X3.146-198x

X3 Project: 378-D

Draft Proposed

American National Standard

X3.146-198x, Device Level Interface for

Streaming Cartridge and Cassette Tape Drives

This draft standard is published for a four-month period of public review and comment and subsequent letter ballot of Accredited Standards Committee X3, Information Processing Systems. Comments received during this period will be considered and answered. Commentors who object to approval of this draft as an American National Standard should so indicate including their reasons. The Public Review period will run from January 3, 1986 to May 3, 1986.

All comments should be returned as soon as possible but not later than May 3, 1986 to:

X3 Secretariat/CBEMA
311 First Street, N. W.
Suite 500
Washington DC 20001

A copy of the comments should be sent to:

Board of Standards Review
American National Standards Institute
1430 Broadway
New York NY 10018

Prepared by

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Working Draft for a

Proposed American National Standard for

Device Level Interface for

Streaming Cartridge and Cassette Tape Drives

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1. Scope

This cartridge and cassette tape drive interface standard specifies a device level interface to a streaming drive. The specification includes hardware interface, bus timing, commands and status.

2. Definitions

block	A group of 512 consecutive octets of data which are transferred as a unit.
BOM	(Beginning of Media) The start of the recordable area of tape on the initial track.
BOT	(Beginning of Tape) A marker indicating the beginning of tape.
cartridge	Refer to American National Standard Unrecorded Magnetic Tape Cartridge for Information Interchange 0.250 inch (6.36 mm), 1600 bpi (6.36 bpmm) Phase Encoded, ANSI X3.55-1982. Other implementations of cartridge media may be used in this class of device.
cassette	Refer to American National Standard Unrecorded Magnetic Tape Cassette for Information Interchange 0.150 in (3.81 mm), 800 bpi (32 bpmm) Phase Encoded, ANSI X3.48-1985. Other implementations of cassette media may be used in this class of device.
command	The instruction octet which specifies the operation to be performed.
continuable	Any error after which an operation can be continued by issuing another command.
controller	A functional unit in a data processing system that controls one or more units of peripheral equipment.
device	A piece of equipment or mechanism which is used to store and recover data onto and from magnetic tape (sometimes used interchangeably with drive.)
drive	See device.
EOT	(End of Tape) A marker indicating the end of tape.

ERM	(End of Recorded Media) The end of recorded media as defined by the format being utilized.
EW	(Early Warning) A marker indicating the approaching end of the permissible recording area.
exception condition	Any condition which prevents the performance of a potential command or the continuation of the current operation.
file mark	A magnetically recorded identification mark.
LP	(Load Point) A marker indicating the beginning of the permissible recording area.
media	Media, for the purpose of this document, is defined as magnetic tape which is used to store and retrieve digital data, prepackaged in a functional enclosure capable of being installed directly into an appropriate drive mechanism.
octet	An eight-bit byte.
search	A read operation that logically repositions the tape and does not transfer data to the controller.
status	Octets transmitted indicating the current condition of a device.
streaming drive	A tape drive that is designed to maintain continuous tape motion without the requirement of start and stop within an interrecord gap. If tape motion is interrupted for any reason, the drive must reposition the tape by moving far enough in the logical reverse direction to allow the tape to be brought up to speed in the logical forward direction before it reaches the point at which the preceding operation was terminated.
underrun	A condition developed when the controller transmits or receives data at a rate less than that required by the device to maintain streaming operation.

3. Interface

This section defines the device level tape drive interface. Data and commands shall be transferred to and from the device on an eight-bit bi-directional data bus, with an optional parity bit, and eight control signals using asynchronous handshaking techniques to eliminate rigorous timing constraints. The interface shall support up to four devices and a total maximum cable length of ten feet (three meters).

3.1 Input/Output Signal Connector and Cable. The signal interface connector on the device shall be a fifty conductor card edge connector. (See Fig. 1) Typically, the signal interface cable connector is a fifty conductor receptacle (See Fig. 2). The signal cable shall have a characteristic impedance of 100 ± 10 ohms.

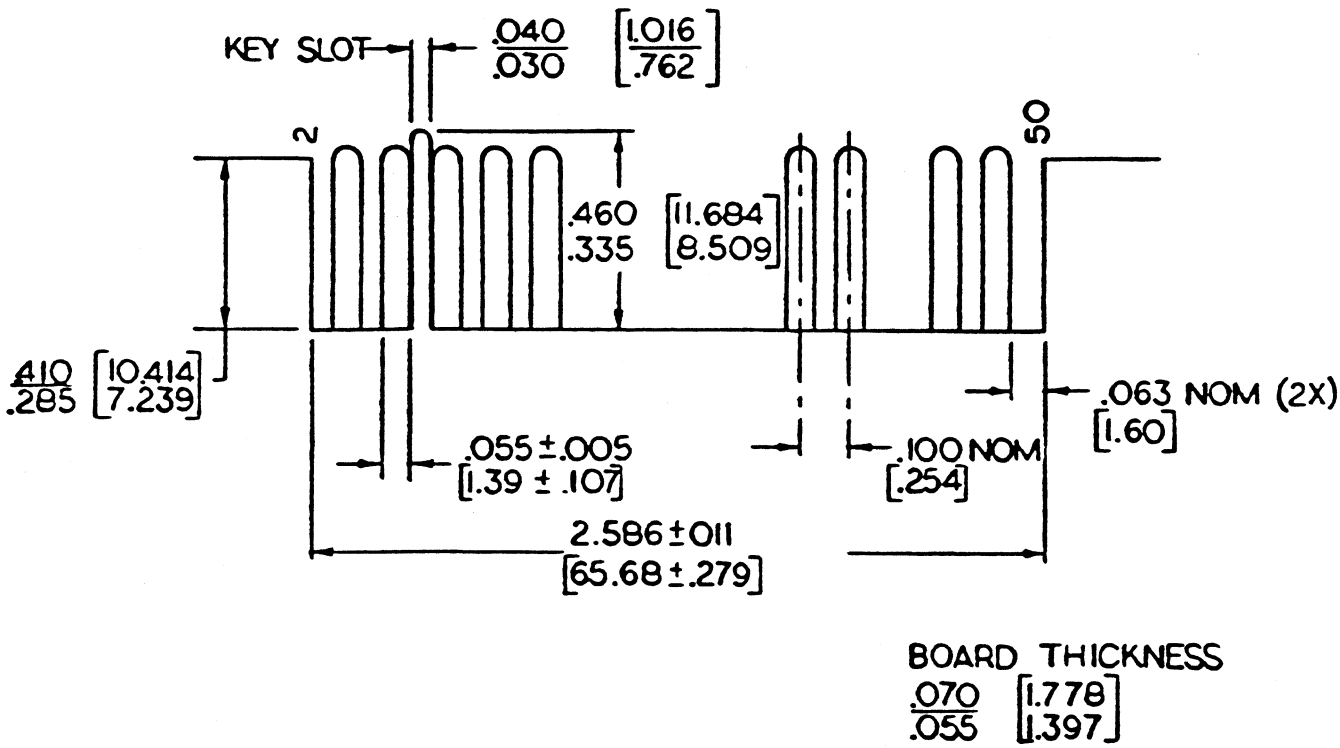


Fig. 1
Device Signal Interface Connector

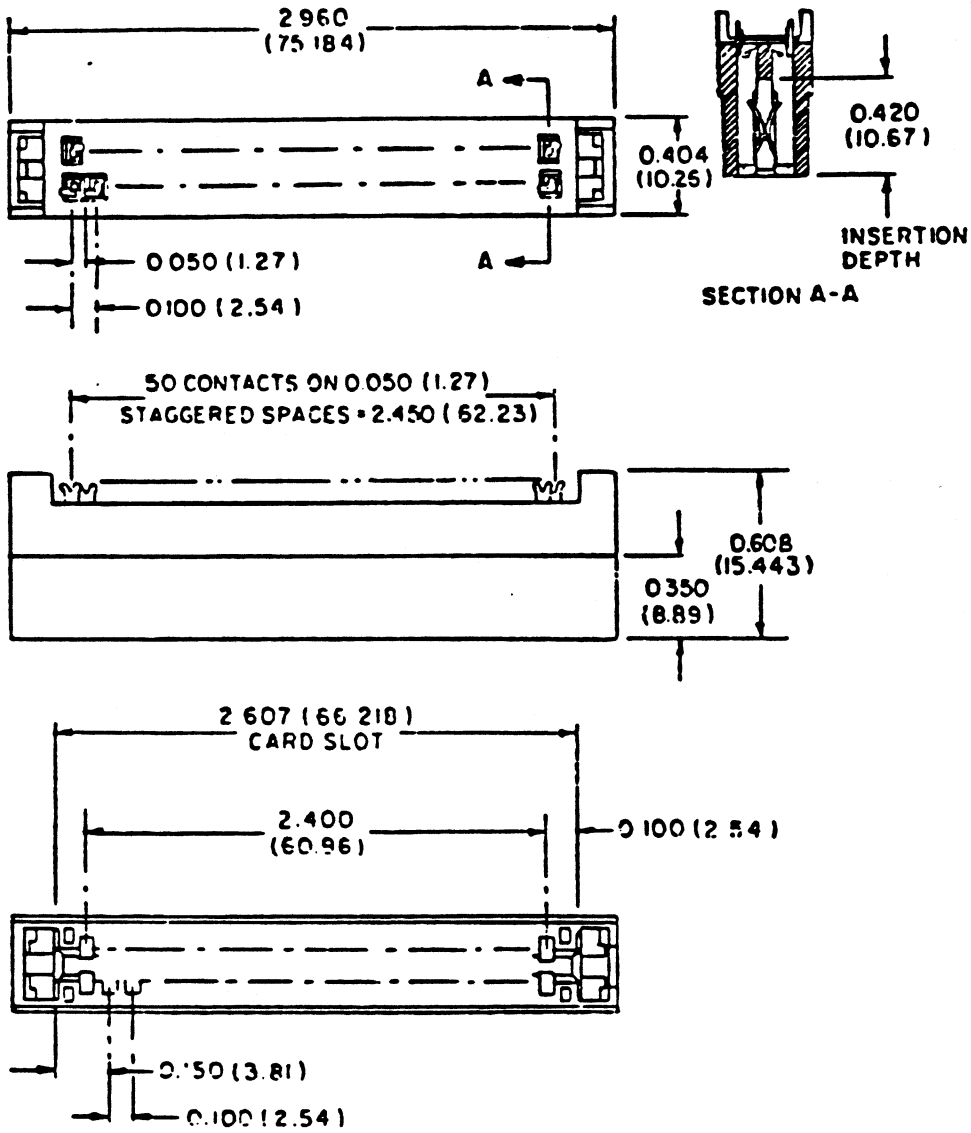


Fig. 2
Signal Interface Cable Connector

3.2 Interface Electrical Description. For these measurements, bus termination is assumed to be internal to the device. A typical device shall have the provision for allowing terminations in the last device on the interface only.

The standard termination shall be 220 ohms to +5 VDC and 330 ohms to GND or Thevenin equivalent. Resistance tolerance shall be ± 5% maximum. The bi-directional data bus and the four control signals from the controller to the device shall be terminated at the device unless daisy-chained; in which case, the last device on the chain shall provide terminations. The controller shall terminate the bi-directional data bus and the four control signals from the devices to the controller.

