TANDBERG DATA

The QIC-24 and QIC-02 Standards, Revision D

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Contents

Part 1
Introduction

Part 2
Quarter-Inch Compatibility

Part 3
QIC-24, Revision D
Proposed Standard for Data Interchange on the Streaming 1/4 Inch Magnetic Tape Cartridge Using Group Code Recording at 10,000 FRPI

Part 4
QIC-02, Revision D
Proposed 1/4 Inch Cartridge Drive Intelligent Interface Standard

Part 1

INTRODUCTION

The purpose of this publication is to give our customers a complete description of the standards for quarter-inch cartridge (QIC) drives.

Tandberg Data's streamer drives in the TDC 3200 and the TDC 3300 series are fully compatible with, or exceed these standards.

Please refer to the reference manuals for the respective drives to find out how our drives comply with the QIC standards.

- "TDC 3224 and TDC 3229 Reference Manual"
  publication number 5431, part number 402104

- "TDC 3319 Reference Manual"
  publication number 5446, part number 402451

Part 2 of this publication describes the background of the QIC-group, why it was established, and what it has achieved.

Part 3 and part 4 contain the proposed standards for data interchange and interface, the QIC-24 and QIC-02, respectively.

They are direct copies of the written material submitted by the QIC-group.

Part 2

QUARTER-INCH COMPATIBILITY

OVERVIEW

In most ways, the quarter-inch streaming tape cartridge drive is an ideal method of backing up 5¼-inch and 8-inch Winchester disk drives.

The quarter-inch streamer is very compact, meeting the packaging requirements of host systems, and features appropriate transfer rates for saving and restoring data. The industry-standard media unit, the quarter-inch cartridge, achieves high storage capacities, eliminating most media changes during backup.

Thousands of quarter-inch streamers have been successfully integrated into computer systems around the world. But one problem has remained in achieving overall acceptance of this drive type. In a word: standardization.

To overcome this reservation, 29 companies have participated in a seven-month effort to resolve the standardization problem. Led by the Working Group for Quarter-Inch Cartridge Drive Compatibility, or QIC for short, they developed and adopted two new proposed standards for the universal manufacture of quarter-inch streamers that are mutually compatible.

THE STANDARDS

Two specific needs were identified by QIC for achieving compatibility: standard interfacing and standard recording format.

The first standard proposal adopted by the group, announced on August 20, 1982, addressed the need for an intelligent interface. Named QIC-02, this interface was designed to work with the majority of existing controllers designed for quarter-inch streamers while also permitting an extended command set for future applications.

The second standard proposal, QIC-24, was adopted by the group and announced on February 24, 1983. This agreement proposed a standardized recording format, enabling the interchangeability of recorded cartridges across several manufacturers' quarter-inch streamers. For the first time, this media type will enjoy the portability of floppy disks.

QIC-02 and QIC-24 are enclosed for your study. Although they have been submitted to worldwide standards bodies for formal consideration, the two QIC documents are expected to serve effectively as de facto standards in the meantime. QIC drives

QUARTER-INCH
QIC
COMPATIBILITY

have already been introduced to the marketplace, and more will follow, creating a standardized product class.

THE ACHIEVEMENT

In our view, the last impediment has been removed in the growth of quarter-inch streamers as the dominant Winchester backup device.

Standards for intelligent interfacing and recording format should trigger much greater market acceptance for this device. According to Freeman Associates' research, companies that purchase Winchester backup devices desire standardized products from multiple sources. Furthermore, these companies want media portability from one system to the next.

Now, the problems of limited second-sourcing and media interchangeability have been overcome by the introduction of these new standards.

THE PARTICIPANTS

The eight formal members of QIC are: Archive Corporation; Cipher Data Products, Inc.; Data Electronics, Inc.; Irwin Magnetics, Inc.; Qantex Division of North Atlantic Industries; Sankyo Seiki Mfg. Co., Ltd.; Tandberg Data A/S; and Wangtek. The total list of participants is below. Both membership and participation are open to everyone in the industry.

Representing three continents and the majority of companies involved in the manufacture of quarter-inch streamers, these firms recognized the need for a spirit of cooperation in removing the last roadblock to universal adoption of streaming drives.

Raymond C. Freeman, Jr., was asked to serve as facilitator and spokesman for the group, which held its first joint meeting on June 17, 1982. Mr. Freeman is president of Freeman Associates, Inc., a Santa Barbara, California, management consulting firm specializing in data storage products and markets.

The following companies have participated in QIC meetings as members and observers:

Adaptive Data & Energy Systems
Apollo Magnetics Corporation
Archive Corporation
Basic Four Corporation
Cipher Data Products, Inc.
Computer Peripherals, Inc. (CDC)
Computer Storage Technology
Data Electronics, Inc.

