



**DATA TECHNOLOGY**

A DIVISION OF QUME CORPORATION

**500DB SERIES INTELLIGENT CONTROLLERS**

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**TAPE INTERFACE AND COMMANDS SPECIFICATION**

## SECTION 1

### 1.0 INTRODUCTION

#### 1.1 Scope of Guide

This guide, for Data Technology Corporation's 500DB Series Disk Drive Controllers, provides:

- Equipment Information and Specifications
- Interface and Configuration Information
- Command and Testing Instructions
- Maintenance and Troubleshooting Hints
- Differences between 500B Series and 500DB Series

This guide is intended to satisfy the information requirements of OEM Engineers; Engineering and Production Technicians; Personal Computer Enthusiasts; and others with a need to know about these disk Controllers.

## 1.2 Overview of Equipment

The DTC-500DB Series are high performance microprocessor-based controllers with on-board Data Separataor logic. The DTC-500DB Series Controllers are designed to control 5.25 inch Winchester disk drives and combination Winchester/flexible disk/quarter-inch streaming tape drives. The DTC-500DB Series consist of a single printed circuit board, 5.75 inches by 8.00 inches for 5X0X. 5.75 x 7.85 for 510X.

Commands to the controller are issued over a bi-directional bus connected to the host computer via a host adapter. The data generator/"serdes" logic serializes bytes and converts to MFM data, and deserializes MFM data into 8-bit bytes.

Due to the microprogrammed approach utilized in the controller, extensive diagnostic capabilities are implemented. This methodology increases fault isolation efficiency and reduces system down time. Error detection and correction occurs via a powerful "computer generated" 32 bit-ECC polynomial.

The DTC-510DB Controller is designed to control two industry standard ST506/406 or compatible 5.25 inch Winchester disk drives.

The DTC-520DB Controller is designed to control a maximum of four disk drives. It supports up to two ST506/406 or compatible 5.25 inch Winchester disk drives plus two industry standard SA460, or equivalent, (48 or 96 tpi) floppy disk drives.

The DTC-530DB Controller is designed to control up to two ST506 drives or equivalent and one QIC-02 streaming tape drive.

The DTC-540DB Controller is designed to control a maximum of four drives of any combination of up to two ST506 drives or equivalent, or up to four 5.25 inch floppy disk drives, and/or one QIC-02 streaming tape drive.

The interface to the Host Computer is via the industry standard SASI bus and is easily accomplished by a standard DTC Host Adapter. DTC is a major supplier of SASI compatible Host Adapters for most computer systems.

### 1.3 Controller Features

The capabilities supplied as standard with the DTC-500DB Series are listed below:

#### **AUTOMATIC SEEK AND VERIFY**

A seek command is implied in every data transfer command (READ, WRITE, CHECK TRACK FORMAT, etc.). If the heads are not positioned over the correct cylinder, a seek is initiated, and a cylinder verification is performed after the seek is completed.

#### **CONSECUTIVE SECTOR TRANSFERS**

An entire track may be transferred in one revolution of the disk.

#### **MULTIPLE BLOCK TRANSFERS**

Up to 256 sectors can be transferred with a single command.

#### **AUTOMATIC HEAD AND CYLINDER SWITCHING**

If during a multi-block data transfer the end of a track is reached, the controller automatically switches to the next track. If the end of a cylinder is reached, the controller issues a seek to the next cylinder, switches to head 0 and resumes the transfer.

#### **PARITY SELECTION**

Odd parity is generated within the controller for all information put on the I/O bus. When parity is enabled (by jumper selection), all bad parity information is flagged.

#### **PROGRAMMABLE SECTOR INTERLEAVING**

Sector interleaving provided is programmable with up to 16 way interleave.

#### **256/512/1024 BYTES/SECT ON HARD DISKS**

Switch selectable sector size.

Winchester disk sectors sizes at 256 or 512 or 1024 bytes per sector are jumper selectable. The number of sectors per track for 256 (33 or 32 sectors) and 512 (18 or 17 sectors) are programmable.

#### **PROGRAMMABLE DISK PARAMETERS**

The disk parameters for both hard and floppy can be passed to the controller from the host (as data) to define the drive's characteristics. Firmware supports up to 1024 cylinders and 16 heads.

#### PROGRAMMABLE FLOPPY TRACK FORMAT

The type of track format on the floppy media that is going to be used can be passed to the controller through software.

#### EFFICIENT HOST INTERFACE PROTOCOL

a bidirectional bus between the controller and host provides a simple yet efficient communication path. In addition, a high level command set permits effective command initiation.

#### LOGICAL TO PHYSICAL DRIVE CORRELATION

Logical unit numbers (LUN's) are independent of physical port numbers. All accesses specify LUN's.

#### DOUBLE STEP FUNCTION

The function allows the user to read/write 48 tpi diskettes on 96 tpi disk drive.

#### SELECTABLE CONTROLLER ID

A jumper is provided to specify the controller ID number.

#### ON BOARD SECTOR BUFFER

A sector buffer is provided on the controller to eliminate the possibility of data overruns during a data transfer.

#### ALTERNATE TRACK ASSIGNMENT

The host can assign an alternate track for each defective track. Subsequent accesses to the defective track will cause the controller to transfer data from the track automatically.

#### DATA ERROR SENSING AND CORRECTION

If a data error is detected during a disk data transfer, the controller indicates whether or not it is correctable. If correctable, the error can be automatically corrected by the controller.

#### FAULT DETECTION

Two classes of faults are flagged to improve error handling:

- o Controller faults
- o Disk faults

#### COMMAND LINKING

Allows commands to be linked together upon successful completion of the prior command.

## 1.4 Tape Features

### **SINGLE COMMAND BACKUP/RESTORE**

Single command disk image back-up and restore on sector or block boundaries accomplished transparent to the host.

### **HEADER RECORD**

An optional user defined header at the beginning of the cartridge allows cartridge identification while being transparent to back-up and restore operations. Special commands allow reading and writing of the header record.

### **DIRECT TAPE ACCESS**

Block oriented host tape read and write operations may be performed.

### **TAPE STREAMING BUFFER**

8192 bytes of buffer space is provided to maintain streaming operations under all normal conditions.



## 1.5 Differences Between the 500DB and the 500B Series

The differences between the 520DB and the 520B are as follows:

### I. Command Set Differences

#### 1. Recalibrate Command - (01h)

500DB Recalibrate Command will only step in for the maximum number of cylinders that have been specified by the drive.

500B The Recalibrate Command will step in for a maximum of 1024 cylinders regardless of the drive parameters.

#### 2. Request Syndrome Command - (02h)

500DB Not included in 500DB.

500B Included.

#### 3. Check Track Command - (05h)

500DB Checks the interleave and ID fields of the sectors on specified tracks. ID fields and Data Fields are verified against ECC value recorded.

500B Checks the interleave and ID fields of the sectors on specified tracks. Data fields are not verified.

#### 4. Change Cartridge Command - (1Bh)

500DB This command causes the "Change Cartridge" interface signal to be asserted for 1ms, allowing a cartridge to be replaced in a fixed/removable cartridge drive.

500B Group 1 Command not included in 500B.

#### 5. Assign Drive Parameter Command (C2h) for Winchester Drives.

##### A. BYTE 0 - Step Pulse Width

500DB The time the Step signal is asserted in 500DB is in 3.5 usec increments. The default for 500DB is 10.8 usec.

500B The time Step signal is asserted ranges from 6.8 to 217.6 microseconds. The default for 500B is 13.6 usec.

##### B. BYTE 2 - Step Mode

500DB Step Mode 4 is specified as 11usec Step Period.

500B Step Mode 4 is specified as 13usec Step Period.

I. Command Set Differences (continued)

5. Assign Drive Parameter Command (C2h) for Winchester Drives.

C. Byte 3 - Maximum Head Address

500DB Supports a maximum of 16 heads.

500B Supports a maximum of 8 heads.

D. BYTE 6 - Reduced Write Current

500DB This is an 8 bit (byte 6 only) value.

500B This is an 8 bit (byte 6 only) value.

E. BYTE 7 - Drive Type Identifier

500DB Bit 7 is set to 0 to indicate that parameters are for a hard disk drive.

Bit 6 is for the seek complete signal.

Bit 5 and 4 indicate whether the drive is fixed or removable.

Bit 1 and 0 of Byte 7 are part of the 10 bit Write Precompensation value of Byte 6.

500B Bit 7 is set to 0 to indicate that parameters are for a hard disk drive.

Bit 6 is for the seek complete signal.

All other bits are set to zero (0) in the 500B Series.

F. BYTE 8 - Maximum Sector Address

500DB This byte may be used to override the default number of sectors per track. If it is left zero the default remains the same. The byte is defined as sectors per track minus one.

500B Byte 8 in the 500B Series is set to zero (0).

I. Command Set Differences (continued)

6. Drive Parameters for Floppy Drives - (C2h)

A. BYTE 0 - Step Pulse Width

520DB Does not care. Value not analyzed.

520B Range is 17 to 255 usec. Default is for 17 usec.

B. BYTES 1 to 3 are the same for the 520DB and the 500B.

C. BYTE 4 to 5

520DB Does not care.

520B See 500B Series Manual.

D. BYTE 7 - Mini Floppy Parameters

520DB Bit 7 is set to 1 to indicate a floppy disk.  
Bit 6 is set to one if Bytes 8 and 9 are to be read.

520B Bit 7 is set to 1 to indicate a floppy disk.  
All other bits are zero (0).

E. BYTE 8 - Floppy Disk Drive

500DB Specifies the type of flexible disk. Zero is for 5 1/4" interface.

520B This Byte is reserved.

F. BYTE 9 - Starting Write Precompensation

500DB Write Precompensation will be applied to all cylinders greater than this value.

500B Reserved. This byte is set to zero (0).

7. Write ECC - (E1h)

500DB Writes a sector of data bytes plus 4 more bytes where the 4 ECC bytes normally reside.

500B Writes a sector of data bytes and displaces the data on the disk by 3 bytes.

8. Read ID - (E2h)

500DB Returns 4 bytes of data including High Cylinder, Low Cylinder Head or Track Flags and Physical Sector Number. It does not return ID ECC bytes.

## I. Command Set Differences (continued)

### 9. Read ECC - (EAh)

500DB Compliment of Write ECC.

500B Not included in the 500B command set.

### 10. Read Data Buffer - (ECh)

500DB Transfers the Controller Data Buffer to the host.

500B Not included in the 500B command set.

### 11. Write Data Buffer - ((EFh)

500DB Causes the Controller Data Buffer to be written from the host.

500B Not included in the 500B command set.

## II. Functional Differences

### 1. Sector Formats

500DB The format for the 500DB Series is incompatible with the 500B Series. The 500DB Series supports the following Winchester Disk formats:

256 bytes/sector with either 32 or 33 sectors/track.  
512 bytes/sector with either 17 or 18 sectors/track.  
1024 bytes/sector with 9 sectors/track.

500B The 500B Series supports the following Winchester Disk formats:

256 bytes/sector with 33 sectors/track.  
512 bytes/sector with 18 sectors/track.  
1024 bytes/sector with 9 sectors/track.

### 2. Linked Commands

500DB Supports Linked commands.

500B Does not support Linked commands.

### 3. Consecutive Sector Transfer

500DB If the Host is fast enough the 500DB Series can transfer a full track on a single disk revolution.

500B Does not support Consecutive Sector Transfer.

## II. Functional Differences (continued)

### 4. ECC Correction

500DB Corrects up to 5 bit burst errors.

The F8 Data Address Mark and Data are included in the calculation of the ECC.

500B Corrects up to 4 bit burst errors.

The Data is included in the ECC calculation. Therefore, if the data of a sector is all zero's, then the ECC will also be zero.

### 5. Error Code Description

500DB 10h Tape Exception

1Fh Tape Drive Failure

31h FDC 765 error (520DB and 540DB models only)

500B 10h ID Read Error

1Fh Sequence timeout during disk or host transfer.

31h Not included

## SECTION 2

### 2.0 ELECTRICAL/MECHANICAL SPECIFICATIONS

#### 2.1 Physical Dimensions

Width	5.75 inches (14.6 cm)
Length	8.0 inches (21.6 cm) (7.85 for 510X)
Height	0.75 inches (2.3 cm)
Weight	9.0 ounces (.25 kg)

#### NOTE:

Mounting holes are identical to 5.25 inch disk drive mounting holes.

#### 2.2 Environmental Parameters

Temp. (degree) F/C	Operating	Storage
	32/0 to 131/55	-40/-40 to 167/75
Relative Humidity (@ 40 degrees F, wet bulb temp no condensation)	10% to 95%	10% to 95%
Altitude	0-10000 Ft	0-15000 Ft.

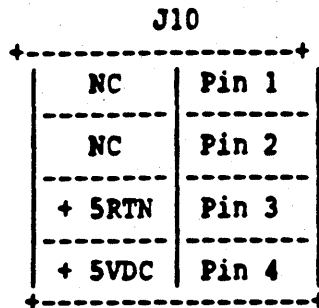
#### 2.3 Power Requirements

Voltage (all Models) +5 Volts DC + 5%

Model 510DB	Model 520DB	Model 530DB	Model 540DB
+5 volts	+5 volts	+5 volts	+5 volts
1.0 amp	1.5 amps	1.5 amps	2.0 amps
5.0 watts	7.5 watts	7.5 watts	10 watts

## 2.4 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.



### WARNING!

Pin 2 is not connected to ground

## 2.5 Maintenance Philosophy

The error detection capability of these controllers allows isolation of a fault to a defective disk drive or controller. If the disk drive is faulty, the manufacturer's documentation should be reviewed to determine disposition.

A two level maintenance philosophy is recommended for the DTC-500DB Series Controller and associated Host Adapter.

Level 1 - Replacement of the defective module at the user's site.

Level 2 - Replacement of defective component at DTC's manufacturing facility.

Section 5.7 of this manual provides maintenance and troubleshooting data that should be reviewed for additional information.

Contact DTC prior to returning any material.

## 2.6 Related Documents

Related documents include:

- Host CPU documentation
- Manufacturer's Disk Drive documentation
- Host Adapter Installation and Software Instructions.

## SECTION 3

### 3.0 HOST AND DISK DRIVE INTERFACES

#### 3.1 Interface Connections

Figure 3-1 is a block diagram of a typical system configuration. (See the Appendices in back of this manual for the location of the Controller's Cable and Power Connections). The Host Computer's I/O Bus is attached to the Controller with the appropriate Host Adapter. The Host Adapter ensures signal compatibility between the host computer and the controller. The Host Adapter translates the signals transferred between the Host Computer's I/O Bus and the Controller's SASI Interface. This includes directing signals with the correct polarity, level and timing to the corresponding connector pin.

The Winchester Disk Drive Control Interface exchanges status and control information between the controller and disk drive (s). It is daisy-chained to each disk drive attached to the controller, and a terminator is installed in the last physical disk drive connected to the chain.

Disk drive parameters, such as the maximum number of cylinders and number of heads, are passed to the controller from the host computer. This allows disk drives with different parameters and characteristics to be attached concurrently to the controller with no special requirements.

The Winchester Disk Drive's Data Interface has a separate cable for each disk drive. It exchanges serial MFM data between the controller and the selected disk drive.

The Flexible Disk Drive Interface exchanges data and control information between the controller and disk drive (s). It is daisy-chained to each disk drive attached to the controller, and a terminator is installed in the last physical disk drive connected to the chain.

The QIC-02 Streaming Tape Interface has a separate cable to exchange status and information between the DTC Controller and the Intelligent Tape Drive Controller.



### 3.2 System Configuration

The host computer is interfaced to the controller by a 50 pin cable connected to J1 on the controller. The host interface cable should not exceed 20 feet (6 meters) in length.

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

The flexible disk drives are interfaced to the controller via J7 which is a 34 pin header type connector. The maximum cable length should not exceed 20 feet (6 meters) or the drive manufacturer's limit, whichever is less.