All signals shall use open collector or three-state drivers.

Each signal driven by the device shall have the following output characteristics when measured at the device's connector:

Signal Assertion = 0.0 VDC to 0.4 VDC
Minimum Driver Output Capability = 48 mA (sinking) @ 0.5 VDC
Signal Nonassertion = 2.5 VDC to 5.25 VDC

Each signal received by a device shall have the following input characteristics when measured at the device's connector:

Signal Assertion = 0.0 VDC to 0.8 VDC
Maximum Total Input Load = -0.4 mA @ 0.4 VDC
Signal Nonassertion = 2.0 VDC to 5.25 VDC
Minimum Input Hysteresis = 0.2 VDC

3.3 Input/Output Signal Pin Assignments. The input/output signal pin assignments shall be as defined in Table 1.

Table 1
Input/Output Signal Pin Assignments

Pin #	Mnemonic	To	Name
02	-	-	Not Used - reserved
04	-	-	Not Used - reserved
06	-	-	Not Used - reserved
08	-	-	Not Used - reserved
10	BBP	B	Bus Bit Parity - (optional)
12	BB7	B	Bus Bit 7
14	BB6	B	Bus Bit 6
16	BB5	B	Bus Bit 5
18	BB4	B	Bus Bit 4
20	BB3	B	Bus Bit 3
22	BB2	B	Bus Bit 2
24	BB1	B	Bus Bit 1
26	BB0	B	Bus Bit 0
28	ONL	D	Online
30	REQ	D	Request
32	RST	D	Reset
34	XFR	D	Transfer
36	ACK	C	Acknowledge
38	RDY	C	Ready
40	EXC	C	Exception
42	DIR	C	Direction
44	-	-	Not Used - reserved
46	-	-	Not Used - reserved
48	-	-	Not Used - reserved
50	-	-	Not Used - reserved

All odd numbered pins shall be connected to signal GND at the device. The "To" nomenclature above shall be as follows:

B = Bi-directional D = Device C = Controller

3.4 Input/Output Signal Descriptions. The functions of the input/output signals shall be as follows.

3.4.1 Data Bus. Bus bits 0 through 7 comprise an eight-bit bi-directional data bus. Bus Bit 0 is the least significant bit and Bus Bit 7 is the most significant bit. A logical ONE of a bus bit is represented by the asserted state. The use of bus parity is optional. When implemented, odd parity shall be used; that is, the number of bits asserted on the nine-bit bus shall be odd. When not implemented, this bit is undefined.

3.4.2 Control Lines

3.4.2.1 Reset. The RESET signal shall be generated by the controller. When RESET is asserted, all devices connected to the bus shall be reset and operating parameters shall be initialized. When RESET is deasserted, the device with address 0 shall take command of the bus and assert EXCEPTION.

If there is no device with address 0, then the bus shall stay in a nonactive state and no indication shall be given to the controller. After a time-out, the controller may issue a SELECT command to select another device.

3.4.2.2 Exception. The EXCEPTION signal shall be generated by the device. EXCEPTION shall be asserted to indicate that the device has information for the controller. EXCEPTION shall be asserted by a device when selected after a RESET. EXCEPTION may be asserted during an operation and should be treated with priority. While EXCEPTION is asserted, the only legal command that shall be transmitted to the device is Read Status.

3.4.2.3 Online. The ONLINE signal shall be generated by the controller. The controller shall assert ONLINE prior to any type of write, read or search operation. Deasserting the ONLINE signal with READY asserted shall terminate any write or read operation and shall rewind the tape to BOT. In all other operations, the status of this signal shall not be relevant. ONLINE shall be deasserted only when READY is asserted.

3.4.2.4 Request. The REQUEST signal shall be generated by the controller. REQUEST shall be asserted to initiate and execute command transfers and to transfer status information. REQUEST shall only be asserted when EXCEPTION or READY is asserted, except as specified in 3.4.2.1.

3.4.2.5 Ready. The READY signal shall be generated by the device. READY shall be asserted to indicate one of the following conditions:

(1) The device is available to receive and execute a new command.

(2) The device is ready for transfer of a new block during a read or write operation.

(3) The device is ready to transfer status information to the controller when REQUEST is asserted.

(4) The device is ready to terminate a read or write operation when ONLINE is deasserted.

3.4.2.6 Transfer. The TRANSFER signal shall be generated by the controller. TRANSFER shall be used in conjunction with ACKNOWLEDGE to move data between the device and controller. For a transfer from controller to device, TRANSFER shall be asserted to indicate that data has been placed on the data bus. For a transfer from device to controller, TRANSFER shall be asserted to indicate that data has been taken from the data bus.

3.4.2.7 Acknowledge. The ACKNOWLEDGE signal shall be generated by the device. ACKNOWLEDGE shall be used in conjunction with TRANSFER to move data between the device and controller. For a transfer from controller to device, ACKNOWLEDGE shall be asserted to indicate that data has been taken from the data bus. For a transfer from device to controller, ACKNOWLEDGE shall be asserted to indicate that data has been placed on the data bus.

3.4.2.8 Direction. The DIRECTION signal shall be generated by the device. DIRECTION shall be asserted to indicate that transfers are from the device to the controller. DIRECTION shall be deasserted to indicate that transfers are from the controller to the device.

4. Commands

All device commands shall be single octet commands as defined in Table 2. Devices shall implement all standard (S) commands in order to meet the minimum requirements of this standard. Optional (O) commands, if implemented, shall be as specified in this standard. Vendor unique commands shall be as specified by the manufacturer of the device. All unimplemented, reserved, and unassigned commands shall return illegal command status from a device. Unselected devices shall not respond to any command other than the SELECT command.

Unless otherwise specified, all references to forward and reverse direction are to be interpreted in the logical sense. In a buffered device, references to tape positioning may be logical rather than physical.

Table 2
Command Summary

HEX	7654 3210			Command
01	0000 0001	S		SELECT (DEVICE 0)
02	0000 0010	S		SELECT (DEVICE 1)
04	0000 0100	S		SELECT (DEVICE 2)
08	0000 1000	S		SELECT (DEVICE 3)
11	0001 0001	O		SELECT (DEVICE 0, LOCKED)
12	0001 0010	O		SELECT (DEVICE 1, LOCKED)
14	0001 0100	O		SELECT (DEVICE 2, LOCKED)
18	0001 1000	O		SELECT (DEVICE 3, LOCKED)
21	0010 0001	S		REWIND
22	0010 0010	S		ERASE
24	0010 0100	S		INITIALIZATION
25	0010 0101		O	SET AUTO MEDIA INITIALIZATION
26	0010 0110		O	SET DEVICE FORMAT 1
	thru			:
2A	0010 1010		O	SET DEVICE FORMAT 5
2B	0010 1011		O	SET DEVICE CONFIGURATION 1
	thru			:
2F	0010 1111		O	SET DEVICE CONFIGURATION 5
40	0100 0000	S		WRITE
41	0100 0001		O	WRITE WITHOUT UNDERRUNS
60	0110 0000	S		WRITE FILE MARK
62	0110 0010		O	WRITE FILE MARK/WRITE
63	0110 0011		O	WRITE FILE MARK/WRITE WITHOUT UNDERRUNS
80	1000 0000	S		READ
81	1000 0001		O	SPACE FORWARD
82	1000 0010		O	READ CONTINUOUS
89	1000 1001		O	SPACE REVERSE
A0	1010 0000	S		READ FILE MARK
A3	1010 0011		O	SEARCH FOR END OF DATA
A8	1010 1000		O	READ FILE MARK REVERSE
B1	1011 0001		O	READ 1 FILE MARK
	thru			:
BF	1011 1111		O	READ 15 FILE MARKS
C0	1100 0000	S		READ STATUS
C2	1100 0010		O	RUN SELF-TEST 1
CA	1100 1010		O	RUN SELF-TEST 2

4.1 Standard Command Descriptions. This section defines the standard commands which shall be implemented by all devices.

4.1.1 Select (Device N) Command. The SELECT command shall select one of up to four devices. The device shall remain selected until changed by either a RESET or another SELECT command.

In the case where no device is selected due to a RESET (NO DEVICE 0 PRESENT) or the attempted selection of a nonexistent device, the controller may then issue a SELECT command to identify another device. (See Section 6 for timing information.)

During deselection and selection of devices while at position, care must be taken to avoid unwanted rewinds as a result of the ONLINE signal. Following a write or read operation, the device shall not rewind when deselected with ONLINE asserted. Deasserting ONLINE while READY is asserted shall cause the tape to rewind to BOT. A rewind shall not occur when the device is reselected, regardless of the state of ONLINE. Prior to any subsequent read, write or search operation, the controller shall ensure that ONLINE is asserted.

During the selection and deselection of devices in a multiple device environment, the following conditions may exist:

(1) If a device is deselected while BOM is reset, it shall retain all of its operational parameters (tape position).

(2) If the currently selected device detects a select code other than its own, it shall assume the deselected state.

(3) The selected device shall assert either READY or EXCEPTION. EXCEPTION indicates a change in status occurred while the device was deselected.

4.1.2 Select (Device N, Locked) Command. The SELECT (DEVICE N, LOCKED) command shall be identical in function to the SELECT (DEVICE N) command and, additionally, shall provide a soft (light) and/or hard lock to prevent removal of the media from the device. Execution of the SELECT (DEVICE N) command or RESET shall unlock the media.

4.1.3 Rewind Command. The REWIND command shall physically position the tape in the device at BOT. The normal completion of this command shall cause READY to be asserted and BOM status to be set.

4.1.4 Erase Command. The ERASE command shall render all previously recorded data on the tape in the device inaccessible to the controller and shall leave the tape in a logically empty state. In addition, this command shall perform all the functions of the INITIALIZATION command. The normal completion of this command shall cause READY to be asserted.

4.1.5 Initialization Command. The INITIALIZATION command shall condition the tape in the device according to the recommendations of the media manufacturer and position it at BOT. The normal completion of this command shall cause READY to be asserted and BOM status to be set.

4.1.6 Write Command. The WRITE command shall cause data to be written on the tape in the device. The controller shall assert ONLINE and shall then issue the WRITE command. The READY line shall be asserted when the device is ready for a data block transfer. If the READY line is asserted between blocks, the controller may terminate transfer of write data by either issuing a WRITE FILE MARK command or deasserting ONLINE. Deasserting ONLINE shall cause a file mark to be written (if not preceded by a WRITE FILE MARK command) and the tape shall be rewound to BOT.

Note: A WRITE command following media insertion, RESET, or any command which positions the tape at BOT shall commence recording at BOM. Otherwise, recording shall commence at the current tape position. If, between blocks, the controller starts data transfer by asserting TRANSFER before the device asserts READY, then the behavior of the READY signal is device dependent. The device shall, regardless of the way READY is handled, continue the TRANSFER and ACKNOWLEDGE handshaking correctly so that no data is lost.