Data Packaging Corporation
Hewlett-Packard Company
Irwin Magnetics, Inc.
Kennedy Company
Memorex Corporation
Moya Corporation
National Bureau of Standards
Nippon Electric Company, Ltd.
Northern Telecom, Inc.
Nortronics Company, Inc.
Qantex Division of North Atlantic Industries
Raymond Engineering Inc.
Rosscomp Corporation
Sankyo Seiki Mfg. Co., Ltd.
Spin Physics, Inc.
Sysgen, Inc.
Tandberg Data A/S
TEAC Corporation
3M
Wangtek
Western Digital Corporation

Part 3

PROPOSED STANDARD

FOR

DATA INTERCHANGE ON THE STREAMING
1/4 INCH MAGNETIC TAPE CARTRIDGE
USING GROUP CODE RECORDING
AT 10,000 FRPI

APRIL 1983

TABLE OF CONTENTS

1.0 SCOPE AND INTRODUCTION
- 1.1 SCOPE
- 1.2 INTRODUCTION

2.0 DEFINITIONS

3.0 RECORDING
- 3.1 METHOD
- 3.2 CODE
- 3.3 NOMINAL DENSITY
- 3.4 NOMINAL BIT CELL LENGTH
- 3.5 AVERAGE BIT CELL LENGTH
- 3.6 LONG TERM AVERAGE BIT CELL LENGTH
- 3.7 MEDIUM TERM AVERAGE BIT CELL LENGTH
- 3.8 SHORT TERM AVERAGE BIT CELL LENGTH
- 3.9 SHORT TERM AVERAGE BIT CELL CENTER
- 3.10 REFERENCE BIT CELL
- 3.11 FLUX TRANSITION POSITION
- 3.12 SIGNAL AMPLITUDE REFERENCE TAPE CARTRIDGE
- 3.13 MEASUREMENT OF SIGNAL AMPLITUDE
- 3.14 STANDARD REFERENCE CURRENT
- 3.15 STANDARD RECORDING CURRENT
- 3.16 AVERAGE STANDARD REFERENCE AMPLITUDE
- 3.17 AVERAGE PREAMBLE AMPLITUDE
- 3.18 DATA AMPLITUDE
- 3.19 ERASURE
- 3.20 AZIMUTH

4.0 TRACKS
- 4.1 NUMBER AND USE OF TRACKS
- 4.2 REFERENCE PLANE
- 4.3 TRACK CENTER LINE LOCATIONS
- 4.4 TRACK WIDTH FOR 0.048 IN TRACK SPACING
- 4.5 TRACK WIDTH FOR 0.024 IN TRACK SPACING
- 4.6 INTERCHANGE BETWEEN 0.048 AND 0.024 IN TRACK SPACING

5.0 DATA BLOCK
- 5.1 PREAMBLE
  - 5.1.1 NORMAL
  - 5.1.2 ELONGATED
  - 5.1.3 LONG
- 5.2 DATA BLOCK MARKER
- 5.3 DATA BLOCK
- 5.4 BLOCK ADDRESS
  - 5.4.1 TRACK NUMBER
  - 5.4.2 CONTROL BLOCK
  - 5.4.3 ADDRESS OF BLOCK
  - 5.4.4 CONTROL BLOCK DATA FIELD (OPTIONAL)
- 5.5 CYCLICAL REDUNDANCY CHECK
- 5.6 POSTAMBLE
  - 5.6.1 NORMAL
  - 5.6.2 ELONGATED

6.0 FILE MARK BLOCK

7.0 REWRITTEN BLOCKS
    7.1 ERROR
    7.2 UNDERRUN, END OF FILE OR END OF TRACK
    7.3 FORCED STREAMING
    7.4 END OF RECORDED DATA
8.0 BEGINNING OF TRACKS
    8.1 TRACK REFERENCE BURST
    8.2 EVEN TRACKS
    8.3 ODD TRACKS

1.0 SCOPE AND INTRODUCTION

1.1 SCOPE

This document provides a format and recording standard for the streaming 0.250 in (6.30 mm) wide magnetic tape cartridge to be used for information interchange among information processing systems, communications systems and associated equipment. Compliance with the standard for the unrecorded magnetic tape cartridge (ref ANSI X3.##-198#) is a requirement for information interchange.

CAUTION NOTICE; The user's attention is called to the possibility that compliance with this standard may require use of an invention covered by patent rights.

By publication of this standard, no position is taken with respect to the validity of this claim or of any patent rights in communication therewith. The patent holder has, however, filed a statement of willingness to grant a license under these rights on reasonable and nondiscriminatory terms and conditions to applicants desiring to obtain such a license. Details may be obtained from the publisher.

No representation or warranty is made or implied that this is the only license that may be required to avoid infringement in the use of this standard.

1.2 INTRODUCTION

This standard defines the requirements and supporting test methods necessary to ensure interchange at acceptable performance levels. It is distinct from a specification in that it delineates a minimum of restrictions consistent with compatibility interchange transactions.

The performance levels contained in this standard represent the minimum acceptable levels of performance for interchange purposes. They therefore represent the performance levels which the interchanged items should meet or surpass during their useful life and thus define end-of-life criteria for interchange purposes. The performance levels in this standard are not intended to be employed as substitutes for purchase specifications.
Wherever feasible, quantitative performance levels which must be met or exceeded in order to comply with this standard are given. In all cases, including those in which quantitative limits for requirements falling within the scope of this standard are not stated but are left to agreement between interchange parties, standard test methods and measurement procedures shall be used to determine such quantities.

U.S. engineering units are the original dimensions in this standard. Conversions of toleranced dimensions from customary U.S. engineering units (similar to British Imperial Units) to SI units have been done in this standard according to ANSI Z210.1-1976 and ISO 370 Method A, except as noted. Method A should be used for economy unless a requirement for absolute asurance of a fit justifies use of Method B. In the national standards of ISO member nations, additional rounding may be done to produce "preferred" values. These values should lie within or close to the original tolerance ranges.