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 part numbers for the connectors are as follows:

J1 and J8 - 3M P/N 3425-6050  
J2 and J7 - 3M P/N 3414-6034  
J3 and J4 - 3M P/N 3421-6020

(Refer to appropriate Appendices for Board Outlines)

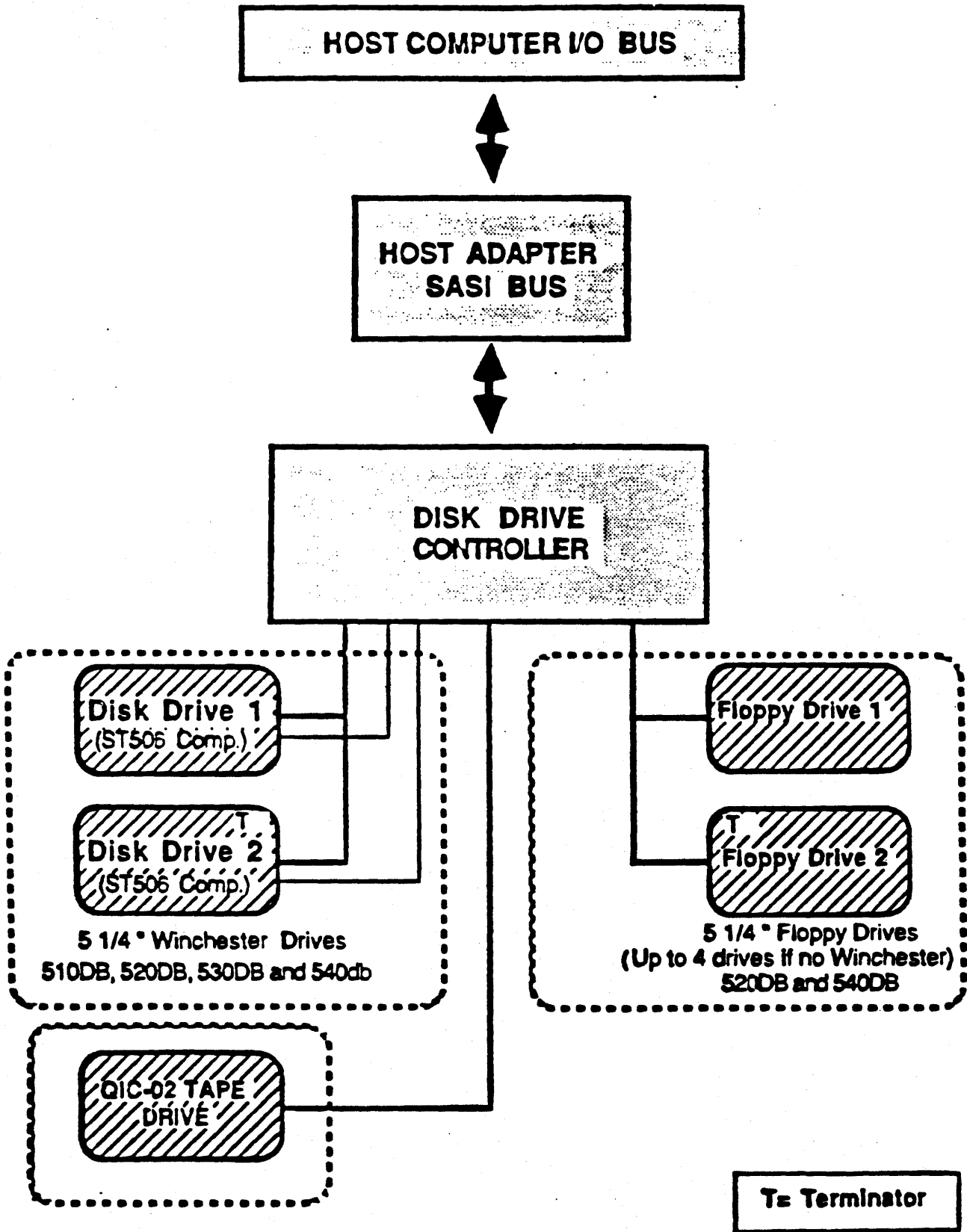


Figure 3-1 Typical System Configuration

### 3.3 Host Interface

The controller's Host Interface is attached, via the appropriate Host Adapter, to the I/O Bus of the host computer. Each computer manufacturer specifies the signal names and timing considerations for their I/O Bus.

Figure 3-2 shows the name and pin designation of the signals on the controller's Host Interface connector.

The Host I/O Bus uses a 50-pin connector (AMP P/N 2-87227-5 or the equivalent). The unused signal pins are considered to be spares for future use. The pin assignments are as follows:

Figure 3-2 Host I/O Connector Pin Assignment

Signal	Pin Number	
DATA0	2	
DATA1	4	
DATA2	6	
DATA3	8	
DATA4	10	
DATA5	12	
DATA6	14	
DATA7	16	
PARITY	18	
GND	20	-----
GND	22	
GND	24	
OPEN	25,26	Future Usage
GND	28	
GND	30	
ATN (not used)	32	
GND	34	-----
BUSY	36	
ACK	38	
RST	40	
MSG	42	
SEL	44	
C/D	46	
REQ	48	
I/O	50	

**NOTE:** All signals are negative true and all odd pins except 25, are connected to ground. The signal lines are terminated with 220 ohms to 5V and 330 ohms to ground.

## SECTION 4

### 4.0 DTC HOST BUS

#### 4.1 Introduction

The DTC Host Bus is a negative-logic, bidirectional 8-bit data bus utilizing odd parity. The controller regulates transfers across the bus in such a way that permits the connection of host systems that utilize direct memory transfer capability as well as those that only support program input/output implementations.

#### 4.2 Electrical Requirements on the Host Interface

The Host Bus is an open collector terminated on each end with 220 ohms to Vcc and 330 ohms to ground. The typical cable used is a 50-pin, mass terminated, cable with a characteristic impedance of approximately 100 ohms. Typical recommended drivers and receivers for the Host Bus is 7438 and 74LS240, respectively. The maximum length of the Host Bus is 20 feet. Driver IC's must be rated at 48 mA.

#### 4.3 Signal Definitions

The signals that comprise the Host Bus are separated into those that are driven by the controller, those that are driven by the host adaptor (H/A), and those that are bidirectional. The term "asserted" means that the signal on the Host Bus is between 0V and 0.4V. The term "deasserted" means that the signal on the host bus is between 2.5V and 5.25V (negative or low true logic).

##### I. Unidirectional Signals Driven By Controller

- I/O**      **Input/Output**  
When asserted, the data on the bus is driven by the controller. When deasserted, the data on the bus is driven by the host adapter. The host adapter must use this line to enable its drivers onto the data bus.
- C/D**      **Command/Data**  
When asserted, the bytes transmitted across the bus are interpreted as command bytes. When deasserted, the bytes are data bytes.
- BUSY**     This bit is asserted as a response to the SEL line from the host adapter and to indicate that the host bus is currently in use.

# I. Unidirectional Signals Driven By Controller (continued)

**MSG**      **Message**  
When asserted, indicates that the command is completed. This bit is always followed with the assertion of I/O, and the assertion of REQ.

**REQ**      **Request**  
This bit operates in conjunction with I/O, C/D, & MSG. When asserted and I/O is asserted, REQ will mean that the data on the host bus is driven by the controller. When asserted and I/O is deasserted, REQ will mean that the data is driven by the host adapter (H/A). The following table lists the legal states of the control bits on the bus; the states are valid only when REQ is asserted.

I/O	C/D	MSG	Meaning
d	a	d	Get a command byte from H/A
d	d	d	Get a data byte from H/A
a	d	d	Send a data byte to H/A
a	a	d	Send the status byte to H/A
a	a	a	Send the message byte to H/A (Command is completed.)

a = asserted, d = deasserted

### 4.3 Signal Definitions (continued)

#### II. Unidirectional Signals Driven By Host Adapter

**ACK Acknowledge**

This bit is asserted as a response to REQ from the controller. ACK must be returned for each REQ assertion. The controller will wait for the assertion of ACK before REQ is deasserted. The H/A must not deassert ACK until after REQ has been deasserted. If the H/A keeps ACK asserted, the controller will not reassert REQ until after ACK is deasserted. This provides the H/A with a means of regulating the transfer of bytes across the bus. Byte transfer regulation can occur for either command or data bytes.

**RST Reset**

When asserted, this bit forces the controller to the beginning of its microcode. Following a Reset, the controller will monitor the bus and wait for the H/A to assert Select. Reset will immediately terminate any pending command without the transmission of the status or the message bytes. All signals to the drives are deasserted. RST must be asserted for a minimum of 25 us and a maximum of 10 seconds.

**SEL Select**

When asserted, indicates the beginning of the command transaction. The H/A asserts SEL to gain the attention of the controller. Data Bit 0 on the bus must also be asserted during SEL time to select the controller. The controller will return BUSY as acknowledgement for SEL. After the assertion of BUSY, the H/A will deassert SEL. The controller will wait until SEL is deasserted before it asserts REQ. This provides a way for the H/A to hold off the command byte fetch until it is ready for the controller. SEL can be asserted immediately following a Reset.

#### III. Bidirectional Data

DB(7-0,P) - Data lines 7 thru 0 represent the eight data bits (DB0 = lsb). Parity is represented by P. The controller utilizes odd parity (the number of asserted bits on the host bus is always odd).

#### 4.4 Controller Interfaces

DTC-500DB SERIES  
WINCHESTER  
CONTROL INTERFACE

ST-506/41  
COMPATIBLE  
CONTROL INTERFACE

	SIGNAL NAME
* 2	REDUCED WRITE CURRENT----
4	HEAD SELECT 2 <sup>2</sup> ----->
6	WRITE GATE ----->
8	<----SEEK COMPLETE
10	<----TRACK 00
12	<----WRITE FAULT
14	HEAD SELECT 2 <sup>0</sup> ----->
16	RESERVED
18	HEAD SELECT 2 <sup>1</sup> ----->
20	<----INDEX
22	<----READY
24	STEP ----->
26	DRIVE SELECT 1----->
28	DRIVE SELECT 2----->
30	DRIVE SELECT 3----->
32	DRIVE SELECT 4----->
34	DIRECTION IN ----->

**NOTE:** All odd numbered pins are connected to signal ground.  
All signals are negative true.  
See Figure 4-2 for Drive's Data Interface information

\* When Controller is programmed to interface with drives having more than eight (8) heads, this line is used as a head select 3 line.

FIGURE 4-1 CONTROLLER to WINCHESTER DRIVE CONTROL INTERFACE

	SIGNAL NAME	
1	<---DRIVE SELECTED	
2		
3	RESERVED	
4		
5	RESERVED	
6		
7	RESERVED	
8		
9	RESERVED	
10	RESERVED	
11		
12		
13	+MFM WRITE DATA----->	
14	-MFM WRITE DATA----->	
15		
16		
17	<-- +MFM READ DATA	
18	<-- -MFM READ DATA	
19		
20		

**NOTE:** Reserved lines may be spares.  
 See Figure 4-1 for Drive's Control Interface information

FIGURE 4-2 CONTROLLER to WINCHESTER DRIVE DATA INTERFACE



DTC-520DB SERIES  
 FLOPPY DISK DRIVE SIGNAL NAME 5.25" FLOPPY DRIVE  
 INTERFACE SA4XX COMPATIBLE

2	SPARE
4	IN USE/SPARE
6	DRIVE 4 SELECT----->
8	<-----INDEX
10	DRIVE 1 SELECT----->
12	DRIVE 2 SELECT----->
14	DRIVE 3 SELECT----->
16	MOTOR ON----->
18	DIRECTION----->
20	STEP----->
22	WRITE DATA----->
24	WRITE GATE----->
26	<-----TRACK 000
28	<-----WRITE PROTECT
30	<-----READ DATA & CLOCKS
32	SIDE SELECT----->
34	SPARE

**NOTE:** All odd numbered pins are connected to signal ground.  
 All signals are negative true.

**FIGURE 4-3** CONTROLLER to FLOPPY DISK DRIVE INTERFACE  
 (520DB and 540DB)

The following table defines 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

FIGURE 4-4 CONTROLLER TO QIC-02 STREAMING TAPE INTERFACE  
(530DB and 540DB)

#### 4.5 Theory of Operation

There are 6 possible phases to a complete command - as follows:

- 1) Bus Free Phase
- 2) Arbitration Phases (NECESSARY FOR MULTIPLE H/A'S)
- 3) Selection Phase
- 4) Command Fetch Phase
- 5) Data Transfer Phase
- 6) Status Phase and Message Phase

##### I. Bus Free Phase

The BUS FREE phase is used to indicate that no device is actively using the Host Bus and that the bus is available for an arbitration phase. During BUS FREE PHASE all bus signals are not asserted. The BUS FREE PHASE is defined by the simultaneous (within 45 ns) condition of both SEL\* and BSY\* non-asserted while RESET is not active. When entering the BUS FREE STATE all devices must release all lines within 100 ns of releasing BSY\* and SEL\*.

##### II. Arbitration Phase

The ARBITRATION PHASE allows a device to gain control of the bus so that it can assume the role of INITIATOR (H/A). The ARBITRATION PHASE is not needed if there is only one Host Adapter.

After a device detects the BUS FREE condition it must wait for a minimum of 100 ns or a maximum of 1.1 us (if it has hope of winning) in order to assert BSY and its own device ID bit. All other data bits are deasserted by the INITIATOR. After a minimum time of 1.7 usec the data bus is examined to see if no other higher priority bit is asserted. (The highest priority is DB7, lowest is DB0). If a higher priority bit has been detected the losing device deasserts all bus lines. If the device determines that it is the highest priority device arbitrating for the bus it asserts SEL.

If a device that is arbitrating detects SEL\* it must assume that it has lost the arbitration and deassert all lines.

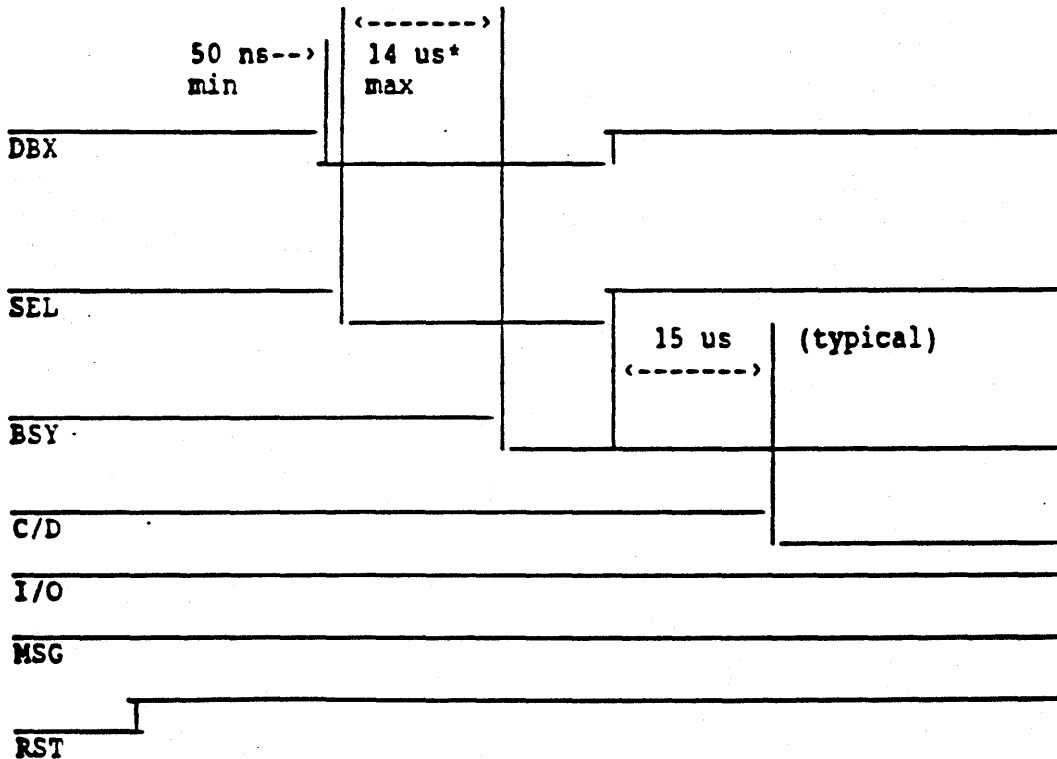
### III. Selection Phase

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:

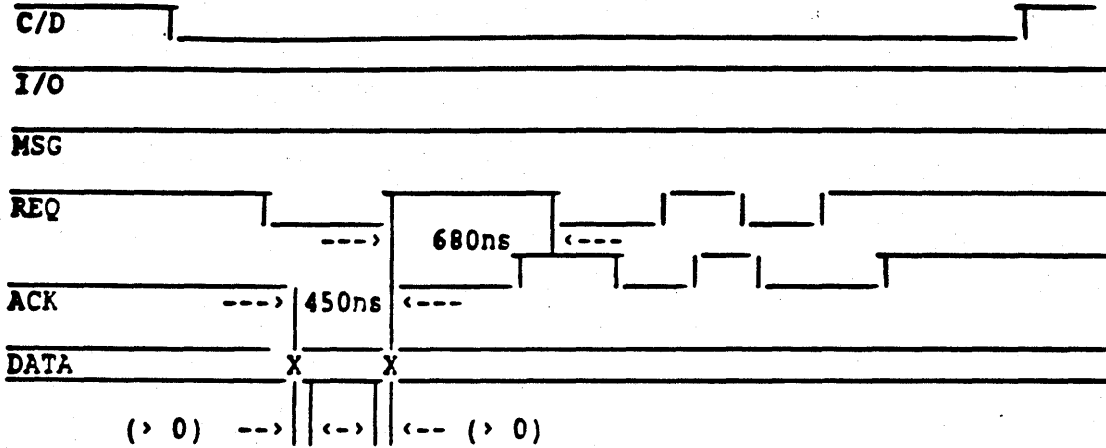
Upon power on reset the controller will execute a comprehensive self test. During the self test the controller will not respond to a Selection sequence for a period of 400 msec (typical) after the RST pulse. The controller will not assert BSY during this time.



\* 14 us max after a Reset with non Tape commands (510DB, 530DB, 540DB).  
 60 us max with 520DB.  
 200 us max with Tape commands (530DB, 540DB).