When EW is detected while recording on the last track, the device shall cease to transfer additional data blocks from the controller. The device shall terminate the WRITE command and report EOM by means of an EXCEPTION and READ STATUS. The device shall allow the transfer of additional blocks of data with a WRITE command after the receipt of EOM. However, EXCEPTION shall be asserted for each block transferred.

4.1.7 Write File Mark Command. The WRITE FILE MARK command shall cause a FILE MARK to be written on the tape in the device. A WRITE FILE MARK command following media insertion, RESET, or any command which positions the tape at BOT shall commence recording from BOM. Otherwise, recording shall commence from the current tape position. The normal completion of this command shall cause READY to be asserted. Deasserting ONLINE shall cause the tape to rewind to BOT.

4.1.8 Read Command. The READ command shall cause data to be read from the tape in the device. The controller shall assert ONLINE and issue the READ command. The device shall transfer data. The READY line shall be activated when the device is ready for a data block transfer. The READ command shall be terminated by the device if a file mark is detected. The

controller shall be informed of file mark detection by means of an EXCEPTION and a read status sequence. When READY is asserted, the controller may terminate the READ command by either:

(1) Deactivating ONLINE, which causes the tape to rewind to BOT.

(2) Issuing another command.

A READ command following media insertion, RESET, or any command which positions the tape at BOT shall commence reading at BOM. Otherwise, the READ command shall commence from the current tape position. If the controller starts a data transfer between blocks, before READY is asserted, READY may not occur.

4.1.9 Read File Mark Command. The READ FILE MARK command shall cause the tape in the device to move in the logical forward direction to position the tape just past the next file mark. No data shall be transferred. A READ FILE MARK command following media insertion, RESET, or any command which positions the tape at BOT shall commence reading from BOM. Otherwise, reading shall commence from the current tape position. The normal completion of this command shall cause EXCEPTION to be asserted with FMD set.

4.1.10 Read Status Command. The READ STATUS command shall cause the device to transfer to the controller information about itself. The device shall transfer six octets of status information. The normal completion of this command shall cause READY to be asserted. The READ STATUS command shall be issued in response to an EXCEPTION condition.

4.2 Optional Command Descriptions. This section defines optional commands which, if implemented, shall be as specified.

4.2.1 Set Auto Media Initialization Command. The SET AUTO MEDIA INITIALIZATION command shall instruct the device to perform a media initialization each time a new media is inserted. The device shall perform this operation for every media insertion until the device is reset or power is turned off. The normal completion of this command shall cause READY to be asserted.

4.2.2 Set Device Format (N). The SET DEVICE FORMAT (N) command shall instruct the device to select the format to be used.

(1) Set Device Format 1 (26_H) Set Format 1

(2) Set Device Format 2 (27_H) Set Format 2

(3) Set Device Format 3 (28_H) Set Format 3

(4) Set Device Format 4 (29_H) Reserved

(5) Set Device Format 5 ($2A_H$) Vendor Unique

These commands are valid only when BOM status is set. Otherwise, illegal command status shall result. Formats are as follows:

Format 1	Recorded tape format as defined by ANSC Document X3T9/84-79 (QIC-11).
Format 2	Recorded tape format as defined by ANSC Document X3T9/84-80 (QIC-24).
Format 3	Recorded tape format as defined by ANSC Document (TBD) (QIC-50).

The format shall remain as selected until changed by another SET DEVICE FORMAT (N) command or a RESET is issued. The normal completion of this command shall cause READY to be asserted.

4.2.3 Set Device Configuration (N). The SET DEVICE CONFIGURATION (N) command shall instruct the device to enable vendor unique configurations.

(1) Set Device Configuration 1 ($2B_H$) Reserved

(2) Set Device Configuration 2 ($2C_H$) Reserved

(3) Set Device Configuration 3 ($2D_H$) Vendor Unique

(4) Set Device Configuration 4 ($2E_H$) Vendor Unique

(5) Set Device Configuration 5 ($2F_H$) Vendor Unique

The configuration shall remain enabled until changed by another SET DEVICE CONFIGURATION (N) command or a RESET is issued. The normal completion of this command shall cause READY to be asserted.

4.2.4 Write Without Underruns Command. The WRITE WITHOUT UNDERRUNS command shall instruct the device to perform all functions of a WRITE command and shall continue tape movement when an underrun occurs. Tape movement shall stop when the end of track is reached.

4.2.5 Write File Mark/Write Command. The WRITE FILE MARK/WRITE command instructs the device to combine the WRITE FILE MARK command and a WRITE command to achieve streaming operation when writing file marks. When executing this command, the device shall first complete the writing of the remaining data blocks in the buffer, if applicable. It shall then write a file mark and thereafter, the device shall proceed with a normal write operation. To maintain streaming operation, the controller shall transfer a complete data block prior to the device committing to an underrun.

4.2.6 Write File Mark/Write Without Underruns. The WRITE FILE MARK/WRITE WITHOUT UNDERRUNS command shall instruct the device to combine the WRITE FILE MARK command and a WRITE WITHOUT UNDERRUNS command to achieve streaming operation when writing file marks. When executing this command, the device shall first complete the writing of the remaining data blocks

in the buffer, if applicable. It shall then write a file mark and thereafter, the device shall proceed with a normal write without underruns operation.

4.2.7 Space Forward Command. The SPACE FORWARD command shall instruct the device to logically move the tape forward over the subsequent data block or file mark. No data shall be transferred. The normal completion of this command shall cause READY to be asserted. If the command is issued at the ERM position or a file mark is detected, EXCEPTION shall result.

4.2.8 Read Continuous Command. The READ CONTINUOUS command shall instruct the drive to begin (or continue) a read operation. During the execution of the standard READ command, it is permissible to stop tape motion when a file mark is encountered. However, during execution of the READ CONTINUOUS command, tape motion shall not stop when a file mark is encountered. The device shall continue reading the following blocks, while simultaneously alerting the controller by asserting the EXCEPTION signal. To maintain streaming operation, the controller shall complete the READ STATUS sequence and issue a new READ or READ CONTINUOUS command prior to the device committing to an underrun.

4.2.9 Space Reverse Command. The SPACE REVERSE command shall instruct the device to logically move the tape in reverse over the previous data block or file mark. No data shall be transferred. The normal completion of this command shall cause READY to be asserted. If the command is issued at BOM position or a file mark is detected, EXCEPTION shall result.

4.2.10 Read File Mark Reverse Command. The READ FILE MARK REVERSE command shall cause the device to move the tape in the reverse direction to the BOM side of the next file mark. No data shall be transferred. The normal

completion of this command shall cause EXCEPTION to be asserted with File Mark Detected status set. If the command is issued at BOM or if no file mark is found between the current tape position and BOM, EXCEPTION shall be asserted and BOM status set.

4.2.11 Read N File Marks Command. The READ N FILE MARKS command shall be identical in function to the READ FILE MARK command except that the number of file marks read shall be equal to the binary value of NNNN. For example, 1011 0001 shall cause one file mark to be read and 1011 0010 shall cause two file marks to be read.

4.2.12 Search for End of Data Command. The SEARCH FOR END OF DATA command shall instruct the device to search for the end of recorded media. The normal completion of this command shall cause EXCEPTION to be asserted and ERM status to be set. New data may then be recorded following the existing recording by issuing a WRITE command.

4.2.13 Run Self-Test 1 Command. The RUN SELF-TEST 1 command shall instruct the device to perform vendor unique self-test operations. This command shall not allow writing on the media. Following transfer of the command octet, the device shall deassert READY and commence with the self-test. At the completion of the self-test, READY shall be asserted indicating that response information is available. The controller shall receive six octets of response information using the REQUEST/READY handshake protocol. The first two octets of response information shall conform to Section 5. Information octets 2, 3, 4, and 5 are vendor unique. The normal completion of this command shall cause READY to be asserted.

4.2.14 Run Self-Test 2 Command. The RUN SELF-TEST 2 command shall instruct the device to perform vendor unique self-test operations. This command allows reading and writing test information on the media. This command may destroy user data if executed on a device with a media containing user data. Following transfer of the command octet, the device shall deassert READY and commence with the self-test. At the completion of the self-test, READY shall be asserted indicating that response information is available. The controller shall transfer six octets of response information using the REQUEST/READY handshake protocol. The first two octets of response information shall conform to Section 5. Information octets 2, 3, 4, and 5 are vendor unique. The normal completion of this command shall cause READY to be asserted.

4.3 Vendor Unique Commands. The following command groups are available for vendor unique applications.

Table 3
Vendor Unique Commands

Binary 7654	Binary 3210	Hexadecimal
0011	1000-1111	38 thru 3F
0100	1000-1111	48 thru 4F
0101	1000-1111	58 thru 5F
0110	1000-1111	68 thru 6F
0111	1000-1111	78 thru 7F
1000	1000	88
1000	1010-1111	8A thru 8F
1001	0000-1111	90 thru 9F
1010	1000-1111	A8 thru AF
1011	0000	B0
1100	0001	C1
1100	0100-1001	C4 thru C9
1100	1011-1111	CB thru CF
1101	0000-1111	D0 thru DF
1110	0000-1111	E0 thru EF

4.4 Reserved Commands. All command codes not listed in Table 2 or Table 3 are reserved for future use. To remain in compliance with this standard, these reserved commands shall not be used for any purpose.

4.5 Command Sequences. All device commands shall conform to the legal command sequences as defined in this section. Some legal command sequences may require repositioning of the tape. The device shall return illegal command status to any command issued which is not in accordance with this section.

The commands belonging to a command group as defined for use in this section, are shown in Table 4. Table 5 defines the next legal command groups by using an X or a note referencing which are used following the normal termination of each command. A command that results in an abnormal termination shall be followed by the assertion of RESET or by a READ STATUS command.

Table 4
Command Groups

COMMAND GROUP	COMMANDS
SEL:	SELECT, SELECT (LOCKED)
WRT:	WRITE, WRITE WITHOUT UNDERRUNS, WRITE FILE MARK/WRITE, WRITE FILE MARK/WRITE WITHOUT UNDERRUNS
WFM:	WRITE FILE MARK
RD:	READ, READ CONTINUOUS, SPACE FORWARD, SPACE REVERSE
RFM:	READ FILE MARK, READ FILE MARK REVERSE, READ N FILE MARKS
READ STATUS:	READ STATUS
SEARCH EOD:	SEARCH FOR END OF DATA
RWD:	REWIND, ERASE, INITIALIZATION
MODE SET:	SET AUTO MEDIA INITIALIZATION,SET DEVICE CONFIGURATION (N), SET DEVICE FORMAT (N)
DIAGNOSTIC:	RUN SELF-TEST 1, RUN SELF-TEST 2

Table 5
Legal Command Group Sequences

These legal command sequences are those which will be accepted and executed by the device, even though they may be undesirable.

CURRENT \ NEXT	SEL	WRT	WFM	RD	RFM	SEARCH EOD	READ STATUS	RWD	MODE SET	DIAGNOSTIC
SEL	X	(X)	(X)	(X)	(X)	(X)	X	X	(X)	X
WRT	X	X	X				X			
WFM	X	X	X				X	X	(X)	X
RD	X			X	X	X	X			
RFM							X			
SEARCH EOD							X			
READ STATUS	X	(X)	(X)	(X)	(X)	(X)	X	(X)	(X)	(X)
RWD	X	X	X	X	X	X	X	X	X	X
MODE SET	X	(X)	(X)	(X)	(X)	(X)	X	X	X	X
DIAGNOSTIC	X	X	X	X	X	X	X	X	(X)	X

(X) Legality is dependent on the command issued prior to the current command.