Except as indicated in the second preceding paragraph, interchange parties complying with the applicable standards should be able to achieve compatibility without need for additional exchange of technical information.

2.0 DEFINITIONS

azimuth - the angular deviation, in minutes of arc, of the mean flux transition line from the line normal to the cartridge reference plane.

bit - a single digit in the binary number system

bit cell - a length of magnetic recording tape within which the occurrence of a flux transition signifies a "one" bit and the absence signifies a "zero" bit.

block - a group of 512 consecutive bytes transferred as a unit.

BOT - beginning of tape marker indicating beginning of tape.

byte - a group of 8 binary (10 GCR) bits operated on as a unit.

cartridge - a four by six inch enclosure containing 0.250 in (6.30 mm) wide magnetic tape wound on two coplanar hubs and driven by an internal belt which is coupled by an internal belt capstan to the external drive (ref ANSI X3.55-1977).

cyclical redundancy check - a two byte code derived from information contained in the data block and block address bytes and recorded after the data block and block address bytes for read after write check and read only check.

density - the maximum allowable flux transitions per unit length for a specific recording standard.

early warning - marker on tape indicating the approaching end of the permissible recording area for even numbered tracks and indicating the approaching start of the permissible recording area for odd numbered tracks.

EOT - end of tape marker indicating the end of tape.

erase - to remove all magnetically recorded information from the tape.

file mark - an identification mark following the last block in a file

flux transition - a point on the magnetic tape which exhibits maximum free space flux density normal to the tape surface.

flux transition spacing - the distance on the magnetic tape between flux reversals

group code recording - (GCR) a data encoding method where a four bit group of data bits is encoded into a 5 bit group for recording on magnetic tape (ref. ANSI X3.54-1976)

load point - marker on tape indicating the approaching start of the permissible recording area for even numbered tracks and indicating the end or approaching end of the permissible recording area for odd numbered tracks.

magnetic tape - an oxide coated mylar base tape capable of accepting and retaining magnetically recorded information.

nibble - a group of 4 binary (5 GCR) bits operated on as a unit.

postamble - guard information recorded after the data block

preamble - synchronization information recorded before the data block

recorded block - a group of consecutive bits comprising preamble, data block marker, data block, block address, CRC and postamble.

reference tape cartridge - a magnetic tape cartridge selected for a specific property to be used as a reference.

streaming - a method of recording on magnetic tape where the tape is continuously moving and data blocks are continuously recorded.

track - a recording strip parallel to the edge of the magnetic tape containing recorded information

underrun - a condition developed when host transmits or receives data at a rate less than that required by the device for streaming operation.

3.0 RECORDING

3.1 METHOD

The method of recording shall be the "non-return to zero, change on one" (NRZI) where a "one" is represented by a flux transition occurring in the bit cell and a "zero" is represented by the absence of a flux transition in the bit cell.

3.2 CODE

Each 8 bit data byte is separated into two 4 bit groups (nibbles). Each 4 bit data nibble is encoded into a 5 bit GCR nibble for recording on the streaming magnetic tape cartridge. The most significant nibble is recorded first. The encoded data has the property that no more than two consecutive "zeros" shall occur. The translation table for data nibbles (B3, B2, B1, B0) and GCR nibbles (G4, G3, G2, G1, G0) shall be as follows:

<u>Note</u>: GCR bit G4 is recorded first.

HEX	B3	B2	B1	B0		G4	G3	G2	G1	G0	HEX
0	0	0	0	0	<--->	1	1	0	0	1	19
1	0	0	0	1	<--->	1	1	0	1	1	1B
2	0	0	1	0	<--->	1	0	0	1	0	12
3	0	0	1	1	<--->	1	0	0	1	1	13
4	0	1	0	0	<--->	1	1	1	0	1	1D
5	0	1	0	1	<--->	1	0	1	0	1	15
6	0	1	1	0	<--->	1	0	1	1	0	16
7	0	1	1	1	<--->	1	0	1	1	1	17
8	1	0	0	0	<--->	1	1	0	1	0	1A
9	1	0	0	1	<--->	0	1	0	0	1	09
A	1	0	1	0	<--->	0	1	0	1	0	0A
B	1	0	1	1	<--->	0	1	0	1	1	0B
C	1	1	0	0	<--->	1	1	1	1	0	1E
D	1	1	0	1	<--->	0	1	1	0	1	0D
E	1	1	1	0	<--->	0	1	1	1	0	0E
F	1	1	1	1	<--->	0	1	1	1	1	0F

3.3 NOMINAL DENSITY

The maximum nominal recording density (flux transition in every bit cell) shall be 10,000 flux transitions per inch (394 flux transitions per millimeter).

3.4 NOMINAL BIT CELL LENGTH

The nominal bit cell length shall be 100 microinches (2.54 micrometers).

3.5 AVERAGE BIT CELL LENGTH

The average bit cell length is the sum of distances between flux transitions over N bit cells divided by N. Any continuously recorded group code pattern may be used to measure the average bit cell.

3.6 LONG TERM AVERAGE BIT CELL LENGTH

The long term average bit cell length is the average bit cell length taken over a minimum of 900,000 bit cells. The long term average bit cell length shall be within +/-4% of the nominal bit cell length.

