY)

"OR Tied" signal asserted by the controller indicates that the bus is being used.

CONTROL / DATA (C/D)

Signal asserted by the controller indicates that command or data 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)

Signal asserted 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)

Signal asserted 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)

Signal asserted 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)

Signal asserted by the controller indicates that the last byte transfered was the Completion Status byte. When the MESSAGE signal is asserted, indicating a Message phase, REQUEST is asserted by the controller in order to transfer an 8-bit byte indicating the end of the operation. When this REQ/ACK handshake is complete, the controller will deassert all interface signal lines and return to the idle state, with BUSY deasserted.

DATA BITS 0-7 (DB0-7) & PARITY

The 8 bidirectional data and odd parity lines are used to transfer 8-bit parallel data to/from the host computer. Bit 7 is the most significant bit.

6.6 HOST INTERFACE PROTOCOL

For detailed information about the Host Interface Protocol, refer to the SCSI specifications as per ANSC X3T9.2/82-2, Revision 8 minimum.

The Host interface includes eight distinct operational phases as follows:

1. Bus Free phase (BSY deasserted)
2. Arbitration phase (Optional. To be used either with a Multi Host configuration or with the SCSI Disconnect/Reconnect feature; neither one supported by the OMTI 5000 Series controllers.)
3. Selection phase
4. Re-Selection phase (not implemented in the OMTI 5000 Series controllers)
5. Command phase
6. Data In or Out phase
7. Status phase
8. Message In or Out phase (Message Out phase is not implemented in the OMTI 5000 Series controllers)

The Host bus can never be in more than one phase at any given time.

The order in which SCSI bus phases are used on the bus follows a prescribed sequence. The Reset condition can interrupt any phase and is always followed by the Bus Free phase.

The controller follows a normal progression from the Bus Free phase to Selection phase, to one or more of the following Information Transfer phases (Command, Data In or Out, or directly to Status phase). The Message In phase is always the last phase before returning to the Bus Free phase.

6.7 SELECTION PHASE

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 bus 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 appropriate 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 the C/D line. I/O remains deasserted throughout the selection sequence.

NOTE:
Upon power on reset the controller will execute a comprehensive self test. During the self test the controller will not respond to a Selection sequence for a period of ~~400~~ 450 msec after the RST pulse. The controller will not assert BSY during this time.

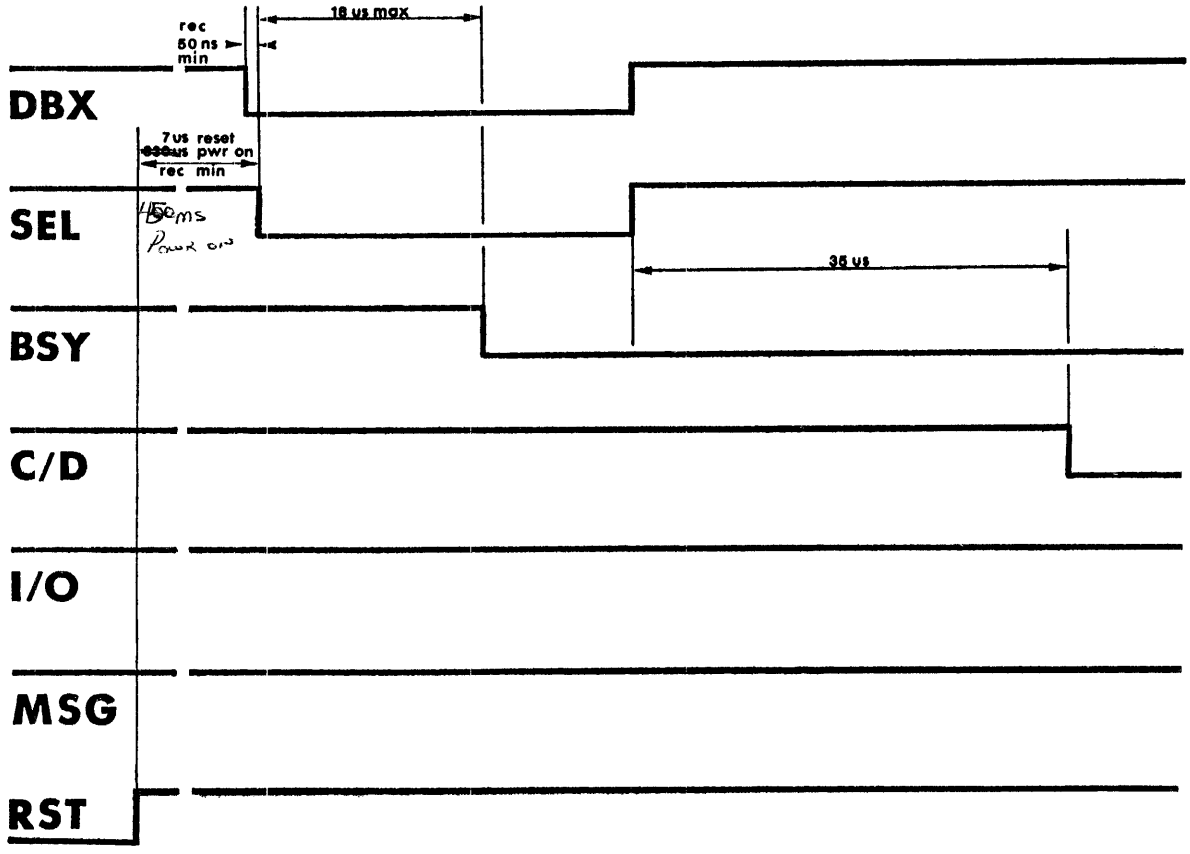


Figure 6.1 Selection Phase Timing Chart

6.8 COMMAND PHASE

After becoming selected, the controller will assert C/D, indicating the start of the command phase, then assert REQ, requesting the first byte of command. The host will then place this first byte of the command descriptor block on the data bus. The host will then assert ACK. The controller will then respond by reading the byte on the data bus and deasserting 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 issued.

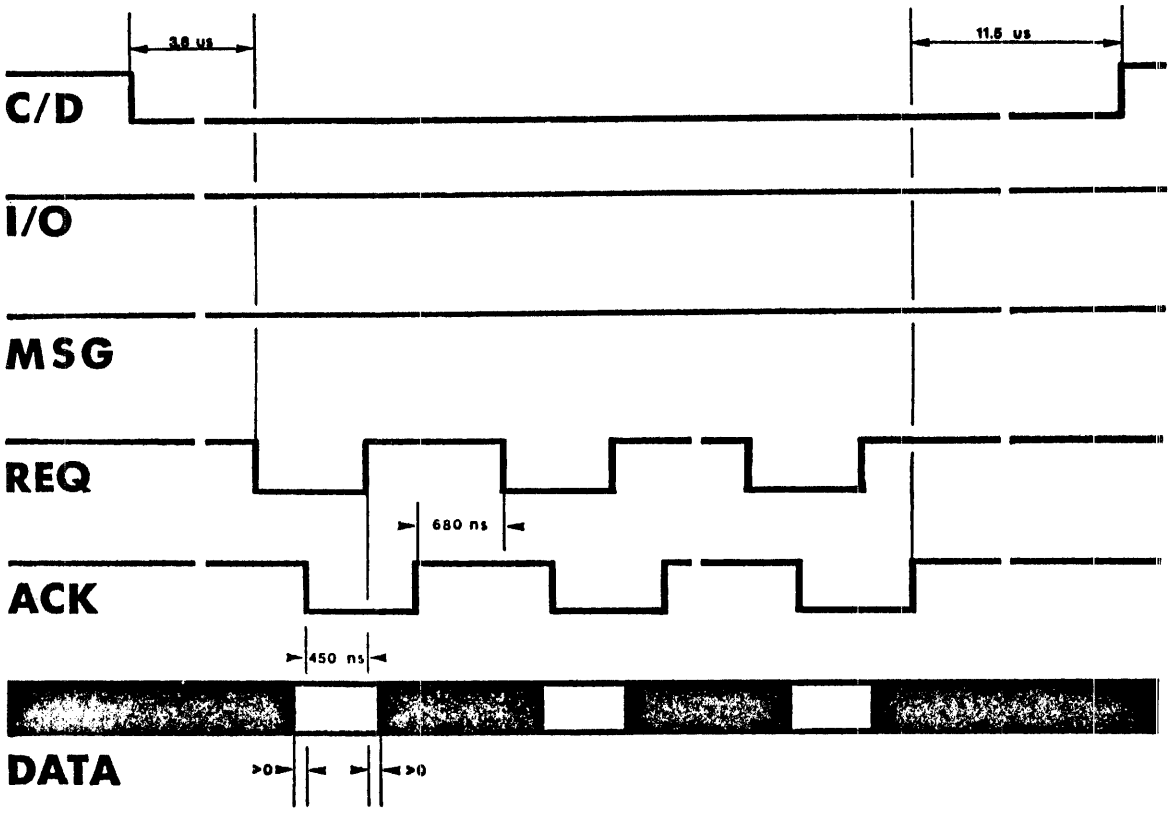


Figure 6.2 Command Phase Timing Chart

6.9 DATA IN OR OUT PHASE

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 responds by transferring a byte across the data bus, and then asserts ACK. The controller then deasserts REQ to finish the data transfer. This handshake continues until all data bytes have been transferred.

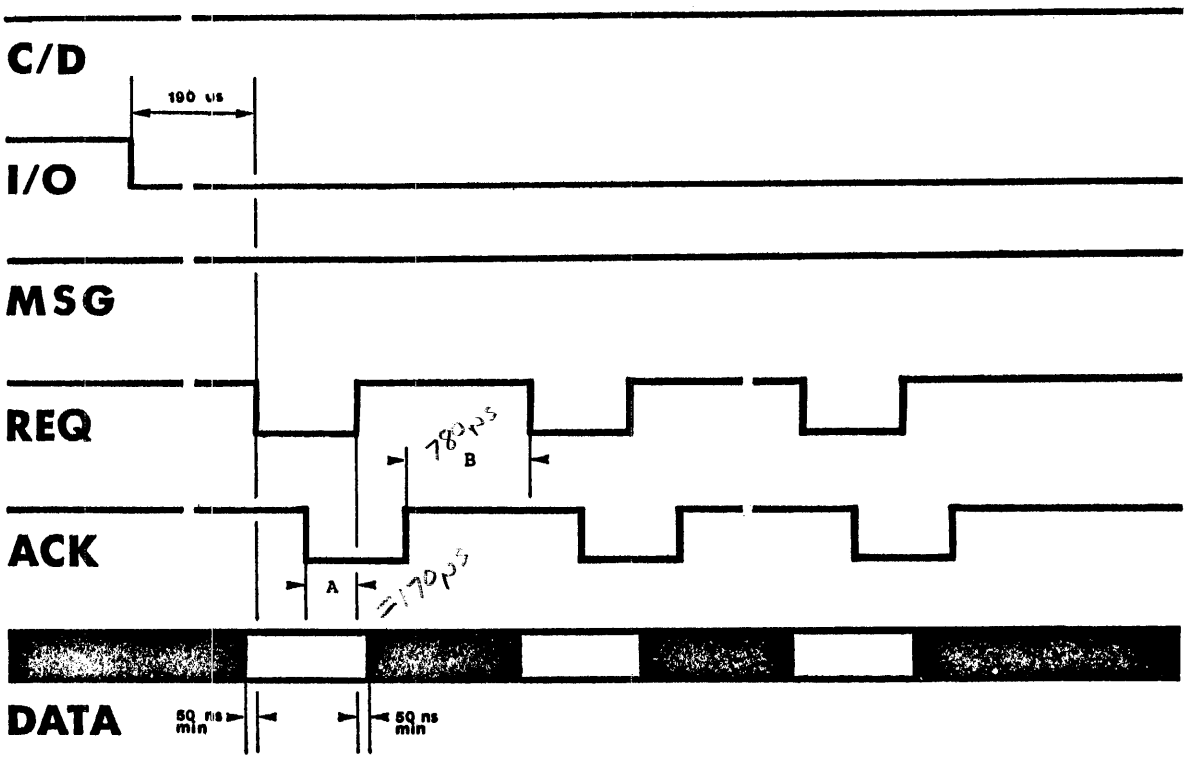


Figure 6.3 Data In Phase Timing Chart

NOTE: Refer to Figures 6.3 and 6.4 for timing variations on boards with the following Revision numbers:

DATA IN - READ

		Rev. 1	Rev. 2
Timing	A:	190 us	170 us
	B:	450 ns	780 ns

DATA OUT - WRITE

		Rev. 1	Rev. 2
Timing	A:	450ns	210 ns
	B:	700ns	560 ns

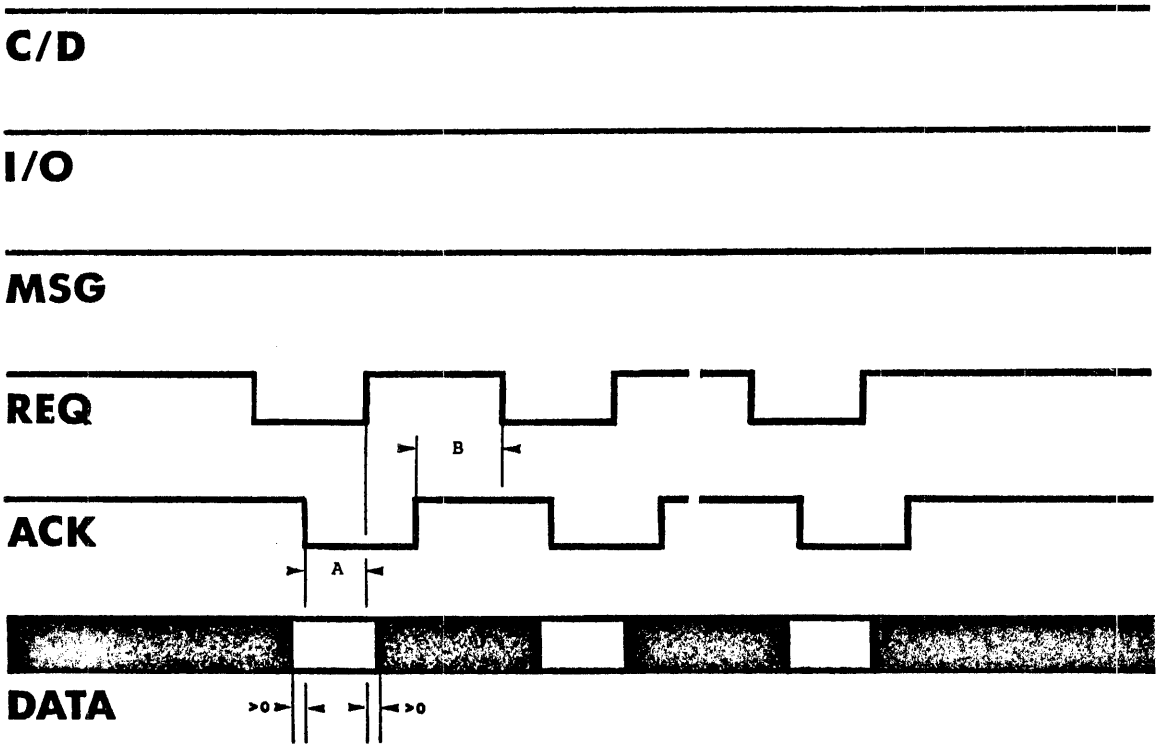


Figure 6.4 Data Out Phase Timing Chart

6.10 STATUS AND MESSAGE PHASES

Following a command or data transfer, the controller will generate a Completion Status byte and a Message In byte. To send the Completion Status byte, the controller will assert C/D and I/O, along with the assertion of 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 Completion Status byte transfer, a message byte will be transferred to indicate that the command is completed. The controller will assert the MSG line, along with C/D and I/O, then assert REQ. The host accepts the "Command Complete" message byte on the data bus and asserts ACK. The controller then responds by deasserting REQ, and the host by deasserts 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 phase.

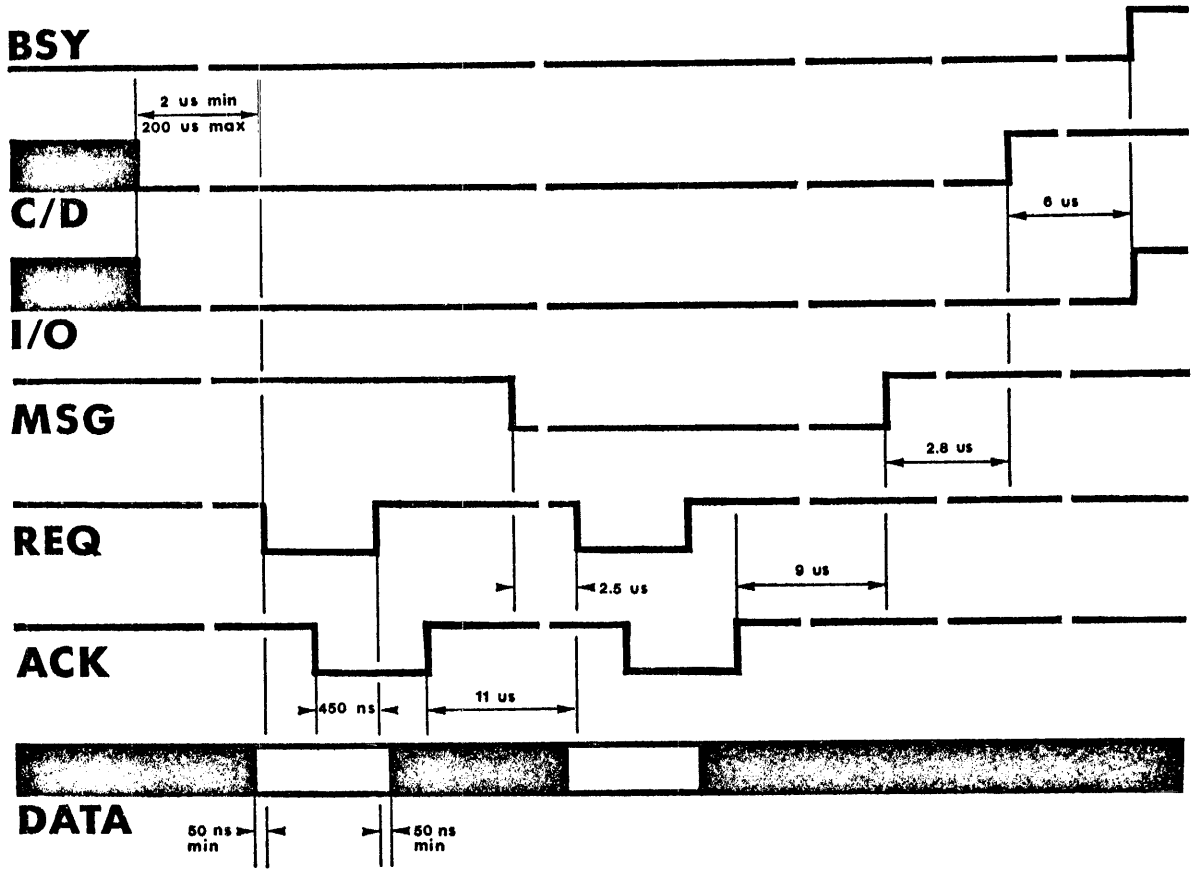


Figure 6.5 Status and Message Phase Timing Chart

SECTION 7

DISK COMMAND SPECIFICATIONS

7.1 GENERAL

Following the selection phase, the controller requests a command descriptor block (CDB) from the host, the length of which is either six, ten, or twelve bytes. The first byte of the CDB contains the command code. The remaining bytes describe the commands.

The controller checks all incoming CDB's validity and, unless disabled, will check both CDB and data for odd parity. An error in the command structure will terminate the command and cause a "check condition" status to occur.

7.2 COMMAND DESCRIPTOR DEFINITION

Command Descriptor Block

	7	6	5	4	3	2	1	0
BYTE 1	COMMAND CODE							
BYTE 2	0	LUN			LOGICAL BLOCK ADDR 2 (MSB)			
BYTE 3	LOGICAL BLOCK ADDRESS 1							
BYTE 4	LOGICAL BLOCK ADDRESS 0 (LSB)							
BYTE 5	BLOCK COUNT/INTERLEAVE FACTOR							
BYTE 6	CONTROL BYTE							

7.2.1 Logical Unit Number

LUN (BYTE 2 - BITS 5, and 6) is the Logical Unit Number for the drive.

Fixed, Removable, or Flexible Drives	Fixed/Removable Drives
DRIVE SELECT 1 = LUN 0	DRIVE SELECT 1 = LUN 0
DRIVE SELECT 2 = LUN 1	DRIVE SELECT 1 = LUN 1
DRIVE SELECT 3 = LUN 2	DRIVE SELECT 3 = LUN 2
DRIVE SELECT 4 = LUN 3	DRIVE SELECT 3 = LUN 3

7.2.2 Logical Block Address

The logical block address is a 21 bit address located in Byte two (Bits 4-0)(MSB), Byte three, and Byte four (LSB). The logical block address relates to a physical address, typically defined in terms of cylinder-head-sector.

The logical block address zero relates to cylinder 0, head 0, sector 0. Logical block addresses continue through all the sectors on the track, then continue to sector 0 on the next head, continuing through all the heads on the cylinder, and then continue to the next cylinder.

For Disk Drives, the logical block address is computed using the following formula:

LOGICAL BLOCK ADDRESS=(CYLADR * HDCYL + HDADR) * SECTRK + SECNUM

Where:

CYLADR	=	Cylinder address
HDCYL	=	Number of Heads per Cylinder
HDADR	=	Head address
SECTRK	=	Number of Sectors per Track
SECNUM	=	Sector Number

7.2.3 Block Count/Interleave Factor

The Block Count or Transfer Length specifies the number of blocks to be transferred per command. A value of 0 will result in a transfer of 256 blocks.

This byte also specifies the interleave factor for the FORMAT command. An interleave factor of 0 will default to an interleave factor of 1. The scheme to calculate interleaving is compatible with the OMTI 20 Series.

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. BLK.	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. BLK.	3	13	23	4	14	24	5	15	25	6	16
PHY. SEC.	22	23	24	25	26	27	28	29	30	31	
LOG. BLK.	26	7	17	27	8	18	28	9	19	29	

Refer to the Appendix for a complete Interleave Table.

7.2.4 Control Byte (Last byte in all commands)

Control Byte

	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 read error occur with the Retry bit of the control byte enabled, the controller will attempt to read the sector up to eight (8) times. ID field errors will recalibrate and reseek after four (4) rereads.

Should a correctable data error occur with the Error Correction bit enabled, the controller will correct the data prior to transferring it to the host.

If both Retry and Error Correction are not disabled, the retry sequence will be attempted prior to error correction.

If the LINK command bit of the Control Byte is enabled, and the current command is executed successfully, the controller will bypass the Status and Message In phases, and the Selection phase of the next command. The controller will then request the next command descriptor block.

7.3 COMPLETION STATUS BYTE

At termination of a command or following an error, the controller will cause a status byte to be transferred from the controller to the host. The completion status byte will report only that an error (CHECK CONDITION) occured, not the type of error. To obtain the error code a REQUEST SENSE command must be issued (03 Hex). 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 causing the error. If no error occurs, bits 0 - 4 will be set to 0.

Completion Status Byte Format

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

CHECK CONDITION = 1.....

PARITY ERROR = 1.....

BIT 0	Parity error
BIT 1	Error occurred during command execution
BIT 2-4	Spare (Set to 0)
BIT 5-6	Logical Unit Number of the drive
BIT 7	Set to 0

7.4 MESSAGE IN BYTE

Following the transfer of the completion status byte, the controller asserts the MSG line to indicate a Message In phase. This message consists of a single byte transfer, with all bits set to 0, indicating Command complete.

7.5 TYPE 0 COMMANDS

7.5.1 TEST DRIVE UNIT Command (HEX 00)

The command selects the LUN specified and returns a Zero Status during the Status phase of the command execution, to indicate that the Winchester drives are selected, ready, SEEK complete, and that flexible drives are ready. In the case of a unit with a Removable Disk drive, Zero Status also indicates that a cartridge is installed.

TEST DRIVE UNIT Command Descriptor Block

	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 BYTE							

Valid Error Codes

Drive not ready	(HEX 04)
Drive not selected	(HEX 05)
Multiple drives selected	(HEX 07)
Cartridge Changed	(HEX 09)
Seek in progress	(HEX 0D)
Power Up Diagnostic Error	(HEX 30)

7.5.2 RECALIBRATE Command (HEX 01)

The drive specified by the LUN is stepped toward the outside cylinder until either:

1. Track 0 signal is detected or
2. More steps have been issued than available cylinders for the device type.

The controller issues one step pulse, waits for SEEK complete (if Winchester), and tests the track 000 signal until track 000 is true.

RECALIBRATE Command Descriptor Block

	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 BYTE							

Valid Error Codes

No seek complete	(HEX 02)
Drive not ready	(HEX 04)
DRive not selected	(HEX 05)
No track 0 found	(HEX 06)
Multiple drives selected	(HEX 07)
Cartridge Changed	(HEX 09)
Power up diagnostic error	(HEX 30)

7.5.3 REQUEST SENSE Command (HEX 03)

Following a Check Condition status from the Completion Status byte of the previous command, the host may perform REQUEST SENSE command, to obtain more detailed information about the error. (Each command description contains a list of valid error codes.)

REQUEST SENSE Command Descriptor Block

	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 BYTE							

Sense Bytes

The following bytes are returned to the host during the Data In phase of the command execution.

Sense Byte Format

	7	6	5	4	3	2	1	0
BYTE 1	COMMAND CODE							
BYTE 2	0	LUN	LOGICAL BLOCK ADDR 2 (MSB)					
BYTE 3	LOGICAL BLOCK ADDRESS 1							
BYTE 4	LOGICAL BLOCK ADDRESS 0 (LSB)							

Sense Byte 1

Sense Byte 1 Error Code Format

BITS	7	6	5	4	3	2	1	0
	AV	0	TYPE		CODE			

AV: Block Address Valid

Error Code Summary (Sense Byte 1)

ERROR	ERROR CODE (HEX)
No error	00
No index signal	01
No seek complete	02
Write fault	03
Drive not ready	04
Drive not selected	05
No track zero found	06
Multiple drives selected	07
Cartridge changed	09
Tape exception (Tape Only)	0A
Not used	0B
Not used	0C
Seek in progress	0D
Uncorrectable error in data field	11 & 91
No address mark in ID field	12 & 92
No address mark in data field	13 & 93
No record found	14 & 94
Seek error	15 & 95
Not used	16 & 96
Write protected	17 & 97
Correctable ECC error	18 & 98
Bad track flag set	19 & 99
Incorrect interleave factor	1A
Unable to read alternate track data	1C
Illegal direct access to alternate track	1E
Tape drive failure (Tape Only)	1F
Invalid command	20
Illegal parameter	21
Illegal function for drive type	22
Volume overflow	23
Power Up diagnostic error	30
FDC 765 error (5200/5400 only)	31
Not used	32 through 90
Not used	A0 through FF

Note 32H CODE USED TO INDICATE 5200 HAD NO RESPONCE TO SELECT

Error Code Definitions (Sense Byte 1)

00 No error or no sense information. Indicates that there is no specific sense information to be reported for the designated Logical Unit Number. This is the case for the successful completion of the previous command.