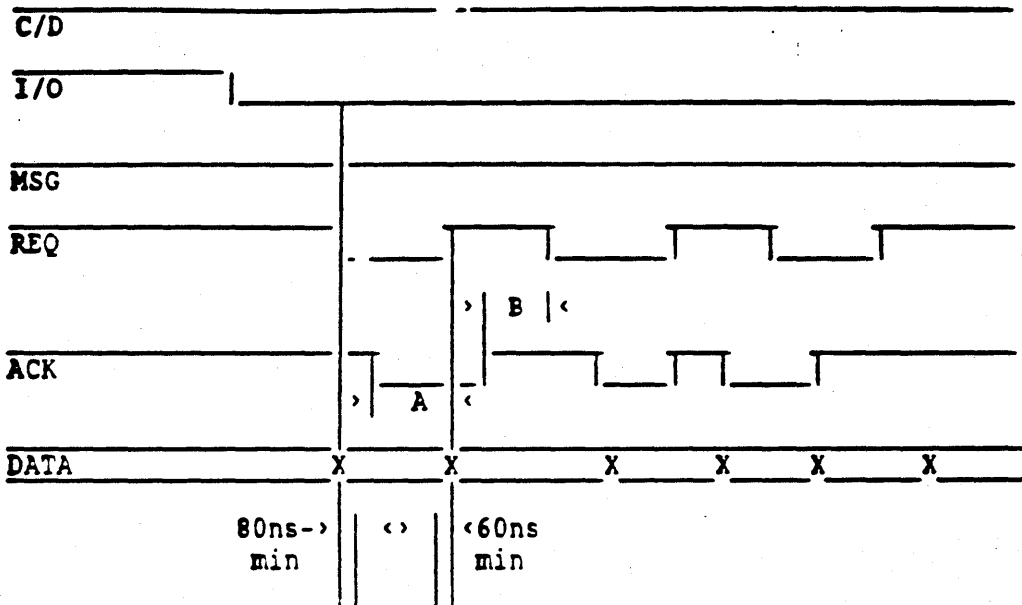
#### IV. Command Fetch Phase

Following the selection sequence, 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 the first byte of the 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 then deassert REQ. The host must then deassert ACK to begin the next REQ/ACK handshake. The handshake continues until all bytes of the command have been issued.



### V. Data Transfer 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 will then respond by transferring a byte across the data bus and then asserts ACK. This handshake continues until all data bytes have been transferred.

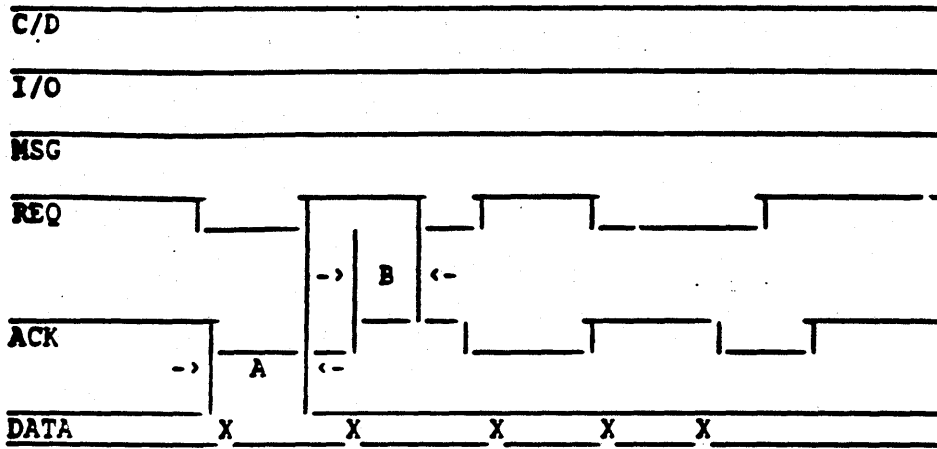


#### DATA IN - READ

Timing A: 190 ns  
 B: 450 ns

V. Data Transfer Phase (continued)

DATA FROM HOST

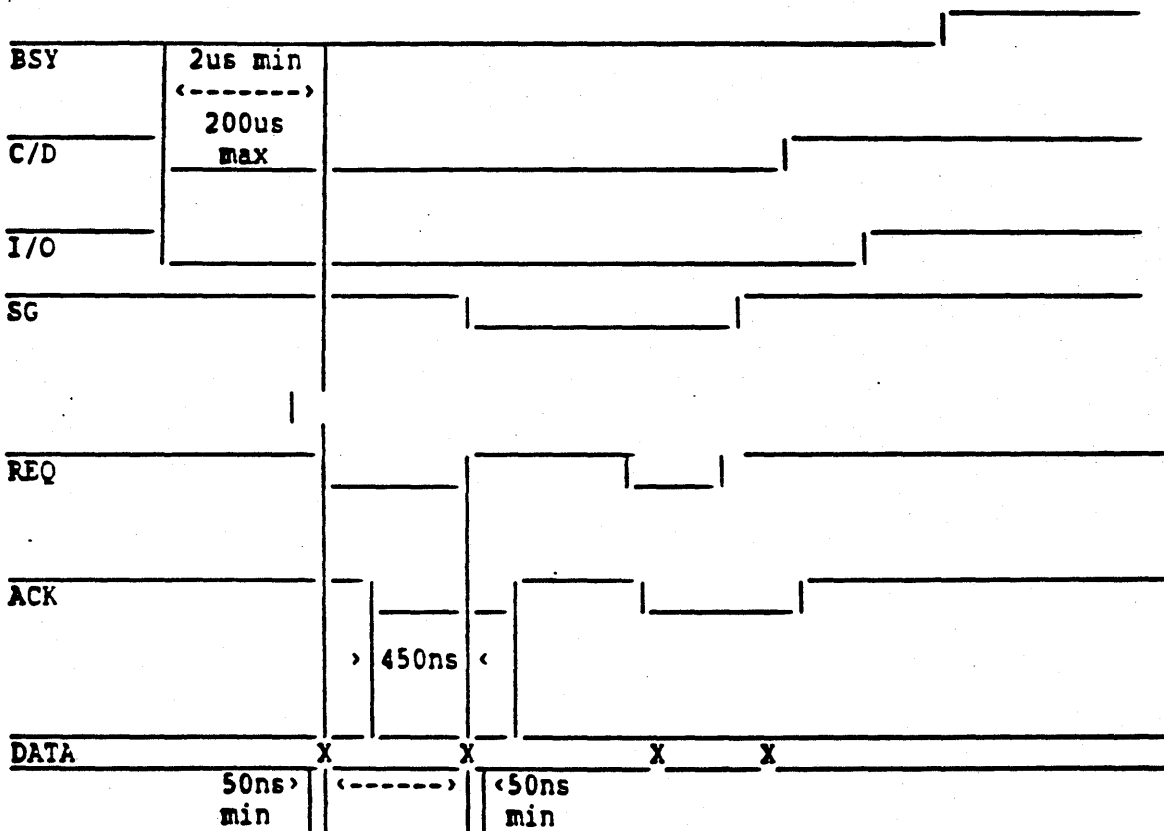


DATA OUT - READ

Timing A: 450ns  
B: 700ns

## VI. Status and Message Transfer Sequence

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





#### 4.6 Bus Conditions

The bus has one asynchronous condition: RESET

##### Reset Condition

The RESET CONDITION is used to immediately clear all devices from the bus and to reset all attached drives or other devices. It is to be used carefully as it can cause data to be lost during a write.

The RESET CONDITION is created by the assertion of the RST\* line for a minimum of 25us.

#### 4.7 Phase Sequencing

The order in which phases can occur follows a prescribed sequence.

The RESET condition can always return the system to the BUS FREE state.

In systems where the ARBITRATION PHASE is not used BUS FREE is followed by SELECTION and by one or more information transfer phases (COMMAND, DATA, STATUS, or MESSAGE)

When the ARBITRATION PHASE is used it is followed by SELECTION and the information transfer phases.

There are no restrictions on the sequencing between information transfer phases. Thus a DATA PHASE may follow another DATA PHASE.

After the information transfer phases are completed the system returns to the BUS FREE state.

#### 4.8 Signal Sources

The following table shows which type of bus device may drive which lines during the various bus phases.

Bus Phase	BSY*	SEL*	C/D* I/O* MSG* REQ*	ACK*	DATA BUS
BUS FREE	none	none	none	none	none
ARBITRATION	ALL	One	none	none	ID bits
SELECTION	I & T	Init	none	Init	Init
COMMAND	Targ	none	Targ	Init	Init
DATA IN	Targ	none	Targ	Init	Targ
DATA OUT	Targ	none	Targ	Init	Init
STATUS	Targ	none	Targ	Init	Targ
MESSAGE IN	Targ	none	Targ	Init	Targ

#### 4.9 Abnormal Command Termination

If no errors occur, the command will proceed as previously described. However, if errors do occur the controller will terminate the command and immediately enter the status & message phase. Error conditions can be classified as follows:

1) Bus Parity errors - The controller checks for bus parity error after each command descriptor and each block transfer. The status byte will indicate if a parity error has occurred.

2) Drive Interface or Controller related errors - After the six command bytes have been accepted, errors of this type can be detected. Upon the detection of the error condition (Drive Fault, Drive Not Ready, Illegal Command, etc.) the controller will enter the status & message phase. The status byte will have the error bit set.

3) Read/Write Channel errors - Upon detection of these errors (Read data error, Record not found, Drive Fault during a write, etc.) the controller may transfer a sector, or more, of data before it enters the status & message phase. The error bit is set in the status byte.

In cases 2 & 3 a Request Sense command may be issued to retrieve error information. In either case, any other command may be issued if the host system does not care about the details of the errors.

See Section 5.3.1 for Command Completion Status.

#### 4.10 SCSI Functions Supported by 500DB

ARBITRATION - This is a Host function

SELECTION - The 520DB controller ID is jumper selectable

COMMAND

STATUS

DATA IN/OUT

MESSAGE IN - Command complete (00) only.

## SECTION 5

### 5.0 COMMANDS / PROGRAMMING

#### 5.1 Description of Commands by Class

Commands to the controller are categorized into various classes as indicated below:

**Class 0** - Non-data Transfer, Data Transfer and Status Commands

**Class 1** - Disk Copy Command

**Class 2-5** - Reserved

**Class 6** - Disk Parameter Assign Commands

**Class 7** - Diagnostic Commands

#### 5.2 Disk Command Specifications

##### 5.2.1 Command Formats

The Host issues a command to the controller by passing it a CDB (Command Descriptor Block).

Figure 5-1 shows the format of a typical Class 0 CDB.

Byte 0 is the first byte sent to the controller.

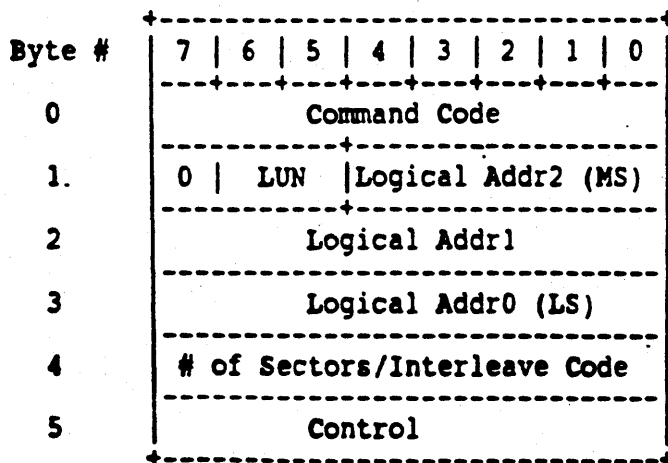


Figure 5-1

### 5.3 Command Formats

#### Description of the fields used in the Command Descriptor Blocks

##### LUN

This field specifies the logical unit number of the drive we are attempting to communicate with. It corresponds to Drive Select jumper on the drives as follows:

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

SLUN = Source drive LUN  
DLUN = Destination drive LUN

A Winchester drive can only be assigned as logical units 0 and 1. A Winchester drive cannot be assigned as logical units 2 or 3. See Appendices F, G, H, or J for the proper LUN assignment for your drive and controller type.

##### LAD (0-2)

Refer to Appendices F, G, H, J, for proper jumper settings.

This is a 21 bit logical sector address of the beginning sector of the group of sectors we wish to access. LAD 0 is the LSB. The LAD field can be from 0 up to the total number of sectors available on a particular drive.

##### NUMBER OF BLOCKS

This field holds the number of sectors we wish to transfer per command. A value of 0 will result in a transfer of 256 sectors.

##### INTERLEAVE

This field is used to tell the controller what interleave to use during the format commands or check track command.

Interleave is a factor used while formatting a drive so the user can optimize the throughput of the data transfer of the system. The throughput of the system depends on the controller's turnaround time for next sector and the data transfer rate on the host bus.

##### NOTE:

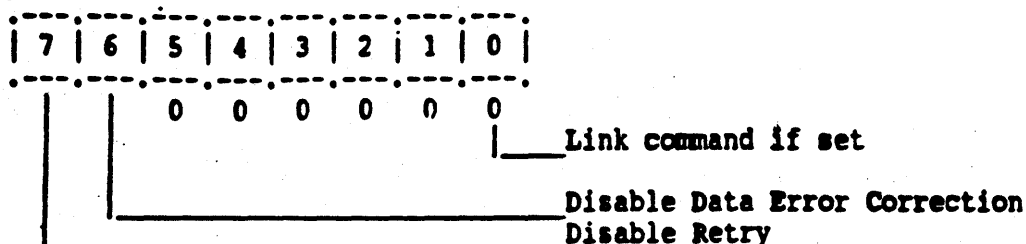
The drive should be formatted with the same interleave throughout the whole drive ie., when using Format Track, Format Bad Track, Assign Alternate Track Commands the interleave specified should be the same as the rest of the tracks. If interleave is not consistent throughout the drive, performance degradation may result.

### 5.3 Command Formats (continued)

#### CONTROL

This field contains the control bits that tells the controller how to react if an error condition is encountered during the command execution phase.

This byte is defined as follows:



#### DISABLE RETRY

If the DISABLE RETRY bit is 1, the controller will not attempt to retry the command.

If the DISABLE RETRY bit is 0, the following errors result in a retry attempt:

a) Record not found, b) seek error, c) uncorrectable data error, d) correctable data error, e) no ID address mark, f) no Data address mark. For seek error, a recalibrate and reseek are performed. A total of eight attempts are performed before an error is reported. If the retry is successful, the controller will not report the error to the host. The retry count is incremented for any retry attempted (refer to Request Logout command).

#### NOTE:

No retry is performed if the check track command encounters the No ID address mark error.

#### DISABLE DATA ERROR CORRECTION

If the DISABLE DATA ERROR CORRECTION bit is 0, the controller will correct the data if a correctable data error occurred. The controller will continue with the command as though there was no data error. The error is not reported to the host.

If the DISABLE DATA ERROR CORRECTION bit is 1, the controller will not correct the data if a correctable data error occurred. The controller terminates the command after the block is transferred to the host and the error is reported to the host.

The permanent error count (refer to Request Logout Command) is incremented by one in both cases (disable/enable data error correction).

### 5.3 Commands Formats (continued)

#### LINK COMMAND

If this bit is set, and the previous command was executed without error, the controller will skip the STATUS and MESSAGE transfer sequence as well as the SELECTION sequence and request the next command immediately. This cuts down on command/status overhead when no error occurred.

#### 5.3.1 Completion Status Byte

##### COMPLETION STATUS

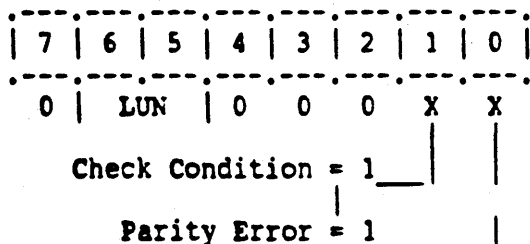
At termination of a command or following an error, the controller will cause a status byte to be transferred to the host from the host controller to the host. The completion status byte will report only that an error (CHECK CONDITION) occurred, not the type of error. To obtain the error code a Request Sense command must be issued (03 Hex).

Bit 0 will be set to 1 if the controller detects a parity error condition during the transfer of bytes from the host. 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. 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 no error occurs, bits 0 - 4 will be set to 0.

The Completion Status Byte Format is as Follows:



- 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

#### 5.3.2 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.

## 5.4 Description of Commands by Opcode

### GROUP 0 COMMANDS FORMAT AND DESCRIPTION

#### Group 0 Command Table

00	Test Drive Ready
01	Recalibrate
03	Request Sense
04	Format Drive
05	Check Track Format
06	Format Track
07	Format Bad Track
08	Read
0A	Write
0B	Seek
0E	Assign Alternate Track

#### 5.4.1 Type 0 Commands

##### TEST DRIVE READY (HEX 00)

Selects the drive and verifies that the drive is Ready and a seek is not in progress.

Byte #	7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	0	0
1	0	LUN		Set to 0				
2	Set to 0							
3	Set to 0							
4	Set to 0							
5	Control							

#### VALID ERROR CODES

	<u>Error Code</u>	<u>Interpretation</u>
	<u>HEX</u>	
04	05	Drive not ready
	07	Drive not selected
	0D	Multiple drives selected
	0D	Seek in progress

### 5.4.1 Type 0 Commands (continued)

#### RECALIBRATE (HEX 01)

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

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

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

Byte #	7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	0	1
1	0	LUN		Set to 0				
2	Set to 0							
3	Set to 0							
4	Set to 0							
5	Control							

#### VALID ERROR CODES

<u>Error Code</u>	<u>Interpretation</u>
<u>HEX</u>	
02	No seek complete
04	Drive not ready
05	Drive not selected
06	No track 0 found
07	Multiple drives selected



### 5.4.1 Type 0 Commands (continued)

#### REQUEST SENSE (HEX 03)

This command returns 4 bytes of drive and controller sense as Data (C/D deasserted) for the specified LUN. It must be issued immediately after an error (Bit 1 of the Status byte set to 0) to get the valid sense of the error.