5. Standard Status Description. All device status information shall be contained in six octet groups as defined in Table 6.

Table 6
Status Octet Summary

Octet	Bit	Mnemonic	Description
0	0	FMD	File Mark Detected
	1	BNL	Block in error Not Located
	2	UDE	Unrecoverable Data Error
	3	EOM	End Of Media
	4	WRP	WRite Protected media
	5	DFF	Device Fault Flag
	6	CNI	Cartridge or Cassette Not In place
	7	ST0	STatus octet 0 bit
1	0	POR	Power On/Reset occurred
	1	ERM	End of Recorded Media (Optional)
	2	BPE	Bus Parity Error (Optional)
	3	BOM	Beginning Of Media
	4	MBD	Marginal Block Detected
	5	NDD	No Data Detected
	6	ILL	ILLegal command
	7	ST1	STatus octet 1 bit
2-3	-	DEC	Data Error Counter
4-5	-	URC	UnderRun Counter

5.1 Device Status. Octets 0 and 1 are defined in a bit significant manner to reflect the current device state. If a change in device status occurs when the device is deselected, this condition cannot be immediately reported to the Controller and must be retained by the device. The device shall not assert EXCEPTION while in the deselected state. The subsequent selection of this device shall proceed as previously described with the device responding with EXCEPTION. The Controller shall then issue a READ STATUS command to determine the reason for EXCEPTION.

5.1.1 Status Octet 0. If bit 0, 1, 2, or 3 is set, then EXCEPTION shall be asserted. EXCEPTION shall be asserted if bits 4, 5, or 6 are set and the conditions specified in the following bit descriptions are met.

5.1.1.1 Bit 0: FMD - The File Mark Detected bit shall be set when a File Mark is detected during a Read or Read File Mark Sequence. The bit shall be reset by a Read Status sequence.

5.1.1.2 Bit 1: BNL - The Block in error Not Located bit shall be set when the device was not able to locate the correct block. This bit is a modifier for bit 2 (UDE), in that data transferred for that block may be filler data or data from a different block. The bit shall be reset by a Read Status or Reset sequence.

5.1.1.3 Bit 2: UDE - The Unrecoverable Data Error bit shall be set when the device experiences an unrecoverable error during a read or write operation. The bit shall be reset by a Read Status or Reset sequence.

5.1.1.4 Bit 3: EOM - The End of Media bit shall be set when the logical early warning marker of the last track is detected during a write operation. This bit shall remain set as long as the device is at logical end of media. The EOM bit shall not be reset by a Read Status sequence.

5.1.1.5 Bit 4: WRP - The WRite Protected media bit shall be set if the media write protect mechanism is set in the file protect, "safe", position. The write protect mechanism position must be changed before the status bit is reset. If the controller issues any command which would cause a write or erase head to be energized (such as an ERASE, WRITE, or WRITE FILE MARK command) when the WRP bit is asserted, then EXCEPTION shall be asserted and the command shall not be executed.

5.1.1.6 Bit 5: DFF - The Device Fault Flag shall be set if the device detects a problem other than data errors during command execution. This bit shall be set to indicate the failure of the RUN SELF-TEST 1 or RUN SELF-TEST 2 commands. If the command being executed was other than a RUN SELF-TEST 1 or RUN SELF-TEST 2 command, then setting this bit shall cause EXCEPTION to be asserted. EXCEPTION shall not be asserted if DFF is set during one of the self-test commands. The bit shall be reset by a Read Status or Reset sequence.

5.1.1.7 Bit 6: CNI - The cartridge or Cassette Not In place bit shall be set if the media is not fully inserted into the device. This bit shall cause EXCEPTION to be asserted under the following conditions:

(1) Media removed from selected device while away from BOT.

(2) A command is issued which involves tape motion.

(3) Whenever the device had been selected using the Select Drive, Locked Command.

The condition must be corrected before the status bit is reset.

5.1.1.8 Bit 7: STO - The Status Octet 0 Bit shall be set if any other bit in Status Octet 0 is set.

5.1.2 Status Octet 1 - Bits 3 and 4 shall be the only bits in this octet that do not assert EXCEPTION when they are set.

5.1.2.1 Bit 0: POR - The PowerOn Reset bit shall be set after the controller asserts RESET or when the device is first powered up. The bit shall be reset by a Read Status Sequence.

5.1.2.2 Bit 1: ERM - The optional End of Recorded Media bit shall be set when the device detects the ERM position. The ERM bit shall be reset when the tape moves away from the ERM position or a Reset sequence occurs. The ERM bit shall be reset when this option is not implemented.

5.1.2.3 Bit 2: BPE - The optional Bus Parity Error bit shall be set when the device detects an odd parity error on the controller bus during a data transfer to the device. This bit shall be reset by a Read Status or Reset sequence. The BPE bit shall be reset when this option is not implemented.

5.1.2.4 Bit 3: BOM - The Beginning of Media bit shall be set whenever the media is logically at BOT, track 0. This bit shall be reset when the tape moves away from the logical beginning of media or a Reset sequence occurs.

5.1.2.5 Bit 4: MBD - The Marginal Block Detected bit shall be set when the device experiences significant difficulty in recovering the data from a block. This bit shall be reset by a Read Status or Reset sequence.

5.1.2.6 Bit 5: NDD - The No Data Detected bit shall be set when an unrecoverable data error occurs due to lack of recorded data. This bit shall be reset by a Read Status or Reset sequence.

5.1.2.7 Bit 6: ILL - The Illegal Command bit shall be set if any of the following occur:

(1) ONLINE is not asserted when the device is reading, writing or searching

(2) A command violates the legal command sequence.

(3) Any unimplemented command is issued.

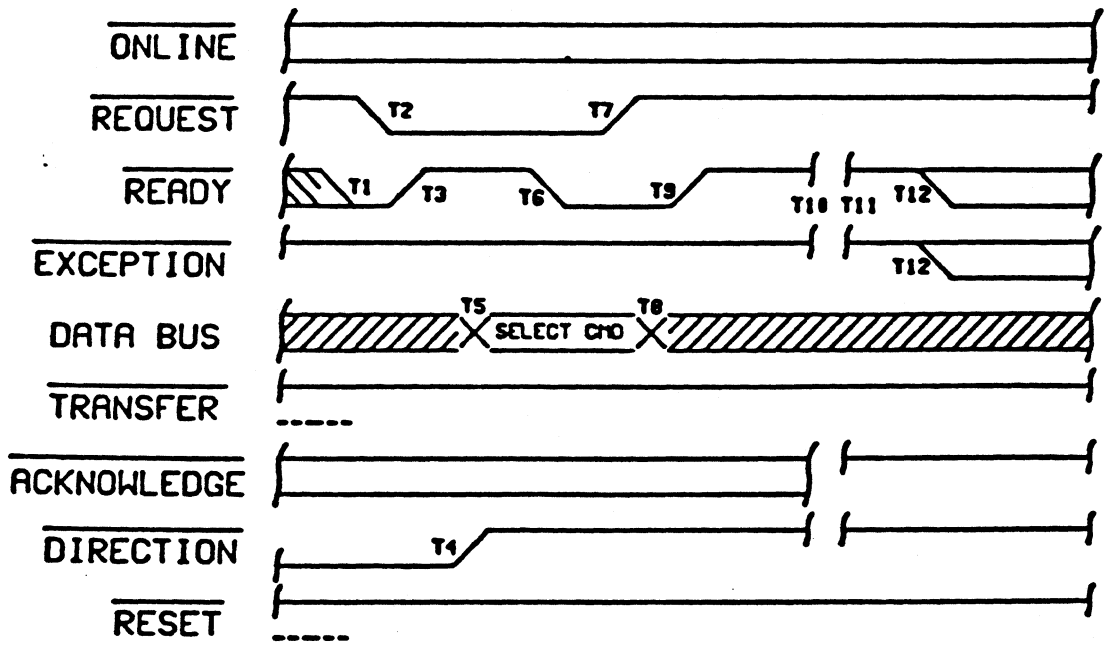
This bit shall be reset by a Read Status or Reset sequence.

5.1.2.8 Bit 7: ST1 - The Status Octet 1 Bit shall be set if any other bit in Status octet 1 is set.

5.2 Status Octets 2 and 3. These octets shall contain the data error counter (DEC) which accumulates the number of recoverable read errors during a READ operation and is an indication of the number of blocks rewritten due to errors during a write operation. During a write operation, this number is device dependent. The lease significant octet is octet 3 and the most significant is octet 2. In response to a RUN SELF-TEST 1 or a RUN SELF-TEST 2 command, these octets provide vendor unique status that may be useful for device configuration and failure analysis. The bits of these octets shall be reset after completion of a Read Status or Reset sequence.

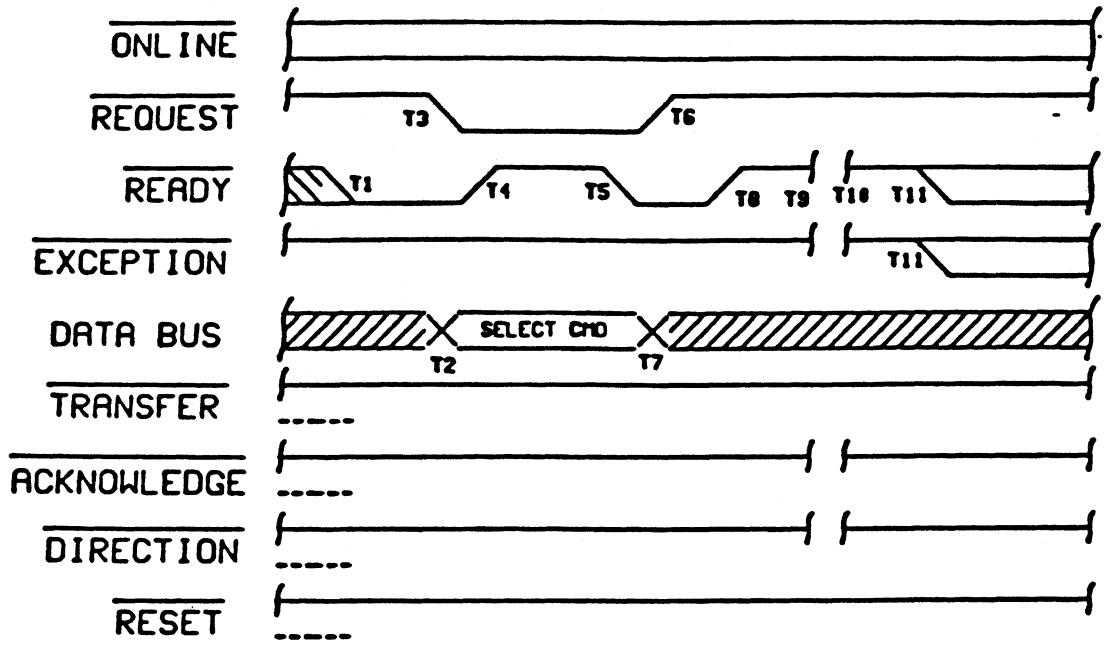
5.3 Status Octets 4 and 5. When the DFF bit in octet 0 is not set, these octets shall contain the underrun counter (URC) which accumulates the number of times that streaming was interrupted because the controller failed to maintain the minimum throughput rate. The least significant octet is octet 5 and the most significant is octet 4. In response to a RUN SELF-TEST 1 or a RUN SELF-TEST 2 command, these octets provide vendor unique status that may be useful for device configuration and failure analysis. The bits of these octets shall be reset by a Read Status or Reset sequence.