01 No Index signal from the disk drive. The drive is ready but the controller does not detect the Index signal coming from the drive interface control cable indicating the beginning of the track. The controller waited at least three seconds. This error may occur during the following commands: FORMAT DRIVE, FORMAT TRACK, FORMAT BAD TRACK, FORMAT ALTERNATE TRACK, and CHECK TRACK FORMAT. Verify the cable and connector before investigating drive or controller problems.

02 No Seek Complete. The controller did not receive the Seek Complete signal from the drive, which indicates that the step function issued has been completed. The controller waits at least three seconds before reporting this error.

03 Write Fault received from the drive. The Write Fault signal is sampled before turning on Write Gate and after turning off Write Gate. Consult the disk drive specifications for all possible conditions reporting this error. Check the drive power supply voltage and drive connector.

04 Drive Not Ready. This status occurs when the selected drive is not ready. The drive may not be at its optimum speed. Absence of cartridge or media in the drive will also cause this status. During the drive selection sequence, if the DRIVE READY signal is not asserted the controller will de-select the drive, re-select the drive, and monitor the READY line for up to two seconds. If the READY signal is still not asserted after this de-select/re-select process, the controller will post a DRIVE NOT READY error. Check the drive power supply and drive connector if this status persists. In the case of Flexible disk drive, check that the diskette is in place and the door is closed.

05 Drive Not Selected. The controller attempted to select a drive and this drive did not assert its selec signal. Ensure that any drive connected to the controller has its address (selected by jumpers on the drive) matching the LUN address of the command. Ensure that the drive data and control cables are in place. There is no relation between this error code and the SASI or SCSI bus selection process.

06 No Track zero found. During a RECALIBRATE command the controller issues steps and checks if it reached Track zero after every step. This error occurs if the controller issued 16 steps more than the total number of cylinders, as currently defined for this LUN, and did not detect the Track zero signal from the drive.

07 Multiple drives selected. More than one drive asserted its Drive Selection signal on its Data cable. Ensure that each drive connected has a unique address selected by jumperss (on the drive). Check cables and connectors.

08 Not used.

09 Cartridge Changed. The controller received the Cartridge Changed signal from the drive, indicating that the door was opened and closed (with the possibility that the cartridge was changed). During the drive selection sequence, if the DRIVE READY signal is not asserted the controller will de-select the drive, re-select the drive, and monitor the READY line for up to two seconds. If the READY signal then becomes asserted, the controller will post a Cartridge Changed error. If the READY signal is still not asserted after this de-select/re-select process, the controller will post a DRIVE NOT READY error.

0A Tape Exception. The controller received the Exception signal from the QIC 02 Tape drive, during a command to that drive, indicating an error condition detected by the Tape formatter.

0B and 0C Not Used.

0D Seek in progress. This error code is returned only in response to a REQUEST SENSE (00) command. The drive is busy seeking to the location defined by the previous SEEK command. This error code is to be expected after overlapping seeks are issued. The controller will keep reporting this code until the disk drive sends the Seek Complete signal.

0E through 10 Not used.

11 and 91 Uncorrectable Data error. The controller detected a data field error that could not be corrected by the ECC. The burst error length might be over the limits of capability of the ECC, or the error might have involved a multiple burst. The data block is not transferred to the host. The command stops its execution when encountering this condition, and does not exhaust the block count. The last data block sent to the host was the last good block for which no error was encountered. The Sense Bytes of the REQUEST SENSE command sent following this

error will report the Logical Block address at which the error occured. The data block that contains the error can be accessed by a Read Data Buffer command. The Read Data Buffer will return the block provided that no other command (including REQUEST SENSE, command) has been issued since the uncorrectable data error occured.

12 and 92 Not used.

13 and 93 No Address Mark in Data Field. The controller did not detect the AM byte (A1,F8) when trying to access a formatted disk. The disk may have a flaw in this particular location.

14 and 94 No Record found. The controller was able to read at least one ID Field and determined that it was on the right track, but could not find the specified ID Field because it could not find the ID Field Address Mark (A1, FE), it detected an ID Field ECC error, or the specified ID does not exist.

15 and 95 Seek error. The controller could not find the specified ID Field, and there was a miscompare of the cylinder or head address between the recorded and the target ID Fields.

16 and 96 Not used.

17 and 97 Write Protected. During WRITE commands, the Flexible Disk, Removable Disk, or Tape drive sent the Write Protect signal to the controller, indicating that the media is protected for write operations.

18 and 98 Correctable ECC error. This error can only be encountered if correction is disabled in the control byte of the command. It indicates that the block which contains an error can be corrected by the ECC algorithm. The data block involved is not sent to the host. The command execution is stopped at this sector; the block count is not exhausted. Note that if correction is enabled and if the error was corrected by the ECC, the controller will not report any error.

19 and 99 Bad Track Flag set. The controller detected that the specified sector is on a track that has been flagged in the ID field by the FORMAT BAD TRACK command. It is not possible to access the sectors on a known bad track

1A and 9A Incorrect Interleave Factor. During the CHECK TRACK FORMAT command, the interleave factor specified in the command did not match the value with which the track had been formatted.

1B and 9B Not used.

1C and 9C Unable to read Alternate Track Data. During an access to a specified sector, the controller found a track with the "Bad track" Flag and the "Alternate track assigned" Flag set in the ID field. The controller stepped the drive to the alternate track but was unable to locate the specified sector on the alternate track, or found that the Alternate Track Flag was not set in the ID field.

1D and 9D Not used.

1E and 9E Illegal Direct Access to Alternate Track. The controller received a command with the logical block address corresponding to an alternate track, and found the "Alternate Track" Flag set in the ID field. The tracks reserved as alternates cannot be accessed directly by a data transfer command. These tracks may be accessed only by the controller's automatic handling of media defects.

1F and 9F Tape Drive Failure. The tape drive interface handshake has failed. The tape drive must be reset before it will accept any new commands.

20 Invalid Command The controller decoded a command code in byte one of the CDB that it does not support. Refer to the Command Set Summary.

21 Illegal Parameters. The controller received a command with a Logical Block Address beyond the capacity of the drive. Refer to the Logical Block Address computation formula, and check the number of cylinders, heads, and sector size that the drive is configured for.

22 Illegal Function for Drive Type. The controller received a command with legal bits and bytes but illegally defined for that drive type. This condition affects the command bytes as well as the bytes sent during the Data Out phase of the command execution. Refer to the appropriate command definition in its respective section of the manual. An example would be that a command valid only on Winchester drives is issued to a LUN defined as a tape drive.

23 Volume Overflow. The controller received a multiple sector command with which the Logical Block address and the block count specified created an overflow condition by trying to access space beyond the capacity of the disk. Refer to the Logical Block Address computation formula, and check the number of cylinders, head, and sector size that the drive is configured for.

24 through 2F Not Used.

30 Power Up Diagnostic error. The internal controller tests at power up detected an error condition. This error code is returned on the first command requiring drive access after power up sequence, or after a Reset condition.

31 FDC 765 Error (5200/5400 Models only)(To be supplied)

32 through 90 Not used.

A0 through FF Not used.

7.5.4 FORMAT DRIVE Command (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 proceeds until the last track of the unit is formatted. The track is written starting with the index. All data fields are filled with HEX E5. The first sector after index is always sector 0. The second sector is 0 plus the interleave factor. An interleave factor of zero is set equal to one. Track and cylinder overflow is handled automatically by the controller.

NOTE: This command does not check data, and does not handle media defects. For verification of format, see CHECK TRACK FORMAT Command. For media defect handling, see the ASSIGN ALTERNATE TRACK, and the FORMAT BAD TRACK Commands.

FORMAT UNIT Command Descriptor Block

	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 BYTE							

VALID ERROR CODES

No index	(HEX 01)
No seek complete	(HEX 02)
Write fault	(HEX 03)
Drive not ready	(HEX 04)
Drive not selected	(HEX 05)
No track 0 found	(HEX 06)
Multiple drives selected	(HEX 07)
Cartridge changed	(HEX 09)
Write protected	(HEX 17)
Power Up Diagnostic error	(HEX 30)

7.5.5 CHECK TRACK FORMAT Command (HEX 05)

This command checks the integrity of the track specified by the Logical Block address. ID fields and data fields are verified against ECC value recorded. The command also ensures that the interleave recorded matches the value in Byte 5 . An interleave factor of 0 is set equal to one. No data is transferred to the host. To specify the track address, any Logical Block address on that track may be used. This command is not valid for LUN's assigned as Flexible Disk drives.

CHECK TRACK FORMAT Command Descriptor Block

	7	6	5	4	3	2	1	0
BYTE 1	0	0	0	0	0	1	0	1
BYTE 2	0	LUN			LOGICAL BLOCK ADDR 2 (MSB)			
BYTE 3	LOGICAL BLOCK ADDRESS 1							
BYTE 4	LOGICAL BLOCK ADDRESS 0 (LSB)							
BYTE 5	INTERLEAVE FACTOR							
BYTE 6	CONTROL BYTE							

VALID ERROR CODES

No index	(HEX 01)
No seek complete	(HEX 02)
Write fault	(HEX 03)
Drive not ready	(HEX 04)
Drive not selected	(HEX 05)
No track 0 found	(HEX 06)
Multiple drives selected	(HEX 07)
Uncorrectable data error —	(HEX 11)
No address found in data field	(HEX 13)
No record found	(HEX 14)
Seek error	(HEX 15)
Correctable data error	(HEX 18)
Bad track flag set	(HEX 19)
Incorrect interleave factor	(HEX 1A and 9A)
Unable to read alternate track data	(HEX 1C)
Illegal sector address	(HEX 21)
Illegal function for drive type	(HEX 22)
Volume overflow	(HEX 23)
Power Up Diagnostic error	(HEX 30)

7.5.6 FORMAT TRACK Command (HEX 06)

This command causes the track specified by the logical block 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 factor of zero is set to one. To specify the track address, any Logical Block address on that track may be used.

FORMAT TRACK Command Descriptor Block

	7	6	5	4	3	2	1	0
BYTE 1	0	0	0	0	0	1	1	0
BYTE 2	0	LUN			LOGICAL BLOCK ADDR 2 (MSB)			
BYTE 3	LOGICAL BLOCK ADDRESS 1							
BYTE 4	LOGICAL BLOCK ADDRESS 0 (LSB)							
BYTE 5	INTERLEAVE FACTOR							
BYTE 6	CONTROL BYTE							

VALID ERROR CODES

No index	(HEX 01)
No seek complete	(HEX 02)
Write fault	(HEX 03)
Drive not ready	(HEX 04)
Drive not selected	(HEX 05)
Multiple drives selected	(HEX 07)
Cartridge changed	(HEX 09)
Write protected	(HEX 17)
Illegal direct access to alternate track	(HEX 1E)
Power Up Diagnostic error	(HEX 30)

7.5.7 FORMAT BAD TRACK Command (HEX 07)

This command is identical to the FORMAT TRACK command except that the defective track flag is set in the ID field. All subsequent accesses to the sectors on this track will result in Bad Track Flag set errors. To specify the track address, any Logical Block address on that track may be used. Interleave factor of zero is set to one. This command is not valid for LUN'S assigned as Flexible Disk drives.

FORMAT BAD TRACK Command Descriptor Block

	7	6	5	4	3	2	1	0
BYTE 1	0	0	0	0	0	1	1	1
BYTE 2	0	LUN			LOGICAL BLOCK ADDR 2 (MSB)			
BYTE 3	LOGICAL BLOCK ADDRESS 1							
BYTE 4	LOGICAL BLOCK ADDRESS 0 (LSB)							
BYTE 5	INTERLEAVE FACTOR							
BYTE 6	CONTROL BYTE							

VALID ERROR CODES

No index	(HEX 01)
No seek complete	(HEX 02)
Write fault	(HEX 03)
Drive not ready	(HEX 04)
Drive not selected	(HEX 05)
Multiple drives selected	(HEX 07)
Cartridge changed	(HEX 09)
Write protected	(HEX 17)
Illegal Direct access to alternate track	(HEX 1E)
Power Up Diagnostic error	(HEX 30)

7.5.8 READ Command (HEX 08)

This command causes the number of blocks specified by byte 5 to be transferred from the disk to the host. The command executes an implied seek to the starting block specified by the logical block address in bytes 2, 3, and 4. Up to 256 blocks can be transferred with a single READ command. (If Byte 5 is equal to zero, 256 blocks will be transferred.)

