REVISIONS

SYM	DESCRIPTION	BY	DATE	APPROVED
A	PILOT RELEASE	MWJ	8/24/81	
B	CORRECTIONS	MWJ	1/28/82	
C	REVISION	JR	8/16/82	

NOTES UNLESS SPECIFIED

1 TOLERANCES
.XX ANGULAR
.XXX 0°30'
2 REMOVE ALL BURRS
3 BREAK ALL SHARP EDGES
.010 APPROX.
4 MACH SURFACES 125 OR BETTER
5 DIM ARE IN INCHES
6 ( ) DIM ARE IN MILLIMETERS

DRAWN		
CHECK		
APPR		1-28-82
RELEASE		

ARCHIVE

MODEL NO.

TITLE

INTELLIGENT TAPE DRIVE
THEORY OF OPERATION

MATERIAL:

FINISH:

SIZE	DWG NO.	REV.
A	20100-001	C

SCALE	DO NOT SCALE DWG	SHEET 1 OF 67

This manual describes the concepts and theory of operation of the Archive Intelligent Streaming Tape Drive.

Contents

1.0 Introduction to Streaming and Archive Tape Drives

The Archive Intelligent Cartridge Tape Drive System is a low cost, high performance, mass storage device. The Archive Intelligent Tape Drive consists of the Archive Controller and a Basic Drive. The drives are available in two versions, 30 IPS and 90 IPS. The Controller will support up to four drives, of the same recording speed. 30 IPS and 90 IPS units can not be mixed on one controller. It has the ability to store 20 Million Bytes of data on a standard 1/4 inch tape cartridge in about four minutes at 90 IPS. It is able to do this because data is written in a streaming mode at high density.

To understand the advantages of a streaming mode, it is necessary to look at the data format on the tape. When the host system is ready to write data on tape, it begins transferring that data in 512 byte blocks. The Archive controller has three 512 byte buffers. When the first of the three buffers is full, the controller starts tape motion and begins writing to the tape, accepting data for the second and third buffers during this operation.

The data will not be written in parallel on the tape, but in a bit serial format, one track at a time.

The controller will first write a Gap of 13 bytes of a unique code (a code that cannot appear in a data field). This gap is actually 104 bits long, written in a bit serial format.

After the Gap, the controller will write a Sync Mark which will be four bits long. Following the Sync Mark, the controller will begin to write the user's data stored in the first buffer to the tape. This 512 byte data field is referred to as a block of data and is 4096 bits long.

When the entire data block is written, the controller will write a block address. The block address is eight bits long. The first block is block one and the address is incremented by one for each consecutive block of data.

After the block address, the controller will write the CRC character. This character is two bytes or 16 bits long.

Thus far 528.5 bytes or 4228 serial bits have been written to track 0. By this time, the second buffer is full and the controller begins the process over again. There are no "dead" spots between blocks. As long as the host system can keep data coming to the controller fast enough to keep the buffers full, the tape motion will not stop.

This method of writing a continuous stream of data is referred to as "streaming tape mode". For every 512 bytes of data stored, 528.5 bytes are written to tape. Because conventional inter-record gaps are not used, tape utilization is about 97%.

The other factor of the Sidewinder's high performance is that data is written at high density. The Sidewinder stores data at a density of 8000 b.p.i.. Because of the recording method, this is actually done with 10,000 flux reversals per inch.

The Archive Streaming Tape Drive uses a 4 to 5 run length limited code. Every four bits of data are translated to a corresponding five bit code. There are 32 possible combinations of bits in each five bit block. Only 16 of these possible combinations are needed to represent four bit nibbles of data. Using only 16 combinations permits choosing those groups of five bits which do not have more than two consecutive zeroes. Also, no matter how the five bit groups are strung together, there will never be more than two consecutive zeroes in the data stream. This code is shown on the following page.

Because there are never more than two consecutive zeroes in this 4 to 5 code, the NRZI recording method can be used reliably.

The 4 to 5 code also permits choosing unique bit patterns for Gap, Sync, and Filemark that will never appear in the user data field.

4-5 RUN LENGTH LIMITED CODE

4 BIT			5 BIT	
HEX	BINARY		HEX	BINARY
0 0	0 0 0 0	=	1 9	1 1 0 0 1
0 1	0 0 0 1	=	1 B	1 1 0 1 1
0 2	0 0 1 0	=	1 2	1 0 0 1 0
0 3	0 0 1 1	=	1 3	1 0 0 1 1
0 4	0 1 0 0	=	1 D	1 1 1 0 1
0 5	0 1 0 1	=	1 5	1 0 1 0 1
0 6	0 1 1 0	=	1 6	1 0 1 1 0
0 7	0 1 1 1	=	1 7	1 0 1 1 1
0 8	1 0 0 0	=	1 A	1 1 0 1 0
0 9	1 0 0 1	=	0 9	0 1 0 0 1
0 A	1 0 1 0	=	0 A	0 1 0 1 0
0 B	1 0 1 1	=	0 B	0 1 0 1 1
0 C	1 1 0 0	=	1 E	1 1 1 1 0
0 D	1 1 0 1	=	0 D	0 1 1 0 1
0 E	1 1 1 0	=	0 E	0 1 1 1 0
0 F	1 1 1 1	=	0 F	0 1 1 1 1

ARCHIVE BLOCK FORMAT
GAP = 1F
SYNC = 07
FILE MARK = 1C

5 BIT CODE = NEVER MORE THAN 2 CONSECUTIVE "O's" ∴ NRZ RECORDING METHOD CAN BE USED RELIABLY

Another important concept of the Sidewinder Tape Drive is the serpentine recording method. The Archive Drive will write four tracks of data on a 1/4" tape cartridge, but these tracks are not written in parallel. They are written in a bit serial manner, one track at a time. Refer to the Figure on page 7.

Once the load point hole is detected, the controller knows that it is in the recording zone. It will then begin writing on Track 0.

In addition to writing to Track 0, the controller will enable the erase bar. As data is being written, the erase bar is erasing the full width of the tape ahead of the write head. The tape will be erased for the full length of track zero only.

The write head will continue writing data to the tape until the Early Warning Hole is detected. When the controller detects this hole, it will stop accepting data on the next block boundary. The controller will continue writing to the tape until all three buffers are empty.

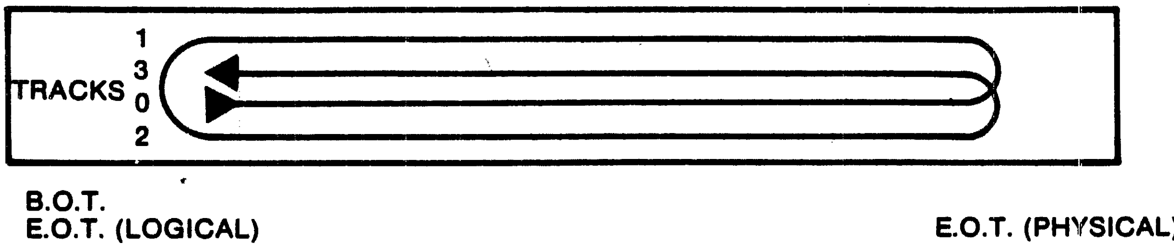
The controller will continue tape motion until the End of Tape holes are detected. When EOT is reached the controller will stop tape motion, disable the erase bar and logically select the read/write gaps for Track 1. Tape motion will begin in the opposite direction while a search for the Early Warning Hole will be initiated. This hole is now logically the Load Point for Track 1.

When the controller detects Early Warning it will begin writing data to track 1. It will continue to write to Track 1 until the Load Point hole is detected. The Load Point hole is logically the Early Warning Hole for Track 1.

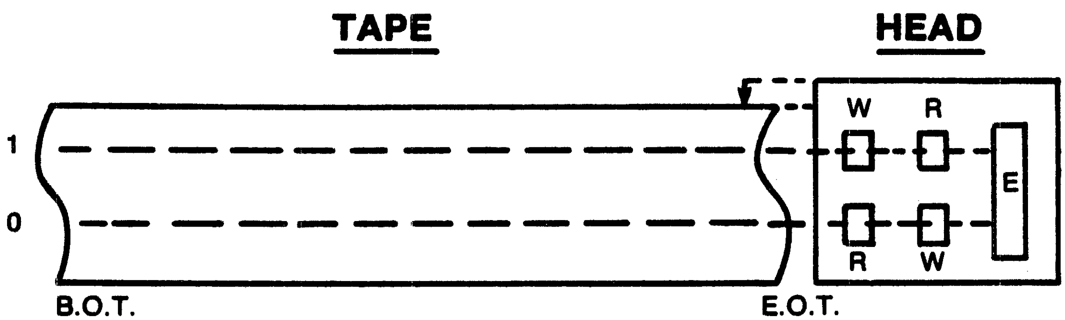
The controller will repeat the End of Tape procedure used for Track 0. The BOT holes are now logically the EOT holes for Track 1. However, once tape motion stops at the end of Track 1, the head is physically repositioned and then the read/write gaps for Track 2 are logically selected.

The controller will write Tracks 2 and 3 in the same manner that it wrote Tracks 0 and 1.

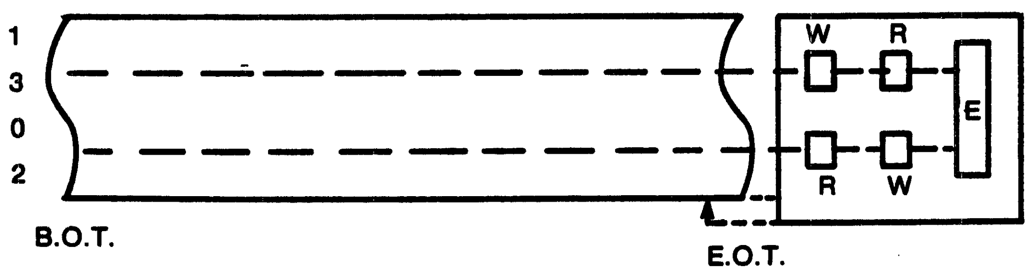
SERPENTINE RECORDING



TRACK POSITIONING



- SELECT HEAD 0; GO TO E.O.T.
- SELECT HEAD 1; REVERSE DIRECTION; GO TO B.O.T.



- STEP HEAD DOWN 48 MILS; SELECT HEAD 2 REVERSE DIRECTION; GO TO E.O.T.
- SELECT HEAD 3; REVERSE DIRECTION; GO TO B.O.T. (LOGICAL E.O.T.)

2.0 Cartridge Tapes and Data Format

The Archive Streaming Tape Drives use a 1/4 inch ANSI Standard tape cartridge (X3.55-1977). Currently the tape cartridge used is a DC 300XL, manufactured by 3M. These cartridges have 450 feet of usable media, and sense hole configurations to tell the drive its position on the tape. On page 9 is a drawing which shows the basic dimensions of the tape itself.

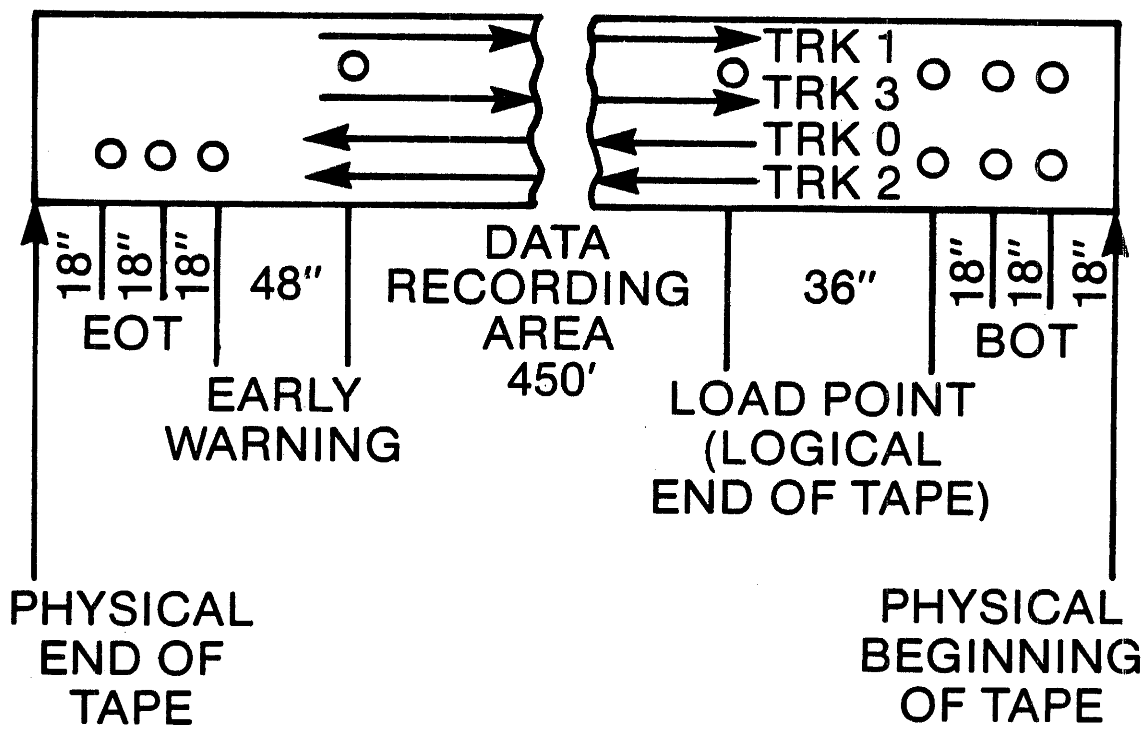
An important part of understanding the Archive drive is understanding the formatting of data on the tape. This is described in section 1.0.