3.7 MEDIUM TERM AVERAGE BIT CELL LENGTH

The medium term average bit cell length is the average bit cell length taken over a minimum of 126 and a maximum of 130 bit cells. The medium term average bit cell length shall be within +/- 7% of the long term average bit cell length.

3.8 SHORT TERM AVERAGE BIT CELL LENGTH

The short term average bit cell length is the average bit ~~cell length taken over a minimum of 39 and a maximum of43~~ bit cells.

3.9 SHORT TERM AVERAGE BIT CELL CENTER

The short term average bit cell center is located at a point 1/2 the short term average bit cell length from either edge.

3.10 REFERENCE BIT CELL

The reference bit cell is the center bit cell in the bit cell group used to measure the short term average bit cell length. Bit cell centers of the bit cell group are positioned such that distances between flux transitions and bit cell centers are minimized ignoring missing flux transitions.

3.11 FLUX TRANSITION POSITION

A flux transition shall be located in the reference bit cell, if the flux transition exists, within a distance not more than 35% of the short term average bit cell length from the center of the reference bit cell. The flux transition position shall be measured by a playback device calibrated for zero azimuth (See Appendix A).

3.12 SIGNAL AMPLITUDE REFERENCE TAPE CARTRIDGE

A signal amplitude reference tape cartridge is a magnetic tape cartridge selected as a standard for signal amplitude when recorded at 10,000 flux transitions per inch (394 flux transitions per millimeter).

3.13 MEASUREMENT OF SIGNAL AMPLITUDE

The signal amplitude shall be measured at a point in the read channel where the signal is proportional to the first derivative of the rate of change of flux. Zero crossings of this signal are equivalent to flux transitions.

3.14 STANDARD REFERENCE CURRENT

The standard reference current is the minimum write current that when applied to the signal amplitude reference tape cartridge provides a 95% output signal at 10,000 flux transitions per inch (394 flux transitions per millimeter).

3.15 STANDARD RECORDING TEST CURRENT

The standard recording test current shall be 130% of the standard reference current.

3.16 AVERAGE STANDARD REFERENCE AMPLITUDE

The average standard reference amplitude is the peak to peak output signal read from the signal amplitude reference tape cartridge when generated by the standard recording test current and averaged over a minimum of 10,000 flux transitions.

3.17 AVERAGE PREAMBLE AMPLITUDE

The average preamble peak to peak amplitude taken over the central 100 flux transitions from a minimum of 100 blocks shall be within +50% and -35% of the average standard reference amplitude.

3.18 DATA AMPLITUDE

The data amplitude shall be measured at a point 1/2 the short term average bit cell length after each flux transition and shall be greater than 25% of the average standard reference amplitude for all flux transitions in each non rewritten block (See Appendix A).

3.19 ERASURE

The magnetic tape cartridge shall be erased prior to recording such that no remaining signal amplitude of any signal up to twice the recorded density is greater than 3% of the average standard reference amplitude. When the magnetic tape cartridge is recorded, erasure shall be tested between the end of recorded data and EOT. The erase signal shall be AC at a frequency at least 4 times the data frequency.

3.20 AZIMUTH

The angular deviation of the mean flux transition line from a line normal to the magnetic tape cartridge reference base shall be less than 3 minutes of arc.

4.0 TRACKS

4.1 NUMBER AND USE OF TRACKS

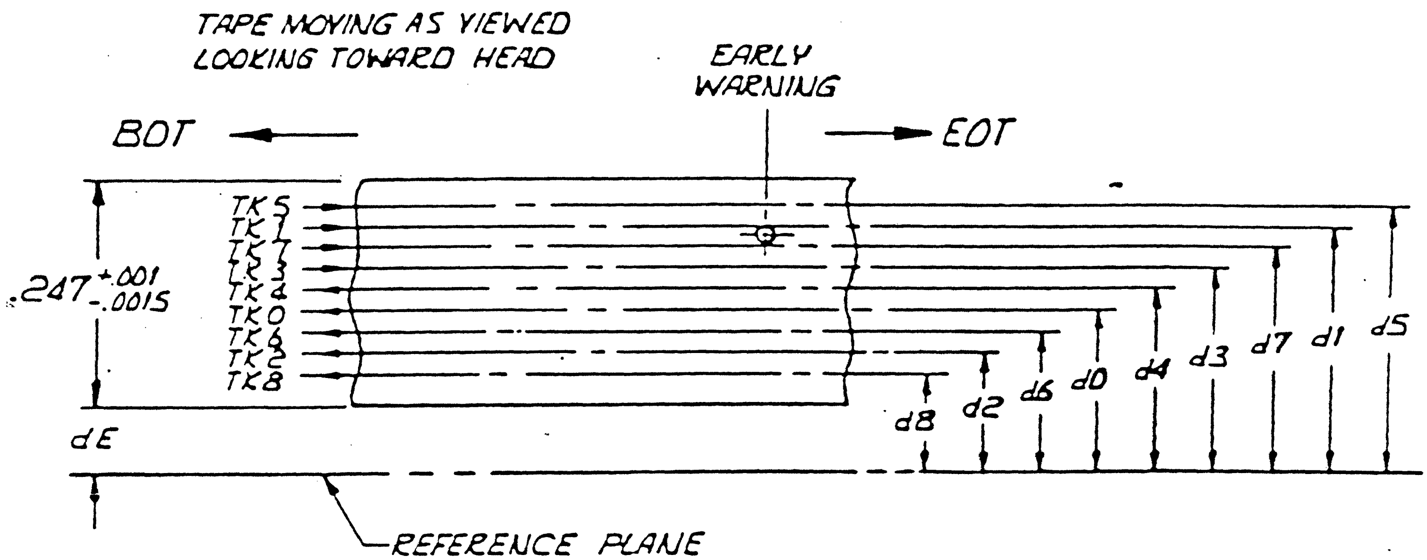
There shall be a maximum of nine tracks numbered 0 through 8 as specified in 4.3. Even numbered tracks shall be recorded serially in the forward direction of tape movement. Odd numbered tracks shall be recorded serially in the reverse direction of tape movement. On even tracks, all data for interchange shall be recorded after the load point marker and before the end of tape marker. On odd tracks 3 and 5, all data for interchange shall be recorded after the early warning marker and before the beginning of tape marker. However, on tracks 1 and 7, all data for interchange shall be recorded between the early warning marker and the load point marker. Tracks shall be recorded sequentially in the order, 0, 1, 2, ... , 8.