READ Command Descriptor Block

	7	6	5	4	3	2	1	0
BYTE 1	0	0	0	0	1	0	0	0
BYTE 2	0	LUN			LOGICAL BLOCK ADDR 2 (MSB)			
BYTE 3	LOGICAL BLOCK ADDRESS 1							
BYTE 4	LOGICAL BLOCK ADDRESS 0 (LSB)							
BYTE 5	BLOCK COUNT							
BYTE 6	CONTROL BYTE							

VALID ERROR CODES

No seek complete	(HEX 02)
Drive not ready	(HEX 04)
Drive not selected	(HEX 05)
Multiple drives selected	(HEX 07)
Cartridge changed	(HEX 09)
Uncorrectable error in data field	(HEX 11)
No address mark in data field	(HEX 13)
No record found	(HEX 14)
Seek error	(HEX 15)
Correctable data error	(HEX 18)
Bad track flag set	(HEX 19)
Unable to read alternate track data	(HEX 1C)
Illegal access to alternate track	(HEX 1E)
Volume overflow	(HEX 23)
Power Up Diagnostic error	(HEX 30)

7.5.9 WRITE Command (HEX 0A)

This command causes the number of blocks specified by byte 5 to be transferred from the host to the disk. The command executes an implied seek to the starting block specified by the logical block address in bytes 2, 3, and 4. Up to 256 blocks can be transferred with a single WRITE command. (If Byte 5 is equal to zero, the block count is set to 256 blocks.)

WRITE Command Descriptor Block

	7	6	5	4	3	2	1	0
BYTE 1	0	0	0	0	1	0	1	0
BYTE 2	0	LUN			LOGICAL BLOCK ADDR 2 (MSB)			
BYTE 3	LOGICAL BLOCK ADDRESS 1							
BYTE 4	LOGICAL BLOCK ADDRESS 0 (LSB)							
BYTE 5	BLOCK COUNT							
BYTE 6	CONTROL BYTE							

VALID ERROR CODES

No seek complete	(HEX 02)
Write fault	(HEX 03)
Drive not ready	(HEX 04)
Drive not selected	(HEX 05)
No track 0 found	(HEX 06)
Multiple drives selected	(HEX 07)
Cartridge changed	(HEX 09)
No record found	(HEX 14)
Seek error	(HEX 15)
Write protected	(HEX 17)
Bad track flag set	(HEX 19)
Unable to read alternate track data	(HEX 1C)
Illegal access to alternate track	(HEX 1E)
Volume overflow	(HEX 23)
Power Up Diagnostic error	(HEX 30)

7.5.10 SEEK Command (HEX 0B)

This command causes the device addressed by the LUN to be physically positioned to the cylinder as defined by the logical block address in bytes 2, 3, and 4.

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 issuing all required step pulses. This allows overlap seek operations. As READ and WRITE commands are issued with implied seek, the SEEK command need not be issued, unless overlap operations are desired.

SEEK Command Descriptor Block

	7	6	5	4	3	2	1	0
BYTE 1	0	0	0	0	1	0	1	1
BYTE 2	0	LUN			LOGICAL BLOCK ADDR 2 (MSB)			
BYTE 3	LOGICAL BLOCK ADDRESS 1							
BYTE 4	LOGICAL BLOCK ADDRESS 0 (LSB)							
BYTE 5	ZERO VALUE							
BYTE 6	CONTROL BYTE							

VALID ERROR CODES

No seek complete	(HEX 02)
Drive not ready	(HEX 04)
Drive not selected	(HEX 05)
Multiple drives selected	(HEX 07)
Seek error	(HEX 15)
Volume overflow	(HEX 23)
Power Up Diagnostic error	(HEX 30)

7.5.11 ASSIGN ALTERNATE TRACK Command (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 blocks on the specified track cause the controller to automatically access those blocks on the alternate track. This command sets flags in the ID field and writes the alternate track address in all blocks 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. To specify the track address, any Logical Block address on that track may be used. Interleave factor of zero is set to one. This command is not valid for LUN's assigned as Flexible Disk drives.

ASSIGN ALTERNATE TRACK Command Descriptor Block

	7	6	5	4	3	2	1	0
BYTE 1	0	0	0	0	1	1	1	0
BYTE 2	0	LUN			LOGICAL BLOCK ADDR 2 (MSB)			
BYTE 3	LOGICAL BLOCK ADDRESS 1							
BYTE 4	LOGICAL BLOCK ADDRESS 0 (LSB)							
BYTE 5	INTERLEAVE FACTOR							
BYTE 6	CONTROL BYTE							

The alternate track address is passed to the controller during the Data Out phase of the command execution, using the following format:

ALTERNATE TRACK ADDRESS Descriptor Block

	7	6	5	4	3	2	1	0
BYTE 1	LOGICAL BLOCK ADDRESS 2 (MSB)							
BYTE 2	LOGICAL BLOCK ADDRESS 1							
BYTE 3	LOGICAL BLOCK ADDRESS 0 (LSB)							
BYTE 4	0	0	0	0	0	0	0	0

NOTE: Data written on the original track as well as on the alternate track will be destroyed.

The controller does not check if the track assigned as alternate track has been previously used as alternate track for another track.

A track reserved as alternate track may include defect(s), and may be shifted to another alternate track. Two levels of alternate tracks are allowed. But the residual block count must be limited to the capacity of the alternate track, otherwise the controller will not seek back to the original track plus one.

VALID ERROR CODES

No index	(HEX 01)
No seek complete	(HEX 02)
Write fault	(HEX 03)
Drive not ready	(HEX 04)
Drive not selected	(HEX 05)
Multiple drives selected	(HEX 07)
Cartridge changed	(HEX 09)
Write protected	(HEX 17)
Power Up Diagnostic error	(HEX 30)

7.5.12 CHANGE CARTRIDGE Command (HEX 1B)

This command is valid only for Removable Winchester Disks. The command causes the "Change Cartridge" line (J2-Pin 2) to be asserted for a period of one (1) millisecond.

CHANGE CARTRIDGE Command Descriptor Block

	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	ZERO VALUE							
BYTE 4	ZERO VALUE							
BYTE 5	ZERO VALUE							
BYTE 6	CONTROL BYTE							

Valid Error Codes

Drive not ready	(HEX 04)
Drive not selected	(HEX 05)
Multiple drives selected	(HEX 07)
Power Up Diagnostic error	(HEX 30)

7.6 TYPE 1 COMMAND

COPY Command (HEX 20)

This command copies a specified number of blocks from a Source LUN to a Destination LUN. Source and Destination LUN's may be the same. Block sizes on both Source and Destination LUNs must be identical. Because the controller uses its internal buffer, no data is transferred to the host.

COPY Command Descriptor Block

	7	6	5	4	3	2	1	0
BYTE 1	0	0	1	0	0	0	0	0
BYTE 2	0	SCR LUN			LOGICAL BLOCK ADDR 2 (MSB)			
BYTE 3	LOGICAL BLOCK ADDRESS 1							
BYTE 4	LOGICAL BLOCK ADDRESS 0 (LSB)							
BYTE 5	BLOCK COUNT							
BYTE 6	0	DST LUN			LOGICAL BLOCK ADDR 2 (MSB)			
BYTE 7	LOGICAL BLOCK ADDRESS 1							
BYTE 8	LOGICAL BLOCK ADDRESS 0 (LSB)							
BYTE 9	NOT USED							
BYTE 10	CONTROL BYTE							

VALID ERROR CODES

No seek complete	(HEX 02)
Write fault	(HEX 03)
Drive not ready	(HEX 04)
Drive not selected	(HEX 05)
No track 0 found	(HEX 06)
Multiple drives selected	(HEX 07)
Cartridge changed	(HEX 09)
Uncorrectable error in data field	(HEX 11)
No address mark in data field	(HEX 13)
No record found	(HEX 14)
Seek error	(HEX 15)
Write protected	(HEX 17)
Correctable data error	(HEX 18)
Bad track flag set	(HEX 19)
Unable to read alternate track data	(HEX 1C)
Illegal access to alternate track	(HEX 1E)
Illegal parameter	(HEX 21)
Volume overflow	(HEX 23)
Power Up Diagnostic error	(HEX 30)

7.7 TYPE 6 COMMANDS

7.7.1 DEFINE FLEXIBLE DISK FORMAT Command (HEX C0)

This command specifies the track format to be used on a LUN assigned as a Flexible disk drive. This command should be issued after all power-on or reset operation if values other than default are desired. The default condition is HEX 06 - double density, single sided, Side 0 - Cylinder 0 = FM recording, 16 sectors per track. All other tracks = MFM recording, 256 bytes per sector, 16 sectors per track. Byte 6 specifies the Flexible disk track format. If byte 5 is zero, the number of blocks per track will be as described in the FDD track format byte. If byte 5 is non-zero, the blocks per track will be as specified in byte 5.

DEFINE FLEXIBLE DISK FORMAT Command Descriptor Block

	7	6	5	4	3	2	1	0
BYTE 1	1	1	0	0	0	0	0	0
BYTE 2	0	LUN			NOT USED			
BYTE 3	NOT USED							
BYTE 4	NOT USED							
BYTE 5	SECTORS PER TRACK							
BYTE 6	FDD TRACK FORMAT							

VALID ERROR CODES

Illegal function for drive type	(HEX 22)

BYTE 5: Sector per track is normally zero because the SECTOR PER TRACK is implied in the track format code in Byte 6. Byte 5 can be used to override that value in certain circomstances.

BYTE 6: 5-1/4 Inch (250 KBit) TRACK FORMAT CODES

HEX 00 — Single density, Single sided, FM recording, 128 bytes per sector, 16 sectors per track.

HEX 01 — Single density, Double sided, FM recording, 128 bytes per sector, 16 sectors per track.

HEX 06 * — Side 0, Cylinder 0:
Single density FM recording, Single sided, 128 bytes per sector, 16 sectors per track.
All other tracks:
Double density MFM recording, Single sided, 256 bytes per sector, 16 sectors per track.

HEX 07 — Side 0, Cylinder 0:
Double density FM recording, Double sided, 128 bytes per sector, 16 sector per track.
All other tracks:
Double density MFM recording, Double sided, 256 bytes per sector, 16 sector per track.

HEX 86 — Double density, Single sided, MFM recording, 256 bytes per sector, 16 sectors per track.

HEX 87 — Double density MFM recording, Double sided, 256 bytes per sector, 16 sectors per track.

HEX 8A ** — Double density, Single sided, MFM recording, 512 bytes per sector, 8 sectors per track.

HEX 8B ** — Double density, Single sided, MFM recording, 512 bytes per sector, 8 sectors per track.

HEX 8E — Double density, Double sided, MFM recording, 1012 bytes per sector, 4 sectors per track.

HEX 8F — Double density, Double sided, MFM recording, 1012 bytes per sector, 8 sectors per track.

* = Default
** = Also supports 9 sectors per track using Byte 5.

BYTE 6: 8 Inch (500 KBit) TRACK FORMAT CODES

HEX 00 — Single density, Single sided, FM recording, 128 bytes per sector, 26 sectors per track.

HEX 01 — Single density, Double sided, FM recording, 128 bytes per sector, 26 sectors per track.

HEX 06 * — Side 0, Cylinder 0:
Double density FM recording, Single sided, 128 bytes per sector, 26 sectors per track.
All other tracks:
Double density MFM recording, Single sided, 256 bytes per sector, 26 sectors per track.

HEX 07 — Side 0, Cylinder 0:
~~Double~~ density FM recording, Double sided, 128 bytes per sector, 26 sector per track.
All other tracks:
Double density MFM recording, Double sided, 256 bytes per sector, 26 sector per track.

HEX 86 — Double density, Single sided, MFM recording, 256 bytes per sector, 26 sectors per track.

HEX 87 — Double density MFM recording, Double sided, 256 bytes per sector, 26 sectors per track.

HEX 8A ** — Double density, Single sided, MFM recording, 512 bytes per sector, 15 sectors per track.

HEX 8B ** — Double density, Single sided, MFM recording, 512 bytes per sector, 15 sectors per track.

HEX 8E — Double density, Single sided, MFM recording, 1012 bytes per sector, 8 sectors per track.

HEX 8F — Double density, Double sided, MFM recording, 1012 bytes per sector, 8 sectors per track.

** = Also supports 16 sectors per track using Byte 5.

7.7.2 ASSIGN DISK PARAMETERS Command (HEX C2)

This command allows the host to specify disk drive parameters for the specified LUN. This allows the controller to communicate with a wide variety of drives from the same or different vendors. This command should be issued after every power-up sequence or reset for each LUN.

The associated Parameter List, including all characteristics of the drive connected, is sent to the controller during the Data Out phase of the command execution. There is no access to the drive during execution of this command.

ASSIGN DISK PARAMETERS Command Descriptor Block

	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	CONTROL BYTE							

The associated Parameter List, including all characteristics of the drive connected, is sent to the controller during the Data Out phase of the command execution.

Winchester Disk Drive Parameters

When bit 7 of byte 8 is set to zero, the following list allows connection of any, and different, ST506/412 compatible disk drives to the two Winchester ports of the controller. This applies to all models of the 5000 Series. When defining disk parameters, the following 10 bytes are passed during the Data Out phase of the command execution.

Winchester Disk Parameter List

	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 ADDRESS HI							
BYTE 6	CYLINDER ADDRESS 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. The minimum value of the step pulse is 4 microseconds.

BYTE 2 - STEP PERIOD: The length of time between the trailing and leading edges of step pulses. A zero value in this byte results in a 11 microsecond step period. A non-zero value specifies the time in 50 microsecond increments.

BYTE 3 - STEP MODE: This byte must be set to zero (buffered or normal mode). Any other value will result in an illegal parameter error (HEX 21).

BYTE 4 - NUMBER OF HEADS (-1): The value of this byte specifies the number of user heads (minus one) on the disk drive. The maximum value of this byte is 15 (0F HEX). Any value greater than 07 HEX causes the reduced write current (WSI) function to be disabled. Write precompensation is not affected.

BYTES 5-6 - NUMBER OF CYLINDERS (-1): These 2 bytes specify the maximum number of user cylinders (minus one) on the disk drive.

The maximum number of cylinders is 65K (FF, FF HEX).