Byte #	7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	1	1
1	0	LUN		Set to 0				
2	Set to 0							
3	Set to 0							
4	Set to 0							
5	Set to 0							

The required fields for this command are: OPCODE and LUN.

The sense bytes are returned in the following format.

Byte #	7	6	5	4	3	2	1	0
0	SENSE BYTE							
1	0	LUN		LAD 2				
2	LAD 1							
3	LAD 0							

**NOTE:**

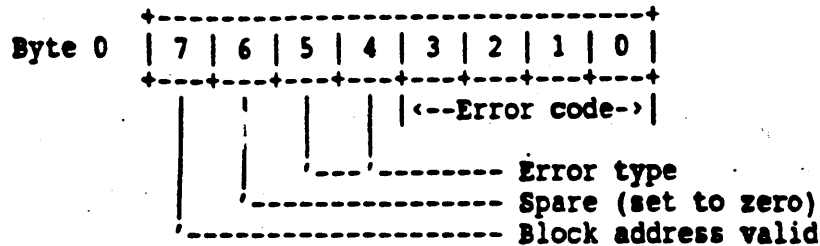
If a permanent tape error occurred during a "Restore" operation, the logical sector address points to the sector in error +1.

REQUEST SENSE (HEX 03) (continued)

DEFINITIONS OF THE FIELDS USED IN THE SENSE BLOCK

SENSE BYTE

This is the byte that describes the details or the nature of the error itself. The bits are defined as follows:



Block Address Valid (Bit 7)

This bit indicates that the Logical Sector Address, LAD in bytes 1 thru 3 contain the valid logical address of the block at which the error occurred.

Error Type (Bit 5,4)

These two bits describes the general type of error. It can contain either one of the following:

- 00 for drive related errors
- 01 for controller related errors
- 10 for command related errors
- 11 for miscellaneous errors

Error Code (Bit 3-0)

This is a 4 bit field that describes the actual error interpretation under each general type of error.

LUN

This field indicates the logical unit number of the drive where the error had occurred.

LAD 2,1,0

This is a 21 bit logical address of the sector at which the error occurred. This field is valid only if the Block Address Valid bit is set in the SENSE byte.

For Error Codes and descriptions refer to Section 6.0 in the Controller specification and Section 4.0 in the Tape Interface and Command specification.

5.4.1 Type 0 Commands (continued)

FORMAT DRIVE (HEX 04)

This command causes the specified LUN to be formatted using the interleave factor specified in byte 4. Formatting starts from track 0 of cylinder 0 and continues until all tracks have been written. Data fields are written with a HEX E5. Interleave factors of 0 and 1 are set to 1. Invalid interleave factors are those that are greater than one half the number of sectors per track. Track and cylinder overflow is handled automatically by the controller.

NOTE:

This command does not check data. For verification of format see CHECK TRACK FORMAT COMMAND.

Byte #	7	6	5	4	3	2	1	0
0	0	0	0	0	0	1	0	0
1	0   LUN		Set to 0					
2	Set to 0							
3	Set to 0							
4	Interleave Factor							
5	Control							

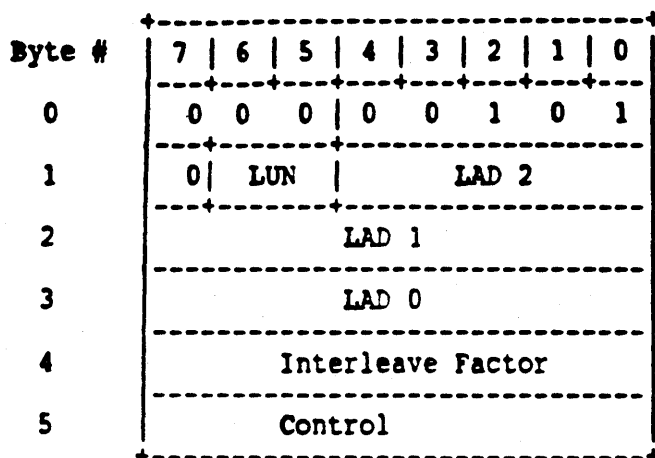
VALID ERROR CODES

<u>HEX</u>	<u>Error Code</u>	<u>Interpretation</u>
01	No index	
02		No seek complete
03		Write fault
04		Drive not ready
05		Drive not selected
06		No track 0 found
07		Multiple drives selected
09		Disk media changed
17		Write protected
30		Ram error

### 5.4.1 Type 0 Commands (continued)

#### CHECK TRACK (HEX 05) (not valid for Floppy)

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.



#### VALID ERROR CODES

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

### 5.4.1 Type 0 Commands (continued)

#### FORMAT TRACK (HEX 06)

This command formats the specified track with no flags set in the ID fields of all sectors on the track. It also fills the data field with data pattern E5 Hex.

Byte #.	7	6	5	4	3	2	1	0
0	0	0	0	0	0	1	1	0
1	LUN			LAD 2				
2	LAD 1							
3	LAD 0							
4	Interleave Factor							
5	Control							

The required fields for this command are OPCODE, LUN, LAD 2,1,0 and INTERLEAVE.

#### VALID ERROR CODES

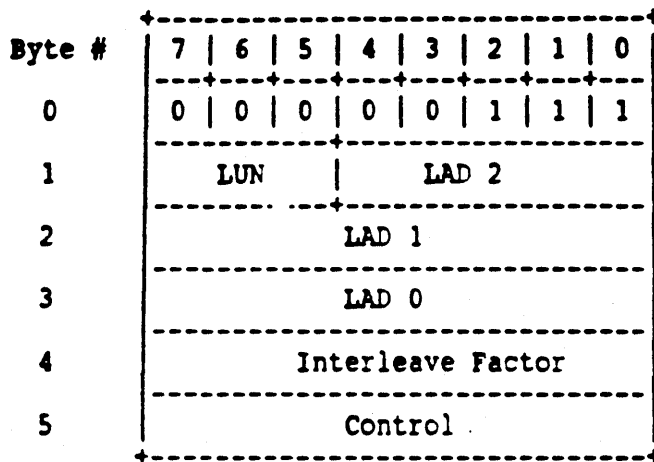
<u>Error Code</u>	<u>Interpretation</u>
<u>HEX</u>	
01	No index
02	No seek complete
03	Write fault
04	Drive not ready
05	Drive not selected
06	No track 0 found
07	Multiple drives selected
09	Cartridge changed
17	Write protected
30	Power up diagnostic error

**FORMAT BAD TRACK (HEX 07) (not valid for floppy)**

Format bad track command formats the specified track with the bad block flag set in all ID fields on the track. Data pattern of E5 hex is filled in the data field. Future accesses to the sectors on this track will get "bad block found" error.

**NOTE:**

Refer to Read ID Command (Opcode E2 for ID bit definition).



The required fields for this command are: OPCODE, LUN, LAD 2,1,0 and INTERLEAVE.

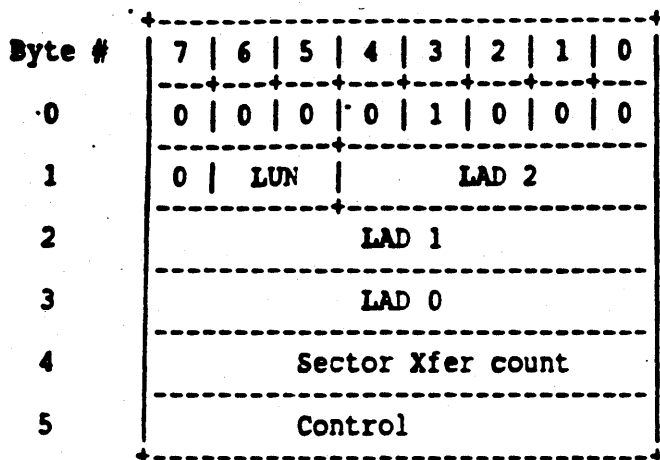
**VALID ERROR CODES**

<u>Error Code</u>	<u>Interpretation</u>
HEX	
01	No index
02	No seek complete
03	Write fault
04	Drive not ready
05	Drive not selected
07	Multiple drives selected
09	Disk media changed
17	Write protected
21	Illegal sector address
30	Ram error

### 5.4.1 Type 0 Commands (continued)

#### READ DATA (HEX 08)

This command causes the number of sectors specified by byte 4 to be transferred to the host. The starting sector is specified by the logical sector address in bytes 1, 2 and 3. Up to 256 sectors can be transferred with a single READ command.

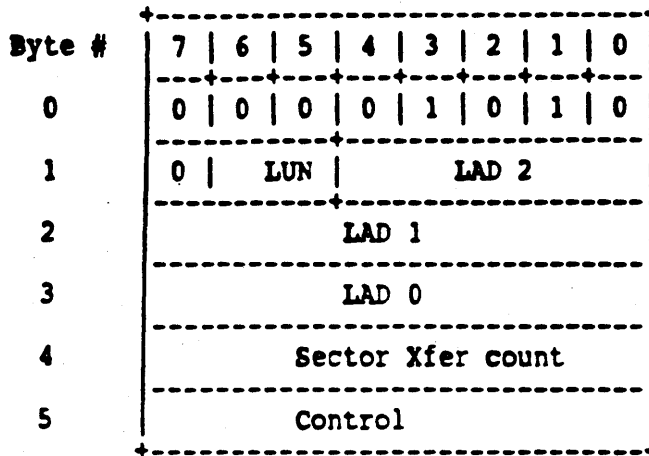


<u>Error Code</u>	<u>VALID ERROR CODES</u>
<u>HEX</u>	<u>Interpretation</u>
02	No seek complete
04	Drive not ready
05	Drive not selected
07	Multiple drives selected
09	Disk media changed
10	ECC error in ID field
11	Uncorrectable error in data field
12	No ID address mark found
13	No data address mark found
14	No record found
15	Seek error
18	Correctable data error
19	Bad track flag set
1C	Unable to read alternate track data
1E	Illegal access to alternate track
21	Illegal sector address
23	Volume overflow

### 5.4.1 Type 0 Commands (continued)

#### WRITE DATA (HEX 0A)

The number of sectors specified by byte 4 are written to the selected LUN beginning with the sector specified by the logical sector address in bytes 1, 2, and 3.



#### VALID ERROR CODES

<u>Error Code</u>	<u>Interpretation</u>
<u>HEX</u>	
02	No seek complete
03	Write fault
04	Drive not ready
05	Drive not selected
07	Multiple drives selected
09	Disk media changed
10	ECC error in ID field
12	No ID address mark found
14	No record found
15	Seek error
17	Write protected
19	Bad track flag set.
1C	Unable to read alternate track data
1E	Illegal access to alternate track
21	Illegal sector address
23	Volume overflow



### 5.4.1 Type 0 Commands (continued)

#### SEEK (HEX 0B)

This command initiates a seek to the cylinder where the block specified in the LAD field is located. For Winchester drives capable of doing overlap seeks, depending on how the drive parameter (Byte 7 bit 6) is set, it could immediately return completion status before the seek complete is found from the drive. Normally it returns the completion status only after the seek had been completed.

**NOTE:**

For further information on implementation of overlapped seek refer to Appendix E, page 91.

Byte #	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	1
1	0	LUN		LAD 2				
2	LAD 1							
3	LAD 0							
4	Set to 0							
5	Set to 0							

The required fields for this command are: OPCODE, LUN and LAD 2,1,0.

#### VALID ERROR CODES

<u>Error Code</u>	<u>Interpretation</u>
<u>HEX</u>	
02	No seek complete
04	Drive not ready
05	Drive not selected
07	Multiple drives selected
21	Illegal sector address

5.4.1 Type 0 Commands (continued)

ASSIGN ALTERNATE TRACK (HEX 0E) (not valid for Floppy)

This command formats the track (Winchester drives only) specified in the LAD field with the alternated bad track flag set in the ID fields and with the track address of the alternate track written in the data fields.

NOTE:

ID bit definition may be found under Read ID Command (Opcode E2).

Future write/read access to that specified track will cause the drive to seek to the alternate track, transparent to the host software, and do the write/read on the alternate track.

Byte #	7	6	5	4	3	2	1	0
0	0	0	0	0	1	1	1	0
1	0	LUN		LAD 2				
2	LAD 1							
3	LAD 0							
4	Interleave Factor							
5	Set to 0							

The required fields for this command are: OPCODE, LUN, LAD 2,1,0 and INTERLEAVE:

After the controller receives the command, it will collect the alternate track address as data (C/D deasserted) from the host in the following format:

Byte #	7	6	5	4	3	2	1	0
0	0	0	0	LAD 2				
1	LAD 1							
2	LAD 0							
3	Set to 0							

ASSIGN ALTERNATE TRACK (HEX 0E) (continued).

NOTE 1:

Alternate tracks can be assigned one level only. That is, an alternate track cannot have another alternate track assigned to it. Also no two defective tracks should be assigned to the same alternate. (For further information on alternate track assignment and usage, refer to Appendix D).

WARNING!

1. Data written on the original track as well as the alternate track will be destroyed.
2. Since the controller does not check whether a track has been previously assigned as an alternate to another track, the user must be careful not to assign two defective tracks to the same alternate.

VALID ERROR CODES

<u>Error Code</u>	<u>Interpretation</u>
<u>HEX</u>	
01	No index
02	No seek complete
03	Write fault
04	Drive not ready
05	Drive not selected
07	Multiple drives selected
09	Disk media changed
17	Write protected
21	Illegal sector address
30	Ram error

**CHANGE CARTRIDGE (HEX 1B)**

This command causes the "Change Cartridge" line (J2 - Pin 2) to be asserted for a period of one (1) millisecond. There are no valid error codes for this command.

Byte #	7	6	5	4	3	2	1	0
0	0	0	0	1	1	0	1	1
1	0	LUN		Not used				
2	Not used							
3	Not used							
4	Not used							
5	Not used							

## 5.5 Type 1 Commands

### COPY COMMAND (HEX 20)

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

Byte #:	7	6	5	4	3	2	1	0
0	0	0	1	0	0	0	0	0
1	0   SRC LUN   Logical Addr2 (MS)							
2	Logical Addr1							
3	Logical Addr0 (LS)							
4	Sector Xfer count							
5	0   DST LUN   Logical Addr2 (MS)							
6	Logical Addr1							
7	Logical Addr0 (LS)							
8	Not used							
9	Control							

VALID ERROR CODES	
Error Code	Interpretation
HEX	
02	No seek complete
03	Write fault
04	Drive not ready
05	Drive not selected
06	No track 0 found
07	Multiple drives selected
09	Disk media changed
10	ECC error in ID field
11	Uncorrectable error in data field
12	No ID address mark found
13	No data address mark found
14	No record found
15	Seek error
17	Write protected
18	Correctable data error
19	Bad track flag set
1C	Unable to read alternate track data
1E	Illegal access to alternate track
21	Illegal sector address
23	Volume overflow

## 5.6 Type 5 Commands

### COPY COMMAND (HEX A0)

This command transfers the data blocks from the specified source device location to the specified destination device location. The number of data blocks to copy is specified in the number of blocks field (byte 7 - byte 9 is LSB). If the field is zero, 16,777,216 blocks will be copied.

Byte #	7	6	5	4	3	2	1	0
0	1	0	1	OPCODE				
1	LUN/s			LAD 2/s*				
2	LAD 1/s*							
3	LAD 0/s*							
4	LUN/c			LAD 2/d*				
5	LAD 1/d*							
6	LAD 0/d*							
7	# OF BLOCKS 2							
8	# OF BLOCKS 1							
9	# OF BLOCKS 0							
10	0							
11	CONTROL							

"s" = the source device

"d" = the destination device.

\*Refer to Appendix A for Logical Address Computation

NOTE: Lun/s, Lun/d and logical addresses are only applicable to the disk drives.

VALID ERROR CODES

Error Code

Interpretation

HEX

02	No seek complete
03	Write fault
04	Drive not ready
05	Drive not selected
06	No track 0 found
07	Multiple drives selected
09	Disk media changed
10	ECC error in ID field
11	Uncorrectable error in data field
12	No ID address mark found
13	No data address mark found
14	No record found
15	Seek error
17	Write protected
18	Correctable data error
19	Bad track flag set
1C	Unable to read alternate track data
1E	Illegal access to alternate track
21	Illegal sector address
23	Volume overflow

## 5.7 Type 6 Commands

### OPCODE 00

This command is sub divided into two commands. The sub-command opcode is specified in byte 2 of the CDB.

<u>Sub-Opcode</u>	<u>DESCRIPTION</u>
0	Define floppy disk track format
1	Enable/disable double step function

### SUB-OPCODE 00 DEFINE FLOPPY DISK TRACK FORMAT

This command is used for defining the track format of the floppy media to the controller, i.e., sides, density and bytes/sector. If Byte 4 is zero, the number of sectors per track will be as described in Byte 5 in the Track Format Code. If Byte 4 is non-zero, the number of sectors per track will be as specified in byte 4 and override the number of sectors per track as implied in the Track Format Code.