6. Interface Timing. Timing specifications are defined at the driven end. Deskew requirements shall be the responsibility of the receiving end. Interface signal timing shall be as specified in the following diagrams.



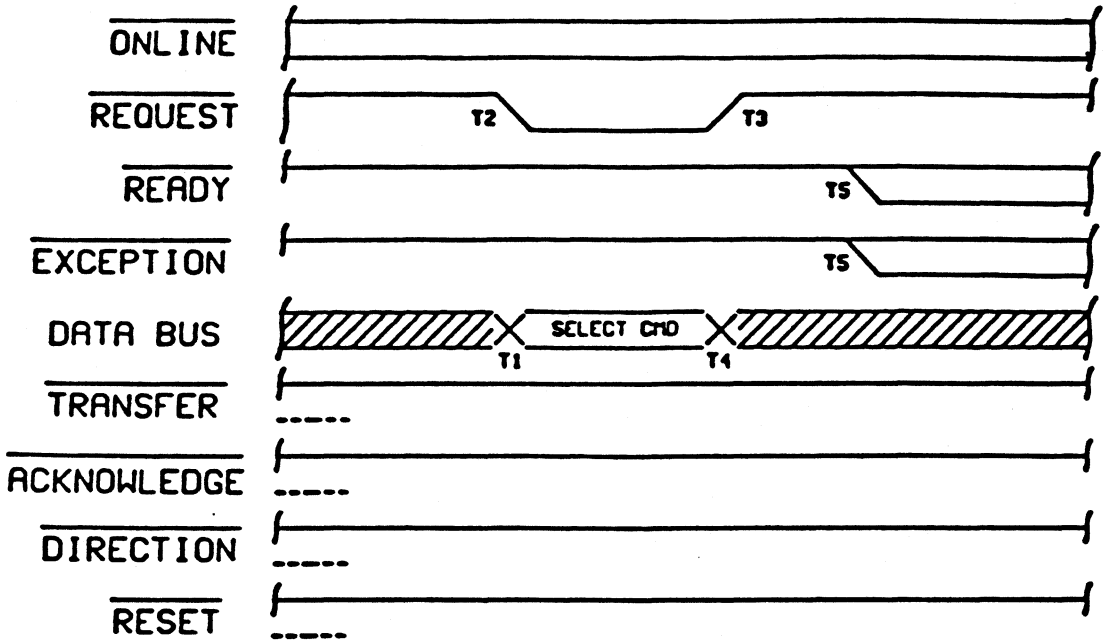
Activity	Timing
T1-Device A Asserts READY	
T2-Controller Asserts REQUEST	0 us. < T1--->T2
T3-Device A Deasserts READY	0 us. < T2--->T3 < 1 us.
T4-Device A Deasserts DIRECTION	0 us. < T3--->T4 < 1 ms.
T5-Bus Data Valid	T4--->T5 < 1 us.
T6-Device A Asserts READY	150 us. < T4--->T6 < 500 ms.
T7-Controller Deasserts REQUEST	0 us. < T6--->T7
T8-Bus Data Invalid	0 us. < T6--->T8
T9-Device A Deasserts READY	20 us. < T7--->T9 < 100 us.
T10-Device A Disconnected from Interface	0 us. < T9--->T10 < 50 us.
T11-Device B Connected to Interface	150 us. < T7--->T11
T12-Device B Asserts READY or EXCEPTION	150 us. < T7--->T12 < 2 min.

Figure 3. SELECT Command, Multi-Device Operation, DIRECTION Asserted



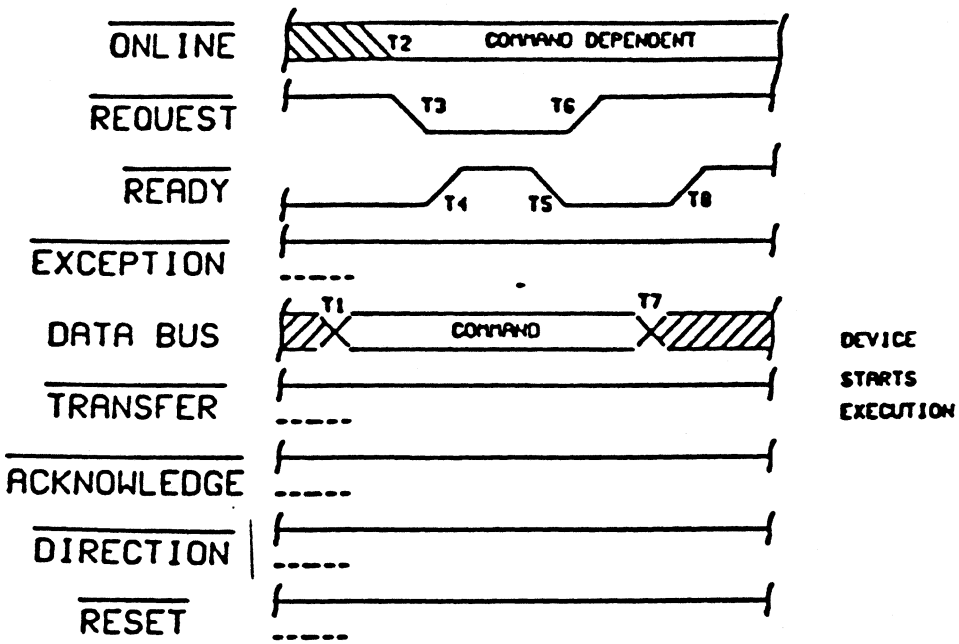
Activity	Timing
T1-Device A Asserts READY	
T2-Bus Data Valid	0 us. < T1--->T2
T3-Controller Asserts REQUEST	0 us. < T2--->T3
T4-Device A Deasserts READY	0 us. < T3--->T4 < 1 us.
T5-Device A Asserts READY	150 us. < T3--->T5 < 500 ms.
T6-Controller Deasserts REQUEST	0 us. < T5--->T6
T7-Bus Data Invalid	0 us. < T5--->T7
T8-Device A Deasserts READY	20 us. < T6--->T8 < 100 us.
T9-Device A Disconnected from Interface	0 us. < T8--->T9 < 50 us.
T10-Device B Connected to Interface	150 us. < T6--->T10
T11-Device B Asserts READY or EXCEPTION	150 us. < T6--->T11 < 2 min.

Figure 4. SELECT Command, Multi-Device Operation, DIRECTION Deasserted



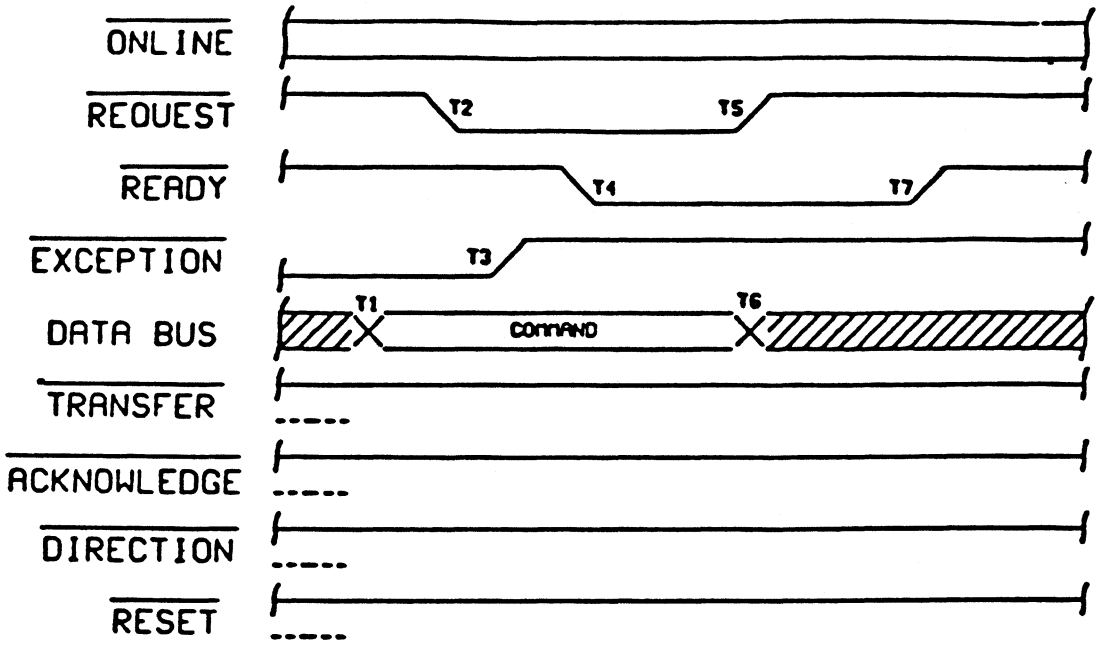
Activity	Timing
T1-Bus Data Valid	
T2-Controller Asserts REQUEST	0 us. < T1--->T2
T3-Controller Deasserts REQUEST	500 us. < T2--->T3
T4-Bus Data Invalid	0 us. < T3--->T4
T5-READY or EXCEPTION Asserted (If Selected Device Present)	0 us. < T3--->T5 < 500 us.