BYTE 7 (and Bits 0-1 of Byte 8) - WSI/WRITE PRECOMPENSATION CYLINDER ADDRESS: This byte specifies the cylinder address where reduced write current and/or 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								PRECOMPENSATION
1	0	7	6	5	4	3	2	1	0	
0	0	0	0	0	0	0	0	0	0	No WSI No Precompensation
0	0	0	0	0	0	1	1	1	1	WSI Starts at 0F(HEX) Precomp. starts at 00F(HEX)
0	1	0	0	0	0	0	0	0	0	No WSI Precomp. starts at 100(HEX)
0	1	1	0	0	1	0	0	0	0	WSI Starts at 90(HEX) Precomp. Starts at 190(HEX)

BYTE 8: Bit 3 of Byte 8 specifies whether the device is a hard or soft sectored disk drive (0=Soft sectored; 1=Hard sectored).

Bits 4 and 5 of Byte 8: These bits specify whether the device is a Fixed, Removable, or Fixed/Removable Winchester Disk drive.

BYTE 8

Bit 5	Bit 4	
0	0	= Fixed Disk Drive
1	0	= Fixed/Removable disk Drive
1	1	= Removable Disk Drive

NOTE: A Fixed/Removable disk drive must have two LUNs assigned. One is for the Removable disk and the other is for the fixed disk (LUN 0 = Removable; LUN 1 = Fixed; or LUN 2 = Removable, LUN 3 = Fixed). This command must be issued to both LUNs.

BYTE 9 - SECTORS PER TRACK (-1): This byte specifies the number of sectors per track (minus one). A zero value is interpreted as 9, 17, 32, or 53 sectors per track, depending upon the position of the sector size jumpers, W3 and W4.

Flexible Disk Drive Parameters

When bit 7 of byte 8 of the Parameter List is set to one, the following Flexible Disk Parameter List allows connection of either 5 1/4" or 8" Flexible Disk drives to the port allocated by the 5200 and 5400 models. High-capacity,half-height 5 1/4" flexible disk drives with the 500 Kbit/sec transfer rate are supported as well by this list.

Flexible Disk Parameter List

	7	6	5	4	3	2	1	0
BYTE 1	STEP PULSE WIDTH							
BYTE 2	STEP PERIOD							
BYTE 3	MAXIMUM CYLINDER ADDRESS (-1)							
BYTE 4	HEAD SETTLING DELAY							
BYTE 5	HEAD SELECT DELAY							
BYTE 6	DRIVE SELECT DELAY							
BYTE 7	WRITE GATE DELAY							
BYTE 8	1	0	0	0	0	0	0	0
BYTE 9	FLOPPY TYPE/WRITE PRECOMP							
BYTE 10	START WRITE PRECOMP CYLINDER							

DEFINITION OF BYTES

BYTE 1 - STEP PULSE WIDTH: The step pulse width is not analyzed. A value of zero is recommended. The FDC 765 controls the step pulses. Typical values are 5 microseconds when using 500 KBit transfer rate, and 10 microseconds when using 250 KBit transfer rate.

BYTE 2 - STEP PERIOD: The time between two step pulses. The value of this byte is specified with bits 3, 2, 1, and 0 only. Since the FDC 765 controls these step pulses, the period changes depending on the drive data rate as follows:

- For a 500Kbit/sec data transfer rate, the value is in one (1) millisecond increments from one to sixteen milliseconds.

- For a 250Kbit/sec data transfer rate, the value is in two millisecond increments from two to thirty-two milliseconds.

In both cases, zero specifies the maximum step rate.

BYTE 3 - NUMBER OF CYLINDERS (- 1): The maximum number of cylinders minus one (- 1).

BYTE 4 - HEAD SETTLING DELAY: The delay required from the last step pulse to a valid read or write. The value of this byte specifies the delay in one (1) millisecond increments.

BYTE 5 - HEAD SELECT DELAY: The head select delay is not analyzed. A value of zero is recommended. (The head select delay is a function of the FDC 765.)

BYTE 6 - DRIVE SELECT DELAY: The drive select delay is not analyzed. A value of zero is recommended. (The drive select delay is a function of the FDC 765.)

BYTE 7 - WRITE GATE DELAY: The write gate delay is not analyzed. A value of zero is recommended. (The write gate delay is a function of the FDC 765.)

BYTE 8: This Byte is 10000000 to indicate Flexible Disks.

BYTE 9 - FLEXIBLE DISK TYPE: Specifies the type of Flexible disk.

Bit 7 = 0 for a 250K bit data rate drive (5 1/4" interface)

Bit 7 = 1 for a 500K bit data rate drive (8" interface)

Bit 6 = 0 means that Pin 16 (motor on) will be asserted.

Bit 6 = 1 means that Pin 16 (motor on) shall not be asserted. This bit shall be set to 1 when using high capacity Disk Drives (192 TPI) and their pre-formatted diskettes.

Bits 5 and 4 are used to to specify the number of step pulses per cylinder. Non-zero values allow a drive to read a diskette formatted on a drive with lower TPI. For example a value of Bit 5 = 0, and a Bit 4 = 1 will allow a 96 TPI drive to access tracks on a diskette from a 48 TPI drive.

Bit 5	Bit 4	Steps/Cyl	
0	0	1	(Normal Usage)
0	1	2	
1	1	4	

Bits 1 and 0 describe write precompensation values as follows:

250 KBits				500 KBits			
BIT 1	BIT 0			BIT 1	BIT 0		
0	0	=	0 NSEC	0	0	=	0 NSEC
1	0	=	125 NSEC	1	0	=	62.5 NSEC
0	1	=	250 NSEC	0	1	=	125 NSEC
1	1	=	375 NSEC	1	1	=	187.5 NSEC

BYTE 10 - STARTING WRITE PRECOMPENSATION CYLINDER: Write precompensation is applied to all cylinders greater than this value.

7.8 TYPE 7 COMMANDS

7.8.1 RAM DIAGNOSTIC Command (HEX E0)

This command performs a pattern test on the sector buffer.

RAM DIAGNOSTC Command Descriptor Block

	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 BYTE							

VALID ERROR CODES

Power Up Diagnostic error	(HEX 30)

7.8.2 WRITE ECC Command (HEX E1)

This command writes a "long" data field 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) more data bytes. These four bytes are written where the four ECC bytes normally reside. A subsequent READ command will treat these extra four bytes as ECC. This command is not valid for LUN's assigned to Flexible disk drives.

WRITE ECC Command Descriptor Block

	7	6	5	4	3	2	1	0
BYTE 1	1	1	1	0	0	0	0	1
BYTE 2	0	LUN			LOGICAL BLOCK ADDR 2 (MSB)			
BYTE 3	LOGICAL BLOCK ADDRESS 1							
BYTE 4	LOGICAL BLOCK ADDRESS 0 (LSB)							
BYTE 5	NOT USED							
BYTE 6	CONTROL BYTE							

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

128 BYTE SECTOR		256 BYTE SECTOR		512 BYTE SECTOR		1024 BYTE SECTOR	
0-127	6C	0-255	6C	0-511	6C	0-1023	6C
128	E8	256	3C	512	77	1024	7B
129	6F	257	FD	513	FB	1025	65
130	DF	258	1E	514	4C	1026	BE
131	82	259	B4	515	DC	1027	79

VALID ERROR CODES

No seek complete	(HEX 02)
Write fault	(HEX 03)
Drive not ready	(HEX 04)
Drive not selected	(HEX 05)
No track 0 found	(HEX 06)
Multiple drives selected	(HEX 07)
Cartridge changed	(HEX 09)
No record found	(HEX 14)
Seek error	(HEX 15)
Write protected	(HEX 17)
Bad track flag set	(HEX 19)
Unable to read alternate track data	(HEX 1C)
Illegal access to alternate track	(HEX 1E)

Illegal function for drive type	(HEX 22)
Volume overflow	(HEX 23)
Power Up Diagnostic error	(HEX 30)

7.8.3 READ IDENTIFIER Command (HEX E2)

On LUNs assigned as Winchester Disk Drives the ID field of the sector specified by the logical sector address is transferred to the host. Only one sector is processed. The command will return four data bytes during the Data In phase of the command execution. On LUNs assigned as Flexible Disk Drives the first ID field encountered is transferred. No seek is performed.

READ IDENTIFIER Command Descriptor Block

	7	6	5	4	3	2	1	0
BYTE 1	1	1	1	0	0	0	1	0
BYTE 2	0	LUN			LOGICAL BLOCK ADDR 2 (MSB)			
BYTE 3	LOGICAL BLOCK ADDRESS 1							
BYTE 4	LOGICAL BLOCK ADDRESS 0 (LSB)							
BYTE 5	NOT USED							
BYTE 6	CONTROL BYTE							

VALID ERROR CODES

No seek complete	(HEX 02)
Drive not ready	(HEX 04)
Drive not selected	(HEX 05)
No track 0 found	(HEX 06)
Multiple drives selected	(HEX 07)
No record found	(HEX 14)
Seek error	(HEX 15)
Unable to read alternate track data	(HEX 1C)
Power Up Diagnostic error	(HEX 30)

Data Byte Format

	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							

BYTE 3, HEAD/FLAGS bit on Winchester LUNs is as follows:

Bit	0	=	Head 1
	1	=	Head 2
	2	=	Head 4
	3	=	Head 8
	4	=	0
	5	=	Alternate track flag
	6	=	Bad track with Alternate assigned
	7	=	Bad track

7.8.4 READ DATA BUFFER Command (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 block size for 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.

READ DATA BUFFER Command Descriptor Block

	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 BYTE

VALID ERROR CODES

Power Up Diagnostic error	(30 HEX)

7.8.5 WRITE DATA BUFFER Command (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 block size for the specified LUN. The host can use this command preceding a READ BUFFER command to verify a READ/WRITE sequence without device participation.

WRITE DATA BUFFER Command Descriptor Block

	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 BYTE							

VALID ERROR CODES

Power Up Diagnostic error	(30 HEX)

SECTION 8

TAPE COMMAND SPECIFICATIONS

8.1 GENERAL

The OMTI 5300 and 5400 controllers support a QIC 02 Cartridge Tape drive interface, which is an intelligent device level interface to a Streaming Tape drive.

8.1.1 DRIVE TYPE

A streaming drive is a tape drive that is designed to maintain continuous tape motion without the requirement to start and stop within an interrecord gap. If the tape motion is interrupted for any reason, the drive must reposition the tape by moving far enough in the reverse direction to allow the tape to be brought up to speed in the forward direction before it reaches the point at which the preceding operation was terminated.

8.1.2 DATA BUS

Data and commands are transferred to and from the QIC 02 device on an eight-bit bidirectional data bus with an asynchronous handshake to eliminate rigorous timing constraints. The controller includes an internal 8K buffer to optimize streaming operations during BACKUP and RESTORE commands between disk and tape.

The recording of information on the tape is performed in the Sequential mode.

Accessing information on the tape may be performed either in Sequential or, when reading, in a Direct mode. The difference between the two modes is the positioning scheme. In the Sequential mode, data is transferred from the current tape position. In the Direct mode, the controller allows the user to specify the location on the tape from which the transfer of data will take place. See Read operations (8.5).

8.1.3 DATA INTEGRITY

The ability to enable or disable the tape drive bus parity is jumper selectable.

8.1.4 HOST/CONTROLLER/DRIVE COMMUNICATION

The tape drive can be commanded by the host, through a set of commands, to either rewind the cartridge to the BOT (beginning of tape), erase the cartridge, write data and file marks onto the tape, read data and/or file marks from the tape, verify the tape, backup data from a disk, or restore data onto the disk connected to the same controller. The host may request sense information from the controller/tape drive to obtain status.

8.1.5 MEDIA

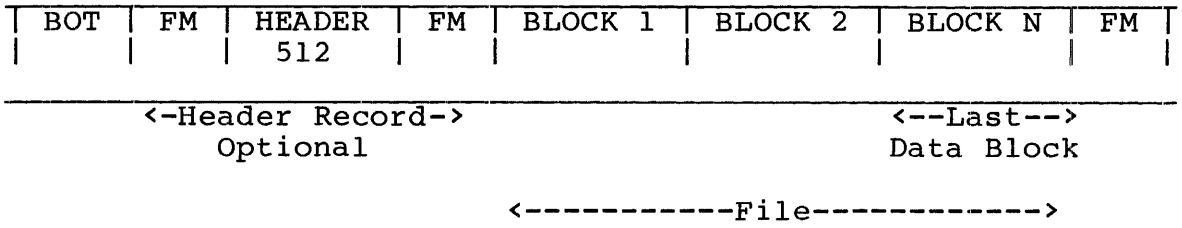
The tape media is an industry-standard one quarter inch (1/4") cartridge, recorded bi-directionally on serpentine tracks.

8.1.6 TAPE FORMAT

The minimum length of data accessible by the controller is a block. Blocks have a fixed length of 512 bytes. A group of blocks constitute a file. Each READ or WRITE command specifies the number of blocks to access. Files are separated by file marks.

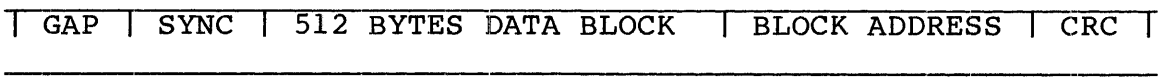
A header may optionally be written at the beginning of the tape to label a cartridge or provide for an Initial Program Load (IPL) block.