Byte #	7	6	5	4	3	2	1	0
0	1	1	0	0	0	0	0	0
1	0	LUN		Set to 0				
2	Set to 0							
3	Set to 0							
4	Sectors per Track							
5	Track Format Code							

### VALID ERROR CODES

<u>Error Code</u>	<u>Interpretation</u>
<u>HEX</u> 22	Illegal function for drive type

### NOTE:

This command cannot be "Linked" to another command.



### 5.7.1 Track Format Codes 5 1/4 Inch (250 Kbit) (Type 6)

<u>HEX</u>	<u>Description</u>
00	Single density, single sided, FM recording, 128 bytes per sector, 16 sectors per track.
01	Single density, double sided, FM recording, 128 bytes per sector, 16 sectors per track.
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
07	Double density, double sided, Side 0 - Cylinder 0 = FM recording All other tracks = MFM recording 256 bytes per sector, 16 sectors per track.
86	Double density, single sided, MFM recording, 256 bytes per sector, 16 sectors per track.
87	Double density, double sided, MFM recording, 256 bytes per sector, 16 sectors per track.
8A*	Double density, single sided, MFM recording, 512 bytes per sector, 8 sectors per track.
8B*	Double density, double sided, MFM recording, 512 bytes per sector, 8 sectors per track.
8E	Double density, single sided, MFM recording, 1024 bytes per sector, 5 sectors per track.
8F	Double density, double sided, MFM recording, 1024 bytes per sector, 5 sectors per track.

#### NOTE:

If track format information for floppy is not specified after each reset or power-on, the default code will be as follows:

Track format 8A (hex)  
Double density, single-sided;  
512 bytes/sector, 8 sectors/track

\* Also supports 9 sectors per track using byte 4 of the C0 Command

### 5.7.1 Track Format Codes 8 Inch (500 Kbit) (Type 6)

<u>HEX</u>	<u>Description</u>
00	Single density, single sided, FM recording, 128 bytes per sector, 26 sectors per track.
01	Single density, double sided, FM recording, 128 bytes per sector, 26 sectors per track.
06	Double density, single sided Side 0 - Cylinder 0 = FM recording 128 bytes per sector, 26 sectors per track All other tracks = MFM recording 256 bytes per sector, 26 sectors per track
07	Double density, double sided, Side 0 - Cylinder 0 = FM recording 128 bytes per sector, 26 sectors per track All other tracks = MFM recording 256 bytes per sector, 26 sectors per track.
86	Double density, single sided, MFM recording, 256 bytes per sector, 26 sectors per track.
87	Double density, double sided, MFM recording, 256 bytes per sector, 26 sectors per track.
8A*	Double density, single sided, MFM recording, 512 bytes per sector, 15 sectors per track.
8B*	Double density, double sided, MFM recording, 512 bytes per sector, 15 sectors per track.
8E	Double density, single sided, MFM recording, 1024 bytes per sector, 8 sectors per track.
8F	Double density, double sided, MFM recording, 1024 bytes per sector, 8 sectors per track.

#### NOTE:

If track format information for floppy is not specified after each reset or power-on, the default code will be as follows:

Track format 8A (hex)  
Double density, single-sided;  
512 bytes/sector, 8 sectors/track

\* Also supports 16 sectors per track using Byte 4 of the C0 Command.

### 5.7.1 Track Format Codes (Type 6) (continued)

#### SUB-OPCODE 01 ENABLE/DISABLE DOUBLE STEP FUNCTION

This function allows the user to read/write 48 tpi diskettes on a 96 tpi disk drive. Set bit 0 of byte 4 of the CDB to 1 to enable double step function. Reset bit 0 of byte 4 of the CDB to 0 to disable double step function.

Byte #	7	6	5	4	3	2	1	0
0	1	1	0	0	0	0	0	0
1	0   LUN		Set to 0					
2	0	0	0	0	0	0	0	1
3	Set to 0							
4	Enable/Disable Double Step							
5	Set to 0							

#### VALID ERROR CODES

<u>Error Code</u>	<u>Interpretation</u>
<u>HEX</u> 22	Illegal function for drive type

#### NOTE:

Upon power-up or reset the default is "disable double step"

5.7.1 Track Format Codes (Type 6) (continued)

ASSIGN DISK PARAMETERS (HEX C2)

This command allows the host to set up rigid disk variable parameters for the specified LUN. The FIXED, REMOVABLE, or FIXED/REMOVABLE disk drive variables are step pulse width, step period, step mode, maximum head address, maximum cylinder address, reduced write current cylinder address, write precompensation cylinder address and number of sectors per track, thus, different manufacturer's drives can be used for each LUN. There are no valid error codes for this command.

Byte #	7	6	5	4	3	2	1	0
0	1	1	0	0	0	0	1	0
1	0	LUN		0	0	0	0	0
2	Set to 0							
3	Set to 0							
4	Set to 0							
5	Set to 0							

The required fields for this command are: OPCODE and LUN.

Depending on how the jumpers are set up on the controller, 10 bytes of parameters will be collected from the host as Data (C/D deasserted) using two different formats for floppy drives or Winchester drives. (For more information on the proper jumper settings refer to Appendices F through J).

**ASSIGN DISK PARAMETERS (HEX C2) (continued)**

When defining Winchester drive parameters the following 10 bytes of disk parameters are passed as data.

Byte #	7	6	5	4	3	2	1	0
0	Step pulse width							
1	Step period							
2	Step mode							
3	Maximum head address							
4	Max Cylinder addr HI							
5	Max Cylinder addr LO							
6	WSI/Write precompensation cyl							
7	0	0	X	X	0	0	Y	Y
8	Max Sector address							
9	Reserved							

### 5.7.1 Track Format Codes (Type 6) (continued)

#### DEFINITION OF BYTES

##### BYTE 0 - Step Pulse Width

This is the time the STEP signal is asserted in 3.5usec increments.

<u>Parameter Value</u>	<u>Yield</u>
1 - 6	7.0 usec
7 - 13	10.5 usec
14 - 20	14.0 usec
21 - 27	17.5 usec
.	.
.	.
.	.

##### BYTE 1 - Step Period

This byte determines the time between two step pulses. The STEP signal is deasserted between two step pulses.

The range is from 50 usec to 12.8 msec in 50 usec increments.

##### BYTE 2 - Step Mode

This byte defines the type of stepping for which the controller is configured. The following describes the modes supported by the controller.

###### MODE 0 Normal or Buffered Step

This mode generates step pulses using the pulse width and rate specified in Bytes 0 and 1.

###### MODE 4 11 usec Step Period

##### BYTE 3 - Maximum Head Address

This byte specifies the maximum head address on the drive. The controller can address a maximum of 16 heads.

The range is from 0 to 15. (i.e., 1 to 16).

##### BYTE 4-5 Maximum Cylinder Address High and Low Bytes

These two bytes specify the maximum cylinder address on the drive. Byte 5 is the least significant byte.

The range is from 0 to 1023. (i.e., up to 1024 cylinders).

**DEFINITION OF BYTES (continued)**

**BYTE 6 - Reduce Write Current Cylinder/Write Precompensation Cylinder**

This byte specifies the cylinder address where reduce write current and write precompensation are initially applied. Write precompensation is applied to all cylinders greater than or equal to the 10 bit value (byte 6 and bits 0-1 of byte 7). A value of 0 in byte 7 means the reduced write current function is disabled. A 10 bit value of 0 (byte 6 and bits 0-1 of byte 7) means the write precompensation function is disabled.

**NOTE:**

If controller is programmed to interface with drives having more than 8 heads, (i.e., Byte 3 is greater than 7) then Reduce Write Current is not implemented.

**BYTE 7 - Drive Type Identifier**

This byte is defined as follows:

**Bit 7**

Must be set to 0 to indicate parameters are for hard disk.

**Bit 6**

This bit informs the controller to wait for the seek complete after a seek command (Opcode 0B) to the Winchester drive. If the drive is capable of overlap seek, this bit can be set to utilize the function.

1. When bit 6 = 1 then the controller will not wait for the seek complete signal to become asserted after the last step pulse.
2. When bit 6 = 0 then the controller will wait for the Seek Complete Signal to become asserted after the last step pulse.

**NOTE:**

The seek incomplete timeout is set to approximately 3 seconds. That is, any seek must be completed within 3 seconds or the controller will report an error.

**Bit 5 & 4**

These bits notify the controller when the drive is a fixed or removable type of drive.

- 00 = fixed drive
- 01 = reserved
- 10 = removable/fixed
- 11 = removable

DEFINITION OF BYTES (continued)

Bits 3 and 2

Set these bits to zero. These bits are reserved for future use.

Bit 0 & 1

Part of the 10-bit write precompensation value. See description for Byte 6.

Byte 8 - Maximum Sector Address

This byte may be used to override the default sector/track or the last sector/track parameters issued. A zero (0) causes the current value to remain the same. The default value is set up during power up initialization. This number is the count of the sectors per track minus one (1). The default value is set up by the Winchester sector size jumpers.

Byte 9 - Reserved

Set byte 9 to 0. This byte is reserved for future use.

Upon power-on or any reset command the controller defaults to the following parameters for the Winchester drives:

Byte 0	(HEX 0A)	Step pulse width = 10.5 microseconds
Byte 1	(HEX 3C)	Step pulse period = 3.0 milliseconds
Byte 2	(HEX 00)	Buffered step mode
Byte 3	(HEX 03)	Number of heads = 4
Byte 4	(HEX 00)	Maximum cylinder address HI = 0
Byte 5	(HEX 98)	Maximum cylinder address LO = 153
Byte 6	(HEX 80)	Reduced write current = 128
Byte 7	(HEX 00)	Wait for Seek Complete
Byte 8	(HEX 00)	256 bytes/sector @ 33 sectors/track or 512 bytes/sector @ 18 sectors/track or 1024 bytes/sector @ 9 sectors/track as set up by jumper.
Byte 9	(HEX 00)	Reserved



DEFINITION OF BYTES (continued)

DESCRIPTION OF THE PARAMETERS FOR FLOPPY DRIVES

Byte #	7	6	5	4	3	2	1	0
0	Step pulse width							
1	Step interval							
2	Max cylinder addr							
3	Head settling delay							
4	Head select delay							
5	Drive select delay							
6	Write gate delay							
7	1	X	0	0	0	0	0	0
8	Floppy type/write precomp							
9	Start write precomp cylinder							

DEFINITION OF BYTES 0 to 9

BYTE 0 - Step Pulse Width

Doesn't care. Value fixed at 10usec.

BYTE 1 - Step Interval

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 pulse period changes depending on the drive. The data rate is as follows:

- For a 500K bit/sec data transfer rate, the value is in one (1) millisecond increments from one (1) to sixteen (16) milliseconds.
- For a 250K bit/sec data transfer rate, the value is in two (2) millisecond increments from two (2) to thirty-two (32) milliseconds.
- In both cases, zero (0) specifies the maximum step rate.

DEFINITION OF BYTES (continued)

BYTE 2 - Maximum Cylinder Address

The maximum number of cylinders -1.

Byte 3 - Head Settling Delay

This specifies the delay required from the last STEP pulse to valid Read/Write. The range is from 1.0 msec to 256.0 msec in 1.0 msec increments.

BYTE 4 - Head Select Delay

Doesn't care. This value is not analyzed by the controller.

BYTE 5 - Drive Select Delay

Doesn't care. This value is not analyzed by the controller.

BYTE 6 - Write Gate Delay

Doesn't care. This value is not analyzed by the controller.

BYTE 7 - Drive Type Identifier

Set bit 7 to 1 to indicate parameters are for floppy disk.

Set bit 6 to 1 to indicate that Bytes 8 and 9 are to be read. Bits 0 through 5 are not used. Set these bits to 0.

DEFINITION OF BYTES (continued)

BYTE 8 - Floppy Disk Drive (If bit 6 of Byte 7 is set to 1)

Specifies the type of flexible disk.

BIT 7 = 0 for a 250Kbits data rate drive (5 1/4" interface)

BIT 7 = 1 for a 500Kbits data rate drive (5 1/4" interface)

BIT 6 = 1 means that Pin 16 (motor on) shall not be asserted.

Set this bit to 1 when using high capacity Disk Drives (192 TPI) and their pre-formatted diskettes.

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

BIT 0 and 1 specify the amount of write precompensation to be applied to data written at and after the STARTING WRITE PRECOMPENSATION CYLINDER (Byte 9)

WRITE PRECOMPENSATION VALUE

250 KB			500 KB		
bit 0	bit 1		bit 0	bit 1	
0	0	= 0 nSec	0	0	= 0 nSec
0	1	= 125 nSec	0	1	= 62.5 nSec
1	0	= 250 nSec	1	0	= 125 nSec
1	1	= 375 nSec	1	1	= 187.5 nSec

NOTE:

If bit 6 of Byte 7 is set to 0, this byte will set to 01 Hex.

BYTE 9 - Starting Write Precompensation Cylinder (if bit 6 of Byte 7 is set to 1).

This byte specifies the cylinder (-1) where write precompensation will be applied.

NOTE:

If bit 6 of Byte 7 is set to 0, the whole drive will be precompensated.

## DEFINITION OF BYTES (continued)

### DEFAULT PARAMETERS FOR A MINI FLOPPY DRIVE

Upon reset, the controller will default to the parameters of an SA410 drive (1 head, 80 cylinders). This also applicable for the drives that are preassigned as floppy drives on the dipswitch. If the floppy drive (s) used are other than the SA410 Drive, the user should set the parameters for the type of floppy drive being used after every reset or power-on for each floppy LUN.

Byte 0	(N/A)	Pulse Width = value not analyzed.
Byte 1	(HEX 07)	Step Pulse Period = 7.0 milliseconds.
Byte 2	(HEX 4F)	Maximum Cylinder = 80 cylinders.
Byte 3	(HEX 16)	Head Settling Delay = 22 milliseconds.
Byte 4	(N/A)	Head Select Delay = value not analyzed.
Byte 5	(N/A)	Drive Select Delay = value not analyzed.
Byte 6	(N/A)	Write Gate Delay = value not analyzed.
Byte 7	(HEX 80)	Drive type = Floppy drive.
Byte 8	(HEX 00)	Floppy Disk Drive Type = 5 1/4" interface.
Byte 9	(HEX 00)	Starting precompensation.

## 5.8 MAINTENANCE AND TROUBLESHOOTING

### 5.8 Overview

Two maintenance and troubleshooting aids are provided with the Controller: Sense Byte Error Codes and Class Code 7 Commands.

The Sense Byte Error Codes (given in Section 6) are provided with the Class Code 0 OpCode 03 (Request Sense Bytes) Command. The Sense Byte Error Codes, described in Section 5.4.1, define an error as:

- Type 0 - Drive Related
- Type 1 - Controller Related
- Type 2 - Command Related
- Type 3 - Miscellaneous

This section describes the Class Code 7 commands.

#### 5.8.1 Class Code 7 Commands

Class Code 7 commands are diagnostic commands that are issued with a standard Command Descriptor Block (CDB). The valid CDB for each OpCode is shown in this section. See Sections 5 of this manual for additional information on CDB's and commands.

#### RAM DIAGNOSTIC (HEX E0)

This command writes the sector buffer with a data pattern, reads it, and compares it byte by byte. The check is performed with the data patterns 00, FF, AA and 55.

Byte #	7	6	5	4	3	2	1	0
0	1	1	1	0	0	0	0	0
1	Set to 0							
2	Set to 0							
3	Set to 0							
4	Set to 0							
5	Control							

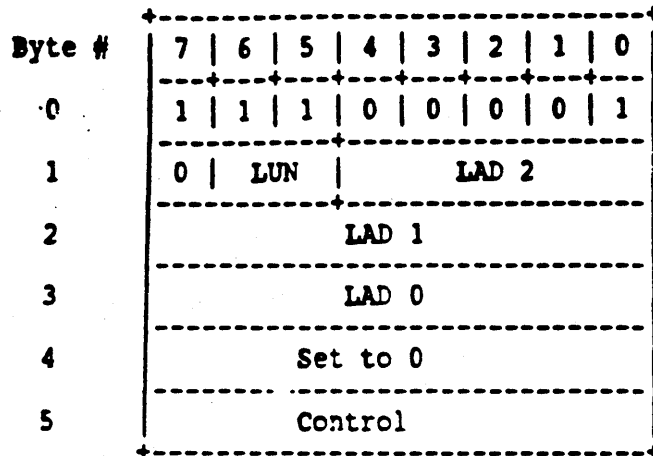
#### VALID ERROR CODES

<u>Error Code</u>	<u>Interpretation</u>
<u>HEX</u> 30	RAM error

### 5.8.1 Type 7 Commands (continued)

#### WRITE ECC (HEX E1) (not valid for floppy)

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



#### VALID ERROR CODES

<u>Error Code</u>	<u>Interpretation</u>
<u>HEX</u>	
02	No seek complete
03	Write fault
04	Drive not ready
05	Drive not selected
06	No track 0 found
07	Multiple drives selected
09	Disk media changed
10	ECC error in ID field
12	No ID address mark found
14	No record found
15	Seek error
17	Write protected
19	Bad track flag set
1C	Unable to read alternate track data
1E	Illegal access to alternate track
21	Illegal sector address
22	Illegal function for drive type
23	Volume overflow

5.8.1 Type 7 Commands (continued)

**READ ID (HEX E2)**

The ID field of the sector specified by the logical sector address is transferred to the host. Only one (1) sector is processed. The data length will be 4 bytes. If this command is issued to a flexible disk drive the HIGH CYLINDER byte will always contain a zero (0) and the PHYSICAL SECTOR byte will contain the number of the first sector found on the track.