4.2 REFERENCE PLANE

The reference plane of the magnetic tape cartridge base is the datum for track location.

4.3 TRACK CENTER LINE LOCATIONS

Track center lines shall be located as indicated below:



d0 = 0.172 +/- .0042 in
d1 = 0.268 +/- .0042 in
d2 = 0.124 +/- .0042 in
d3 = 0.220 +/- .0042 in
d4 = 0.196 +/- .0042 in
d5 = 0.292 +/- .0042 in
d6 = 0.148 +/- .0042 in
d7 = 0.244 +/- .0042 in
d8 = 0.100 +/- .0042 in
dE = 0.070 in reference

4.4 TRACK WIDTH FOR 0.048 IN TRACK SPACING

When an 0.048 in track spacing is used, the number of recorded tracks shall be limited to a maximum of four tracks. The width of the recorded track shall be 0.036 +/- 0.002 inches. The width of the verified recorded track (read after write) shall be 0.020 +/- 0.001 inches.

4.5 TRACK WIDTH FOR 0.024 IN TRACK SPACING

When an 0.024 in track spacing is used, all nine tracks may be recorded. The width of the recorded track shall be 0.0135 +/- 0.0005 inches. All of the recorded track shall be verified (read after write).

4.6 INTERCHANGE BETWEEN 0.048 AND 0.024 IN TRACK SPACING

Magnetic tape cartridges recorded with the 0.048 in track spacing shall provide data interchange with magnetic tape cartridges with the 0.024 in track spacing where the recording has been limited to tracks 0 through 3.

<u>Note</u>: Nominal signal amplitiudes may be reduced due to narrower track width.

5.0 DATA BLOCK

The data block format shall be as follows:

```
+----/ /----+---+--------/ /--------+-------+---+----------+
|           | 1 |                   |   4   | 2 |          |
|  See      |   |                   |       |   | See      |
|           | B |                   |   B   | B |          |
|  Section  | Y |     512 BYTES     |   Y   | Y | Section  |
|           | T |                   |   T   | T |          |
|  5.1      | E |                   |   E   | E | 5.6      |
|           |   |                   |   S   | S |          |
+----/ /----+---+--------/ /--------+-------+---+----------+
|___________|  |  |_________________|   |       |      |
      |        |           |            |       |      |
      |        |           |--DATA      |       |   POSTAMBLE
      |        |                        |       |
      |        |--DATA BLOCK MARKER     |       |--CRC
      |                                 |
      |--PREAMBLE                       |--BLOCK ADDRESS
```

5.1 PREAMBLE

5.1.1 Normal

The preamble shall contain a minimum of 120 and a maximum of 300 flux transitions recorded at the maximum normal recording density of 10,000 flux transitions per inch (394 flux transitions per millimeter). The preamble shall be used to synchronize the phase locked loop in the read electronics to the data frequency. The preamble shall also be used to measure the average preamble amplitude.

5.1.2 Elongated

An elongated preamble shall contain a minimum of 3500 and a maximum of 7000 flux transitions and shall preceed the first data block recorded after an underrun (7.2).

5.1.3 Long

A long preamble shall contain a minimum of 15,000 and a maximum of 30,000 flux transitions, and shall preceed the first data block for interchange recorded at the beginning of a track.

5.2 DATA BLOCK MARKER

The data block marker identifies the start of data and shall consist of the following GCR pattern:

G4	G3	G2	G1	G0	G4	G3	G2	G1	G0
1	1	1	1	1	0	0	1	1	1
MS nibble					LS nibble				

5.3 DATA BLOCK

The data block shall contain 512 bytes of data for interchange encoded into GCR bytes in accordance with the CODE (section 3.2).