TAPE FORMAT



FM = File Mark

BLOCK FORMAT (QIC 24)



8.1.7 HEADER

The HEADER is an optional field that is used to identify and label cartridges. It is written to the first 512 byte block of the cartridge. The contents of this block are user difined. Issuing the WRITE HEADER command rewinds the tape to BOT, erases the entire tape, rewinds, then records the header. Therefore, any prewritten data on the cartridge is lost. A HEADER cannot be altered by a WRITE command. The controller allows only one header per cartridge.

A cartridge does not necessarily need a HEADER to be useable. The host software may implement the READ HEADER command to identify the information in a HEADER.

8.1.8 CONTROLLER BLOCK COUNT

Starting from BOT, if no header is recorded, or starting from the first block after the header, the controller will increment a counter for each block accessed in the forward direction. Blocks and File Marks are counted in the same fashion in this counter. This counting occurs either in Sequential or Direct modes. See READ OPERATIONS paragraph (Section 8.3.5). The counting also takes place with the SPACE command.

8.1.9 OPERATIONAL WARNINGS

- The BACKUP and RESTORE commands will report an "error 21" (invalid parameter), if the Disk sector size is 1024 bytes, and the Tape block count is odd.

- Write Protect Status: If a cartridge was write protected, and the user removes it, when the cartridge is replaced, two consecutive REQUEST SENSE, or READ SENSE commands are needed to get "no write protect" status reported in the sense bytes.

- File Mark encountered, unexpectedly, with the READ and RESTORE commands: Because the Tape Formatter may read more blocks from the Tape than the READ or RESTORE controller commands ask for, an exception may be generated from the Tape for a File Mark detected by the Tape Formatter in the block count limit requested. (Some Tape Formatters include a large buffer to minimize this problem.) This problem is more likely to occur with tape formatters containing a large buffer.

8.2 COMMAND SPECIFICATIONS

8.2.1 COMMAND PHASE

The command process for the Tape drive is similar to the command process for the Disk drives, except that some Tape commands require more bytes (10 or 12) to be transferred during the command phase.

In the tables of this section, all bits specified as "Reserved" should be set to zero.

LUN 3

The Logical Unit Number (LUN) specified in byte 2 of all exclusively Tape related commands is three (3), with bits 5 and 6 set to 1. All BACKUP and RESTORE commands imply the use of LUN 3.

6 BYTE COMMAND FORMAT (Sequential Mode)

	7	6	5	4	3	2	1	0
BYTE 1	COMMAND CODE							
BYTE 2	0	1	1	0	0	0	0	0
BYTE 3	BLOCK COUNT (MSB)							
BYTE 4	BLOCK COUNT							
BYTE 5	BLOCK COUNT (LSB)							
BYTE 6	CONTROL BYTE							

These commands offer up to 16 MBlocks per Command.

6 BYTE COMMAND FORMAT (Direct Mode)

	7	6	5	4	3	2	1	0
BYTE 1	COMMAND CODE							
BYTE 2	0	1	1	TAPE LOGICAL BLOCK ADDR (MSB)				
BYTE 3	TAPE LOGICAL BLOCK ADDRESS							
BYTE 4	TAPE LOGICAL BLOCK ADDRESS (LSB)							
BYTE 5	BLOCK COUNT							
BYTE 6	CONTROL BYTE							

The 6 byte READ commands (Direct Mode) are limited to transfer up to 256 Blocks, and limited to 21 bit addressing.

10 BYTE COMMAND FORMAT

	7	6	5	4	3	2	1	0
BYTE 1	COMMAND CODE							
BYTE 2	0	DISK LUN		DISK LOGICAL BLOCK ADDR (MSB				
BYTE 3	DISK LOGICAL BLOCK ADDRESS							
BYTE 4	DISK LOGICAL BLOCK ADDRESS (LSB)							
BYTE 5	ZERO VALUE							
BYTE 6	ZERO VALUE							
BYTE 7	TAPE BLOCK COUNT (MSB)							
BYTE 8	TAPE BLOCK COUNT							
BYTE 9	TAPE BLOCK COUNT (LSB)							
BYTE 10	CONTROL BYTE							

These commands offer a Block count of 3 bytes.

12 BYTE COMMAND FORMAT

	7	6	5	4	3	2	1	0
BYTE 1	COMMAND CODE							
BYTE 2	0	DISK LUN			DISK LOGICAL BLOCK ADDR (MSB			
BYTE 3	DISK LOGICAL BLOCK ADDRESS							
BYTE 4	DISK LOGICAL BLOCK ADDRESS (LSB)							
BYTE 5	ZERO VALUE							
BYTE 6	TAPE STARTING LOGICAL BLOCK ADDR (MSB)							
BYTE 7	TAPE STARTING LOGICAL BLOCK ADDRESS							
BYTE 8	TAPE STARTING LOGICAL BLOCK ADDR (LSB)							
BYTE 9	TAPE BLOCK COUNT (MSB)							
BYTE 10	TAPE BLOCK COUNT							
BYTE 11	TAPE BLOCK COUNT (LSB)							
BYTE 12	CONTROL BYTE							

These commands offer a Block count of 3 bytes. The Tape Block size is 512 bytes. The Disk Block size may be different. The value of the Disk Block size is selected by jumpers.

Control Byte

The Contol Byte is the last byte of all commands.

CONTROL BYTE FORMAT

	7	6	5	4	3	2	1	0
CONTROL BYTE	DR	DC	SR	0	0	0	0	LK

DR - Disable Retry: Bit 7, if set to one, will disable the controller automatic retries. This bit 7 is valid for those commands involving retries. This is only to be used for test or evaluation purposes.

DC - Disable Correction: Bit 6, if set to one, will disable the disk automatic error correction with the ECC algorithm. This is to be used only for disk media evaluation or test purposes.

SR - Sequential Record: Bit 5, if set to zero, a File Mark will be written when the block count of the command is exhausted or if an abnormal condition causing the ending status was encountered; if set to one, and if the command code is WRITE BLOCKS (4A), READ BLOCKS (4B), BACKUP (22), or RESTORE (23) then this flag can have two possible meanings:

- During a READ, the controller will start to read at the current tape position, therefore read the next block. This is called the Sequential Mode.

- During a WRITE, the controller will start to write at the current position, and a File Mark will not be written on the tape at completion of the WRITE or BACKUP command execution. This allows segmented Disk files to be backed up onto the Tape on a contiguous file without File Marks separating every segment of the file. When the last segment is transferred with the last command issued, the user should set bit 5 (SR) of the Control Byte to zero. This automatically records a File Mark.

LK - Link Command: Upon successful completion of the command, if this bit is set to one, the controller will enter the command phase and request command bytes for the next linked command to be executed. Linking commands avoids entering the Selection phase again, and keeps control of the bus to the same host/controller.

WARNING: It is recommended not to link commands such as REWIND, RETENTION, or ERASE (for which the SCSI Busy line is deasserted during Tape motion) to other commands. Doing so could result in Busy status error to the linked commands. This is due to the fact that the Tape drive is performing offline mechanical functions which cause it to be busy to the controller. This could cause the drive to be busy for up to several minutes.

8.2.2 STATUS PHASE

COMPLETION STATUS BYTE FORMAT

	7	6	5	4	3	2	1	0
CONTROL BYTE	0	LUN		0	0	0	CC	PE

CC - Check Condition
PE - Parity Error

Status is always sent to the host during the Status Phase, at the end of a command, in a single byte called "Completion Status Byte".

A value of zero in bits 0 (PE) and 1 (CC) indicates a successful command completion.

Any abnormal condition encountered during the command execution will cause command termination and ending status with the Check Condition (bit 1) set to one. Any Parity Error (PE, bit 0) encountered during the transfer of bytes from the host will cause command termination and ending status with the Parity error bit 0 set to one.

Bits 5 and 6 report the LUN address of the device originating the error condition or the LUN to which the command was issued to. For example, in a BACKUP command, the LUN specified is the disk address. If a disk error occurs, the disk LUN is reported in the Completion Status byte, if a Tape error occurs, the tape LUN (3) is reported.

If the Check Condition status (CC, bit 1) is set, the host should issue the REQUEST SENSE command to determine the nature of the condition.

NOTE: The status byte is not the last byte transferred by the controller. The Initiator should not generate the Interrupt for the command when receiving this byte but instead should wait for the Command Complete message (00) issued in the next Message In phase.

8.2.3 MESSAGE IN PHASE

Every command ends with the Message In phase. The 5000 series controllers send a single byte to the host during this phase, with the value of zero, indicating "Command Complete".

8.2.4 TAPE COMMAND SET SUMMARY

COMMAND TYPE	CODE (HEX)	COMMAND BYTES	DATA LENGTH
TEST UNIT READY	00	6	0
REWIND	01 & 4F	6	0
RETENTION	02 & 44	6	0
REQUEST SENSE	03	6	12 bytes
READ	08	6	up to 16 M blocks
WRITE	0A	6	up to 16 M blocks
WRITE FILE MARK	10 & 4C	6	0
SPACE FORWARD	11 & 4D	6	0
VERIFY	13 & 45	6	0
ERASE	19 & 4E	6	0
BACKUP	22	10	up to 16 M blocks
RESTORE	23	10	up to 16 M blocks
BACKUP WITH HEADER	24	10	up to 16 M blocks
RESTORE CONTINUE	26	12	up to 16 M blocks
READ SENSE	46	6	8 bytes
WRITE HEADER	48	6	512 bytes
READ HEADER	49	6	512 bytes
WRITE BLOCKS	4A	6	up to 256 blocks
READ BLOCKS	4B	6	up to 256 blocks

8.3 COMMAND SET

8.3.1 TEST UNIT READY Command (00)

This command returns a zero status during the Status phase of the command execution to indicate that the unit is on line and ready.

TEST UNIT READY Command Descriptor Block

	7	6	5	4	3	2	1	0
BYTE 1	0	0	0	0	0	0	0	0
BYTE 2	0	1	1	0	0	0	0	0
BYTE 3	ZERO VALUE							
BYTE 4	ZERO VALUE							
BYTE 5	ZERO VALUE							
BYTE 6	0	0	0	0	0	0	0	LK

8.3.2 REWIND Command (01) and (4F)

The unit is rewound to the beginning of tape (BOT). Status is returned as soon as the tape motion is initiated. Overlap operations with the disk drives connected to the other ports is allowed during the tape motion. If a REWIND command is issued after a WRITE command and a File Mark has not been written, the controller will automatically write a File Mark before initiating the rewind. The code (4F) provides software compatibility to an earlier controller model.

REWIND Command Descriptor Block

	7	6	5	4	3	2	1	0
BYTE 1	0	0	0	0	0	0	0	1
BYTE 2	0	1	1	0	0	0	0	0
BYTE 3	ZERO VALUE							
BYTE 4	ZERO VALUE							
BYTE 5	ZERO VALUE							
BYTE 6	0	0	0	0	0	0	0	LK

Valid Errors: - Unit Not Ready

8.3.3 RETENTION Command (02) and (44)

The unit rewinds to the beginning of tape (BOT), if not already positioned at the load point, then moves from the BOT to the end of tape (EOT) without transferring any data or altering the contents of the cartridge, then rewinds to the BOT. Status for the command is returned as soon as the tape motion is initiated, allowing host/controller to overlap operations with the disk drives connected to the other controller ports. The code (44) is provided for software compatibility with an earlier controller model.

RETENTION Command Descriptor Block

	7	6	5	4	3	2	1	0
BYTE 1	0	0	0	0	0	0	1	0
BYTE 2	0	1	1	0	0	0	0	0
BYTE 3	ZERO VALUE							
BYTE 4	ZERO VALUE							
BYTE 5	ZERO VALUE							
BYTE 6	0	0	0	0	0	0	0	LK

Valid Errors: - Unit Not Ready

8.3.4 REQUEST SENSE Command (03)

The sense information to be returned during the Data In phase of this command execution is valid for the Check Condition Status just presented to the host. Sense data will be cleared upon reception of any subsequent command issued to the LUN or by a Reset condition.

The host must be able to receive a minimum of 4 sense bytes and a maximum of 12 bytes. Byte 5 of the CDB will specify the number of bytes that the host has allocated for returned sense. If byte 5 is less than or equal to four, the controller will return four bytes of sense data, otherwise it will return the required number of bytes between four and twelve, with the following condition: up to 4 bytes are returned for Disks; up to 12 bytes are returned for Tape. If more than 12 bytes are requested in byte 5, the Data phase will stop after the 12th byte.

REQUEST SENSE Command Descriptor Block

	7	6	5	4	3	2	1	0
BYTE 1	0	0	0	0	0	0	1	1
BYTE 2	0	1	1	0	0	0	0	0
BYTE 3	ZERO VALUE							
BYTE 4	ZERO VALUE							
BYTE 5	NUMBER OF SENSE BYTES ALLOCATED (MAX. 12)							
BYTE 6	0	0	0	0	0	0	0	LK

SENSE BYTES: The following bytes are returned to the host during the Data In phase of the command execution.