Byte #	7	6	5	4	3	2	1	0
0	1	1	1	0	0	0	1	0
1	0	LUN		LAD 2				
2	LAD 1							
3	LAD 0							
4	Not used							
5	Control							

The ID bytes are returned in the following format:

Byte #	7	6	5	4	3	2	1	0
0	MSB cylinder							
1	LSB cylinder							
2	Flags/Head							
3	Sector							

5.8.1 Type 7 Commands (continued)

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

VALID ERROR CODES

<u>Error Code</u>	<u>Interpretation</u>
<u>HEX</u>	
02	No seek complete
04	Drive not ready
05	Drive not selected
06	No track 0 found
07	Multiple drives selected
10	ECC error in ID field
12	No ID address mark found
14	No record found
15	Seek error
1C	Unable to read alternate track data
21	Illegal sector address



5.8.1 Type 7 Commands (continued)

**DRIVE DIAGNOSTIC (HEX E3) NOT CURRENTLY SUPPORTED**

This command performs a diagnostic on the specified LUN. It reads sector 0 on the tracks sequentially and then reads sector 0 on 256 random tracks.

Byte #	7	6	5	4	3	2	1	0
0	1	1	1	0	0	0	1	1
1	0	LUN		Set to 0				
2	Set to 0							
3	Set to 0							
4	Set to 0							
5	Set to 0							LNK

**VALID ERROR CODES**

<u>Error Code</u>	<u>Interpretation</u>
<u>HEX</u>	
02	No seek complete
04	Drive not ready
05	Drive not selected
06	No track 0 found
07	Multiple drives selected
10	ECC error in ID field
12	No ID address mark found
14	No record found
15	Seek error
1C	Unable to read alternate track data

5.8.1 Type 7 Commands (continued)

REQUEST LOGOUT (HEX E6)

This command is used to retrieve four bytes of log for the specified LUN.

Byte #	7	6	5	4	3	2	1	0
0	1	1	1	0	0	1	1	0
1	0	LUN		Set to 0				
2	Set to 0							
3	Set to 0							
4	Set to 0							
5	Set to 0							LNK

The log transferred to the host as Data using the following format:

Byte #	7	6	5	4	3	2	1	0
0	Retry count high							
1	Retry count low							
2	Permanent error high							
3	Permanent error low							

The following errors get accumulated in the error log:

1. Uncorrectable error in data field.
2. No ID address mark
3. No data address mark.
4. Seek error
5. Record not found
6. Correctable data error.
7. ID read error.

### 5.8.1 Type 7 Commands (continued)

#### READ ECC (HEX EA)

This command reads a block of data from the disk without detecting /correcting ECC errors. It transfers the data and four (4) bytes of ECC to the host in order to verify the ECC logic of the controller.

Byte #	7	6	5	4	3	2	1	0
0	1	1	1	0	1	0	1	0
1	LUN			LAD 2				
2	LAD 1							
3	LAD 0							
4	Set to 0							
5	Control							

The required fields for this command are: OPCODE, LUN LAD and CONTROL. This sector count is forced to one (1) internally. The error codes are the same as READ except data ECC errors are not reported.

#### READ DATA BUFFER (HEX EC)

This command transfers the specified number of blocks from the controller data buffer to the host. A value of zero (0) for the number of blocks defaults to one (1). The LUN can be any number since no device participates. The number of bytes returned is determined by the sector size of the specified LUN. The host can use this command following a WRITE DATA BUFFER command to verify READ/WRITE sequences without drive participation or, on a permanent ECC error in the data field, to obtain the bad record. There are no valid error codes for this command.

Byte #	7	6	5	4	3	2	1	0
0	1	1	1	0	1	1	0	0
1	0	LUN		Not used				
2	Not used							
3	Not used							
4	# of Blocks							
5	Control							

### 5.8.1 Type 7 Commands (continued)

#### WRITE DATA BUFFER (HEX EF)

This command causes the specified number of data blocks to be written from the host to the controller data buffer. A value of zero (0) for the number of blocks defaults to one (1). The LUN can be any number since no device participates. The number of bytes written is determined by the sector size of the specified LUN. The host can use this command preceding a READ BUFFER command to verify a READ/WRITE sequence without device participation. There are no valid error codes for this command.

Byte #	7	6	5	4	3	2	1	0
0	1	1	1	0	1	1	1	1
1	0	LUN		Not used				
2	Not used							
3	Not used							
4	# of Blocks							
5	Control							

## 6.0 ERROR CODE DESCRIPTIONS

These error code descriptions are related to Byte 0 of the Sense Block after the Request Sense command (Class 0, Opcode 03).

### Type 0 (Drive) Error Codes

0	No error status.
1	No Index signal.
2	No Seek Complete. (approximately 1 sec)
3	Write fault.
4	Drive not ready.
5	Drive not selected.
6	No Track 00.
7	Multiple Winchester drives selected.
9	Cartridge changed
D	Seek in progress.

### Type 1 (Controller) Error Codes

0	Tape exception. (Tape Only)
1	Uncorrectable data error during a read.
2	ID Address Mark not found.
3	Data Address Mark not found.
4	Record not found. Found correct cylinder and head but not sector.
5	Seek error. R/W head positioned on a wrong cylinder and/or selected a wrong head.
7	Write protected.
8	Correctable data field error.
9	Bad block found.
A	Format Error. The controller detected that during the Check Track command, the format on the drive was not expected.
C	Unable to read the Alternate Track address. The address of the alternate track cannot be read correctly with no ECC error.
E	Attempted to directly access an alternate track.
F	Tape drive failure. (Tape Only)

### Type 2 (Command) Error codes

0	Invalid Command received from the host.
1	Illegal disk address. Address is beyond the maximum address.
2	Illegal function for the current drive type.
3	Volume overflow. Maximum sector address was passed during a multiple sector read or write.

### Type 3 (Misc) Error codes

0	Ram error or power up self test error.
1	FDC 765 error (520DB and 540DB models only)

## 7.0 INSTALLATION AND GENERAL INFORMATION

### Introduction

The following Appendices contain general information, jumper settings and board outlines for the DTC 500DB Series Controllers.

### Mounting

There are no special mounting requirements. The Appendices for the board outlines provide the location of the mounting holes. To facilitate mounting the controller on the drives, the mounting holes provided are compatible to those used with industry standard 5.25" drives.

Up to eight (8) controllers can be easily daisy chained on the SASI bus. Only the controller that is physically at the end of the daisy chain should have the terminator resistors installed.

The temperature specifications given in Section 2 must be maintained to ensure reliability standards.

## APPENDIX A LOGICAL ADDRESS

### A.1 Overview

Logical Address is an accumulation of the number of Sectors, for each head, at each cylinder.

For example:

If the drive (designated by the LUN) has 16 Sectors per track (0 through 15) and 2 heads (0 and 1).

Cylinder 0, Head 0 would contain Logical Address 000 through 015, and Head 1 would contain Logical Address 016 through 031.

Cylinder 1, Head 0 would contain Logical Address 032 through 047, and Head 1 would contain Logical Address 048 through 063, etc. The highest possible Logical Address is assigned to the 16th Sector of Head 1, at the maximum allowable Cylinder Address.

The Logical Address concept is an attempt to enable software to be written which is device independent. This is accomplished by using the selected drive's parameters (such as the highest possible cylinder address, number of sectors per track) when calculating the Logical Address.

When the selected drive is changed (a new LUN) the parameters can be changed if required. The formula (used to calculate the Logical Address) determines the new Logical Addresses assigned to each Sector within the drive.

### A.2 Calculation of Logical Address

Each Logical Address is calculated by multiplying the cylinder address, by the number of heads per cylinder, then multiplying this result by the number of sectors per track, and then adding this result. The results obtained by multiplying the number of sectors by the head address; to this value the sector address is added.

The formula for this calculation is:

$$LA = (C)(h)(s) + (H)(s) + (S)$$

Where LA = Logical Address  
C = Cylinder Address  
h = Number of heads per cylinder  
s = Number of sectors per track  
H = Head Address  
S = Sector Address

## A.2 Calculation of Logical Address (continued)

With this formula a unique Logical Address for each Sector on any drive can be established.

For example:

Assume LUN 0 is a drive with a maximum Cylinder Address of 256 (0 to 255) that has 4 heads per cylinder (head addresses of 0 to 3), and 33 sectors per track (sector addresses of 0 to 32). The highest Logical Address for this drive would be calculated as follows:

$$( (255) (4) (33) ) + ( (3) (33) ) + 32 = \text{Logical Address}$$

or

$$33,660 + 99 + 32 = 33,791$$

which is the highest Logical Address for this drive.

Another way to visualize the formula is to recognize that the Logical Address is being incremented by a value of 1 each sector during a format of the drive.

In the above example, each head at cylinder 0 would advance the Logical Address by 33, and the Logical Address, at cylinder 0, Sector Address 32 (the 33rd sector), Head 3 (the 4th head) would be 131 (4 times 33 less 1 because of starting at 0).

Each cylinder increment would advance the Logical Address an equivalent amount (132) and since there are 256 cylinders the largest Logical Address is  $132 \times 256 = 33,792 - 1$  (because of 0) or 33,791.



### A.3 Determining Cylinder Addresses

One method of determining the cylinder address from the Logical Address is to divide the Logical Address value by the result obtained by multiplying the number heads per cylinder by the number of sectors per track.

The results of this calculation will be a whole number and a fraction. The whole number is the Cylinder Address, the fraction is explained below.

$$(LA / h \times s) = \text{Cylinder Address and fraction}$$

Where LA = Logical Address

h = heads per cylinder

s = sectors per track

/ = indicates divide and x indicates multiply

The fraction is a function of the number of heads. In our example (with 4 heads):

A fraction between .001 and .250 indicates head 0, .251 to .500 indicates head 1, .501 to .750 indicates head 2, and .751 to .999 indicates head 3.

If we had chosen an example using 2 heads, a value of .50 or less would indicate head 0 and a value of .51 or greater would indicate head 1.



## APPENDIX C

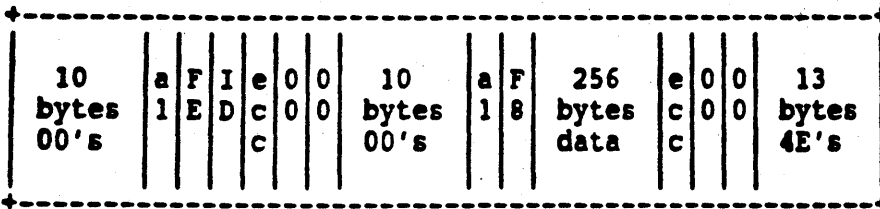
### SECTOR FORMATS

#### C.1 Winchester Drive Sector Formats

The DTC 500DB Series Controller has the option of five different types of Winchester drive formats. The formats are as follows:

256 bytes/sector @ 32 sectors/track  
 256 bytes/sector @ 33 sectors/track  
 512 bytes/sector @ 17 sectors/track  
 512 bytes/sector @ 18 sectors/track  
 1024 bytes/sector @ 9 sectors/track

The track layout for the 256 bytes/sector @ 32 sectors/track is shown below:



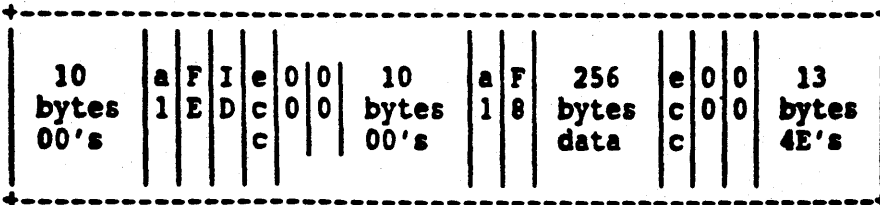
a1, FE, 00, F8 = 1 byte  
 ecc = 4 bytes, ID = 4 bytes  
 Track Capacity = 10416

11 = Index Gap (4E)  
 10048 = 32 sectors @ 309 bytes/sector  
 517 = Speed Tolerance

-----  
10416

This track format provides (+ or -) 4.96% speed tolerance.

The track layout for the 256 bytes/sector, 33 sectors/track is shown below:



a1, FE, 00, F8 = 1 byte  
 ecc = 4 bytes, ID = 4 bytes  
 Track Capacity = 10416

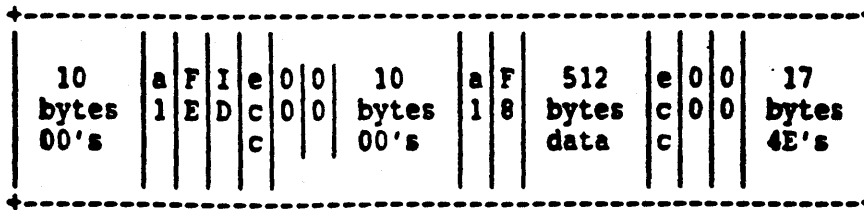
11 = Index Gap (4E)  
 10197 = 33 sectors @ 309 bytes/sector  
 208 = Speed Tolerance

-----  
10416

This track format provides (+ or -) 2.00% speed tolerance.

C.1 Winchester Drive Sector Formats (continued)

The track layout for the 512 bytes/sector, 17 sectors/track is shown below:

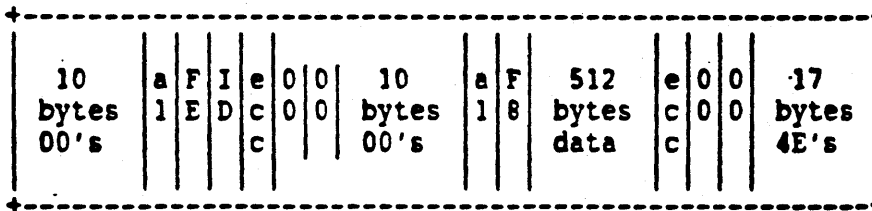


a1, FE, 00, F8 = 1 byte  
 ecc = 4 bytes, ID = 4 bytes  
 Track Capacity = 10416

11 = Index Gap (4E)  
 9673 = 17 sectors @ 569 bytes/sector  
 732 = Speed Tolerance  
 -----  
 10416

This track format provides (+ or -) 7.02% speed tolerance.

The track layout for the 512 bytes/sector, 18 sectors/track is shown below:



a1, FE, 00, F8 = 1 byte  
 ecc = 4 bytes, ID = 4 bytes  
 Track Capacity = 10416

11 = Index Gap (4E)  
 10242 = 18 sectors @ 569 bytes/sector  
 163 = Speed Tolerance  
 -----  
 10416

This track format provides (+ or -) 1.56% speed tolerance.



## APPENDIX D

### ALTERNATE TRACK USAGE WITH DTC CONTROLLERS

Alternate Tracks are used to replace the bad tracks found during system initialization so that the Host system will have a continuous range of disk memory with no defects. The preferred scheme is to place all the alternate tracks at the top of the disk memory, (i.e., the inner track), so that the Host system can simply map out these tracks and reduce the maximum logical address that the Host system is allowed to access on the disk. Following this scheme, a sample procedure for assigning alternate tracks might be as follows:

1. Initialize Controller with the appropriate drive characteristics. (All cylinders and heads must be specified).
2. Format the entire drive and verify the disk.
3. Assign an alternate for each defective track making sure that no two defective tracks are assigned to the same alternate.
4. Consider assigning alternates for tracks on the drive manufacturer's list of defects.
5. Accumulate the number of tracks taken by the alternates and map them out from the range of disk memory which the Host system is allowed to access on the disk (i.e., if the top two tracks are used for alternates, the maximum track address that the system should access directly is two less than the amount specified in the Define Drive Parameter Command).
6. Repeat steps 1 through 5 if more than one Winchester drive is to be implemented.

Future accesses to those defective tracks will result in accessing the corresponding alternates and will be transparent to the Host system.