5.4 BLOCK ADDRESS

The block address shall consist of 4 bytes which uniquely identify a block recorded on tape. The block address shall be encoded into GCR bytes in accordance with the CODE (section 3.2), and is defined below:

```
       0                 1                 2                 3
+-----------------+-----------------+-----------------+-----------------+
|                 | Con-  |         |                 |                 |
|     Track       | trol  |         |                 |                 |
|                 |       |         |                 |                 |
|    Address      |Nibble |         |                 |                 |
|                 |       |         |                 |                 |
+-----------------+-----------------+-----------------+-----------------+

                          |---------Block Address-------------|
```

BYTE	BITS	FUNCTION
0	7	Track number bit 7 (MSB)
	6	Track number bit 6
	5	Track number bit 5
	4	Track number bit 4
	3	Track number bit 3
	2	Track number bit 2
	1	Track number bit 1
	0	Track number bit 0 (LSB)
1	7	Control Nibble bit 3 (MSB)
	6	Control Nibble bit 2
	5	Control Nibble bit 1
	4	Control Nibble bit 0 (LSB)
	3	Block Address bit 19 (MSB)
	2	Block Address bit 18
	1	Block Address bit 17
	0	Block Address bit 16
2	7	Block Address bit 15
	6	Block Address bit 14
	5	Block Address bit 13
	4	Block Address bit 12
	3	Block Address bit 11
	2	Block Address bit 10
	1	Block Address bit 9
	0	Block Address bit 8
3	7	Block Address bit 7
	6	Block Address bit 6
	5	Block Address bit 5
	4	Block Address bit 4
	3	Block Address bit 3
	2	Block Address bit 2
	1	Block Address bit 1
	0	Block Address bit 0 (LSB)

5.4.1 Track Number

The track number as specified in Section 4.3 shall be recorded in byte 0.

5.4.2 Control Block

Definition of control block should be as follows:

Control Nibble

3 2 1 0	Value	Meaning
0 0 0 0	0	The current block contains user data or file mark
0 0 0 1	1	The current block contains control information
0010-1111	2-15	Reserved

Note: The use of control blocks as defined by this specification is an optional feature. It shall be permissible for a device to recognize and process only blocks with control nibble=0 and to ignore all blocks with control nibble=1 and still meet the requirements for data interchange as specified by this document.

5.4.3 Address of Block

The first block on the tape shall be block 1, and subsequent blocks shall be numbered sequentially. The block address shall not reset at the end of a track.

5.4.4 Control Block Data Field (Optional)

When the control nibble=1 the current 512 byte data block contains control information. This control information is defined as follows:

BYTE	MEANING
0 (M.S)	Drive type: 04H = 4 track device 09H = 9 track device
1	Type of Control Block 00H = none 01H = first block on a track 02H = last block on a track. This block may be used to terminate a completed track. 03H = extended file marks 04H = partial block count. This indicates that bytes 2 and 3 specify the number of valid data bytes in the following data block. In the data block, the valid data bytes are recorded first, followed by filler characters. 05-1FH = Reserved. 20-FFH = Not Defined.
2	File Mark Number (MSB), or number of data bytes (MSB) in the partial block.
3	File Mark Number (LSB), or number of data bytes (LSB) in the partial block.
4-0F	Reserved (Set to 00H).
10-1FF	Not definedin this standard.

Note: The use of the partial block option will generate a recorded tape which does not meet the requirements for data interchange at the minimum machine level (QIC-24 with no options).

5.5 CYCLICAL REDUNDANCY CHECK

The cyclical redundancy check (CRC) shall consist of two bytes calculated over the 512 bytes of interchange data and the 4 byte block address starting with all ones CRC initial value and using the CRC generating polynomial:

$$x^{16} + x^{12} + x^5 + 1$$

The CRC shall be encoded into GCR bytes in accordance with the CODE (section 3.2).

5.6 POSTAMBLE

5.6.1 Normal

A normal postamble with a minimum of 5, and a maximum of 20 flux transition, recorded at the maximum nominal flux density, shall be recorded following the CRC as a guard band.

5.6.2 Elongated

Anelongated postamble with a minimum of 3500 and a maximum of 7000 flux transitions, recorded at the maximum nominal flux density, shall be recorded following an underrun sequence.

6.0 FILE MARK BLOCK

The file mark block format shall be identical to the data block format except that the data field shall contain 512 bytes consisting of the following GCR pattern:

G4	G3	G2	G1	G0	G4	G3	G2	G1	G0
0	0	1	0	1	0	0	1	0	1
	MS nibble					LS nibble			

The GCR nibble (00101) shall be converted to the HEX nibble (1111) to form the data field for CRC generation and checking.

7.0 REWRITTEN BLOCKS

7.1 ERROR

Data for interchange, if written such that all requirements for interchange are not met, shall be rewritten such that requirements for data interchange are met. Each data and file mark block that do not meet the requirements for interchange shall be rewritten. A data block shall be tested for interchange requirements during the read after write check. Writing of block N + 1 shall begin before the read after write check of block N is completed. If block N satisfies the requirements for interchange, the read after write check of block N + 1 is begun. However, if block N does not satisfy the requirements for interchange, it is rewritten after the writing of block N + 1 is completed. It shall be permissable to truncate the writing of block N + 1 with postamble before re-writing block N. Block N + 1 is also rewritten after block N in order to preserve the sequential order of records. During error processing of block N it shall be permissable to rewrite block N without rewriting block N + 1. A Block in Error shall be written up to 16 times before the recording operation is aborted. Various sequences of rewritten blocks are shown below.

```
    +-------+-------+-------+-------+-------+-------+
... | N-1   |   N   |  N+1  |   N   |  N+1  |  N+2  | ...
    +-------+-------+-------+-------+-------+-------+

        +-------+-------+-------+-------+-------+
    ... | N-1   |   N   |   N   |   N   |  N+1  | ...
        +-------+-------+-------+-------+-------+

    +-------+-------+-------+-------+-------+-------+-------+
... | N-1   |   N   |  N+1  |   N   |   N   |  N+1  |  N+2  | ...
    +-------+-------+-------+-------+-------+-------+-------+
```