The Archive Tape Format contains a total of 528.5 bytes per block arranged into five fields:

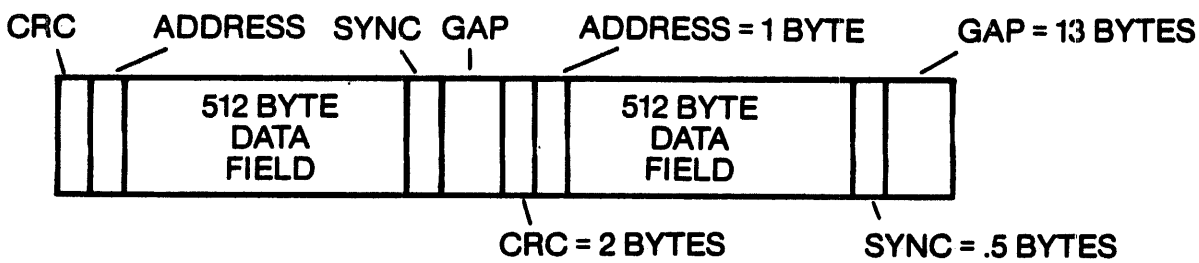
Gap	13 bytes
Sync Mark	0.5 bytes
User Data	512 bytes
Block Address	1 byte
CRC	2 bytes

They are written to the tape in the order that they are listed above and as shown on the following page.

¼" CARTRIDGE TAPE PHYSICAL FORMAT



ARCHIVE ¼" STREAMING TAPE FORMAT = 97% EFFICIENT



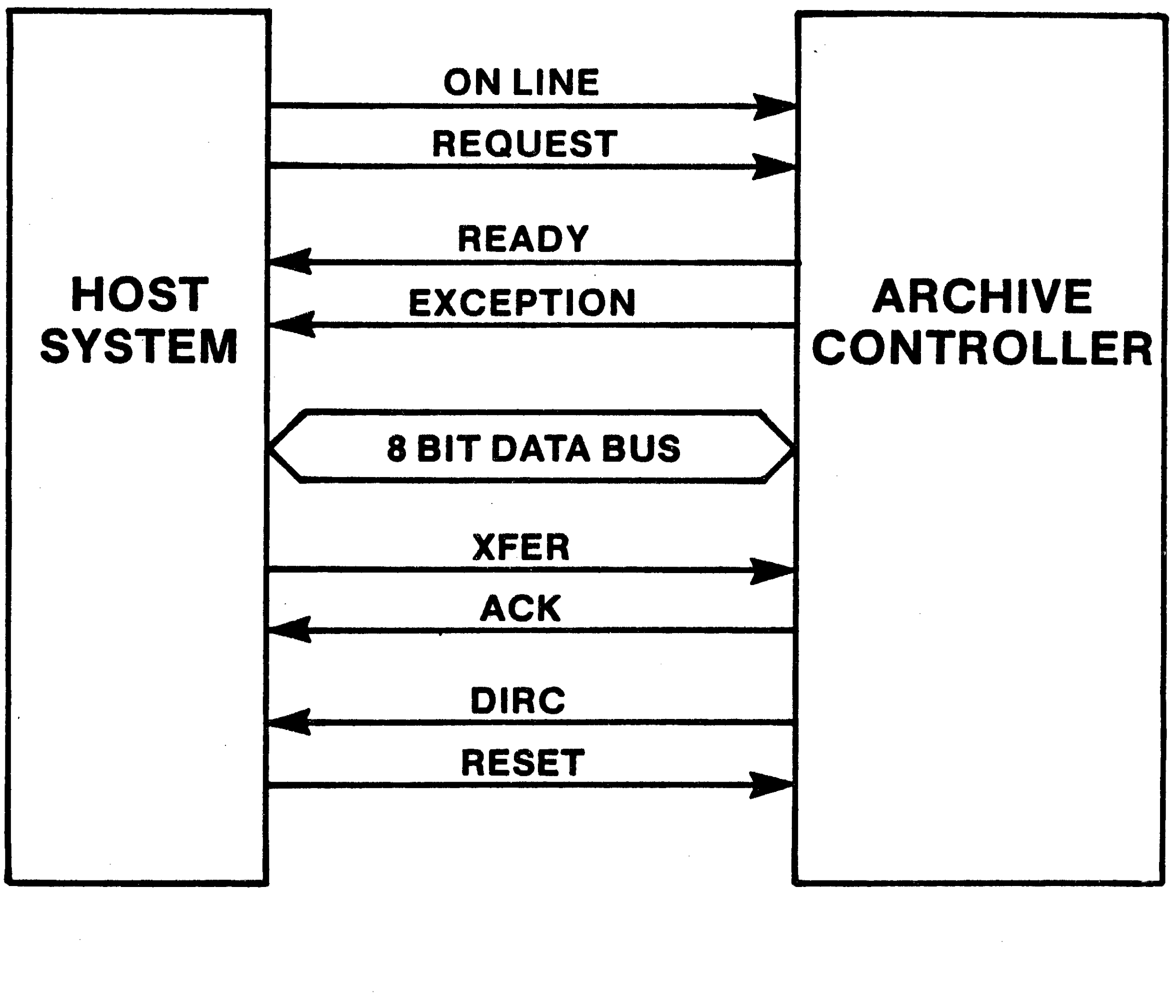
ARCHIVE	TITLE: Intelligent Tape Drive Theory of Operation	SIZE: A	DWG. NO.: 20100-001	REV: C
		SCALE	DO NOT SCALE DWG	SHEET 9 OF 67

3.0 Host Interface

The Archive Controller is micro-processor based. Because it uses a micro-processor, the controller is able to relieve the host of many overhead functions such as tape formatting, error processing and tape positioning. It also minimizes the time and cost required to integrate a streaming drive into a user's system.

The host interface on the controller is designed for easy connection to a host adapter. It has an eight bit bi-directional bus and eight control lines, four from the host to the controller and four from the controller to the host.

INTERFACE



By using the bus and control lines, the host and controller communication is asynchronous.

The four control lines from the controller are: READY, EXCEPTION, ACKNOWLEDGE, and DIRECTION.

3.1 READY is used to signal several things, depending on the operation being performed.

1. If no operation is being performed READY indicates that the controller is able to accept a command.

2. During a command transfer READY going to its true state means that the controller has taken the command from the data bus.

3. When the status bytes are being transferred from the controller to the host, READY going to its true state means that the next byte is available on the bus.

4. During a write operation, READY going to its true state means that a buffer is ready to be filled by the host or that a Write File Mark Command may be issued.

5. During a read operation, READY going to its true state means that a buffer is ready to be emptied to the host.

3.2 EXCEPTION is used to alert the host to a condition which has terminated the execution of a command. The controller sets EXCEPTION to signal the termination of an operation. The only legal response to EXCEPTION going true is for the host to issue a Read Status Command and transfer all six status bytes.

EXCEPTION will go true for an error condition or for two other conditions. EXCEPTION will be set whenever the controller reads a file mark or receives a RESET signal. The RESET signal may come from the host or could be the result of a power-up. Any time power is applied to the controller, the first command it must receive is a Read Status Command.

3.3 DIRC (DIRECTION) is used by the controller to indicate the direction of data flow across the bus. DIRC is true for transfers from the controller to the host and is false for transfers from the host to the controller, DIRC is normally false and will only go true to transfer data on a read operation or status bytes. DIRC is provided as a convenience for host interface design to be used to enable the host bus drivers.

3.4 ACK (ACKNOWLEDGE) is used by the controller during data transfers. During a write operation, ACK going true means that the controller has received the information from the host. During a read operation, ACK going true means that data is available for the host.

The four lines from the host to the controller are: ONLINE, REQUEST, XFER, and RESET.

3.5 REQUEST is used by the host to initiate command operations. When REQUEST goes to its true state, it means that the host has a command to transfer to the controller. REQUEST is also used to handshake the six status byte from the host.

3.6 ONLINE is used for any read or write operation. It must be true prior to placing a Read, Write, RFM, or WFM Command on the bus and setting REQUEST. ONLINE can be used to terminate a Write Command by resetting it to its false state. When the controller detects ONLINE going false, it will finish writing its remaining buffers to the tape, write a file mark and rewind the tape to BOT. If a WFM Command was issued prior to resetting ONLINE, the controller will not write another file mark.

ONLINE going false will also terminate a read operation. The controller will stop transferring data on the next block boundary, even if other blocks remain in its buffers. After the transfers stop, the controller will rewind the tape to BOT.

3.7 XFER is used by the host during data transfers. During a write operation, XFER going true means that data is available to the controller. During a read operation, XFER going true means that the host has read the data from the bus.

3.8 RESET is a direct signal to the reset circuitry of the controller and performs the same function as a power-on reset.

4.0 Command Construction and Timing

All commands to the controller are single byte commands. The command byte has two fields. The three most significant bits (7, 6, 5) define the type of command; the five least significant bits (4, 3, 2, 1, 0) contain the command data.

Command Type	Command Data
7 6 5	4 3 2 1 0

The command type field may define one of seven commands.

Select	0	000	MMMMM
Position	1	001	OOMMM
Write Data	2	010	00000
Write File Mark	3	011	00000
Read Data	4	100	00000
Read File Mark	5	101	00000
Read Status	6	110	00000
Reserved	7		

The controller will accept a command when READY is true. One command can be accepted when READY is not true. This command is Read Status. This command will be accepted by the controller if EXCEPTION is true. If EXCEPTION is true, Read Status is the only command that will be accepted.

In addition to READY being true, four commands require that ONLINE, from the host, be true. These commands are:

Write Data
Write File Mark
Read Data
Read File Mark

If one of these four commands is given to the controller without ONLINE being true, the controller will respond with EXCEPTION.

The other three commands do not require or care if ONLINE is true or false.

4.1 Read Status Command (Refer to chart on page 15).

The Read Status Command will have 110 in bits 7 through 5 and all zeroes in bits 4 through 0.

This command is used by the host to request a status report from the controller. The host must read status anytime that the controller sets EXCEPTION.

The host should also read status at the completion of a read or write operation. This allows the host to receive the error report for that operation and clears the error count in the controller. This is a user option.

4.1.1 Read Status Timing in response to EXCEPTION.

4.1.1.1 T1

Seeing EXCEPTION true, the host places the Read Status Command on the bus at T1.

4.1.1.2 T2

Some period of time (T1 to T2, > 0 u sec.) after the command is on the bus, the host sets REQUEST. This tells the controller that a command is present.

4.1.1.3 T3

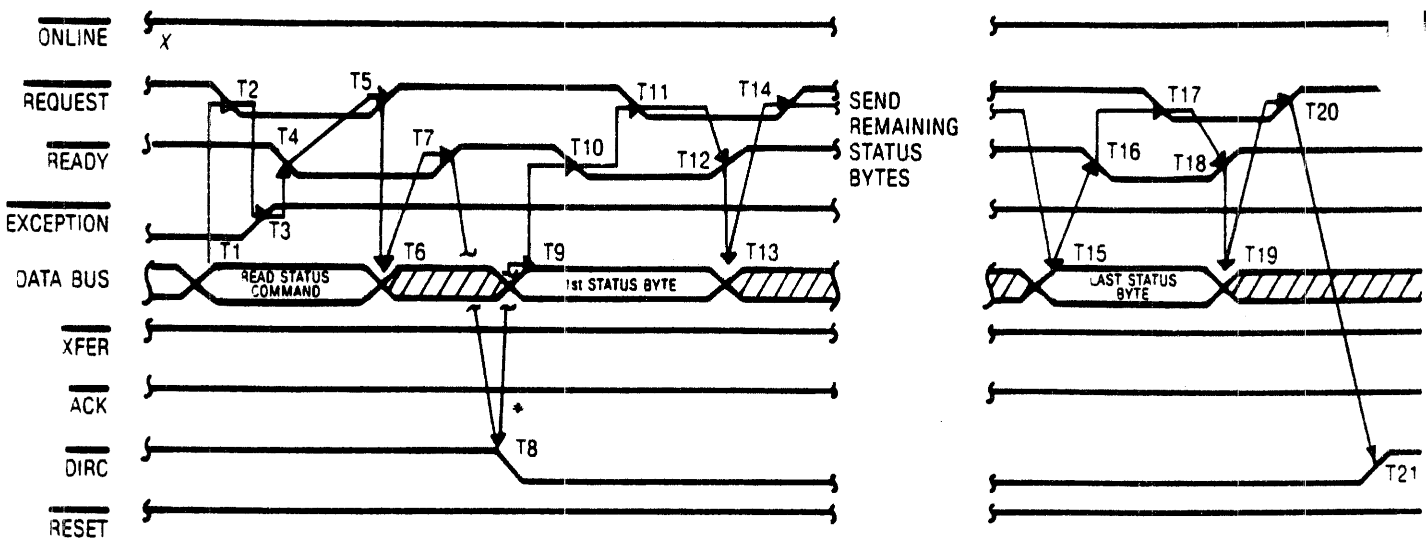
After the host sets REQUEST, the controller will reset EXCEPTION at T3. This timing is not critical, the host should be watching READY.

4.1.1.4 T4

Some period of time (> 50 u sec. and < 500 u sec. T2 to T4) after REQUEST is set, the controller will set READY. This informs the host that the Read Status Command has been read off the bus by the controller.