SENSE BYTE FORMAT (Sequential Read Mode)

	7	6	5	4	3	2	1	0
BYTE 1	ERROR CODE							
BYTE 2	0	LUN		BLOCK COUNT ACCESSED (MSB)				
BYTE 3	BLOCK COUNT ACCESSED							
BYTE 4	BLOCK COUNT ACCESSED (LSB)							
BYTE 5	TAPE SENSE BYTE 0							
BYTE 6	TAPE SENSE BYTE 1							
BYTE 7	TAPE SENSE BYTE 2							
BYTE 8	TAPE SENSE BYTE 3							
BYTE 9	TAPE SENSE BYTE 4							
BYTE 10	TAPE SENSE BYTE 5							
BYTE 11	TAPE SENSE BYTE 6							
BYTE 12	TAPE SENSE BYTE 7							

SENSE BYTE FORMAT (Direct Read Mode)

	7	6	5	4	3	2	1	0
BYTE 1	ERROR CODE							
BYTE 2	0	LUN			LOGICAL BLOCK ADDRESS (MSB)			
BYTE 3	LOGICAL BLOCK ADDRESS							
BYTE 4	LOGICAL BLOCK ADDRESS (LSB)							
BYTE 5	TAPE SENSE BYTE 0							
BYTE 6	TAPE SENSE BYTE 1							
BYTE 7	TAPE SENSE BYTE 2							
BYTE 8	TAPE SENSE BYTE 3							
BYTE 9	TAPE SENSE BYTE 4							
BYTE 10	TAPE SENSE BYTE 5							
BYTE 11	TAPE SENSE BYTE 6							
BYTE 12	TAPE SENSE BYTE 7							

CONTROLLER SENSE BYTE 1: ERROR CODE

BITS	7	6	5	4	3	2	1	0
CONTROL BYTE	AV	0	TYPE		CODE			

AV: Block Address Valid

Bits 5	4	Meaning
0	0	Drive Errors
0	1	Data Errors
1	0	Command Errors
1	1	Diagnostic Errors

CONTROLLER SENSE BYTE 1 - ERROR CODE - TYPE 0:

MEANING	HEX
NO ERROR	00
DRIVE NOT READY	04
DRIVE NOT SELECTED	05
TAPE EXCEPTION	0A

CONTROLLER SENSE BYTE 1 - DATA ERRORS - TYPE 1

MEANING	HEX
WRITE PROTECTED	17 & 97
TAPE DRIVE FAILURE	1F & 9F

CONTROLLER SENSE BYTE 1 - COMMAND ERRORS - TYPE 2

MEANING	HEX
INVALID COMMAND	20
ILLEGAL PARAMETERS	21
ILLEGAL FUNCTION FOR DRIVE TYPE	22

CONTROLLER SENSE BYTE 1 - DIAGNOSTIC ERRORS - TYPE 3

MEANING	HEX
POWER UP DIAGNOSTIC ERROR	30
FDC 765 ERROR (5400 Only)	31

SENSE BYTE 2 (Bits 6 and 5): LUN of the drive.

SENSE BYTES 2 TO 4:

- Sequential Read Mode: These bytes report the number of Blocks accessed during the command. In the case of a READ command requesting access to more blocks than recorded, the difference between the Block Count of the command and Sense bytes 2 through 4, computed by the host software, will provide the remaining blocks.

- Direct Read Mode: These bytes report the address of the last Block accessed during the command.

- SPACE command: These bytes report the number of Blocks spaced with the Block Mode or the number of File Marks spaced with the File Mark Mode.

TAPE SENSE BYTES

The next 6 Bytes come from the Tape Formatter, as specified in the QIC 02 specifications. The last two Tape Sense Bytes are generated by the controller. The Exception condition bit 7 of bytes 1,2,6, and 7 are set to one only if this byte contains an error condition. More than one byte may have bit 7 set to one. When the Tape is On-Line or rewinding, and the REQUEST SENSE or READ SENSE command is issued, only bytes 6 and 7 of the Tape Sense bytes reported are valid, and the other six Tape Sense bytes are meaningless.

TAPE SENSE BYTE 0

BIT 7 Exception condition (at least 1 of bits 0-6 is on)
BIT 6 Cartridge not installed
BIT 5 Unselected Tape drive
BIT 4 Write Protected cartridge
BIT 3 End of media (EOT)
BIT 2 Unrecoverable data error
BIT 1 Bad block not located
BIT 0 File Mark detected

TAPE SENSE BYTE 1

BIT 7 Exception condition (at least 1 of bits 0-6 is on)
BIT 6 Illegal QIC 02 command
BIT 5 No data detected
BIT 4 Reserved
BIT 3 Beginning of media (BOT)
BIT 2 Reserved
BIT 1 Reserved
BIT 0 Power On Reset occured

TAPE SENSE BYTES 2 and 3

- The number of blocks rewritten by the controller recovery procedure, for WRITE and VERIFY commands.

- The number of READ retries exercised by the controller recovery procedure.

The most significant byte is 2.

TAPE SENSE BYTES 4 and 5 (Underflow Counter)

- These bytes indicate the the number of times streaming operations were interrupted due to host failure to maintain minimum troughput rate. The most significant byte is byte 4.

Note: If a permanent tape error occurs during a RESTORE command, the logical sector address points to the sector in error + 1.

The following two bytes are prepared by the controller itself, not by the Tape Formatter.

TAPE SENSE BYTE 6

BIT 7 Exception Condition (at least 1 of bits 0-6 is on)
BIT 6 DMA time out during handshake on the QIC 02 bus
BIT 5 Reserved
BIT 4 No header found (only with READ HEADER command)
BIT 3 Drive disconnected
BIT 2 Reserved
BIT 1 Reserved
BIT 0 Reserved

TAPE SENSE BYTE 7

BIT 7 Reserved (at least 1 of bits 0-6 is on)
BIT 6 Reserved
BIT 5 Reserved
BIT 4 Rewind in progress
BIT 3 End of data recorded on the tape
BIT 2 Reserved
BIT 1 See table below
BIT 0 See table below

Bits 1	0	Meaning
0	0	Off Line
0	1	Read operation in progress
1	0	Illegal
1	1	Write operation in progress

8.3.5 READ OPERATIONS

The Controller offers two methods to read data from the Tape. The user may use either:

- the READ command code (08) in the Sequential Mode, or
- the READ BLOCK(S) command code (4B) in the Direct Mode.

Comparison

- The READ command (08) reads blocks of data starting at the current tape position, that is, the next block of the unit. The media has to be previously positioned at the starting block prior to issuing the READ command. The positioning can be achieved with the SPACE command.

- **The READ BLOCK(S) command** (4B) accesses the blocks of data with an implied tape search to a specified starting logical block address, similar to a disk command with an implied seek. The controller counts each block and allocates a logical block address from BOT to all blocks accessed. Therefore when receiving the READ BLOCK(S) (4B) command, in which the user specifies the logical block address of the starting block, the controller determines if a rewind or forward motion is necessary to reach the first block. This approach allows access to the data faster than if the tape had to be rewound first, then spaced forward, until the starting block is reached. The host software is to keep track of the starting block address of the files such as the disk directories usually do. Specific Block(s) of data inside a file may be accessed in a Direct Mode, but cannot be accessed in a Sequential Mode.

8.3.6 READ Command (08) (Sequential Mode only)

The READ command transfers the specified Block Count to the host, starting with the next block of the unit. Blocks are transfered unitl either the Block count is exhausted, or a File Mark is encountered, or the End of Tape (EOT) is encountered. The last two conditions create an Exception condition, and the Block Count read is available in the Sense Bytes. Up to 16 Megablocks can be transfered by a single command.

READ Command Descriptor Block

	7	6	5	4	3	2	1	0
BYTE 1	0	0	0	0	1	0	0	0
BYTE 2	0	1	1	0	0	0	0	0
BYTE 3	BLOCK COUNT (MSB)							
BYTE 4	BLOCK COUNT							
BYTE 5	BLOCK COUNT (LSB)							
BYTE 6	DR	DC	0	0	0	0	0	LK

8.3.7 WRITE Command (0A)

The WRITE command transfers the specified number of blocks from the host, starting at the current position, that is, the next block of the unit. The operation terminates when the number of blocks to be transferred is exhausted, or when the Tape Formatter recovery procedure of unsuccessful retries of rewrite has been exhausted, or when the end of the media (EOT) is encountered. The last two conditions create an exception condition, and the Block Count written will be available in the Sense Bytes.

WRITE Command Descriptor Block

	7	6	5	4	3	2	1	0
BYTE 1	0	0	0	0	1	0	1	0
BYTE 2	0	1	1	0	0	0	0	0
BYTE 3	BLOCK COUNT (MSB)							
BYTE 4	BLOCK COUNT							
BYTE 5	BLOCK COUNT (LSB)							
BYTE 6	DR	DC	0	0	0	0	0	LK

8.3.8 WRITE FILE MARK(S) Command (10) and (4C)

This command causes the specified number of File Marks to be written onto the cartridge. A zero value in byte 5 indicates that no File Mark is to be written. File Marks can be searched by SPACE FORWARD commands. The code (4C) provides software compatibility to an earlier controller model.

Note that if the Control Byte SR bit 5 had been set to zero in the previous WRITE command, a File Mark was written when the Block Count was exhausted. Therefore, if the host software issues a WRITE FILE MARK command with a File Mark count of one, two consecutive File Marks will be recorded onto the cartridge.

WRITE FILE MARK(S) Command Descriptor Block

	7	6	5	4	3	2	1	0
BYTE 1	0	0	0	1	0	0	0	0
BYTE 2	0	1	1	0	0	0	0	0
BYTE 3	FILE MARK COUNT (MSB)							
BYTE 4	FILE MARK COUNT							
BYTE 5	FILE MARK COUNT (LSB)							
BYTE 6	DR	DC	0	0	0	0	0	LK

8.3.9 SPACE FORWARD Command (11) and (4D)

This command covers three positioning modes. It moves the tape forward:

- over the subsequent data Block(s), (Block Mode),
- over the subsequent File Mark(s), (File Mark Mode), or
- to the physical end of the data (Physical End of data Mode).

The mode must be specified in the byte 2 of the command. The number of Blocks or File Marks to space is specified in byte 3 to 5. If the value of these bytes is zero, no tape motion will be initiated. The code (4D) provides software compatibility to an earlier controller model.

Block Mode: Up to three bytes of Block Count may be spaced. The controller will not skip more blocks after reaching a File Mark. Reaching a File Mark creates an Exception condition. The media will remain positioned after the File Mark. The sense bytes 2 to 4 will specify the number of blocks spaced, if less than the command Block Count. The code (4D) provides software compatibility to an earlier controller model.

NOTE: The controller remains Busy while executing the spacing, in all three modes, except under one condition. With the File Mark Mode set, if the bit 7 (SP) of byte 6 is set to one, the controller will release the Busy signal of the SCSI bus right after receiving the command. The Tape will move and search for a File Mark. Other commands may be issued to the Disk Drives connected to the controller. Bytes 3, 4, and 5 are not analyzed during this File Mark Mode.

File Mark Mode: Up to three bytes of File Mark Count may be spaced. The media will remain positioned after the last File Mark spaced, or at the End of Tape, if reached. If the end of media is encountered, an Exception condition is created, and the Sense bytes 2 to 4 indicate the number of File Mark(s) spaced.

Physical End of data Mode: The controller will move the tape forward, toward the end of media, until no more data is recorded (EOD). The tape will then remain positioned after the last block or File Mark recorded. Writing, or Backing up new data is then allowed from this location. The Tape Sense Bytes report the Physical End of Data. The controller will not analyse bytes 3 to 5 in this mode.

SPACE FORWARD Command Descriptor Block

	7	6	5	4	3	2	1	0
BYTE 1	0	0	0	1	0	0	0	1
BYTE 2	0	1	1	0	0	0	CODE	
BYTE 3	BLOCK(s) or FILE MARK(s) COUNT (MSB)							
BYTE 4	BLOCK(s) or FILE MARK(s) COUNT							
BYTE 5	BLOCK(s) or FILE MARK(s) COUNT (LSB)							
BYTE 6	SP	0	0	0	0	0	0	LK

CODE

Bits 1	Bits 0	Meaning
0	0	Block Mode
0	1	File Mark Mode
1	1	Physical End of Data Mode

8.3.10 VERIFY Command (13) or (45)

This command verifies the entire media, from the beginning of tape (BOT) to the end of tape (EOT). The pattern (E5) is written. The Tape Formatter performs a CRC check on every block. When reaching the EOT, the tape rewinds. The media will be erased, from BOT to EOT. Finally, the tape is rewound. The user may then issue the REQUEST SENSE command, to obtain the number of blocks rewritten during the Verify process , and is available in the Tape Sense bytes.

The code (45) provides software compatibility with an earlier controller model.

If the read after write drive function detects a bad block, rewrite will occur. If the Tape Formatter exhausts its rewrite count, and the procedure is still unsuccessful, the process stops, and an Exception condition is created.

VERIFY Command Descriptor Block

	7	6	5	4	3	2	1	0
BYTE 1	0	0	0	1	0	0	1	1
BYTE 2	0	1	1	0	0	0	0	0
BYTE 3	ZERO VALUE							
BYTE 4	ZERO VALUE							
BYTE 5	ZERO VALUE							
BYTE 6	DR	DC	0	0	0	0	0	LK

8.3.11 ERASE Command (19) and (4E)

This command erases the entire media, from BOT to EOT, then rewinds the tape. The code (4E) provides software compatibility to an earlier controller model.

ERASE Command Descriptor Block

	7	6	5	4	3	2	1	0
BYTE 1	0	0	0	1	1	0	0	1
BYTE 2	0	1	1	0	0	0	0	0
BYTE 3	ZERO VALUE							
BYTE 4	ZERO VALUE							
BYTE 5	ZERO VALUE							
BYTE 6	0	0	0	0	0	0	0	LK

8.3.12 BACKUP Command (22)

This command will backup data from the Disk Drive, as specified by the DISK LUN, to the tape drive in a streaming fashion, and for the specified number of blocks.