7.2 UNDERRUN, END OF FILE OR END OF TRACK

Streaming operation shall normally be terminated when underrun, end of file or end of track conditions exist. The normal sequence of recording of blocks N, N + 1, etc. shall be replaced by the sequence of blocks N, N, etc. until the recording of block N meets the requirements for interchange. When block N is recorded such that the requirements of interchange are met, the associated rewriting of block N is completed or truncated. An elongated postamble (Section 5.6.2) shall be written as shown below.

```
        +-------+-------+-------+-------+
    ... | N-1   |   N   |   N   |///////|
        +-------+-------+-------+-------+
                                |_______|
                                    |
                                    |--ELONGATED POSTAMBLE
```

Recording in the elongated postamble shall begin at 3000 flux transitions minimum, 3500 flux transitions maximum from the end of the block preceding the elongated postamble. An elongated ~~preamble shall be recorded before recording~~ any other field in the block.

```
                                    |--ELONGATED POSTAMBLE
                                    |
                                ____|____
                                |       |
        +-------+-------+-------+-----+-+------+
    ... | N-1   |   N   |   N   |/////|X|\\\\\\| ...
        +-------+-------+-------+-----+-+------+
                                |_____||
                                  |    |--OVERLAP
                                  |
                                  |    |_______|
                                  |        |
 3000 Flux Transitions MIN. --|        |--ELONGATED PREAMBLE
 3500 Flux Transitions MAX.
```

7.3 FORCED STREAMING

Termination of streaming operation due to underrun may optionally be prevented by continued recording of the last block until end of file or end of track occurs. Standard length format fields shall be used during forced streaming operation.

```
      +-------+-------+-------+       +-------+-------+
  ... |  N-1  |   N   |   N   |  ...  |   N   |   N   | ...
      +-------+-------+-------+       +-------+-------+
```

7.4 END OF RECORDED DATA

On other than the last track, the end of recorded data shall be indicated by a valid file mark block and optional control blocks followed by a minimum of 45 inches of erased track.

8.0 RECORDED TRACKS AT BEGINNING AND END OF TAPE

8.1 TRACK REFERENCE BURST

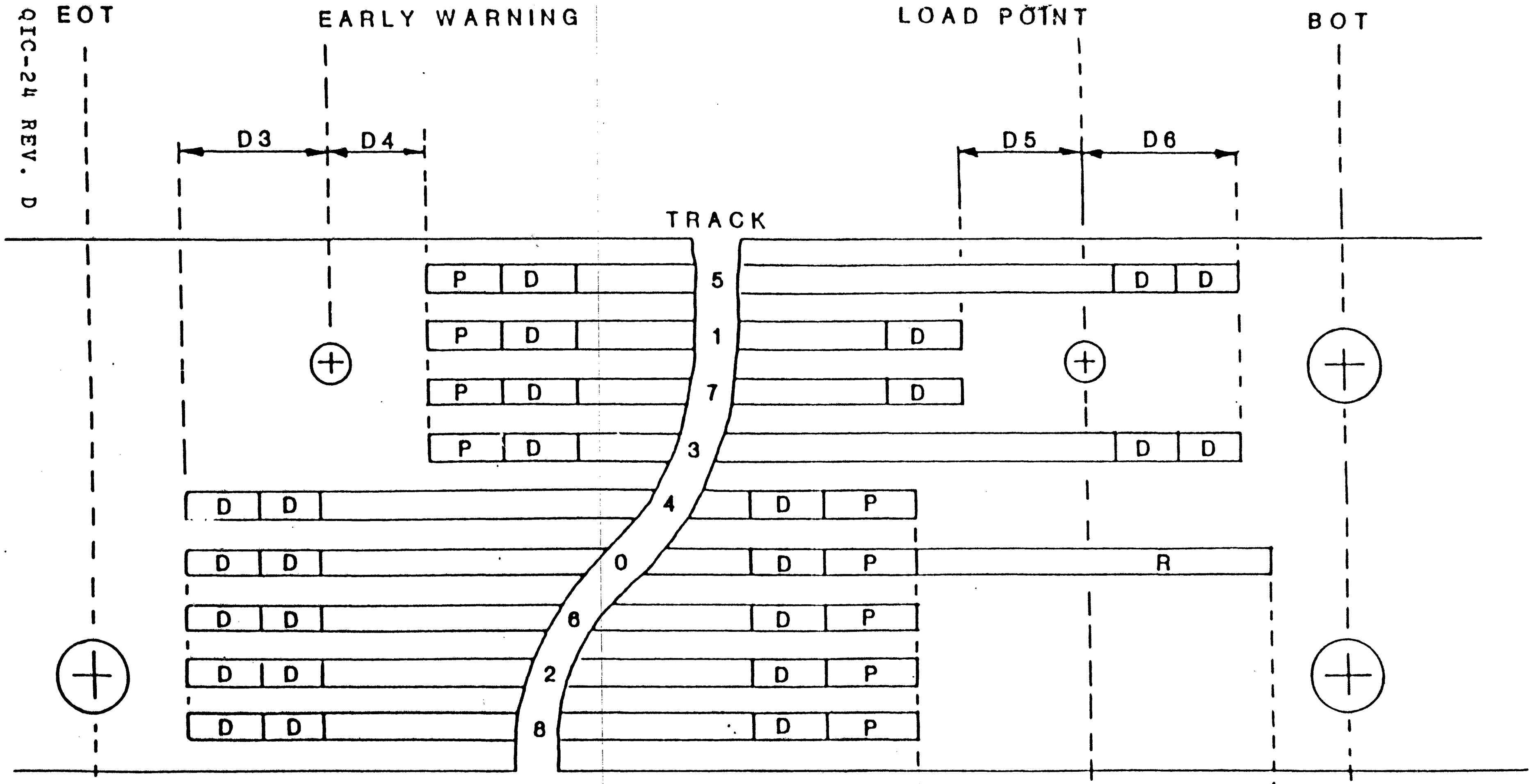
A track reference burst recorded at the maximum nominal recording density of 10,000 flux transitions per inch (394 flux transitions per millimeter) shall be written between the BOT holes and recorded data on track 0. The reference burst shall start a minimum of 0 inches and a maximum of 15 inches from the BOT hole and shall extend past the load point hole for a minimum of 3 inches and a maximum of 4 inches. A long preamble shall preceed the first data block.