4.1.1.5 T5

Seeing READY go true, the host should reset REQUEST in some period of time > 0 u sec. (T4 to T5).



READ STATUS COMMAND

ACTIVITY	CRITICAL TIMING
T1-HOST COMMAND TO BUS	N/A
T2-HOST SETS REQUEST	T1→T2>0 U sec
T3-CONTROLLER RESETS EXCEPTION	T3→T4>10 U sec
T4-CONTROLLER SETS READY	20<T2→T4<500 U sec *
T5-HOST RESETS REQUEST	T4→T5>0 U sec
T6-BUS DATA INVALID	T4→T6>0 U sec
T7-CONTROLLER RESETS READY	20<T5→T7<100 U sec
T8-CONTROLLER CHANGES BUS DIRECTION	N/A
T9-1ST STATUS BYTE TO BUS	T9→T10>0 U sec.
T10-CONTROLLER SETS READY	T7→T10>20 U sec.
T11-HOST SETS REQUEST	T10→T11>0 U sec.
T12-CONTROLLER RESETS READY	T11→T12<0.25 U sec.
T13-BUS DATA INVALID	T11→T13>0 U sec.
T14-HOST RESETS REQUEST	T11→T14>20 U sec.
T15-LAST STATUS BYTE TO BUS	N/A
T16-SAME AS T10	SAME AS T10
T17-SAME AS T11	SAME AS T11
T18-SAME AS T12	SAME AS T12
T19-SAME AS T13	SAME AS T13
T20-SAME AS T14	SAME AS T14
T21-CONTROLLER CHANGES BUS DIRECTION	N/A

*NOTE: THIS TIME MAYBE>500 M SEC IF THE FOLLOWING OCCURS:

a. THE ONLINE SIGNAL IS DEASSERTED
b. RETRY SEQUENCE AND NO DATA DETECTED
c. AT END OF THE TRACK AND TURN AROUND OR START UP.

4.1.1.6 T6

When READY goes true, the host may remove the Read Status Command in some period of time > 0 u sec. (T4 to T6). At this point the controller will no longer consider the bus data to be valid.

4.1.1.7 T7

The controller will reset READY some period of time (> 20 u sec. and < 100 u sec., T5 to T7) after REQUEST goes false.

4.1.1.8 T8

At T8, the controller will change the DIRECTION of the bus (DIRC goes true). This is in preparation for sending the first status byte.

4.1.1.9 T9

At T9, the controller will place the first status byte on the bus.

4.1.1.10 T10

At T10, the controller begins the handshaking of the status bytes to the host by setting READY. This will be in some period of time > 20 u sec. (T7 to T10) after READY reset.

4.1.1.11 T11

The host, seeing READY set, will read the first byte from the bus. The host will then set REQUEST in some period of time > 0 u sec. (T10 to T11) to inform the controller that it has received the data.

4.1.1.12 T12

In response to the hosts confirmation, the controller will reset READY in some period of time. < 0.25 u sec. (T11 to T12).

4.1.1.13 T13

When the host sets REQUEST, the data on the bus becomes invalid.

4.1.1.14 T14

The host will reset REQUEST in some period of time > 20 u sec., (T11 to T14) after the controller resets READY. This completes the transmission of the first byte. The controller will now place the second and status byte on the bus and begin again at T10.

4.1.1.15 T15

Placing the last status byte on the bus, the controller will follow the same procedure for T16 to T20 as was done for T10 to T14.

4.1.1.16 T21

After the host resets REQUEST on the last status byte, the controller will reset DIRECTION. This period of time (T20 to T21) is undefined. The host should watch READY to see when it may begin its next operation.

4.1.2 Read Status timing at the end of a Read or Write sequence.

4.1.2.1 T1

Having verified that READY (or EXCEPTION) is true, the host places the Read Status Command on the bus at T1.

4.1.2.2 T2

Some period of time (> 0 u sec., T1 to T2) after the command is on the bus, the host sets request. This tells the controller that a command is present on the bus.

4.1.2.3 T3

Seeing REQUEST go true, the controller will respond by resetting READY (or EXCEPTION) in some period of time < 0.25 u sec. (T2 to T3).

4.1.2.4 T4

Some period of time (> 50 u sec. and < 500 u sec., T3 to T4) after the controller resets READY (or EXCEPTION), it will set READY. This will inform the host that the command has been read.

4.1.2.5 T5

T5 through T20 will be the same as 4.1.1.5 through 4.1.1.16 of the response to EXCEPTION.

4.2 Select Command (Refer to the chart on page 20)

The Select Command will have 000 in bits 7 through 5 and one of the five remaining bits set to identify the drive to be selected.

Select-Light Bit	000	10000
Drive 3	000	01000
Drive 2	000	00100
Drive 1	000	00010
Drive 0	000	00001

This command will select one of four drives attached to the controller. If a Select Command is not issued after power-up/reset (following Read Status) the controller will default to Drive 0. On a multiple drive system, care should be taken to select the proper drive.

Bits 0 through 3 are used to specify the drive to be selected. Bit 4 is used as a logical cartridge lock. When a Select Command is issued with bit 4 not set, the select light will go off when any operation is concluded (read, write, position, read status, etc.) and the tape is at BOT, track 0. When a Select Command is issued with bit 4 set, the select light will stay on even between operations. This will inform any system user that the tape drive is being used and that they should not remove the cartridge. If the cartridge is removed while the light is on, EXCEPTION will go true and bit 6 of Status Byte 0 will go true (cartridge not in place). If a cartridge is removed or exchanged while the select light is off, it will not be noted by the drive.

If a Select Command is issued which selects two drives simultaneously, the controller will respond with EXCEPTION (Illegal Command). If a Select Command is issued with no drive selected, the controller will also respond with EXCEPTION (Illegal Command).

4.2 Select Command Timing

4.2.1 T1

The host polls READY for true state. When READY is true, the host places Select Command on the bus at T1.

4.2.2 T2

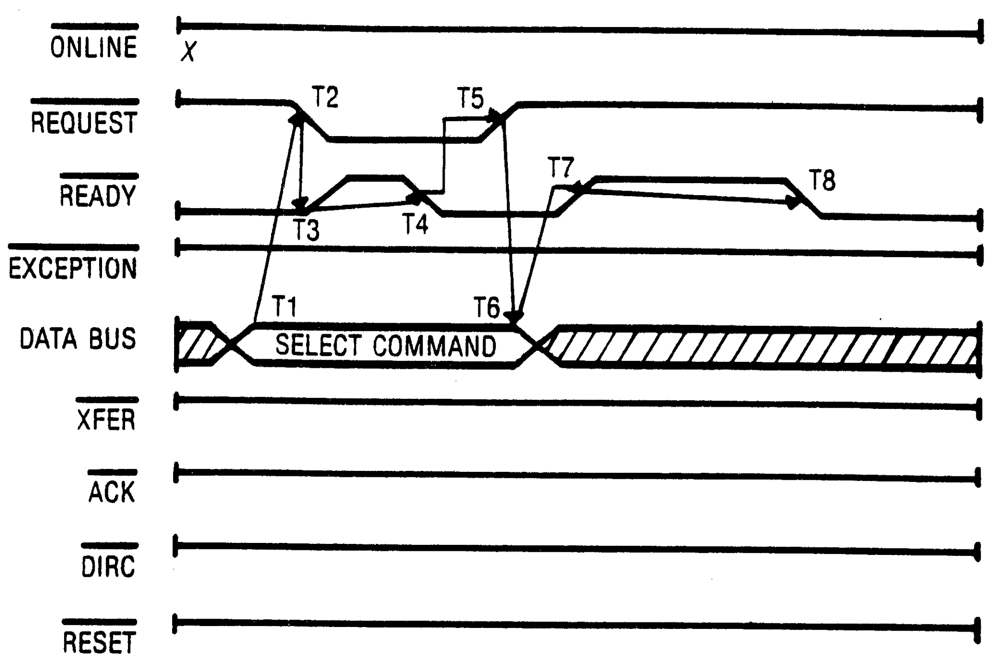
Some period of time (> 0 u sec., T1 to T2) after the command is on the bus, the host sets REQUEST.

4.2.3 T3

The controller will respond to REQUEST by resetting READY (T2 to T3, < 0.25 u sec.). The host must maintain the command on the data bus and keep the REQUEST line in a true state until some period of time (> 0 u sec.) after the controller returns READY to its true state.

4.2.4 T4

In some period of time (> 50 u sec. and < 500 u sec., T3 to T4) the controller will set READY true. This will tell the host that the command has been accepted.



SELECT COMMAND

ACTIVITY	CRITICAL TIMING
T1-HOST COMMAND TO BUS	N/A
T2-HOST SETS REQUEST	T1→T2>Ø U sec.
T3-CONTROLLER RESETS READY	T2→T3<0.25 U sec.
T4-CONTROLLER SETS READY	50<T3→T4<500 U sec.*
T5-HOST RESETS REQUEST	T4→T5>Ø U sec.
T6-BUS DATA INVALID	T4→T6>Ø U sec.
T7-CONTROLLER RESETS READY	20<T5→T7<100 U sec.
T8-CONTROLLER SETS READY	T7→T8>20 U sec.

*NOTE: THIS TIME MAYBE >500 M SEC IF THE FOLLOWING OCCURS:

a. THE ONLINE SIGNAL IS DEASSERTED
b. RETRY SEQUENCE AND NO DATA DETECTED
c. AT END OF THE TRACK AND TURN AROUND OR START UP.

X-DON'T CARE

4.2.5 T5

Detecting READY going to its true state, the host resets REQUEST in some period of time > 0 u sec. (T4 to T5).

4.2.6 T6

After the controller sets READY to its true state, the host may remove the command from the bus in some period of time > 0 u sec. (T4 to T6).

4.2.7 T7

The controller, detecting the host resetting REQUEST, will reset READY in some period of time > 20 u sec. and < 100 u sec. (T5 to T7).

4.2.8 T8

After some period of time (> 20 u sec., T7 to T8) the controller will set READY to its true state, indicating that it has performed the command and is ready for the next operation.

4.3 Position Command (Refer to the Chart on page 23)

The Position Command is used to perform one of three functions. This command will have 001 in bits 7 through 5 and one of the five remaining bits set to identify the function.

Reserved	001	10000
Reserved	001	01000
Retension	001	00100
Erase Tape	001	00010
Rewind to BOT	001	00001

The Rewind to Beginning of Tape command permits the host to position the tape prior to executing a Read or Write function. If this command is not preceded by a Select Command, the controller will automatically select Drive 0.

Upon receiving a Rewind Command, the controller will check to see if a cartridge is inserted in the selected drive. If a cartridge is not fully inserted, the controller will abort the command and set EXCEPTION. At the completion of the Rewind Command, if no abnormal condition exists, the controller will set READY.

The controller will position the tape to BOT if the host does not issue a Position Command (Tension, Erase, Rewind) before a Read, Write, Read Filemark or Write Filemark Command. (See the section on Read/Write Operations.)

The Erase Command is used to completely erase the cartridge. This command will cause the drive to rewind the tape to BOT, erase from BOT to EOT (end of tape) and then rewind the tape to BOT. During a normal write operation, the erase head is activated, erasing ahead of the write head for the full width of the tape. However if new data is written to a cartridge and that file is less than the length of track 0, old data may remain on the tape, as in multiple Read File Mark commands to determine the number of files on a tape.

The Retension Command is used to do a retensioning pass as recommended by cartridge tape manufacturers. To do a retensioning pass, the controller will first bring the cartridge to BOT and then move the tape from BOT to EOT and back to BOT. Best results are obtained if a retensioning pass is used prior to writing, when excessive read errors are encountered, or prior to reading for hard tape errors.

During any one of the position commands, the tape is moved at 90 IPS, on both the 30 IPS and 90 IPS drives.

Position Command Timing

4.3.1 T1

Seeing that READY is true, the host places the Position Command on the bus.

4.3.2 T2

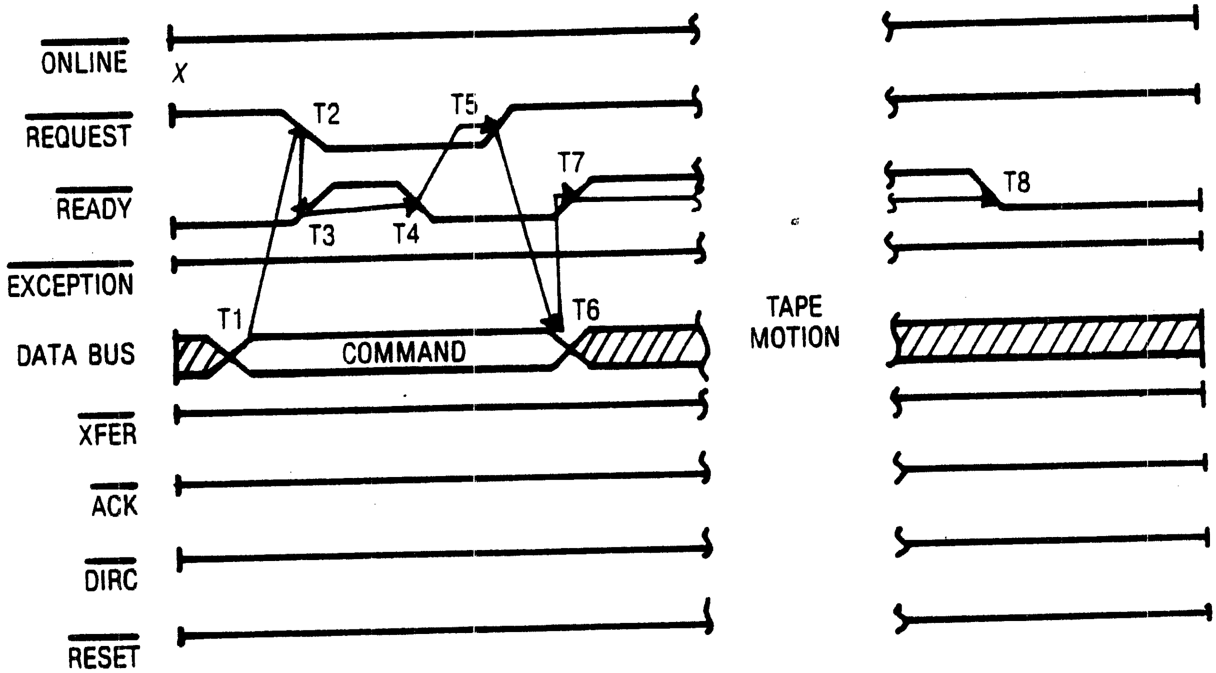
At some period of time (> 0 u sec., T1 to T2) after the command is on the bus, the host sets REQUEST. This informs the controller that a command is on the bus.