Figure 5. SELECT Command, No Previous Device Selected



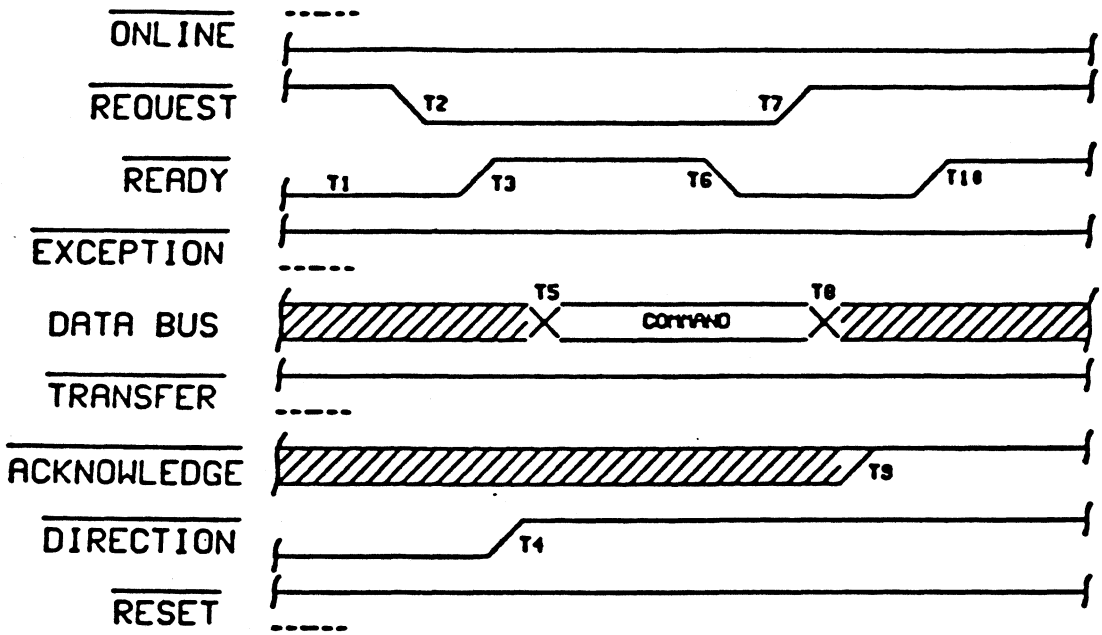
Activity	Timing
T1-Bus Data Valid	
T2-Controller Asserts ONLINE	0 us. < T1--->T3
T3-Controller Asserts REQUEST	0 us. < T2--->T3
T4-Device Deasserts READY	0 us. < T3--->T4 < 1 us.
T5-Device Asserts READY	170 us. < T4--->T5 <500 ms.
T6-Controller Deasserts REQUEST	0 us. < T5--->T6
T7-Bus Data Invalid	0 us. < T6--->T7
T8-Device Deasserts READY	20 us. < T6--->T8 <100 us.

Figure 6. Command Transfer, READY Asserted



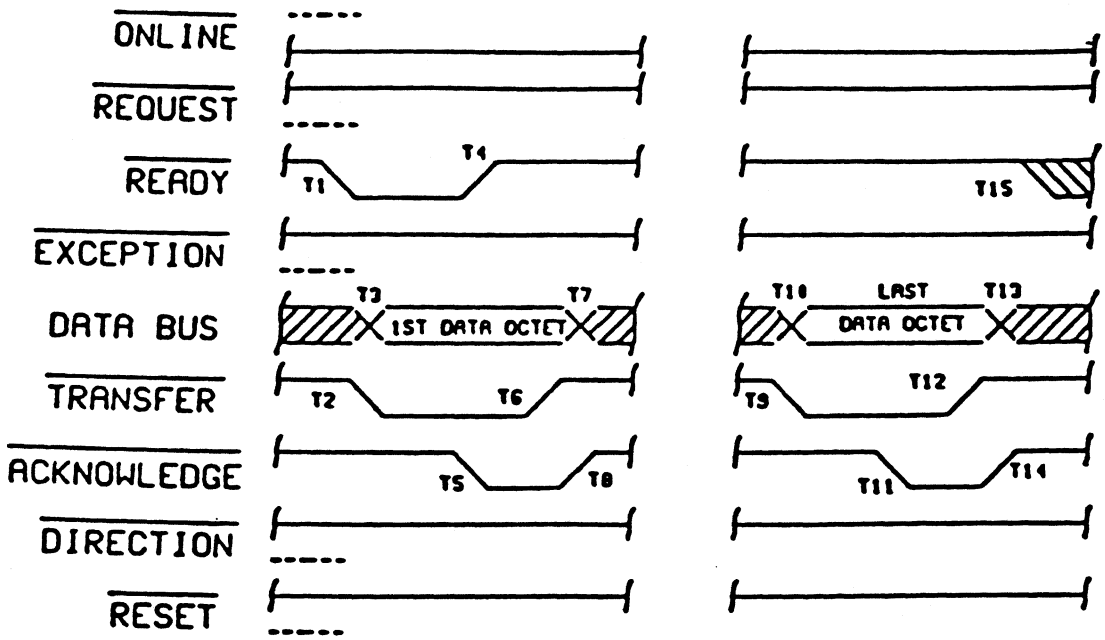
T1-Bus Data Valid	
T2-Controller Asserts REQUEST	0 us. < T1--->T2
T3-Device Deasserts EXCEPTION	0 us. < T2--->T3 < 1 sec.
T4-Device Asserts READY	20 us. < T3--->T4 < 500 us.
T5-Controller Deasserts REQUEST	0 us. < T4--->T5
T6-Bus Data Invalid	0 us. < T5--->T6
T7-Device Deasserts READY	20 us. < T5--->T7 < 100 us.

Figure 7. Command Transfer, EXCEPTION Asserted



Activity	Timing
T1-READY Asserted	
T2-Controller Asserts REQUEST	0 us. < T1--->T2
T3-Device Deasserted READY	0 us. T2--->T3 < 1 us.
T4-Device Deasserts DIRECTION	0 us. < T3--->T4 < 150 us.
T5-Bus Data Valid	T4--->T5 < 1 us.
T6-Device A Asserts READY	170 us. < T4--->T6 < 500 us.
T7-Controller Deasserts REQUEST	0 us. < T6--->T7
T8-Bus Data Invalid	0 us. < T7--->T8
T9-Device Deasserts ACKNOWLEDGE	0 us. < T9--->T10
T10-Device Deasserts READY	20 us. < T7--->T10 < 100 us.

Figure 8. Command Transfer, DIRECTION Deasserted



Activity

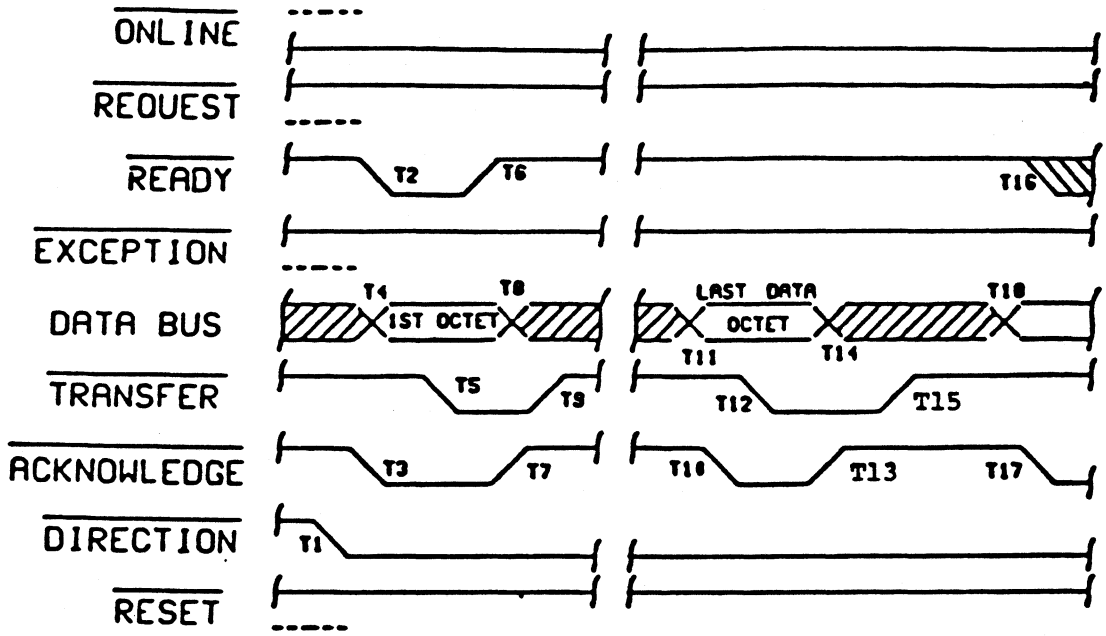
T1-Device Asserts READY
(Device READY for First Data Block)
T2-Controller Asserts TRANSFER
T3-Data Bus Valid
T4-Device Deasserts READY
T5-Device Asserts ACKNOWLEDGE
T6-Controller Deasserts TRANSFER
T7-Bus Data Invalid
T8-Device Deasserts ACKNOWLEDGE
T9-Controller Asserts TRANSFER
T10-Data Bus Valid
T11-Device Asserts ACKNOWLEDGE
T12-Controller Deasserts TRANSFER
T13-Bus Data Invalid
T14-Device Deasserts ACKNOWLEDGE
T15-Device Asserts READY
(Device READY For Next Data Block)

Timing

0 us.	< T1---->	T2	
	T2---->	T3	< 40 ns.
0 us.	< T2---->	T4	< 1 us.
0.5 us.	< T2---->	T5	<100 us.
0 us.	< T5---->	T6	
0 us.	< T5---->	T7	
0 us.	< T6---->	T8	< 3 us.
0 us.	< T8---->	T9	
	T9---->	T10	< 40 ns.
0.5 us.	< T9---->	T11	<100 us.
0 us.	< T11--->	T12	
0 us.	< T11--->	T13	
0 us.	< T12--->	T14	< 3 us.
100 us.	< T14--->	T15	

*Note: If the Controller asserts TRANSFER before the device asserts READY, then the behavior of READY is device dependent. READY shall not be asserted for an EXCEPTION condition.

Figure 9. Data Transfer, Write Operation

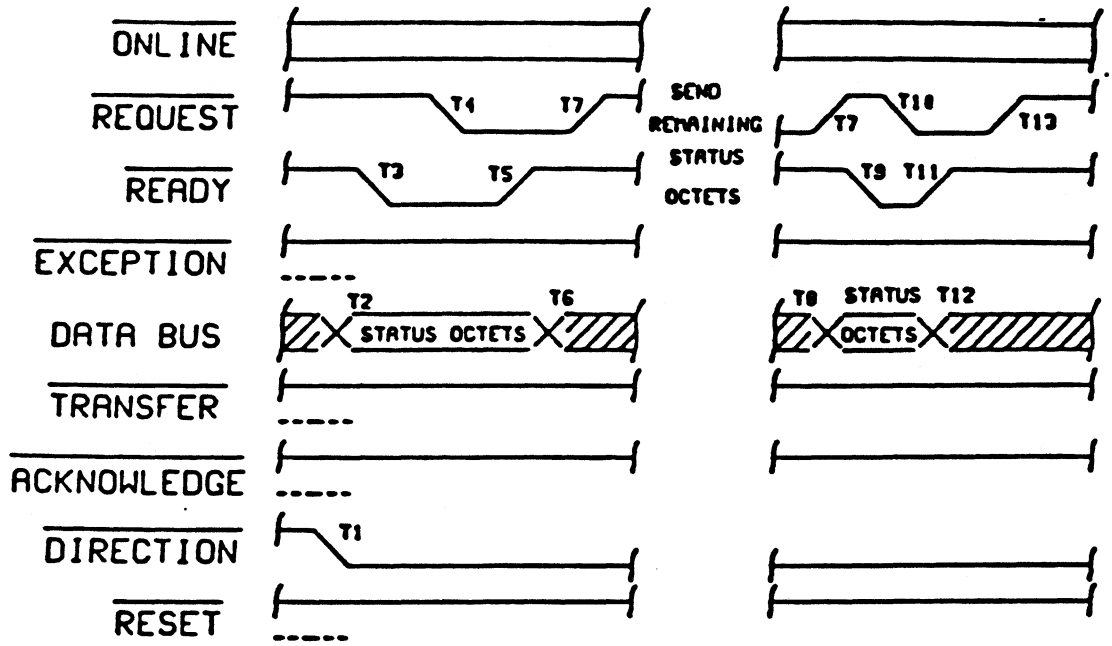


T1-Device Changes DIRECTION
T2-Device Asserts READY
T3-Device Asserts ACKNOWLEDGE
T4-Bus Data Valid
T5-Controller Asserts TRANSFER
T6-Device Deasserts READY
T7-Device Deasserts ACKNOWLEDGE
T8-Bus Data Invalid
T9-Controller Deasserts TRANSFER
T10-Device Asserts ACKNOWLEDGE
T11-Bus Data Invalid
T12-Controller Asserts TRANSFER
T13-Device Deasserts ACKNOWLEDGE
T14-Bus Data Invalid
T15-Controller Deasserts TRANSFER
T16-Device Asserts READY
T17-Device Asserts ACKNOWLEDGE
T18-Bus Data Valid

T3---->T4	<	40 us.
0 us. < T1---->T4		
0 us. < T4---->T5		
0 us. < T5---->T6	<	1 us.
0.5 us. < T5---->T7	<	3 us.
0 us. < T5---->T8		
0 us. < T7---->T9		
T10--->T11	<	40 ns.
0 us. < T11--->T12		
0.5 us. < T12--->T13	<	3 us.
0 us. < T12--->T14		
0 us. < T13--->T15		
T17--->T18	<	40 ns.