Disk:

The read operation from the disk starts at the specified logical disk block address and continues for the specified number of blocks. A volume overflow will stop the operation. Only valid data is backed up from the disk. The controller activates the disk drive's automatic handling of media defects, including retries (if not disabled), ECC correction (if not disabled), and alternate track accessing.

Tape:

The data is written starting at the current Tape position, that is, the next block. A volume overflow will stop the operation. If the tape is positioned at BOT, and if a header is recorded, the first block will be written after the header and its File Mark.

Whenever streaming cannot be maintained (i.e., because the disk had to access an alternate track, the Tape Formatter will move the tape in the reverse direction, and stop. When the disk data buffer allows streaming again, the tape will move forward, come up to proper speed, and will continue recording. If bit 5 SR of the Control Byte is set to zero, when the block count is exhausted, a File Mark is written at the current tape position.

If this bit is set to one, no File Mark is written, and the tape remains at its current position.

The Tape Block Size is 512 bytes. The Disk Block Size may be different, and have its value selected by jumper.

BACKUP Command Descriptor Block

	7	6	5	4	3	2	1	0
BYTE 1	0	0	1	0	0	0	1	0
BYTE 2	0	DISK LUN			DISK LOGICAL BLOCK ADDR (MSB)			
BYTE 3	DISK LOGICAL BLOCK ADDRESS							
BYTE 4	DISK LOGICAL BLOCK ADDRESS (LSB)							
BYTE 5	ZERO VALUE							
BYTE 6	ZERO VALUE							
BYTE 7	TAPE BLOCK COUNT (MSB)							
BYTE 8	TAPE BLOCK COUNT							
BYTE 9	TAPE BLOCK COUNT (LSB)							
BYTE 10	DR	DC	SR	0	0	0	0	LK

8.3.13 RESTORE Command (23)

This command will restore data from the Tape drive to the Disk drive, specified by the DISK LUN, in a streaming fashion, and for the specified number of blocks.

Disk:

The write operation to the Disk starts at the specified logical disk block address, for a specified number of blocks. A volume overflow will stop the operation. The controller activates the disk drive's automatic handling of media defects, including retries (if not disabled), and alternate track addressing.

Tape:

The data is read starting at the current Tape location, that is, the next block. The access mode to the data is Sequential only. A volume overflow will stop the operation. If the tape is positioned at BOT, and if a header is recorded, the first block will be read after the header and its file mark.

Whenever streaming cannot be maintained (i.e., because the disk had to access an alternate track), the Tape Formatter stops the tape, moves the tape in the reverse direction, and stops. When the disk data buffer is available again for streaming, the tape will move forward, come up to proper speed, and will continue reading.

The Tape Block Size is 512 bytes. The Disk Block Size may be different, and have its value selected by jumper.

RESTORE Command Descriptor Block

	7	6	5	4	3	2	1	0
BYTE 1	0	0	1	0	0	0	1	1
BYTE 2	0	DISK LUN			DISK LOGICAL BLOCK ADDR (MSB)			
BYTE 3	DISK LOGICAL BLOCK ADDRESS							
BYTE 4	DISK LOGICAL BLOCK ADDRESS (LSB)							
BYTE 5	ZERO VALUE							
BYTE 6	ZERO VALUE							
BYTE 7	TAPE BLOCK COUNT (MSB)							
BYTE 8	TAPE BLOCK COUNT							
BYTE 9	TAPE BLOCK COUNT (LSB)							
BYTE 10	DR	DC	0	0	0	0	0	LK

8.3.14 BACKUP WITH HEADER Command (24)

This command is a combination of WRITE HEADER and BACKUP commands. The tape is first rewound to BOT, then erased from BOT to EOT, then rewound. The header is then recorded with its File Marks similar to the WRITE HEADER command. The BACKUP operation takes place last, in the same fashion as in the BACKUP command.

BACKUP WITH HEADER Command Descriptor Block

	7	6	5	4	3	2	1	0
BYTE 1	0	0	1	0	0	1	0	0
BYTE 2	0	DISK LUN			DISK LOGICAL BLOCK ADDR (MSB)			
BYTE 3	DISK LOGICAL BLOCK ADDRESS							
BYTE 4	DISK LOGICAL BLOCK ADDRESS (LSB)							
BYTE 5	ZERO VALUE							
BYTE 6	ZERO VALUE							
BYTE 7	TAPE BLOCK COUNT (MSB)							
BYTE 8	TAPE BLOCK COUNT							
BYTE 9	TAPE BLOCK COUNT (LSB)							
BYTE 10	DR	DC	SR	0	0	0	0	LK

8.3.15 RESTORE CONTINUE Command (26)

This command will restore data from the Tape drive to the Disk drive, as specified by the DISK LUN, in a streaming fashion, and for the specified number of blocks.

Rewind takes place first. Then the controller moves the tape to the Tape starting Logical Block address, counting blocks in the process.

This command differs from the RESTORE command in the way that the data is read from Tape starting at the Tape Logical Block Address specified in the command, instead of starting at the current tape position. The operation of the command is similar to the RESTORE command operation as far as Disk functions and error reports are concerned.

RESTORE CONTINUE Command Descriptor Block

	7	6	5	4	3	2	1	0
BYTE 1	0	0	1	0	0	1	1	0
BYTE 2	0	DISK LUN			DISK LOGICAL BLOCK ADDR (MSB)			
BYTE 3	DISK LOGICAL BLOCK ADDRESS							
BYTE 4	DISK LOGICAL BLOCK ADDRESS (LSB)							
BYTE 5	ZERO VALUE							
BYTE 6	TAPE STARTING LOGICAL BLOCK ADDRESS (MSB)							
BYTE 7	TAPE STARTING LOGICAL BLOCK ADDRESS							
BYTE 8	TAPE STARTING LOGICAL BLOCK ADDRESS (LSB)							
BYTE 9	TAPE BLOCK COUNT (MSB)							
BYTE 10	TAPE BLOCK COUNT							
BYTE 11	TAPE BLOCK COUNT (LSB)							
BYTE 12	DR	DC	0	0	0	0	0	LK

Application: - Assuming that a Disk error occured during a RESTORE command. The operation stops. The Sense bytes report the Disk logical block address. With this, the host software computes, depending on the Disk block size, the Tape Block Count transferred until the Disk error occured. Then the host software determines at which Tape Starting Logical Block Address, and starting Disk Logical Block address, and for what remaining Tape Block count should the transfer of data continue. This information is provided to the RESTORE CONTINUE command.

8.3.16 READ SENSE Command (46)

This command returns to the host 8 Tape Sense bytes. The function of this command is similar to the REQUEST SENSE command, but it reports less sense information. The Opcode and format of this command is compatible with an earlier controller model.

READ SENSE Command Descriptor Block

	7	6	5	4	3	2	1	0
BYTE 1	0	1	0	0	1	1	0	0
BYTE 2	0	1	1	0	0	0	0	0
BYTE 3	ZERO VALUE							
BYTE 4	ZERO VALUE							
BYTE 5	ZERO VALUE							
BYTE 6	0	0	0	0	0	0	0	LK

See the REQUEST SENSE command for the format of the 8 Tape Sense Bytes (0 to 7) returned by the READ SENSE command.

8.3.17 WRITE HEADER Command (48)

This command writes an user defined block of data to the first block of the tape. Rewind takes place first. The tape is then erased from BOT to EOT, then rewound. The 512 bytes/block is finally written between two File Marks at the Beginning of Tape (BOT). At the completion of this command, the tape is positioned after the second File Mark. The contents of this user defined block cannot be altered by a WRITE command. This block is intended to provide cartride labelling.

WRITE HEADER Command Descriptor Block

	7	6	5	4	3	2	1	0
BYTE 1	0	1	0	0	1	0	0	0
BYTE 2	0	1	1	0	0	0	0	0
BYTE 3	ZERO VALUE							
BYTE 4	ZERO VALUE							
BYTE 5	ZERO VALUE							
BYTE 6	DR	DC	0	0	0	0	0	LK

8.3.18 READ HEADER Command (49)

This command reads an user defined block located at the Beginning of the Tape (BOT) that was written by the WRITE HEADER command. This block is intended to provide cartridge labelling. If no header is recorded, an Exception condition occurs. The Tape Sense bytes report a "No header found" error; then the tape is rewound.

At the completion of the command, if the header is found, the media is positioned after the second File Mark located behind the header block.

READ HEADER Command Descriptor Block

	7	6	5	4	3	2	1	0
BYTE 1	0	1	0	0	1	1	0	1
BYTE 2	0	1	1	0	0	0	0	0
BYTE 3	ZERO VALUE							
BYTE 4	ZERO VALUE							
BYTE 5	ZERO VALUE							
BYTE 6	DR	DC	0	0	0	0	0	LK

8.3.19 WRITE BLOCK(S) Command (4A)

The WRITE BLOCK(S) command transfers a specified number of blocks from the host, starting from End of Data (EOD). The controller will search for EOD, if not positioned. The operation terminates when the number of blocks to transfer is exhausted, or when the Tape Formatter recovery procedure of unsuccessful retries of rewrite has been exhausted, or when the end of the media (EOT) is encountered. The last two conditions cause an Exception condition to occur, and the Block Count written will be available in the Sense Bytes. Up to 256 blocks may be recorded. Upon completion of the WRITE BLOCK(S) command the media is positioned: - after the last block written, if the SR bit 5 is set to one, - or after the File Mark written specifying the end of the file. Writing the File Mark automatically, when the Block Count is exhausted, is dependent on bit 5 (SR), in the Control Byte being set to zero.

The code (4A) provides software compatibility to an earlier controller model.

WRITE BLOCK(S) Command Descriptor Block

	7	6	5	4	3	2	1	0
BYTE 1	0	1	0	0	1	0	1	0
BYTE 2	0	1	1	0	0	0	0	0
BYTE 3	ZERO VALUE							
BYTE 4	ZERO VALUE							
BYTE 5	BLOCK COUNT							
BYTE 6	DR	DC	SR	0	0	0	0	LK

8.3.20 READ BLOCK(S) Command (4B)

This command accesses data on the tape in the direct mode and transfers the specified Block Count to the host by

- starting at the specified Tape Logical Block address, if bit 5 (SR) of the Control Byte is set to zero, or
- starting at the current tape position, that is at the next

block, if bit 5 (SR) of the Control Byte is set to one. In the last case, bytes 2 to 4 are not analyzed.

Blocks are transferred until the block count is exhausted, a File Mark is encountered, or End of Tape (EOT) is encountered.

Up to 256 Blocks of data can be accessed. If the block count is not exhausted, an Exception condition occurs, and the Block Count read is available in the Sense bytes.

The code (4B) provides software compatibility to an earlier controller model.

READ BLOCK(S) Command Descriptor Block

	7	6	5	4	3	2	1	0
BYTE 1	0	1	0	0	1	0	1	1
BYTE 2	0	1	1	TAPE LOGICAL BLOCK ADDR (MSB)				
BYTE 3	TAPE LOGICAL BLOCK ADDRESS							
BYTE 4	TAPE LOGICAL BLOCK ADDRESS (LSB)							
BYTE 5	BLOCK CLOUNT							
BYTE 6	DR	DC	SR	0	0	0	0	LK

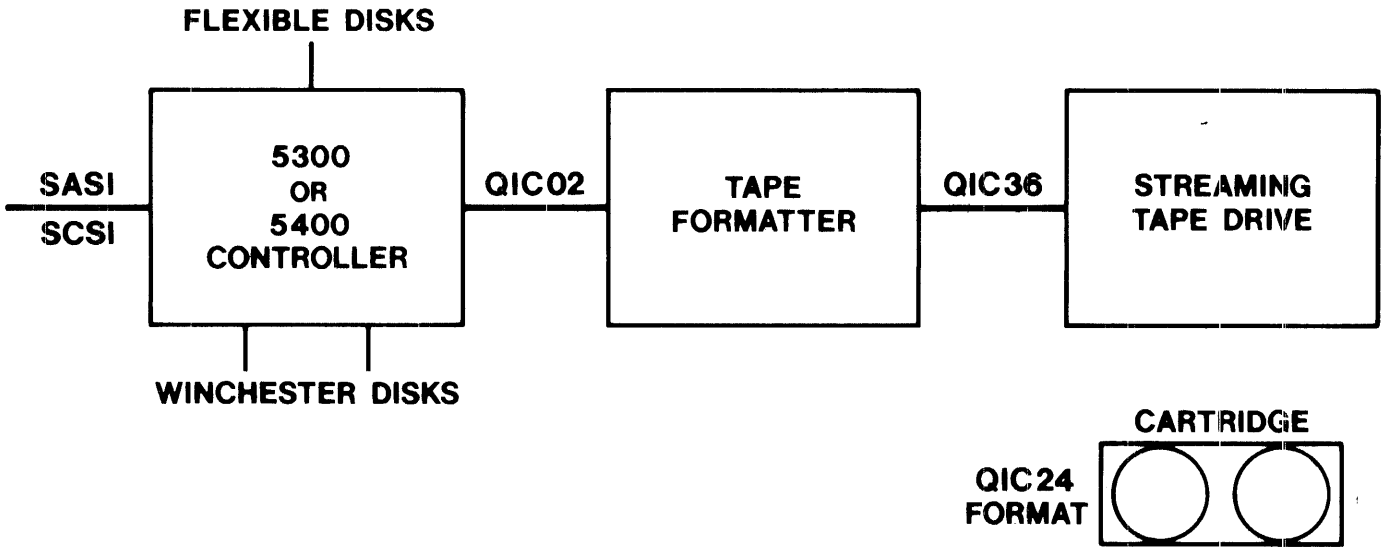


Figure 8.1 Tape Drive Configuration