4.3.3 T3

The controller, detecting REQUEST set, will reset READY in some period of time < 0.25 u sec. (T2 to T3).

4.3.4 T4

After some period of time (> 50 u sec. and < 500 u sec. T3 to T4) the controller will set READY to its true state. This indicates that the controller has accepted the command.



BOT, RETENSION OR ERASE COMMAND

ACTIVITY

T1-HOST BUS DATA VALID
T2-HOST SETS REQUEST
T3-CONTROLLER RESETS READY
T4-CONTROLLER SETS READY
T5-HOST RESETS REQUEST
T6-BUS DATA INVALID
T7-CONTROLLER RESETS READY
T8-CONTROLLER SETS READY

X-DON'T CARE

CRITICAL TIMING

N/A
T1→T2 = >Ø U sec.
T2→T3 = <0.25 U sec.
50<T3→T4<500 U sec.*
T4→T5 = >Ø U sec.
T3→T6>Ø U sec.
20<T5→T7<100 U sec.
T7→T8 = >20 U sec.

*NOTE: THIS TIME MAYBE>500 M SEC IF THE FOLLOWING OCCURS:
a. THE ONLINE SIGNAL IS DEASSERTED
b. RETRY SEQUENCE AND NO DATA DETECTED
c. AT END OF THE TRACK AND TURN AROUND OR START UP.

4.3.5 T5

Seeing READY go true, the host will reset REQUEST in some period of time > 0 u sec. (T4 to T5).

4.3.6 T6

Seeing READY go true, the host will remove the command from the bus in some period of time > 0 u sec. (T4 to T6). At this point, the bus data is no longer considered valid.

4.3.7 T7

The controller will reset READY in some period of time (> 20 u sec. and < 100 u sec., T5 to T7) after the host resets REQUEST.

4.3.8 T8

Having reset READY the controller will perform the Position Command which will take some period of time > 20 u sec. (T7 to T8). This is a mechanical operation which could take up to three minutes. At the end of the operation, the controller will set READY to its true state, indicating to the host that it can accept another command.

4.4 The Write Data Command (Refer to the chart on page 26)

The Write Data Command will have 010 in bits 7 through 5 and all zeroes in bits 4 through 0.

This command is used to write user data blocks to the tape. If a write operation is not preceded by a Select or Position command, the controller will default to Drive 0 and BOT, Track 0. Before issuing the Write Data Command, the host must set ONLINE. If ONLINE is not true before a Write Data Command is issued, the controller will respond with EXCEPTION (Illegal Command).

Upon receiving a Write Data Command, the controller will check for CARTRIDGE IN and WRITE PROTECT. If either condition prevents writing to tape, the controller will set EXCEPTION. The write operation will continue until terminated by the host (by dropping ONLINE) or writing a FILEMARK, or until terminated by the controller if a hard data error occurs.

The host can terminate a write operation by issuing a Write File Mark Command after transmitting the last data block.

Upon receiving a Write File Mark Command, the controller will stop accepting new data from the host. The controller will then finish writing and read-checking the remaining data in its buffers and write and read-check a file mark.

Having issued a Write File Mark Command, the host can resume writing by issuing another Write Command; can issue another Write File Mark; or can return to BOT by issuing a Position Command or by going OFFLINE.

The host can also terminate a write operation by resetting ONLINE. When ONLINE goes false, the controller will finish writing and read-checking the data in its buffers, write and read-check a File Mark and then position the tape to BOT.

When the Early Warning Hole of the last track is detected, the controller will stop accepting new data from the host on a 512 byte block boundary. The controller will then write and read-check the remaining data in its buffers, stop tape motion and set EXCEPTION. The host must respond with a Read Status Command. The Status Bytes will inform the host of the End of Media Status.

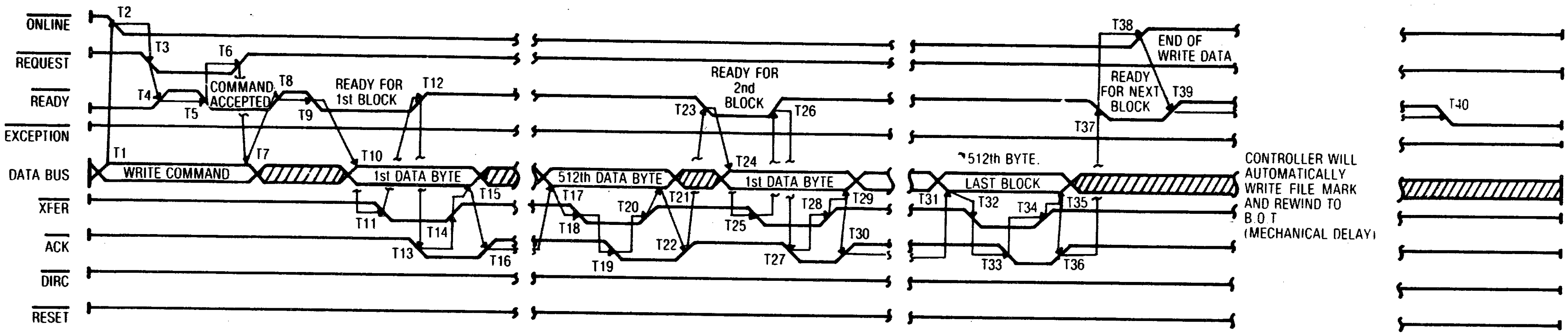
When End of Media is reached, the host may do one of three things: 1) issue a Write Command 2) issue a Write File Mark Command or 3) reset ONLINE.

If a Write Command is issued, two blocks of data will be accepted by the controller and the End of Tape procedure will be repeated. The host should use these blocks to note that the file, if it is not complete, is continued on another cartridge.

A File Mark should be written after these two blocks so that when the cartridge is read, the File Mark will indicate that all the data was recovered.

If a Write Command is issued, but no data is transferred, resetting ONLINE will cause a File Mark to be written and the tape to be rewound to BOT.

If no Write or WFM Command is issued and ONLINE is reset, the tape will be rewound to BOT and no File Mark will be written. A File Mark should be written so that the host can be sure that all the data was recovered.



WRITE DATA COMMAND

ACTIVITY	CRITICAL TIMING
T1-HOST COMMAND TO BUS	T1→T3>Ø U sec
T2-HOST SETS ONLINE	N/A
T3-HOST SETS REQUEST	T2→T3>Ø U sec.
T4-CONTROLLER RESETS READY	T3→T4<Ø .25 U sec.
T5-CONTROLLER SETS READY	20<T4→T5<500 U sec.
T6-HOST RESETS REQUEST	T5→T6>Ø U sec.
T7-BUS DATA INVALID	T5→T7>Ø U sec.
T8-CONTROLLER RESETS READY	20<T6→T8<100 U sec. *
T9-CONTROLLER SETS READY	T8→T9>20 U sec.
T10-HOST DATA TO BUS	N/A
T11-HOST SETS XFER	T10→T11>-40 NANO sec.
T12-CONTROLLER RESETS READY	T11→T12<0.25 U sec.
T13-CONTROLLER SETS ACK	.56<T11→T13<4.47 U sec.
T14-HOST RESETS XFER	T13→T14>Ø U sec.

ACTIVITY	CRITICAL TIMING
T15-BUS DATA INVALID	T13→T15>Ø U sec.
T16-CONTROLLER RESETS ACK	0<T14→T16<.56 U sec.
T17-HOST DATA TO BUS	N/A
T18-SAME AS T11	SAME AS T11
T19-SAME AS T13	SAME AS T13
T20-SAME AS T14	SAME AS T14
T21-SAME AS T15	SAME AS T15
T22-SAME AS T16	SAME AS T16
T23-CONTROLLER SETS READY	T22→T23>100 U sec.
T24-HOST DATA TO BUS	N/A
T25-HOST SETS XFER	SAME AS T11
T26-CONTROLLER RESETS READY	SAME AS T12
T27-CONTROLLER SETS ACK	SAME AS T13

ACTIVITY	CRITICAL TIMING
T28-HOST RESETS XFER	SAME AS T14
T29-BUS DATA INVALID	SAME AS T15
T30-CONTROLLER RESETS ACK	SAME AS T16
T31-HOST DATA TO BUS	N/A
T32-HOST SETS XFER	SAME AS T18
T33-CONTROLLER SETS ACK	SAME AS T19
T34-HOST RESETS XFER	SAME AS T20
T35-BUS DATA INVALID	N/A
T36-CONTROLLER RESETS ACK	SAME AS T22
T37-CONTROLLER SETS READY	SAME AS T23
T38-HOST RESETS ONLINE	N/A
T39-CONTROLLER RESETS READY	N/A
T40-CONTROLLER SETS READY	N/A

***NOTE: THIS TIME MAYBE>500 M SEC IF THE FOLLOWING OCCURS:**

a. **THE ONLINE SIGNAL IS DEASSERTED**
b. **RETRY SEQUENCE AND NO DATA DETECTED**
c. **AT END OF THE TRACK AND TURN AROUND OR START UP.**

Write Data Command Timing

4.4.1 T1

Having verified that READY is true, the host places a Write Data Command on the bus.

4.4.2 T2

Some period of time (> 0 u sec., T1 to T2) after the command is on the bus, the host sets ONLINE.

4.4.3 T3

Some period of time (> 0 u sec., T2 to T3) after ONLINE is set, the host sets REQUEST.

4.4.4 T4

Detecting REQUEST going true, the controller will reset READY in some period of time < 0.25 u sec. (T3 to T4).

4.4.5 T5

Some period of time (> 50 u sec. and < 500 u sec., T4 to T5) after READY went false the controller will set READY true. During this time the controller will read the command from the bus and verify that ONLINE was set. By setting READY true the controller has informed the host that the command was accepted.

4.4.6 T6

Seeing READY go true, the host will reset REQUEST in some period of time > 0 u sec. (T5 to T6).

4.4.7 T7

In some period of time > 0 u sec.,(T5 to T7) after READY was set, the host may remove the command from the bus.

4.4.8 T8

After the host resets REQUEST, the controller will reset READY in some period of time > 20 u sec. and < 100 u sec. (T6 to T8). This is the controller preparing to accept data and write to tape.

4.4.9 T9

At T9 the controller will set READY true. This will occur in some period of time (> 20 u sec., T8 to T9) after READY went false. By setting READY to its true state, the controller is telling the host that it is ready to accept the first block of data. The controller will wait indefinitely for the first byte.

4.4.10 T10

The host should place the first byte of data on the bus at T10.

4.4.11 T11

At T11 the host should set XFER. The controller will look for XFER first, then take the byte from the bus. XFER can actually occur 40 nano seconds prior to having settled data on the bus.

4.4.12 T12

The controller, detecting XFER set, will reset READY in some period of time < 0.25 u sec. (T11 to T12). This is the beginning of the transfer of a block of data, byte by byte, using ACK-XFER handshake. READY will remain false during the transfer of all 512 bytes.

4.4.13 T13

By setting XFER, the host has informed the controller that a byte of data is on the bus. The controller will read the data from the bus and tell the host that it has the data. This is done by the controller setting ACK to its true state in some period of time > .56 u sec. and < 4.47 u sec. (T11 to T13).

4.4.14 T14

In response to ACK, the host resets XFER in some period of time (> 0 u sec., T13 to T14), preparing for the next handshake.

4.4.15 T15

Once ACK is set at T13, the data has been read from the bus. At that point the data may be removed in some period of time > 0 u sec. (T13 to T15).

4.4.16 T16

The controller will reset ACK some period of time (> 0.56 u sec. and < 1.12 u sec., T14 to T16) after XFER goes false. This completes the handshake of the first byte of data.

4.4.17 T22

The XFER-ACK handshake will cycle 512 times. The controller will count the number of bytes. At the conclusion of the 512th byte, the controller will reset ACK as it did at T16 and then prepare for the next block of data.

4.4.18 T23

At T23, the controller will set READY in some period of time (> 100 u sec., T22 to T23) after ACK was reset for the last byte.

4.4.19 When READY goes true at T23, the host knows that the controller is ready for the next block of data. The host will begin transferring the first byte of the next block of data. The controller knows that the contents of the bus is data because REQUEST has remained false.