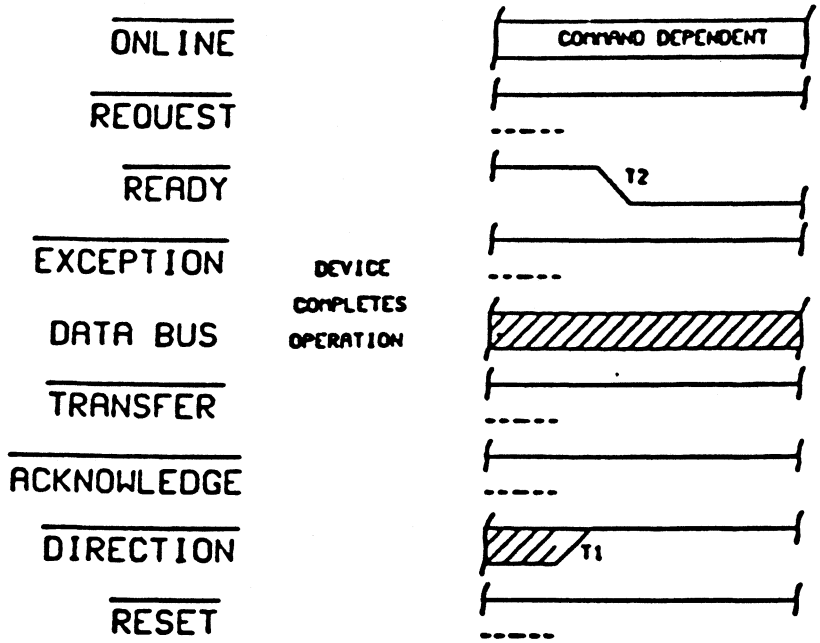
*Note: If the Controller asserts TRANSFER before the device asserts READY, then the behavior of READY is device dependent. READY shall not be asserted for an EXCEPTION condition.

Figure 10. Data Transfer, Read Operation



Activity	Timing
T1-Device Changes Bus DIRECTION	
T2-Bus Data Valid	0 us. < T1----->T2
T3-Device Asserts READY	0 us. < T2----->T3
T4-Controller Asserts REQUEST	0 us. < T3----->T4
T5-Device Deasserts READY	0 us. < T4----->T5 < 1 us.
T6-Bus Data Invalid	0 us. < T5----->T6
T7-Controller Deasserts REQUEST	20 us. < T4----->T7
T8-Bus Data Valid	0 us. < T7----->T8
T9-Device Asserts READY	20 us. < T7----->T9
T10-Controller Asserts REQUEST	0 us. < T9----->T10
T11-Device Deasserts READY	0 us. <T10----->T11 < 1 us.
T12-Bus Data Invalid	0 us. <T10----->T12
T13-Controller Deasserts REQUEST	20 us. <T10----->T13

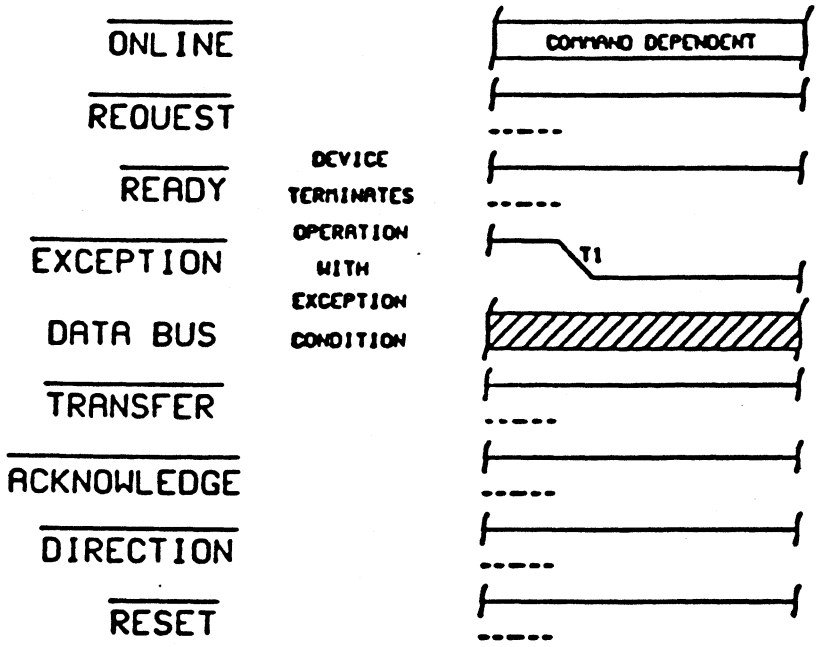
Figure 11. Status Octets Transfer



Activity
T1-Device Deasserts DIRECTION
T2-Device Asserts READY

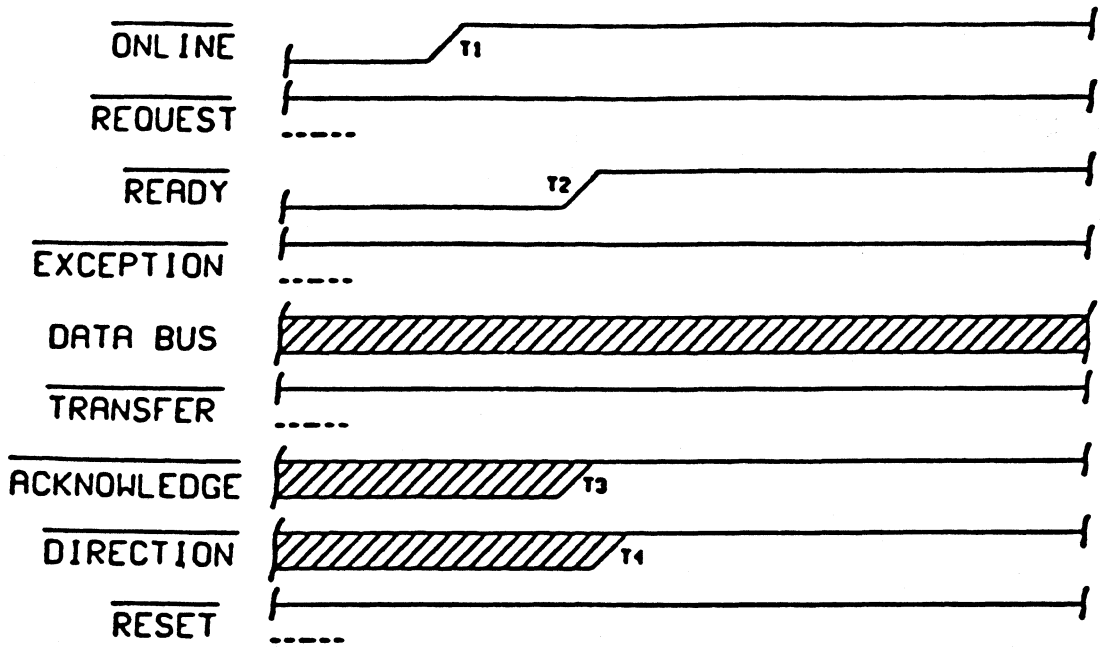
0 us. <T1---->T2

Figure 12. Termination, Non-Data Transfer with READY



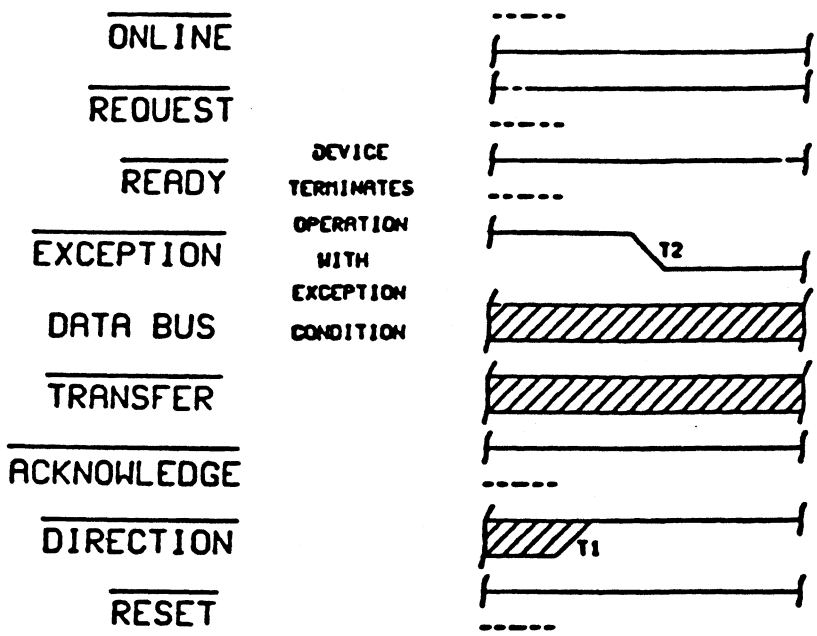
Activity	Timing
T1-Device Asserts EXCEPTION	N/A