## APPENDIX E

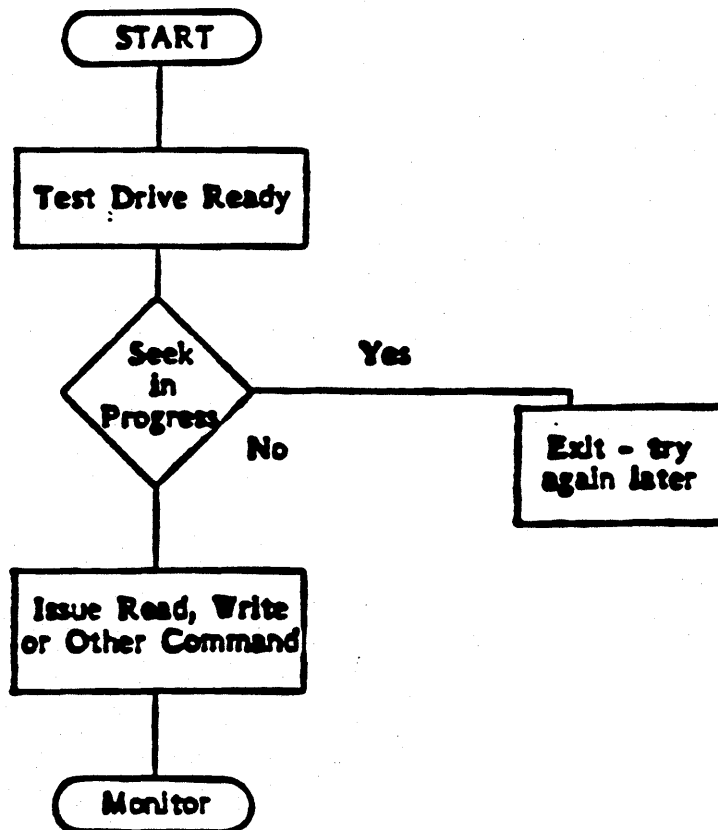
### IMPLEMENTING OVERLAPPED SEEKS ON DTC DISK CONTROLLERS

For Winchester drives capable of performing overlapped seeks, the overlap function can be utilized by setting a bit in the drive parameters while issuing the Class 6 OpCode 2 command. When the DTC disk Controller receives a seek command it issues the required step pulses which the drive buffers. The Controller then checks a bit in the internal drive characteristic table and if the overlapped function is allowed, it returns the completion status to the Host without waiting for the seek complete condition from the drive.

A typical implementation of this function might be where the Host issues an overlapped seek to drive "A" and while the drive is seeking, the Host could perform other tasks which includes servicing or initiating yet another task on other drives.

If Test Drive Ready command is received for the drive while the drive is still seeking, the Controller will respond with an error Type 0 Code D, seek in progress. The Host can decide to perform some other task or keep issuing the command until a normal termination is received, signifying a successful completion of the command.

This mode cannot be used on drives like the ST506 that cannot support overlap seek operation. The Controller will deselect the drive after the step pulses have been sent to the drive.



## APPENDIX F JUMPER CONFIGURATIONS FOR 510DB

The 500DB Series Controllers allow the user to jumper select various controller functions. These functions are:

### W0 - CONTROLLER ADDRESS

- \* 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 shorted = enabled.
- Pins 2 - 3 shorted = disabled.

### W3 and W4 - WINCHESTER DISK SECTOR SIZE

W3	W4	Bytes per Sector
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, W6, W7 and W8 - LUN assignment. Not analyzed on 510DB. Winchester drives can be assigned as logical units 0 and 1 only.

LUN	JUMPER	OPEN	SHORTED
0	W5	*Winchester	not used
1	W6	*Winchester	not used
2	W7	not used	not used
3	W8	not used	not used

### W31 - OPTIONAL RESET - For Internal Use Only

- \* Open : This jumper should not be in place.

See Figure F-1 for DTC-510DB Jumper locations.

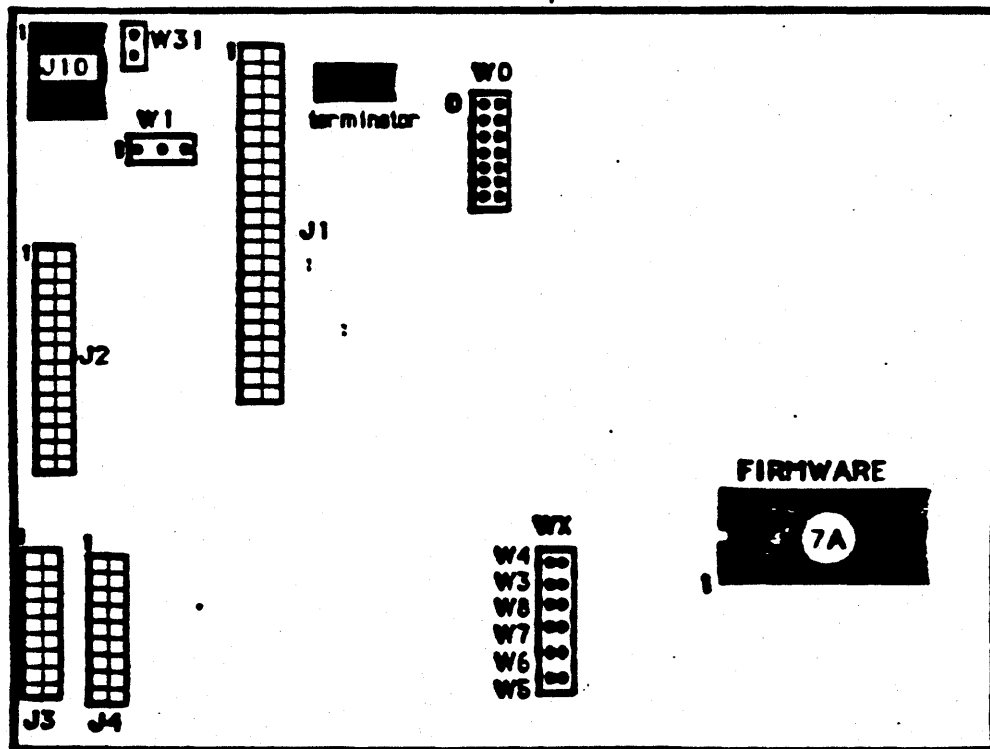
\* As shipped



**Figure F-1 DTC-510DB Cable Connectors**

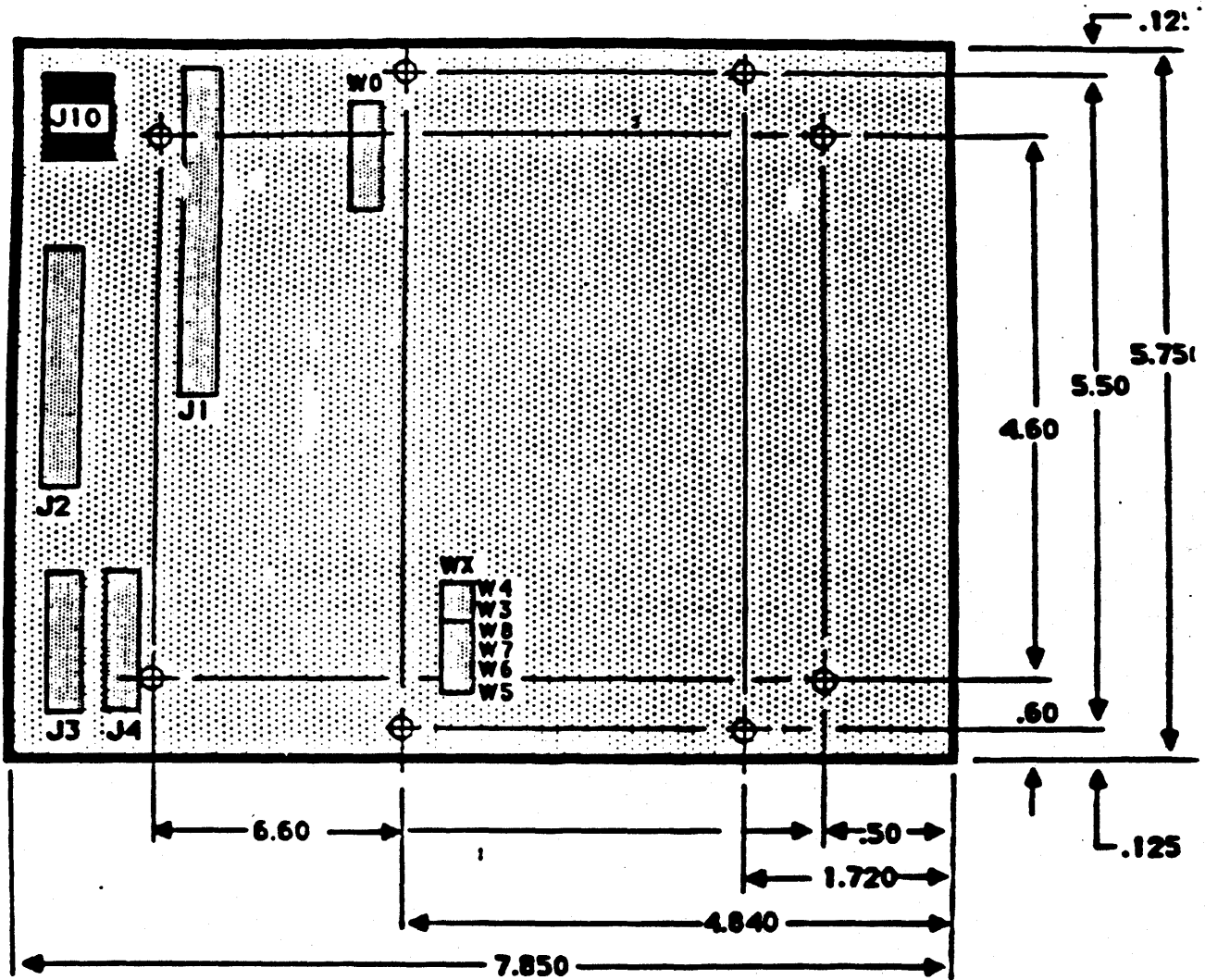
- J1 - 50 pin connector:** Connects the Host to the Controller.  
See Figure F-1 for pin designations.
- J2 - 34 pin connector:** Connects Winchester Drive's Control Interface to the Controller.  
See Figure F-1 for pin designations.
- J3,J4 - 20 pin connector:** Connects Winchester Drive's Data Interface to Controller.  
See Figure F-1 for pin designations.
- J10 - 4 pin connector:** AMP - 1-48042-1 for connector,  
AMP- 350078-4 for pins (or equivalent),  
connects D.C. Power to Controller.  
Pin assignment is shown below:

- Pin 1 - No connection
- Pin 2 - Ground
- Pin 3 - Ground
- Pin 4 - +5 vDC, 2.6 Amps



not drawn to scale

**Figure F-1**



ALL DIMENSIONS ARE INCHES

NOT DRAWN TO SCALE

Figure F-2 DTC 510DB Board Dimensions with Mounting Holes

## APPENDIX G JUMPER CONFIGURATIONS FOR 520DB

The 500DB Series Controllers allow the user to jumper select various controller functions. These functions are:

### W0 - CONTROLLER ADDRESS

* 0	shorted ID = 0	4	shorted ID = 4
1	shorted ID = 1	5	shorted ID = 5
2	shorted ID = 2	6	shorted ID = 6
3	shorted ID = 3	7	shorted ID = 7

### W1 - HOST PARITY

\* Pins 1-2 shorted = enabled, Pins 2-3 shorted = disabled

W2 = Not On Board

### W3 and W4 Winchester Disk Sector Size

W3	W4	Bytes per Sector
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, W6, W7, W8 = LUN assignment. These jumpers are used to select the default LUN assignment for Winchester and flexible drives.

LUN	JUMPER	OPEN	SHORTED
0	W5	*Winchester	Flexible
1	W6	Winchester	*Flexible
2	W7	not used	Flexible
3	W8	not used	Flexible

W12, W13 = Not On Board.

W14 = Motor On Override.

SHORTED: The Motor On signal will always be asserted. This overrides bit 6 of byte 08 in the ASSIGN FLEXIBLE DISK PARAMETERS command.

\*OPEN: The Motor On signal is asserted or deasserted according to bit 6 of byte 08 in the ASSIGN FLEXIBLE DISK PARAMETERS command.

W15 = Ready Override.

SHORTED: The flexible drive is considered to always be ready.

\*OPEN: This jumper should not be in place for 250 kb flexible drives.

W31 - OPTIONAL RESET - \* Open : This jumper should not be in place.

W32 - FLOPPY CLOCK - \* Pins 1-2 must be shorted for 520DB.

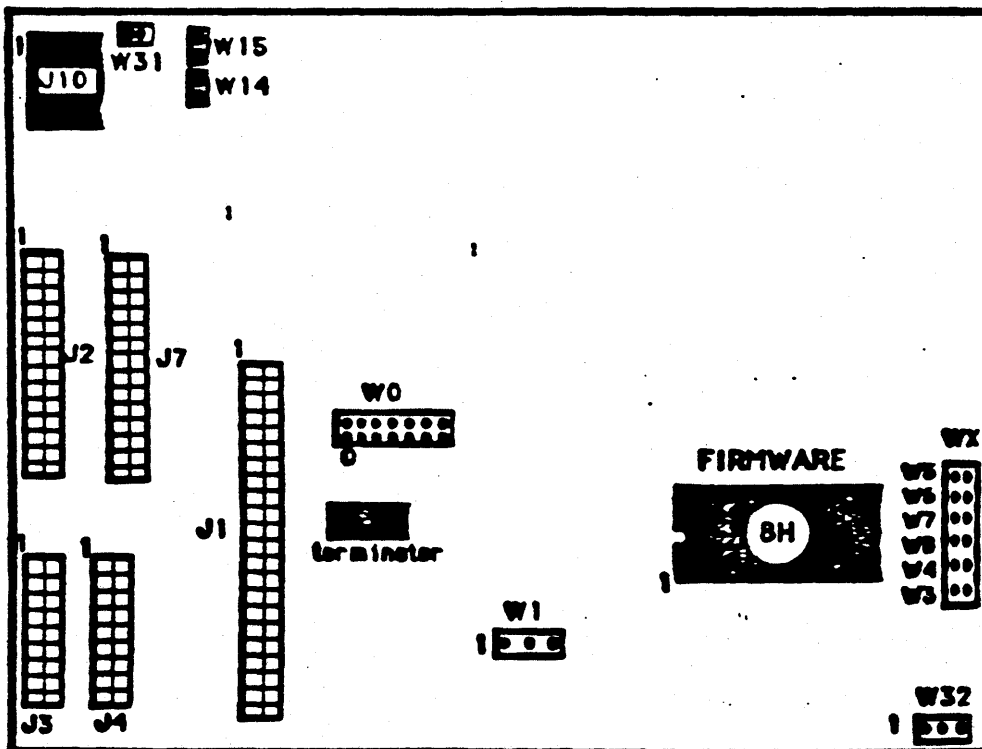
See Figure G-1 for DTC-520DB Jumper locations.

\* As shipped

Figure G-1 DTC-520DB Cable Connectors

- J1 - 50 pin connector: Connects the Host to the Controller.  
See Figure G-1 for pin designations.
- J2 - 34 pin connector: Connects Winchester Drive's Control Interface to the Controller.  
See Figure G-1 for pin designations.
- J3, J4 - 20 pin connector: Connects Winchester Drive's Data Interface to Controller.  
See Figure XXX for pin designations.
- J7 - 34 pin connector: Connects floppy drives to the Controller  
See Figure G-1 for pin designations.
- J10 - 4 pin connector: AMP - 1-48042-1 for connector, AMP- 350078-4 for pins (or equivalent), connects D.C. Power to Controller.  
Pin assignment is as shown below:

- Pin 1 - No connection  
Pin 2 - Ground  
Pin 3 - Ground  
Pin 4 - +5 vDC, 2.6 Amps



not to scale

Figure G-1

**APPENDIX H JUMPER CONFIGURATIONS FOR 530DB**

The 500DB Series Controllers allow the user to jumper select various controller functions. These functions are:

**W0 - CONTROLLER ADDRESS**

- \* 0 shorted ID = 0      4 shorted ID = 4
- 1 shorted ID = 1      5 shorted ID = 5
- 2 shorted ID = 2      6 shorted ID = 6
- 3 shorted ID = 3      7 shorted ID = 7

**W1 - HOST PARITY**

- \* Pins 1 - 2 jumpered = enabled.
- Pins 2 - 3 jumpered = disabled.

**W2 - QIC-02 PARITY**

- \* Pins 1 and 2 shorted = parity enabled.
- Pins 2 and 3 shorted = parity disabled.

**W3 and W4 - Winchester Disk Sector Size**

W3	W4	Bytes per Sector
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, W6, W7, W8 - LUN assignment W5, W6, W7 and W8 is used to jumper select the default LUN assignment for Winchester and Tape Drive.

LUN	JUMPER	OPEN	SHORTED
0	W5	*Winchester	not used
1	W6	*Winchester	not used
2	W7	not used	not used
3	W8	*Tape	not used

**NOTE:**

Tape is always LUN 3.

W12, W13, W14, W15 - Not On Board.

W31 - OPTIONAL RESET - For Internal Use Only

- \* Open : This jumper should not be in place.

W32 - FLOPPY CLOCK - \* Pins 2-3 must be shorted for 530DB.