4.4.20 T38

The host can terminate the write sequence by issuing a Write File Mark command or by resetting ONLINE. After the last block of data has been transferred, the host may reset ONLINE at any time. The controller will set READY true at the end of the last block, as it did for all previous blocks. It will then see that ONLINE is false. This will tell the controller to terminate the write operation and write a file mark.

4.4.21 T39

In response to ONLINE being false, the controller will reset READY, write a file mark and rewind the tape to BOT.

4.4.22 T40

After the tape is rewound to BOT, the controller will set READY, indicating that the controller is ready for its next instruction.

4.5 Write File Mark Command (Refer to the chart on page 31)

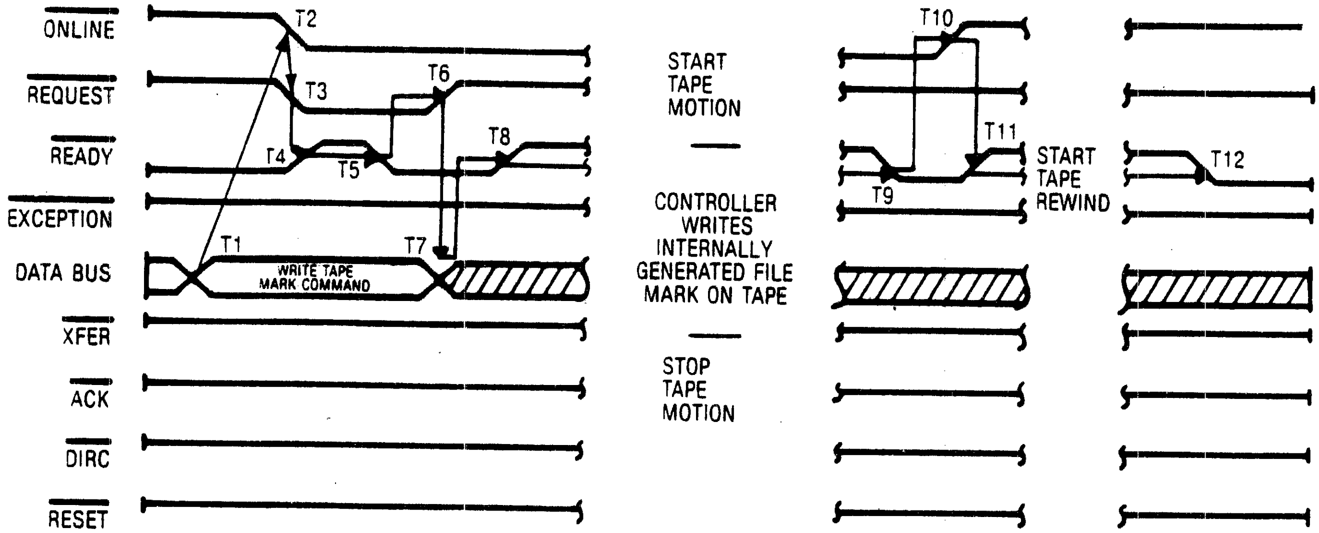
The Write File Mark Command will have 011 in bits 7 through 5 and all zeroes in bits 4 through 0.

This command permits the user to write file marks. File marks can be used to separate the data stored on the cartridge into smaller segments. The segments can be along physical divisions, like disk tracks and cylinders; or along logical divisions like data files. Dividing data into smaller segments can be useful from a system software point of view.

ONLINE must be true to issue a Write File Mark Command. During a Write Command, it can only be issued in between data block boundaries. During a data block transfer, READY is false and the controller will not accept a command.

Issuing a Write File Mark when the controller is in a write mode will terminate the write operation. It will cause the controller to write a file mark but as long as ONLINE is held true, the tape will not rewind to BOT.

A file mark is a full block of data. However, instead of user data, the controller will write 512 bytes of a unique code that can not appear in a user data field. The host issues a WFM Command, but transfers no data. The controller creates the pattern.



WRITE FILE MARK COMMAND

ACTIVITY	CRITICAL TIMING
T1-HOST COMMAND TO BUS	N/A
T2-HOST SETS ONLINE	T1→T2>Ø U sec.
T3-HOST SETS REQUEST	T2→T3>Ø U sec.
T4-CONTROLLER RESETS READY	T3→T4<0.25 U sec.
T5-CONTROLLER SETS READY	20<T4→T5<500 U sec. *
T6-HOST RESETS REQUEST	T5→T6>Ø U sec.
T7-BUS DATA INVALID	T5→T7>Ø U sec.
T8-CONTROLLER RESETS READY	20<T6→T8<100 U sec.
T9-CONTROLLER SETS READY	N/A
T10-HOST RESETS ONLINE	T9→T10>Ø U sec.
T11-CONTROLLER RESETS READY	N/A
T12-CONTROLLER SETS READY (AT B.O.T.)	N/A

*NOTE: THIS TIME MAYBE>500 M SEC IF THE FOLLOWING OCCURS:

a. THE ONLINE SIGNAL IS DEASSERTED
b. RETRY SEQUENCE AND NO DATA DETECTED
c. AT END OF THE TRACK AND TURN AROUND OR START UP.

Write File Mark Timing

4.5.1 T1

Having verified that READY is true, the host places the Write File Mark Command on the bus.

4.5.2 T2

Some period of time (> 0 u sec., T1 to T2) after the command is on the bus, the host sets ONLINE.

4.5.3 T3

Some period of time (> 0 u sec. T1 to T3) after the host sets ONLINE the host sets REQUEST.

4.5.4 T4

Seeing REQUEST go true, the controller will reset READY in some period of time < 0.25 u sec. (T3 to T4).

4.5.5 T5

The controller will take the command from the bus and set READY to its true state in some period of time > 50 u sec. and < 500 u sec. (T4 to T5).

4.5.6 T6

Seeing READY return to its true state, the host should reset REQUEST in some period of time > 0 u sec.. (T5 to T6).

4.5.7 T7

When READY returned to its true state, the controller was indicating to the host that it has read and accepted the command. In some period of time (> 0 u sec., T5 to T7) after READY set, the command can be removed from the bus.

4.5.8 T8

In some period of time (> 20 u sec. and < 100 u sec., T6 to T8) after the host resets REQUEST, the controller will reset READY and perform the command.

4.5.9 T9

Having written the file mark the controller will set READY to its true state. This period is undefined; the host should monitor READY.

4.5.10 T10

At T10, the host can drop ONLINE. If the last command was a WFM Command, the controller will not write another file mark.

4.5.11 T11

When the host resets ONLINE, the controller will reset READY in some period of time < 0.25 u sec. (T10 to T11) and rewind the tape to BOT.

4.5.12 T12

When the controller has returned the tape to BOT, it will set READY to indicate to the host that it can accept another command.

4.6 Read Command (Refer to the chart on page 35)

The Read Command will have 100 in bits 7 through 5 and all zeroes in bits 4 through 0.

The Read Command is used to read user data from the tape. If a unit is not selected prior to issuing a Read Command, the controller will default to unit 0. If no position Command was issued prior to a read operation, the controller will move the tape to BOT.

ONLINE must be true when a Read Command is issued. If it is not, the controller will respond with EXCEPTION and an Illegal Command status report.

Upon receiving the Read Command, the controller will check the drive status for CARTRIDGE IN. If a cartridge is not completely inserted, the controller will assert EXCEPTION and abort the read operation.

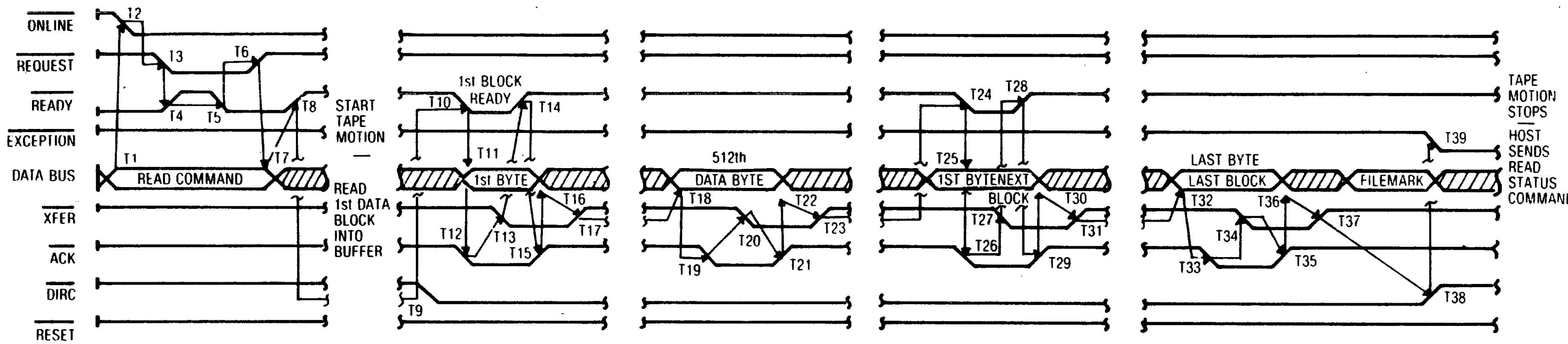
The controller will terminate a read operation after reading a file mark or after transferring a Block-In-Error (B.I.E.) when an unrecoverable read error occurs or upon detecting erased tape.

If the host wishes to continue reading the next file after a file mark or the next data block after a B.I.E., the host must maintain ONLINE in the true state and issue another Read Command. If the B.I.E. was a file mark, the next block of data will be the first block of the next file.

The host can terminate a read operation by resetting ONLINE. If ONLINE goes false, the tape will be rewound to BOT, track 0.

If ONLINE is held true after the read operation is terminated by the controller, it is possible to return to BOT, track 0 with a Rewind Command.

During a read operation, the host may issue a Read File Mark Command. If the first few blocks of a file have been read during the read operation and the user has determined that the required data is not in that file, a Read File Mark Command will cause the tape drive to read to the next file mark without transfering data. This relieves the host of data handling while searching for a specific file. Until a read operation is terminated, a RFM Command is the only legal command that may be issued.



READ DATA COMMAND

ACTIVITY	CRITICAL TIMING	ACTIVITY	CRITICAL TIMING	ACTIVITY	CRITICAL TIMING
T1-HOST COMMAND TO BUS	N/A	T14-CONTROLLER RESETS READY	T13→T14<.25 U sec.	T27-HOST SETS XFER	SAME AS T13
T2-HOST SETS ONLINE	N/A	T15-CONTROLLER RESETS ACK	.56<T13→T15<1.12 U sec.	T28-CONTROLLER RESETS READY	SAME AS T14
T3-HOST SETS REQUEST	T2→T3>Ø U sec.	T16-BUS DATA INVALID	T13→T16>0 U sec.	T29-CONTROLLER RESETS ACK	SAME AS T15
T4-CONTROLLER RESETS READY	T3→T4<0.25 U sec	T17-HOST RESETS XFER	T15→T17>0 U sec.	T30-BUS DATA INVALID	SAME AS T16
T5-CONTROLLER SETS READY	20<T4→T5<500 U sec. *	T18-BUS DATA VALID	N/A	T31-HOST RESETS XFER	SAME AS T17
T6-HOST RESETS REQUEST	T5→T6>Ø U sec.	T19-CONTROLLER SETS ACK	SAME AS T12	T32-LAST BYTE TO BUS	N/A
T7-BUS DATA INVALID	T5→T7>Ø U sec.	T20-HOST SETS XFER	SAME AS T13	T33-CONTROLLER SETS ACK	SAME AS T12
T8-CONTROLLER RESETS READY	20<T6→T8<100 U sec.	T21-CONTROLLER RESETS ACK	SAME AS T15	T34-HOST SETS XFER	SAME AS T13
T9-CONTROLLER CHANGES DIRC	N/A	T22-BUS DATA INVALID	SAME AS T16	T35-CONTROLLER RESETS ACK	SAME AS T15
T10-CONTROLLER SETS READY	N/A	T23-HOST RESETS XFER	SAME AS T17	T36-BUS DATA INVALID	SAME AS T16
T11-1ST DATA BYTE TO BUS	N/A	T24-CONTROLLER SETS READY	N/A	T37-HOST RESETS XFER	SAME AS T17
T12-CONTROLLER SETS ACK	T11→T12>-40 NANO sec.	T25-1ST BYTE TO BUS	N/A	T38-CONTROLLER SETS EXCEPTION	N/A
T13-HOST SETS XFER	T12→T13>Ø U sec.	T26-CONTROLLER SETS ACK	SAME AS T12	T39-CHANGE BUS DIRECTION	N/A

*NOTE: THIS TIME MAYBE >500 M SEC IF THE FOLLOWING OCCURS:

a. THE ONLINE SIGNAL IS DEASSERTED
b. RETRY SEQUENCE AND NO DATA DETECTED
c. AT END OF THE TRACK AND TURN AROUND OR START UP.

Read Data Command Timing (Refer to the chart on previous page)

4.6.1 T1

Having verified that READY is true, the host places the Read Data Command on the bus.

4.6.2 T2

Some period of time (> 0 u sec., T1 to T2) after the command is on the bus, the host sets ONLINE.

4.6.3 T3

Some period of time (> 0 u sec., T1 to T3) after the host sets ONLINE, the host sets REQUEST.

4.6.4 T4

In response to REQUEST going true the controller resets READY in some period of time < 0.25 u sec. (T3 to T4).