Figure 13. Termination, Non-Data Transfer with EXCEPTION



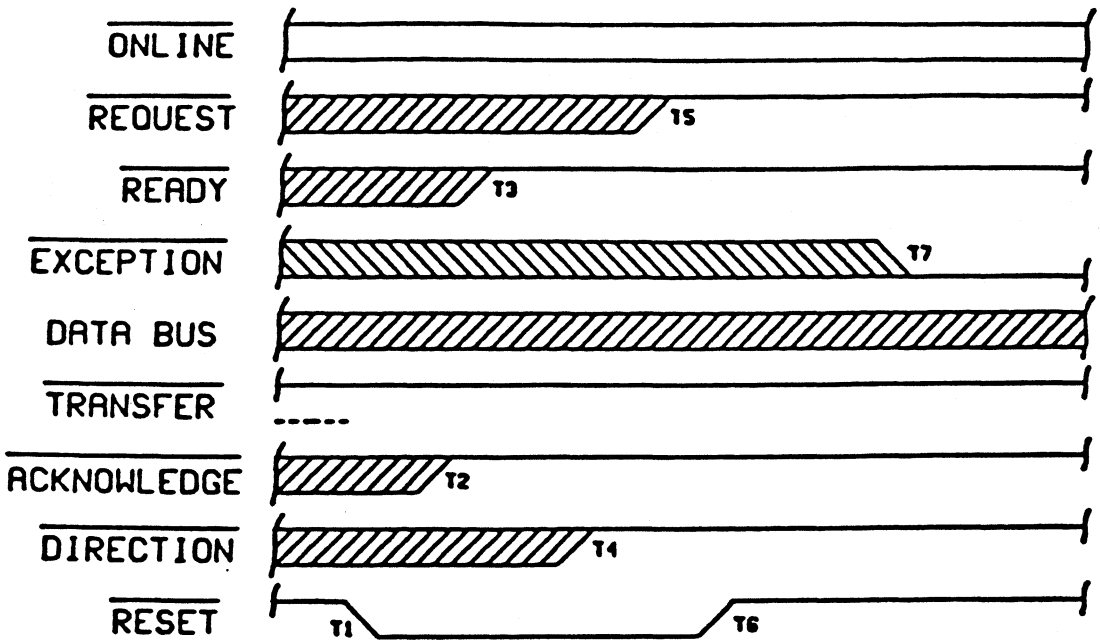
Activity	Timing
T1-Controller Deasserts ONLINE	
T2-Device Deasserts READY	T1---->T2 < 500 us.
T3-Device Deasserts ACKNOWLEDGE	T2---->T3 < 500 us.
T4-Device Deasserts DIRECTION	T2---->T4 < 500 us.

Figure 14. Termination, Data Transfer, ONLINE Deasserted



Activity	Timing
T1-Device Deasserts DIRECTION	
T2-Device Asserts EXCEPTION	0 us. < T1----->T2

Figure 15. Termination, Data Transfer, EXCEPTION Condition



Activity	Timing
T1-Controller Asserts RESET	
T2-Device Deasserts ACKNOWLEDGE	T1---->T2 < 1 us.
T3-Device Deasserts READY	T1---->T3 < 1 us.
T4-Device Deasserts DIRECTION	T1---->T4 < 3 us.
T5-Controller Deasserts REQUEST	0 us. < T5---->T6
T6-Controller Deasserts RESET	25 us. < T1---->T6
T7-Device 0 Asserts EXCEPTION (If Device 0 Present)	100 us. < T6---->T7 < 5 sec.

Figure 16. RESET

Appendix A

Command Code Differences
TG X3T9.6/83-20 and TC X3T9/84-79 (QIC-02 Rev D)

COMMAND CODE	X3T9.6	QIC-02
22	Erase (Logical)	Erase Entire Tape
26 - 2A	Set Device Format	Vendor Unique
2B - 2F	Set Device Configuration	Vendor Unique
48	Vendor Unique	Enter 6 Byte Parameter Block
62	Write File Mark/Write	Vendor Unique
63	Write File Mark/Write Without Underruns	Vendor Unique
70 - 77	Reserved	Write N File Marks
78 - 7F	Vendor Unique	Write N File Marks
82	Read Continuous	Vendor Unique
84	Reserved	Read Reduced Track Density
85	Reserved	Space Forward Reduced Track Density
88	Vendor Unique	Read Reverse
8C	Vendor Unique	Read Reverse Reduced Track Density
8D	Vendor Unique	Space Reverse Reduced Track Density
A4	Reserved	Read File Mark Reduced Track Density
A7	Reserved	Seek EOD Reduced Track Density
AC	Vendor Unique	Read File Mark Reverse Reduced Track Density
B0	Vendor Unique	NOP
C1	Vendor Unique	Read Extended Status 1
C4	Vendor Unique	Read Extended Status 2
E0	Vendor Unique	Read Extended Status 3

ANSI X3T9 Membership List
August 12, 1985

MEMBERS	ALTERNATES
Mr. James R. Barnette AIR-7132B Naval Air Systems Command Washington, DC 20361	
Mr. Duane Barney HONEYWELL INFORMATION SYSTEMS P.O. Box 8000, M.S. C-60 Phoenix, AZ 85066 (602) 862-4925	Mr. Kris Kowai HONEYWELL INFORMATION SYSTEMS MS: 829A 300 Concord Road Billerica, MA 01821 (617) 671-3333
Mr. John Blagaila AMCODYNE INC. 1301 S. Sunset Street Longmont, CO 80501 (303)772-2601	Mr. Tom Fiers AMCODYNE INC 1301 S. Sunset Steet. Longmont, CO 80501 (303)772-2601
Mr. William E. Burr (X3T9.2 chair) NATIONAL BUREAU OF STANDARDS Building 225, Room A216 Gaithersburg, MD 20899 (301)921-3723	Mr. George Clark NATIONAL BUREAU OF STANDARDS Building 225, Room A216 Gaithersburg, MD 20899 (301)921-3723
Mr. Fred Ciechowski RAYMOND ENGINEERING INC. RAYCORDER PRODUCTS DIVISION 217 Smith Street Middletown, CT 06457	Mr. Henry Ginter RAYMOND ENGINEERING INC. RAYCORDER PRODUCTS DIVISION 217 Smith Street Middletown, CT 06457
Mr. Steve Cooper PCM SERVICES 1386 Dentwood Dr. San Jose, CA 95118 (408)448-2130 (415)964-1249	
Mr. Louis C. Domshy (X3T9.6 chair) ARCHIVE CORPORATION 3540 Cadillac Avenue Costa Mesa, CA 92626 (714)641-0279 x:317	
Mr. Robert Dugan IBM CORPORATION E57/901 P.O.Box 390 Poughkeepsie, NY 12602 (914)432-5512	Mr. Roger Cormier IBM CORPORATION G48/707 P.O. Box 390 Poughkeepsie, NY 12602 (914) 432-5512

MEMBERS	ALTERNATES
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Mr. John B. Lohmeyer NCR CORPORATION 3718 North Rock Road, MS #19 Wichita, KS 67226 (316) 688-8703	
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Mr. Gene Milligan (X3T9.5 chair) MAGNETIC PERIPHERALS P.O. BOX 12313 Oklahoma City, OK 73157 (405)324-3070	
Mr. Dennis Appleyard STORAGE TECHNOLOGY CORPORATION 2270 South 88th - MS/PE Louisville, CO 80028 (303) 673-6685	Mr. Mark Hammang STORAGE TECHNOLOGY CORPORATION 2270 South 88th - MS/T4 Louisville, CO 80028 (303) 673-3315
Mr. Ted Petrowich 4300 Commerce Court Lisle, IL 60532 (312)983-3553	
Mr. Al Reszka AT&T TECHNOLOGIES Room 326 4513 Western Avenue Lisle, Il 60532 (312)810-6496	
Mr. Gary S. Robinson (X3T9.3 chair) DIGITAL EQUIPMENT CORP. ML012/3 E51 146 Main Street Maynard, MA 01754-2571 (617)493-4094	Mr. Del Shoemaker DIGITAL EQUIPMENT CORP. 1331 Pennsylvania Ave.,NW Ste 600 Mail Stop: WNP Washington, DC 20004 (202) 383-5622

MEMBERS	ALTERNATES
Mr. Arnold J. Roccati EG&G WASHINGTON ANALYTICAL SERVICES CENTER, INC. 1396 Piccard Drive Rockville, MD 20850 (301) 840-3277	Mr. Robert B. Anthony EG&G WASHINGTON ANALYTICAL SERVICES CENTER, INC. P.O. Box 552 Dahlgren, VA 22448 (703) 663-2161
Mr. Floyd E. Ross SPERRY Box 500, MS E8-106 Blue Bell, PA 19424 (215)542-2518	Mr. Kirk Moulton SPERRY Box 500, MS E8-110 Blue Bell, PA 19424 (215)542-3717
Mr. James P. Smitherman SIDPERS - 3 PROJECT OFFICE RM 806, Hoffman Building I Attn: DAPE-MP-S3 2461 Eisenhower Avenue Alexandria, VA 22331	
Mr. Irvin Stafford MS B4 DATA ELECTRONICS, INC. 10150 Sorrento Valley Road San Diego, CA 92121 (619) 454-7840 x264	Mr. Dave Krula MS B4 DATA ELECTRONICS, INC 10150 Sorento Valley Road San Diego, CA 92121 (619) 454-7840 x276

OBSERVERS

Mr. William Bernstein
CALCOMP/SANDERS
POPE TECHNICAL PARK
M/S - PTP2-2H15
65 River Road, CS 908
Hudson, NH 03051

Mr. David E. Carlson
AT&T INFORMATION SYSTEMS
Room LZ-3E314
307 Middletown/Lincroft Road
Lincroft, NJ 07738
(201)576-3516

Mr. Cassarino
HONEYWELL INFORMATION SYSTEMS
300 Concord Road, MS890A
Billerica, MA 01812

Mr. Steven Gilbert
GTE/CSD
77 Ast
Needham, MA 02194

Mr. John Hancock
AT&T BELL LABORATORIES
Room 2G-316
25 Lindsley Drive
Morristown, NJ 07960
(201)898-1242

Mr. D. Hekimi
ECMA
114 Rue du Rhone
1204 Geneva Switzerland
+41 22 35.36.34
Telex: 22288

Mr. Donald C. Loughry
c/o IND
HEWLETT-PACKARD
19420 Homestead Road
Cupertino, CA 95014
(617)895-6047

OBSERVERS

Mr. Richard Brand 16-197
NATIONAL SEMICONDUCTOR CORP.
2900 Semiconductor Drive
Santa Clara, CA 95051

Mr. John Farnsworth MS F-51
DATAPOINT CORPORATION
9725 Datapoint Drive
San Antonio, TX 78284

Mr. Steve Heissenbuttel
MATSUSHITA TECHNOLOGY CENTER
One Panasonic Way
Secaucus, NJ 07094
(201)348-7000

Mr. Thomas McNamara
HONEYWELL INFORMATION SYSTEMS INC.
333 Wyman Street
Waltham, MA 02154

OBSERVERS

Mr. James F. Moore
DATAQUEST INC.
1290 Ridder Park Drive
San Jose, CA 95131

Mr. Robert Snively
ADAPTEC INC.
580 Cottonwood Drive
Milpitas, CA 95035
(408)946-8600

Mr. John L. Wheeler
XEROX CORPORATION
Xerox Square, 052
Rochester, NY 14644
(716)423-4674

X3 Secretariat
COMPUTER & BUSINESS EQUIPMENT
MANUFACTURERS ASSOCIATION
311 First Street, N.W. Suite 500
Washington, DC 20001
(202)737-8888

OBSERVERS

Mr. Ron Norden-Paul
EMTEK HEALTHCARE SYSTEMS
3821 Broadway Road
Phoenix, AZ 85040
(602) 437-9035

Mr. Naished T. Vashi
FAIRCHILD CORPORATION
MS: 4-370
313 Fairchild Drive
Mountain View, CA 94039