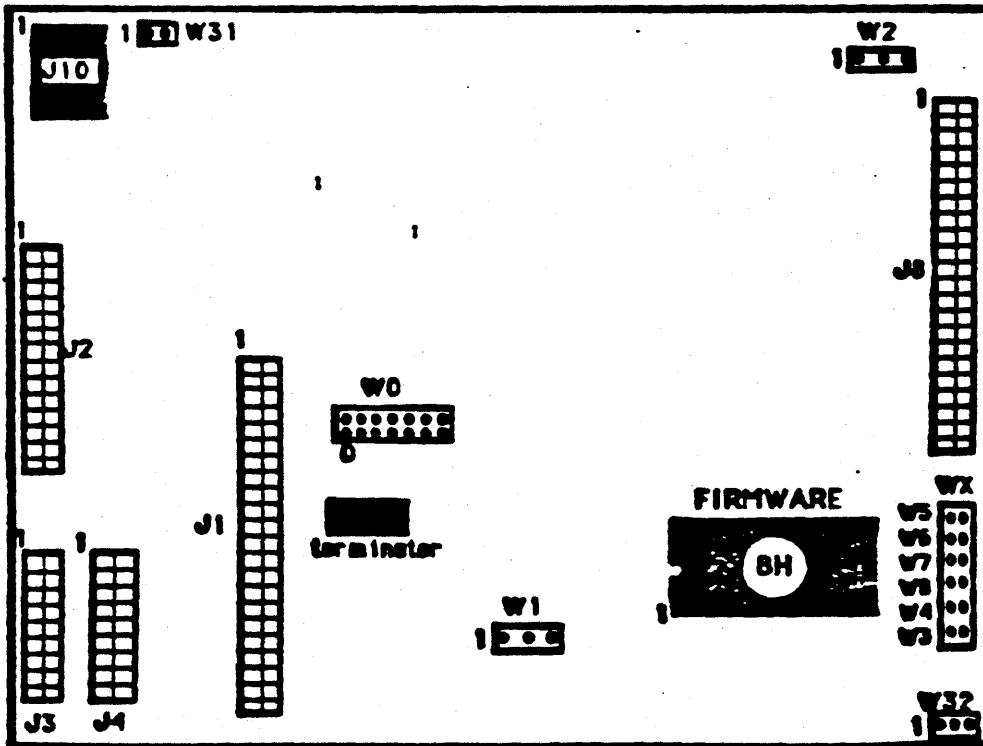
See Figure H-1 for DTC-530DB Jumper locations.

\* As shipped

Figure H-1 DTC-530DB Cable Connectors

- J1 - 50 pin connector: Connects the Host to the Controller.  
See Figure H-1 for pin designations.
- J2 - 34 pin connector: Connects Winchester Drive's Control Interface to the Controller.  
See Figure H-1 for pin designations.
- J3,J4 - 20 pin connector: Connects Winchester Drive's Data Interface to Controller.  
See Figure H-1 for pin designations.
- J8 - 50 pin connector: Connects the Host to the QIC-02 Interface Streaming Tape Drive. See Figure H-1 for pin designations.
- J10 - 4 pin connector: AMP - 1-48042-1 for connector, AMP- 350078-4 for pins (or equivalent), connects D.C. Power to Controller. Pin assignment is as shown below:

- Pin 1 - No connection  
Pin 2 - Ground  
Pin 3 - Ground  
Pin 4 - +5 vDC, 2.6 Amps



not to scale

Figure H-1

**APPENDIX J JUMPER CONFIGURATIONS FOR 540DB**

The 500DB Series Controllers allow the user to jumper select various controller functions. These functions are:

**W0 - CONTROLLER ADDRESS**

- \* 0 shorted ID = 0      4 shorted ID = 4
- 1 shorted ID = 1      5 shorted ID = 5
- 2 shorted ID = 2      6 shorted ID = 6
- 3 shorted ID = 3      7 shorted ID = 7

**W1 - HOST PARITY**

- \* Pins 1-2 shorted = enabled      Pins 2-3 shorted = disabled

**W2 - QIC-02 PARITY**

- \*Pins 1-2 shorted = enabled.      Pins 2-3 shorted = disabled.

**W3 and W4 - Winchester Disk Sector Size**

W3	W4	Bytes per Sector
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, W6, W7, W8 = LUN assignment. These jumpers are used to select the default LUN assignment for Winchester and flexible drives.

LUN	JUMPER	OPEN	SHORTED	
0	W5	*Winchester	Flexible	
1	W6	Winchester	*Flexible	
2	W7	not used	Flexible	
3	W8	*Tape	Flexible	Tape is always LUN 3.

W12, W13 = Not On Board.

W14 = Motor On Override.

SHORTED: The Motor On signal will always be asserted. This overrides bit 6 of byte 08 in the ASSIGN FLEXIBLE DISK PARAMETERS command.

\* OPEN: The Motor On signal is asserted or deasserted according to bit 6 of byte 08 in the ASSIGN FLEXIBLE DISK PARAMETERS command.

W15 = Ready Override.

SHORTED: The flexible drive is considered to always be ready.

\*OPEN: This jumper should not be in place for 250 kb flexible drives.

W31 - OPTIONAL RESET - \* Open : This jumper should not be in place.

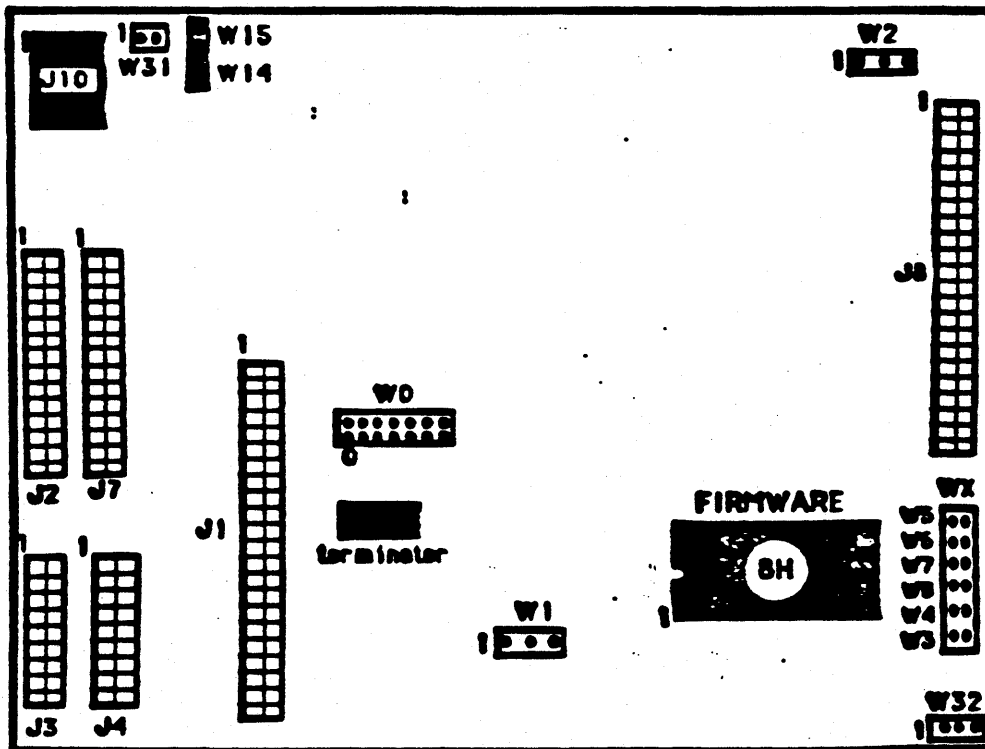
W32 - FLOPPY CLOCK - \* Pins 1-2 must be shorted for 540DB.

\* As shipped.      See Figure J-1 for DTC-540DB Jumper Locations

Figure J-1 DTC-540DB Cable Connectors

- J1 - 50 pin connector: Connects the Host to the Controller. See Figure J-1 for pin designations.
- J2 - 34 pin connector: Connects Winchester Drive's Control Interface to the Controller. See Figure J-1 for pin designations.
- J3,J4 - 20 pin connector: Connects Winchester Drive's Data Interface to Controller. See Figure J-1 for pin designations.
- J7 - 34 pin connector: Connects floppy drives to the Controller See Figure J-1 for pin designations.
- J8 - 50 pin connector: Connects the Host to the QIC-02 Interface Streaming Tape Drive. See Figure J-1 for pin designations.
- J10 - 4 pin connector: AMP - 1-48042-1 for connector, AMP- 350078-4 for pins (or equivalent), connects D.C. Power to Controller. Pin assignment is as shown below:

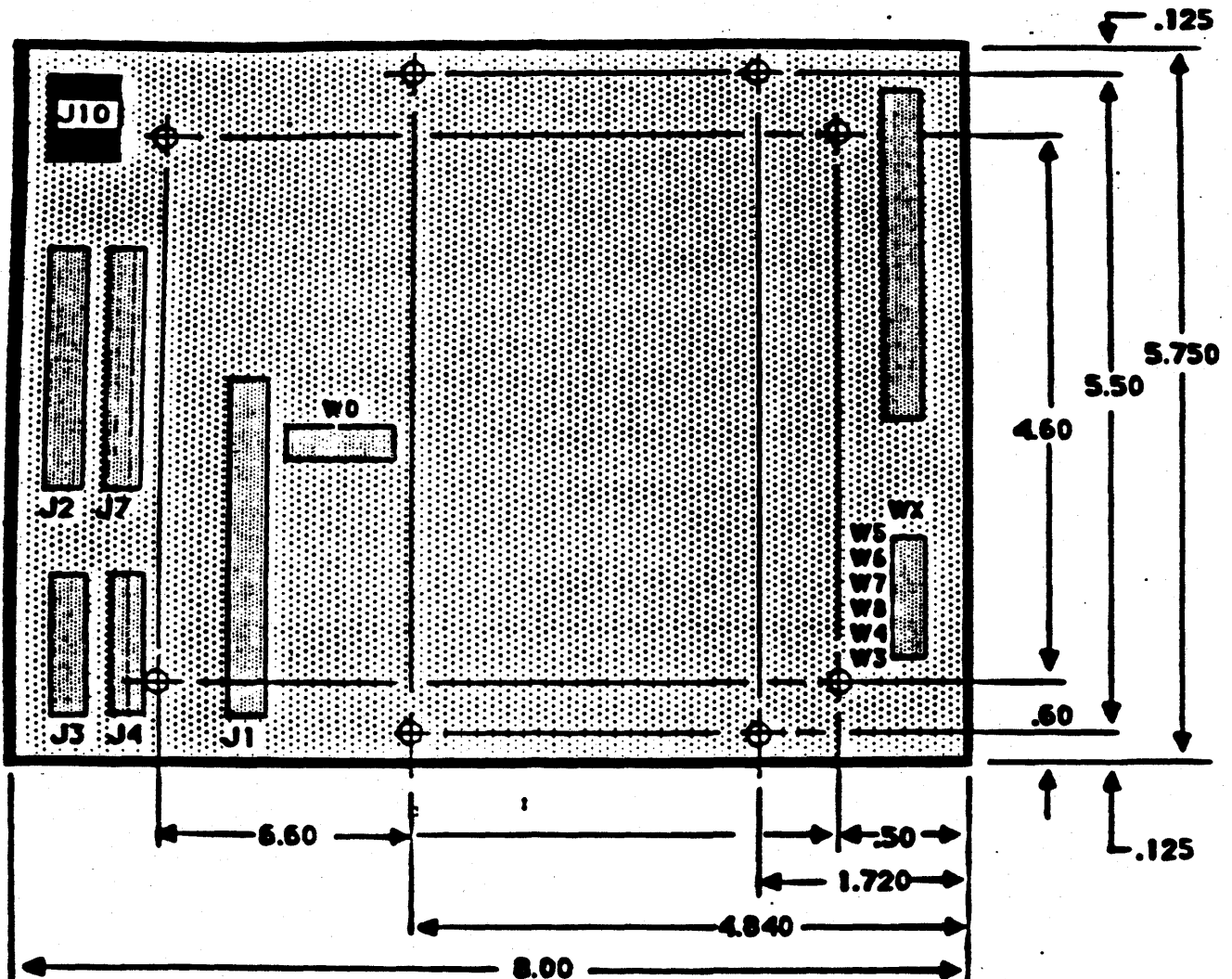
- Pin 1 - No connection
- Pin 2 - Ground
- Pin 3 - Ground
- Pin 4 - +5 VDC, 2.6 Amps

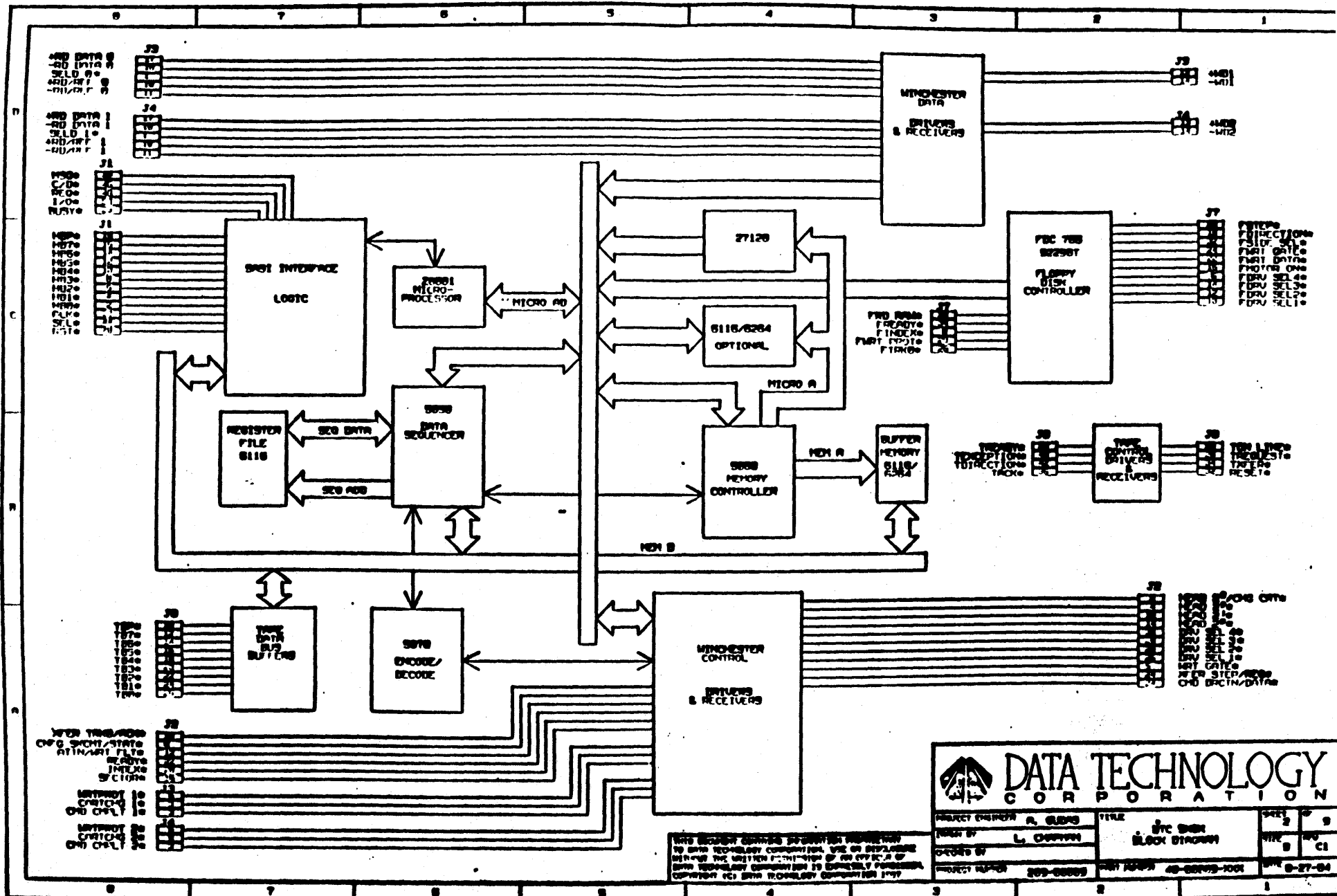


not to scale

Figure J-1







**DATA TECHNOLOGY CORPORATION**

PROJECT ENGINEER	A. GLENN	TITLE	SPC DRAW	DATE	2	9
DESIGNED BY	L. OSWALD		BLOCK DIAGRAM	REV	0	1
DRAWN BY				NO	B	CI
PROJECT NUMBER	209-00009	REV NUMBER	48-00009-1001	DATE	8-27-84	

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APPENDIX K 500DB SERIES COMMAND SET SUMMARY

COMMAND	OPCODE (HEX)
<u>TYPE 0</u>	
Test Unit Ready	00
Recalibrate	01
Rewind	01
Request Sense	03
Format Unit	04
Check Track Format	05
Format Track	06
Format Bad Track	07
Read	08
Read Tape Blocks	08
Write	0A
Write Tape Blocks	0A
Seek	0B
Assign Alternate Track	0E
Write File Mark	10
Space Forward	11
Erase	19
<u>TYPE 1</u>	
Copy	20
Backup	22
Restore	23
Backup with Header	24
Restore Continue	26
<u>TYPE 2</u>	
Retension Tape	44
Verify Tape	45
Read Tape Sense	46
Write Header	48
Read Header	49
Write Blocks	4A
Read Blocks	4B
<u>TYPE 5 &amp; 6</u>	
Copy	A0
Define FDD Format	C0
Assign Disk Parameters	C2
<u>TYPE 7</u>	
Ram Diagnostics	E0
Write ECC	E1
Read ID	E2
Drive Diagnostic	E3
Request Logout	E6
Read ECC	EA
Read Data Buffer	EC
Write Data Buffer	EF

Revision Record

ECO #	Rev	Date	Description
0567	00	11-12-85	Updates by J.L.
	A	1-8-86	Initial release 500DB Spec includes Tape
		3-30-86	pp.25, 30, 58, 74, 89, and 93
0567	A	1-8-86	Tape Support Update to rev A
	A	3-30-86	Update pp.25