4.6.5 T5

The controller will read the command from the bus and set READY to its true state in some period of time > 20 u sec. and < 500 u sec. (T4 to T5).

4.6.6 T6

Seeing READY go true, the host should reset REQUEST in some period of time > 0 u sec. (T5 to T6).

4.6.7 T7

When READY returned to its true state, the controller was telling the host that it read the command and accepted it. In some period of time (> 0 u sec., T5 to T7) after READY set, the command can be removed from the bus.

4.6.8 T8

In some period of time (> 20 u sec. and < 100 u sec., T6 to T8) after the host resets REQUEST, the controller will reset READY in preparation for performing the command.

4.6.9 T9

After resetting READY, the controller will change DIRECTION of the bus (DIRC goes true). This time is undefined. The host should be watching READY to begin transfer of first block of data.

4.6.10 T10

At T10 the controller will set ready, to inform the host that the first BLOCK of data is ready. This signal can lag ACK, but the host should ensure that ready is true before looking for ACK.

4.6.11 T11

At T11, the controller will place the first byte of the first block of data on the bus.

4.6.12 T12

At T12, the controller will have placed the first byte on the bus and sets ACK simultaneously. These signals may vary within plus or minus 40 nanoseconds of each other.

4.6.13 T13

At T13, the host has detected ACK going true, has read the data from the bus and sets XFER. This tells the controller that the host has received the data.

4.6.14 T14

When the host sets XFER on the first byte of a block, the controller will reset READY in some period of time < 0.25 u sec. (T13 to T14). READY will remain false until the first byte of the next block.

4.6.15 T15

In addition to resetting READY, the controller will reset ACK in some period of time (> 0.56 u sec. and < 1.12 u sec., T13 to T15) after XFER goes true.

4.6.16 T16

When the host set XFER at T13, the controller was told that the data had been read off the bus. Some period of time after T13 (> 0 u sec., T13 to T16) the data will be considered invalid.

4.6.17 T17

In preparation for the next byte, the host will reset XFER in some period of time (> 0 u sec., T15 to T17) after ACK goes false.

4.6.18 T18

At T18, the controller will place the next byte on the bus.

4.6.19 T19

At T19, the controller will signal the host that the next byte is available by setting ACK to its true state. This will be in some period of time (> 0 u sec., T18 to T19) after the new byte was available.

4.6.20 The handshaking procedure will continue until a total of 512 bytes have been transferred from the controller to the host.

4.6.21 T24

When the next block of data is available to be transferred to the host, the controller will notify the host by setting READY to its true state.

4.6.22 T25

At T25 the controller will place the first byte of the next block on the bus.

4.6.23 T26

At T26 the controller will signal the host that the first byte of the next block is available on the bus. The controller will do this by setting ACK to its true state in some period of time (> 0 u sec., T25 to T26) after the data is on the bus.

4.6.24 The handshake procedure will be repeated for this block as it was for the first.

4.6.25 T37

At T37 the host will conclude the last transfer by resetting XFER.

4.6.26 T38

Some time after the last byte was read from tape by the controller, the controller will read a file mark. In response to reading a file mark, the controller will reset DIRC, set EXCEPTION (at T39) and stop tape motion.

The only legal response to EXCEPTION going true is for the host to issue a Read Status Command.

4.7 Read File Mark Command (Refer to the chart on page 41)

The Read File Mark Command will have a 101 in bits 7 through 5 and all zeroes in bits 4 through 0.

The Read File Mark Command is the same as a Read Command, except that no data is transferred to the host.

At each file mark, the controller sets EXCEPTION and informs the host that a file mark has been found.

If the host is looking for a particular file, the host must count the number of file marks found and re-issue RFM after each file mark.

Read File Mark Command Timing

4.7.1 T1

At T1, the host verifies that READY is true and places the Read File Mark Command on the bus.

4.7.2 T2

Some period of time (> 0 u sec., T1 to T2) after the command is on the bus the host will set ONLINE.

4.7.3 T3

Some period of time (> 0 u sec., T2 to T3) after ONLINE is set, the host will set REQUEST. This informs the controller that there is a command on the bus.

4.7.4 T4

Seeing REQUEST go true, the controller will reset READY in some period of time < 0.25 u sec. (T3 to T4).

4.7.5 T5

Some period of time (> 20 u sec., and < 500 u sec., T4 to T5) after READY went false, the controller will set READY to its true state. By setting READY, the controller has informed the host that the command has been read and accepted.

4.7.6 T6

When the host detects READY going true, it will respond by resetting REQUEST in some period of time > 0 u sec. (T5 to T6).

4.7.7 T7

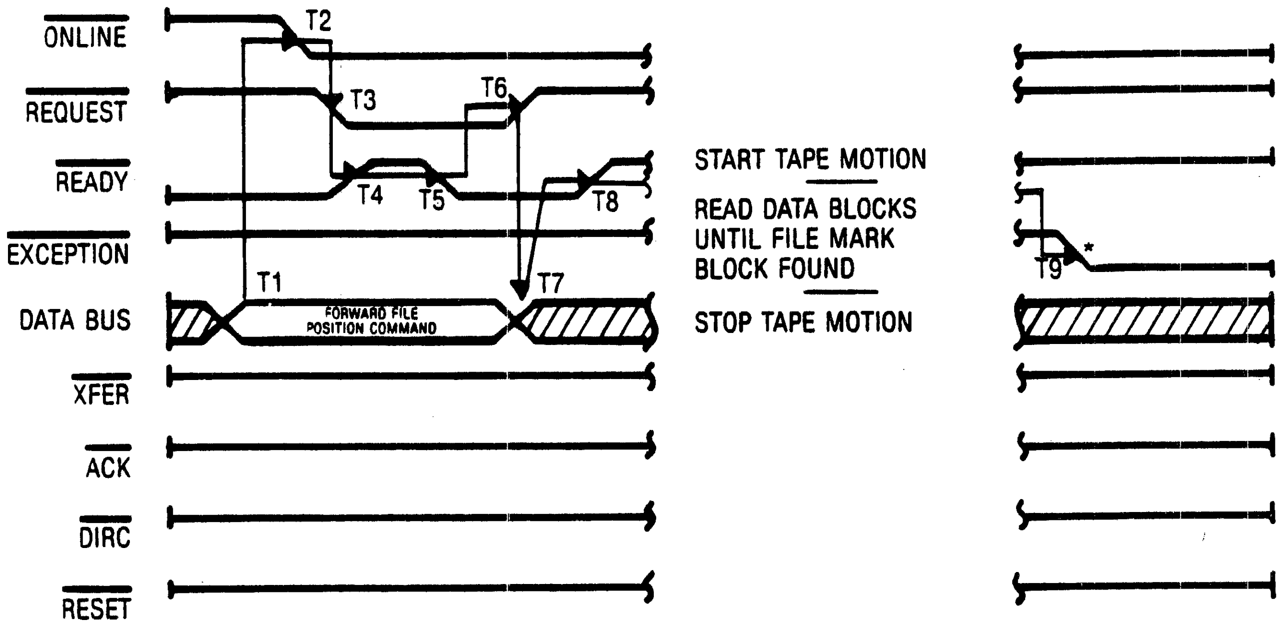
When the controller sets READY to its true state at T4, the controller ceased to regard the data on the bus as valid.

4.7.8 T8

Some period of time (> 20 u sec. and < 100 u sec., T6 to T8) after the host reset REQUEST, the controller will reset READY and perform the command.

4.7.9 T9

The controller began reading from tape at T8. It will continue to read tape until it encounters a file mark. When the controller reads a file mark it will stop tape motion and set EXCEPTION. The only legal response to exception is Read Status. The status bytes will inform the host that a file mark was read.



READ FILE MARK COMMAND

ACTIVITY	CRITICAL TIMING
T1-HOST COMMAND TO BUS	T1→T3>Ø U sec
T2-HOST SETS ONLINE	T2→T3>Ø U sec
T3-HOST SETS REQUEST	N/A
T4-CONTROLLER RESETS READY	T3→T4<0.25 U sec
T5-CONTROLLER SETS READY	20<T4→T5<500 U sec *
T6-HOST RESETS REQUEST	T5→T6> Ø U sec
T7-BUS DATA INVALID	T5→T7> Ø U sec
T8-CONTROLLER RESETS READY	20<T6→T8<100 U sec
T9-CONTROLLER SETS EXCEPTION	N/A

**SYSTEM MUST ISSUE READ STATUS COMMAND*

*NOTE: THIS TIME MAYBE>500 M SEC IF THE FOLLOWING OCCURS:
- a. THE ONLINE SIGNAL IS DEASSERTED
- b. RETRY SEQUENCE AND NO DATA DETECTED
- c. AT END OF THE TRACK AND TURN AROUND OR START UP.

4.8 Reset Timing (Refer to the chart on page 43)

4.8.1 T1

At T1, the host sets RESET to its true state.

4.8.2 T2

If ACK was true, the controller will reset it in some period of time < 0.25 u sec. (T1 to T2).

4.8.3 T3

If READY was true, the controller will reset it in some period of time < 0.25 u sec. (T1 to T3).

4.8.4 T4

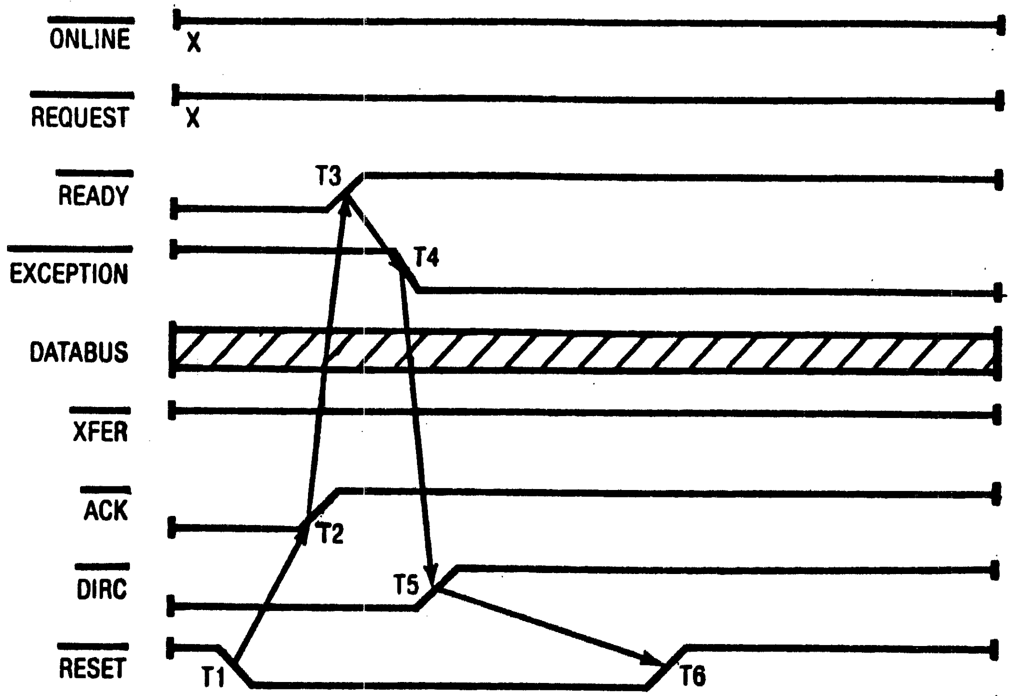
In response to RESET going true, the controller will set EXCEPTION to its true state in some period of time < 3 u sec. (T1 to T4).

4.8.5 T5

If DIRC was true, the controller will reset it in some period of time < 3 u sec. (T1 to T5).

4.8.6 T6

In some period of time > 13 u sec. (T1 to T6), the host may disable RESET.



RESET TIMING

ACTIVITY	CRITICAL TIMING
T1-HOST ASSERTS RESET	NA
T2-CONTROLLER DISABLES ACK	T1→T2<0.25 U sec.
T3-CONTROLLER DISABLES READY	T1→T3<0.25 U sec.
T4-CONTROLLER ASSERTS EXCEPTION	T1→T4<3 U sec.
T5-CONTROLLER DISABLES DIRC	T1→T5<3 U sec.
T6-HOST DISABLES RESET	T1→T6>13 U sec.

X-DON'T CARE

4.9 Basic Data Timing

	90 IPS	30 IPS
Tape Transfer Rate		
Byte Rate	90 KHz	30 KHz
Byte to Byte	11.17 u sec.	33.52 u sec.
512 Byte Data Block	5.72 M sec.	17.16 M sec.
Inter Block Time	184.38 u sec.	553.14 u sec.
Total Block Time	5.91 M sec.	17.73 M sec.
Average Byte Rate	86.69 KHz	28.89 KHz
DMA Transfer Rate		
Host DMA Timing		
Byte to Byte	5.03 u sec.	5.03 u sec.
512 Byte Block Time	2.58 M sec.	2.58 M sec.
Free Inter-block Time	3.33 M sec.	15.15 M sec.

5.0 Status Bytes

There are six Status Bytes which are maintained by the controller's microprocessor. These bytes contain data which is useful to the host. The host may request the Status Bytes at any time. This is done by issuing a Read Status Command.

The Status Bytes are:

Byte 0

- Bit 7 Exception Byte 0
- Bit 6 Cartridge Not In Place
- Bit 5 Drive Not Online
- Bit 4 Write Protected
- Bit 3 End of Media
- Bit 2 Unrecoverable Data Error
- Bit 1 BIE Not Located
- Bit 0 File Mark Detected

Byte 1

- Bit 7 Exception Byte 1
- Bit 6 Illegal Command
- Bit 5 No Data Detected
- Bit 4 8 or more Read Retries
- Bit 3 Beginning of Media
- Bit 2 Reserved
- Bit 1 Reserved
- Bit 0 Reset/Power-up Occurred

Bytes 2 and 3

Write Operations: Number of Blocks re-written

Read Operations: Number of soft read errors

Bytes 4 and 5

Write Operations: Number of Write Underruns

Read Operations: Number of Read Underruns

The first two bytes (0 and 1) will define the condition that caused EXCEPTION to go true. In both bytes, the most significant bit will be set if any other bit in the byte in set. If bit 7 is not set, no other bit should be set.

5.1 Status Byte 0

Bit 7 - Exception byte 0 bit is set if any other bit in the byte is set.

Bit 6 - Cartridge Not in place is set if a cartridge is not fully inserted into the drive.

Bit 5 - Drive not Online is set if the selected drive is not physically connected to the controller or is not receiving power.

Bit 4 - Write Protect is set if the cartridge write protect plug is set in the file protect position. (SAFE).

Bits 6 through 4 are dependent on the drive selected. The operator must correct the error condition before these status bits will reset.

Bit 3 - End of Media bit is set when the Logical Early Warning Hole of Track 3 is detected during a Write operation. This bit will remain set as long as the drive is at Logical End of Media. The EOM bit will not be reset by a Read Status command, nor will it be set during a normal Read operation.

Bit 2 - Unrecoverable Data Error bit is set when the controller experiences a hard error during read or write operations. After 16 retries to write or read a block of data this bit will set. The tape will be rewound to BOT if the error occurred during a write operation. This bit will reset after the Read Status Command.

Bit 1 - BIE Not Located is set when an Unrecoverable Data Error Occurs and the controller can not confirm that the last block transmitted was the Block In Error. This bit will reset after the Read Status Command.

Bit 0 - File Mark Detected bit is set when a file mark is detected during a Read or RFM Command. Read Status will cause this bit to reset.

5.2 Status Byte 1

Bit 7 - Exception Byte 1 bit is set if any other bit in the byte is set.

Bit 6 - Illegal Command bit is set if any of the following occurs:

1. Select Command is issued with no drives or more than one drive selected.
2. Position Command is issued with no qualifier bits.
3. ONLINE is off and a Write, Write File Mark, Read or Read File Mark Command is issued.
4. Issuing a command other than Write or Write File Mark during the execution of a Write Command.
5. Issuing any command other than a Read or Read File Mark Command during the execution of a Read Command.
6. De-selecting a drive when the tape cartridge is not at BOT, track 0.
7. Any command is issued with modifier bits set when they should not be.

A Read Status Command will cause this bit to reset.

Bit 5 - No Data Detected bit is set when an Unrecoverable Data Error occurred due to lack of recorded data. Absence of recorded data is the failure to detect a data block within a controller time out period (32 block times). This bit will reset after a Read Status Command.

Bit 4 - 8 or more Read Retries bit is set when 8 or more Read Retries were required to recover a data block. (Indicative of a tape cartridge nearing end of life.)

Bit 3 - Beginning of Media is set whenever the tape is logically at the BOT track 0. As the tape moves away from the beginning of tape, this bit will reset. This bit alone will not cause EXCEPTION to go true, nor will it be reset by a Read Status Command.

Bit 2 - Reserved

Bit 1 - Reserved

Bit 0 - Reset/Power Up Occurred bit is set after the controller receives a Reset signal from the host or when the controller is powered up. A Read Status Command will reset this bit.

5.3 Status Bytes 2 and 3

These two bytes will contain a 16-bit binary count of tape data errors. For write operations, this count will increment for each data block that is rewritten due to a read-after-write error. Byte 2 contains the MSB and Byte 3 contains the LSB. Since the rewrite sequence rewrites two data blocks for each error, the counter will be incremented twice for each error.

During read operations, this count will be incremented for each soft error. A soft error is defined as a block of data that requires from 1 to 16 read retries to be recovered. A read retry occurs whenever an unexpected CRC error occurs.

An expected CRC error was one that occurred during a write sequence and was corrected by writing a second iteration of the block.

5.4 Status Bytes 4 and 5

These two bytes will contain a 16 bit binary count of buffer underruns. Byte 4 contains the MSB and Byte 5 contains the LSB. For write operations this count will be incremented each time the host is unable to keep data flowing to the controller. If the controller is ready to write the next block, but a buffer is not full and ready to write, the controller will stop tape motion and wait for the host.

During a Read Operation, this count will increment when the Host is unable to empty the controller buffers fast enough. If an empty buffer is not available for the next block of data to be read from the tape, tape motion will stop.

6.0 Operational Sequences

The host and controller communicate via the eight bit bus and control lines. The sequences of operations are explained here.

6.1 Write Operation

6.1.1 The host, wishing to begin a write operation, checks to see if the controller is ready. If it is, the host will place a write command on the bus and notify the controller.

6.1.2 The controller will read the command, verify that a cartridge is in place and not write protected, and signal the host that the command was accepted.

6.1.3 If the host had not preceded the Write Command with Select and Position Commands the controller will automatically select unit 0 and track 0, BOT.

6.1.4 The controller will begin accepting data. When the first buffer is full, the controller will begin writing.

6.1.5 The controller will enable the drive capstan motor. When the tape has reached speed and the write head has reached the recording area (past the load point hole), the controller will begin writing data on the tape.

6.1.6 If the controller is writing on track 0, the Erase Bar will be enabled. The Erase Bar will remain enabled for the full length of track 0, erasing the full width of the tape, ahead of the write head.

6.1.7 The controller will write blocks of data on the tape, automatically adding gap, sync, block address and CRC.

6.1.8 After the data is written, it passes over the read head, which read-checks the data for CRC errors.

6.1.9 After the data has been verified by the read-after-write check, the buffer which held that data will be released for the next transfer of data from the host.

6.1.10 The controller will continue writing blocks of data to the tape until it detects the early warning hole. When the controller detects this hole, it will stop accepting new data from the host on the next block boundary. The controller will write all existing buffers to tape and then write a constant gap signal to the EOT hole.

6.1.11 The controller will then deselect the write mode, disable the erase head and stop tape motion.

6.1.12 The controller will switch to Track 1, reverse the capstan motor direction, and start tape motion. When the tape is up to speed and in the recording zone, the controller will resume writing.

6.1.13 The controller will continue writing for the full length of Track 1. When the load point hole is reached, the controller will again halt tape motion. This time the controller will physically reposition the read/write head and select Track 2.

6.1.14 If the host continues writing data until the early warning hole of Track 3, the controller will stop accepting data and inform the host that the tape is full. The host may now write a block describing that the file is not complete and write a file mark.

6.2 Read Operation

6.2.1 The host issues the Read Command.

6.2.2 If this is the first Read Command in the operation, the controller will move the tape to BOT, Track 0. If no Select Command was issued prior to the Read Command, the controller will default to Unit 0.

6.2.3 The controller brings the tape up to speed and begins searching for the first block of data.

6.2.4 The controller reads the entire block into a buffer and verifies the CRC. The controller also verifies that the blocks are read in consecutive order. This is done with the block address.

6.2.5 When the EOT holes are detected for Track 0, the controller will stop the drive, select Track 1, reverse the direction of the capstan motor and bring the tape up to speed.

6.2.6 When Track 1 is read, the controller will again reverse tape direction and this time it will physically reposition the head. Tracks 2 and 3 will be read as were Tracks 0 and 1.

6.2.7 The Read Command can be terminated by the host on a block boundary, by dropping ONLINE; or by the controller if a file mark or EOT holes for the last track are detected. The controller will inform the host of a Filemark or EOT with EXCEPTION and the Status Bytes.

6.3 Write File Mark

6.3.1 The Write File Mark Command will generate a 512 byte block with a unique code in the user data field. This block will be written as would any user data block, with sync, gap, block address and CRC. The host does not transfer any data for this block, it only issues the command.

6.3.2 The host issues a Write File Mark Command at a block boundary.

6.3.3 After issuing a WFM Command, the host can not transfer any more data to the controller without issuing another Write Data Command.

6.3.4 The controller will write all the data remaining in its buffers.

6.3.5 The controller generates a file mark and writes this block to tape.

6.3.6 The file mark block is read-after-write checked and is treated like any other block if an error occurs.

6.3.7 The host may terminate a Write Command by resetting ONLINE. If this is done, the controller will automatically write a file mark.

6.3.8 A Read Command will automatically terminate when the controller encounters a file mark. The controller will set EXCEPTION and set the file mark status bit.

6.4 Read File Mark Command

6.4.1 A Read File Mark Command is performed the same as a Read Command, but no data is transferred to the host.

6.4.2 A Read File Mark Command is terminated by reading a file mark. Counting the total number of files (or file marks) on a tape would require reissuing the RFM Command for each file mark found.

6.5 Error Processing and Recovery

The Archive controller has error processing and recovery routines which are transparent to the host. This reduces the overhead in the host and simplifies software developement, but it is important that the host be aware of error rates in order to track media reliability. The controller will issue a status report to the host which contains the error rate for the previous read or write operation. This report will be issued in response to the Read Status Command.

6.5.1 Read After Write Errors

The Archive Streaming Tape Drive is designed to accomodate occasional data errors due to contamination and imperfections in the media. To ensure that the data has been written correctly, a read check is performed on each block of data as it is written.

If a CRC error is found during the read check, that block will be re-written.

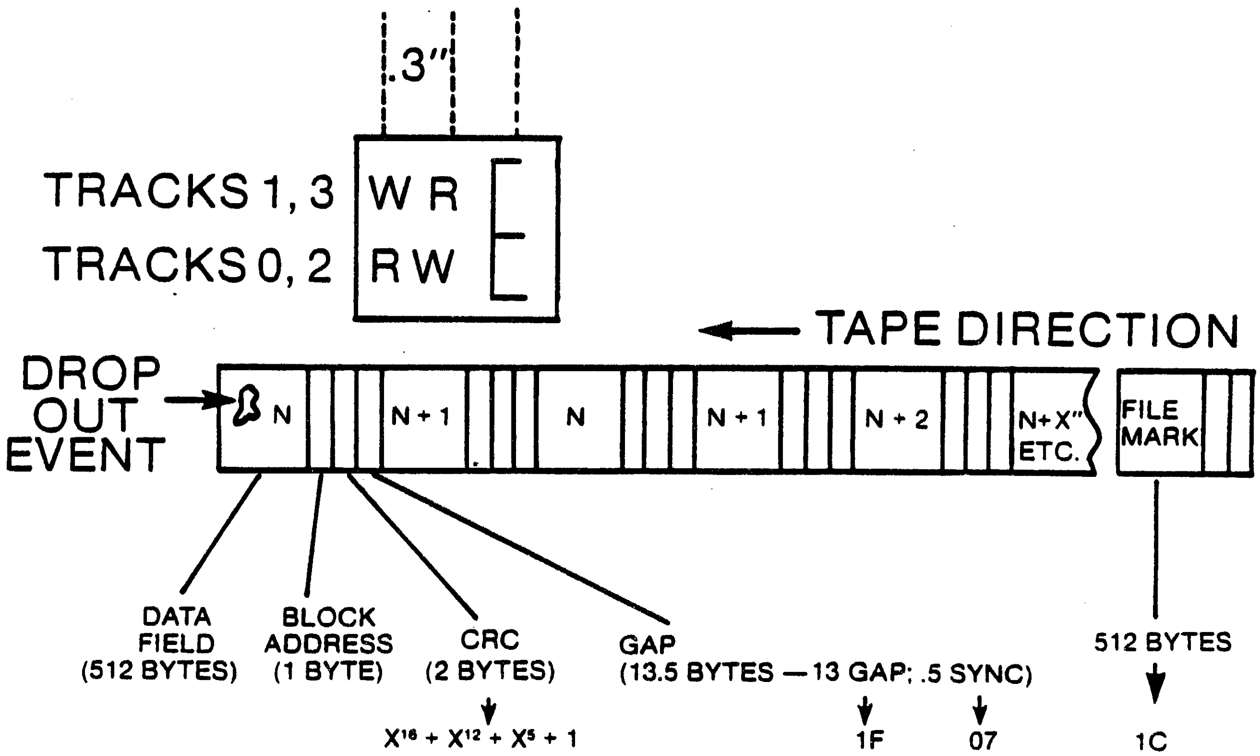
During a Write Command, the three buffers are allocated as follows: one for the block being written; one for the block being read checked, so that the data is available for rewriting; and one available for receiving the next data block from the host.

The tape drive head has two gaps, one for writing and one for reading. There are two sets of gaps, one set for each direction of tape motion. The write gap and the read gap are set 0.3 inches apart.

The read gap is used for read-after-write checking of new data. Since the inter-record gap is only 0.013 inches, the controller will begin writing block (N+1) before it finishes read-checking block (N). By the time a CRC error can be found in block (N), block (N+1) is already half written. Because of this, the following sequence is used. (Refer to the illustration on the next page.)

READ AFTER WRITE ERROR SEQUENCE

.3" = 300 BYTES



1. Read head detects error on block N →write head at byte 287 of N + 1.
2. Hold buffer N until N + 1 written →hold buffer N + 1 and rewrite N and N + 1.
3. If new record N is good, continue on →or if still bad retry sequence 16 times before terminating write command with unrecoverable write error status.
4. This scheme eliminates need for ECC — bad spot by-passed.

6.5.1.1 The controller begins writing block (N).

6.5.1.2 When block (N) reaches the read head (3000 flux reversals later), read checking begins.

6.5.1.3 The write channel finishes writing block (N) by appending a block address and CRC.

6.5.1.4 A short resynchronization gap is generated and written.

6.5.1.5 The write channel begins writing block (N+1).

6.5.1.6 The read channel finds a CRC error in block (N).

6.5.1.7 Because a CRC error was found, block (N) must be rewritten. Block (N+1) is already half written.

6.5.1.8 The controller will finish writing block (N+1) as it normally would. It then begins writing block (N) a second time.

6.5.1.9 If no errors are found in the second iteration of (N) during the read check, then the controller will continue writing the second iteration of block (N+1) and proceed with its normal sequences.

6.5.1.10 If the second writing of block (N) still had a CRC error, then a third copy of (N) would be written. (N+1) would also be written a third time. The controller will repeat its efforts to write block (N) until a total of 16 attempts have been made. If, after 16 copies of (N), block (N) still has a CRC error, the controller will stop tape motion, set EXCEPTION, and return the tape to BOT. The controller will inform the host of an Unrecoverable Data Error.

6.5.1.11 This error recovery procedure is transparent to the host if no hard failure occurs (16 repetitions). To keep the host informed of the media quality, the controller will report the number of blocks rewritten in response to a Read Status Command.

6.5.1.12 The total number of soft errors is cumulative. Only issuing a Read Status Command will zero the error count. (Other than a power down or RESET).

6.5.1.13 The controller will record every block written. Each time (N) is written, (N+1) is also written. The error count will usually be a multiple of two and may reflect as much as twice the number of write errors.

6.5.2 Write Buffer Underrun

To write in the streaming mode, the tape must be in constant motion. For tape motion to be constant, the flow of data from the host must be sufficient to keep the controller's buffers full of data.

If the controller has written block (N) and the next buffer of data (N+1) is not ready to be written, an Underrun Sequence will begin.

The controller will begin writing block (N) a second time and continue the read-after write check of the first copy of block (N). If a buffer of data is still not ready when the controller completes the read check, the controller will make the decision to stop the tape if N was written successfully. Before stopping the tape, the controller will finish the second copy of (N) and begin writing Gap. When the Gap reaches the read head the controller will stop tape motion and reposition the tape in preparation for writing new data. When the controller receives its next full block of data, it will start tape motion, reach correct tape speed and begin writing the new data after the gap. Each extended gap will be logged as an underrun and will be reported at the next Read Status Command. This underrun procedure allows about 3.33 milliseconds (at 90 i.p.s) of delay for the host to catch up to the controller before tape motion is interrupted. It also ensures that the controller will wait for the host if something interrupts the data flow.

6.5.3 Read Buffer Underruns

In a normal Read Operation, the controller will read a block of data from the tape into one of its buffers. It is then transferred via the bus, from the controller buffer to the host. The buffers are allocated so that one buffer is used for data being read in, one for data to be transferred to the host and one in reserve in case the host gets behind.

If the host should fail to empty the controller buffers, a Read Buffer Underrun may occur. An underrun occurs when the read channel has located the next block of data and none of the three buffers are available.

To prevent the loss of this next block of data, the controller will stop the tape, reverse direction of the tape and position the tape in preparation for continuing reading. When the next buffer becomes available, the controller will get the tape up to speed and begin reading again.

6.5.4 Read Data Errors

During a Read Operation, a temporary read error may occur. If the controller encounters a block with a CRC error, it will continue reading the next two blocks. If the second block has no CRC error and is the same block address as the original Block In Error (BIE), the controller will know that it was rewritten during the write operation.

This is the expected condition and will be invisible to the host. The controller will continue reading without logging an error. However if the controller reads the next two blocks and the BIE block address is not found, the controller will assume that the BIE was not rewritten. The controller will now perform a soft error retry.

First, the controller will stop the tape and reposition behind the BIE. It will then start the tape and reread the BIE and recheck the CRC. The controller will attempt to reread a BIE 16 times. If, after 16 retries, the data block has not been read without an error, the controller will terminate the read operation. The controller will transfer a block of data and inform the host of an unrecoverable read error. The controller will always transfer a block of data. If this is not the block in error, the host will be informed.

Successful soft error retries are invisible to the host. The controller will log all soft error retries and will pass the count to the host in response to a Read Status Command.

6.5.5 Read Sequence Errors

The controller assigns a block address to every block written to tape. This block address is written with the block on the tape. If a CRC error occurs during writing, the controller will rewrite the block of data, maintaining its original block address. This will alter the normal sequence. The controller uses the block addresses to maintain the proper sequence of data blocks sent to the host.

If a block is read during a read operation, which does not have a CRC error, but has an unexpected block address, a block sequence error will result. A block sequence error will cause a soft error retry sequence, just as a read data error would. If after 16 retries, the controller has not established normal sequence, the controller will transfer a block to the host, terminate the Read Command and inform the host of an unrecoverable data error. If the block transferred was not the block in error, the controller will set the BIE bit in Status Byte 1 to inform the host.

7.0 INTERFACE DESCRIPTION

7.1 INTERFACE SIGNAL LEVELS

All interface signals are low active standard TTL logic levels as follows:

False, Logic 0 (high level) = +2.4 to +5.0 VDC
True, Logic 1 (low level) = 0 to 0.8 VDC

Signal voltages are to be measured at the controller connector. The maximum cable length is 10 meters.

7.2 SIGNAL TERMINATIONS

The signal termination used is 220 ohms to +5VDC and 330 ohms to GND. Control signals from Host to Controller are terminated in the Controller. Control signals from Controller to Host must be terminated in the Host. The bi-directional data bus (HB0-HB7) is terminated in the Controller and must also be terminated in the Host.

7.3 SIGNAL LOADING

All signals from Host to Controller must be capable of driving one standard TTL load (1.6 mA) in addition to the signal terminator. All signals from Controller to Host are capable of driving one standard TTL load in addition to the signal terminator.

7.4 INPUT/OUTPUT SIGNAL CONNECTOR

The signal connector on the controller (J1) is a 50 conductor edge connector. The mating connector (P1) is a 3M type 3415-0001 or equivalent.

7.5 INPUT/OUTPUT SIGNAL PIN ASSIGNMENTS

PIN #	NAME	DESCRIPTION
01	GND	
02	SPARE-	
03	GND	
04	SPARE-	
05	GND	
06	SPARE-	
07	GND	
08	SPARE-	
09	GND	
10	SPARE-	
11	GND	
12	HB7-	HOST BUS BIT 7 - most significant bit of 8-bit host bidirectional data bus
13	GND	
14	HB6-	HOST BUS BIT 6
15	GND	
16	HB5	HOST BUS BIT 5
17	GND	
18	HB4-	HOST BUS BIT 4
19	GND	
20	HB3-	HOST BUS BIT 3
21	GND	
22	HB2-	HOST BUS BIT 2
23	GND	
24	HB1-	HOST BUS BIT 1
25	GND	
26	HB0-	HOST BUS BIT 0 - least significant bit of 8-bit host bidirectional data bus
27	GND	
28	ONL-	ON LINE - host-generated control signal which is activated prior to transferring a READ or WRITE command and deactivated to terminate that READ or WRITE command

29	GND	
30	REQ-	REQUEST - host-generated control signal which indicates that command data has been placed on the data bus in COMMAND MODE or that status has been taken from the data bus in STATUS INPUT MODE
31	GND	
32	RES-	RESET - causes controller to perform the same sequence as a POWER-ON sequence
33	GND	
34	XFER-	TRANSFER - host-generated control signal which indicates that data has been placed on the data bus in WRITE MODE or that data has been taken from the data bus in READ MODE
35	GND	
36	ACK-	ACKNOWLEDGE - controller--generated signal which indicates that data has been taken from the data bus in READ MODE or that data has been placed on the data bus in WRITE MODE
37	GND	

38	RDY-	READY - controller-generated signal which indicates the following: (1)data has been taken from the data bus in COMMAND TRANSFER MODE (2)data has been placed on the data bus in STATUS INPUT MODE (3)a position command has been completed in position mode (4)a buffer is ready to be filled by the host, or a WFM command can be issued (5)a WFM command is completed in WRITE FILE MARK mode (6)a buffer is ready to be emptied by the host in READ MODE (7)OTHERWISE, controller is ready to receive a new command
39	GND	
40	EXC-	EXCEPTION - controller--generated signal which indicates that an exception condition exists in the controller. The host MUST perform a STATUS INPUT to determine the cause.

41	GND	
42	DIRC-	DIRECTION - Controller-- generated signal which can be used to enable the host data bus drivers. When direction is False (HIGH), data transfers are from the host to the controller, and the host bus drivers should be enabled. When direction is True (LOW), data transfers are from the controller to the HOST, and the HOST bus drivers should assume their high impedance state.
43	GND	
44	SPARE-	
45	GND	
46	SPARE-	
47	GND	
48	SPARE-	
49	GND	
50	SPARE-	

8.0 POWER REQUIREMENTS FOR CONTROLLER

8.1 VOLTAGES REQUIRED

+24 VDC +/- 10% including maximum ripple of 500 mv
+ 5 VDC +/- 5% including maximum ripple of 200 mv

8.2 CURRENT REQUIRED

+24 VDC: 100mA max
+ 5 VDC: 2.5A max

8.3 POWER CONNECTOR

The DC power connector (J2) is AMP PN 1-480426-0. The mating connector (P2) is AMP PN 1-480424-0 and uses AMP PN 60619-1 female contacts. The power connections are as follows:

PIN 1	+24 VDC
PIN 2	+24 RET
PIN 3	+5 RET
PIN 4	+5 VDC

Pins 2 and 3 are connected together at the controller.

9.0 POWER REQUIREMENTS FOR BASIC DRIVE

DC Voltage	+24 Volts
Tolerance including	+/- 10%
max ripple of	500 millivolts
Current	
Standby	0.1 amps nom
operational	0.8 amps nom
tape start surge	2.5 amps max for up to 300 millisec (may be longer for defective cartridge)
power on surge	thru 1250 MFD max capacitance
Time to rated voltage	10 msec max
Power sequence	turn on 24 VDC simultaneously with 5 VDC, or issue system reset

DC Voltage	+5 Volts
Tolerance including	+/-5%
max ripple of	100 millivolts
Current	
standby	1.0 amps max
operational	1.0 amps max
	1.6 amps max
tape start surge	N/A
power on surge	thru 100 MFD max capacitance
Time to rated voltage	50 msec max
Power Sequence	turn on 5 VDC simultaneously with 24 VDC, or issue system reset

Power Disipation
30 Watts typical
50 Watts maximum

The DC Power Connector (J2) is an AMP P/N 1-480426-0. The mating connector (P2) requires an AMP P/N 10480424-0 and uses AMP P/N 60619-1 female contacts. The power connections are as follows:

Pin 1	+24 VDC
Pin 2	+24 VRET
Pin 3	+5 VRET
Pin 4	+5 VDC

Pins 2 and 3 are connected together at the drive.

10.0 PHYSICAL CHARACTERISTICS

10.1 MOUNTING

Physical mounting of the SIDEWINDER INTELLIGENT Drive is achieved with the Archive standard 1/4" cartridge tape drive mounting, within a standard 8" floppy "footprint".

The drive can be mounted in any orientation without affecting performance except that the drive should not be mounted such that any material removed from the tape by the tape guide can fall back onto the oxide surface due to gravity. Therefore, orientations where the oxide surface is under the tape guide (cartridge insertion slot down) are not recommended.

If the drive is mounted for operation in a dirty environment, positive measures should be taken to insure that contaminants do not enter the drive.

The basic SIDEWINDER Drive is normally supplied without a front panel. There is no rear panel. All connections are made directly to the printed wiring board via ribbon cable (I/O) and AMP (power) type connectors.

10.2 CARTRIDGE LOADING AND UNLOADING

The cartridge is loaded by pushing it to a hard stop through the loading aperature. There is only one orientation of the cartridge which allows it to be loaded.

The cartridge is unloaded by pulling it from the drive.

10.3 MEAN TIME BETWEEN FAILURES

The Mean Time Between Failures (MTBF) shall be greater than 3500 hours. This time includes all power on and operational time but excludes any maintenance periods. The operational versus power on time is assumed to be 30%.

10.4 CLEANING

The recording head and tape guide should be cleaned after the first 2 hours of tape movement of a new cartridge and then after every 8 hours of tape movement with a lintless cotton swab coated with isopropyl alcohol or IBM Tape Cleaner.

11.0 ENVIRONMENTAL CHARACTERISTICS

11.1 TEMPERATURE

Equipment Operational +5 to +45 degrees C

Equipment Non-Operational -30 to +60 degrees C

11.2 RELATIVE HUMIDITY

Equipment Operational 20 to 80% noncondensing
Equipment Non-Operational 0 to 99% noncondensing

11.3 THERMAL GRADIENT

Equipment Operational 1.0 degree C/min

11.4 ALTITUDE

Equipment Operational -200 ft to 15,000 ft
Equipment Non-Operational -200 ft to 50,000 ft

11.5 AMBIENT CONDITIONS

Free air flow is required to prevent the drive ambient temperature from rising above 45 degrees C (113 degrees F) under operating conditions. Otherwise forced cooling to achieve the operating temperature requirements should be supplied.