8.2 EVEN TRACKS

All even tracks shall start a minimum of 3 inches and a maximum of 4 inches past the load point hole. A long preamble ~~shall preceed the first data block for interchange.~~ On even tracks, no data for interchange shall be recorded beyond a point 36 inches past the early warning hole.

8.3 ODD TRACKS

All odd tracks shall start a minimum of 1 inch and a maximum of 2 inches past the early warning hole. A long preamble shall preceed the first data block for interchange. On tracks 1 and 7, no data for interchange shall be recorded past the load point hole. The last block of data for interchange written on these tracks prior to track switching to the next sequential track shall end a maximum of 4 inches and a minimum of 0.1 inch before the load point hole as measured from the center line of the hole. On tracks 3 and 5 it shall be permissible to record data for interchange past the load point hole. No data for interchange shall be recorded beyond a point 27 inches past the load point hole.



R = Reference Burst
P = Preamble
D = Data or Control Block

Dimension	Min (in)	Max (in)	Description
D1	0	15	BOT to Start of track reference burst
D2	3	4	Load point to end of track reference burst & start of preamble on even tracks
D3	-	36	Early warning to end of data on even tracks
D4	1	2	Early warning to start of preamble on odd tracks
D5	0.1	4	End of data to load point on tracks 1 and 7
D6	-	27	Load point to end of data on tracks 3 and 5

APPENDIX A

JUSTIFICATION FOR 41 BIT AVERAGE METHOD FOR BIT SHIFT MEASUREMENT

The ANSI draft specification for the unrecorded cartridge (X3B5. 82-89) calls out a method of measuring ISV on a cartridge by considering the amount of time displacement error (TDE) remaining after the off-tape signal has been operated on by a standard phase locked loop (PLL).

Please refer to the explanation given in that appendix. Note that the residual TDE is a function of the ISV amplitude and frequency and the suppression of the standard loop at that frequency.

If $$\text{ISV} = a.\sin(wt),$$

and $$\text{Suppression} = \frac{s^2/W^2}{1+(\text{sqrt}2)s/W + s^2/W^2}$$

then the remaining error for a continuous single-frequency signal off tape (i.e. for a signal containing no peak shift due to the head) will be:

$$\text{TDER} = \frac{a}{w} . \frac{w^2/W^2}{\text{sqrt}((1 - w^2/W^2)^2 + 2w^2/W^2)}$$

where W is the natural frequency of the PLL.

A graph of this function is shown in Figure A1.

When the draft standard for recorded tape, IMFM, 6400 ftpi was discussed, it ~~was agreed that the tape must meet the~~ ISV specification as called out in the draft unrecorded standard and that there was no need to state this specifically again. Since there was precedent for using an averaging method (4-bit average) from the previous standard, and since considerable empirical work had been done to investigate the actual performance of tapes, the ANSI X3B5 ad hoc group felt justified in adding a "medium term ISV" specification.

This specification states that the 4 bit cell average of the bit cell length shall be within $\pm 7\%$ of the long term average and shall be within 2% of the average of the surrounding 128 bit cells.

The GCR, 10,000 ftpi specification requires that the 128 bit average shall be within 7% of the long term average.

The averaging function is performed by adding up the samples of bit cell length and dividing by the total number of samples.

If a component of ISV is (a sin wt), then the frequency off tape will be: $f = f_0(1+ (a \sin wt))$

Cell time is 1/f which is approximately $T_0\ (1 - (a \sin wt)) = T$.

In general, $T = T_0\ (1 - a(w))$ where

$T_0 = 1/F_0$ and a (w) is some function of w which could be a sine wave.

The sample function may be developed as follows:

Samples are taken at

$$t_{-(n-1)/2}, \ldots, t_{-1}, t_0, t_1, \ldots, t_{(n+1)/2}$$

and added up so that the average is

$$\frac{T_{-(n-1)/2} + \cdots + T_{-1} + T_0 + T_1 + \cdots + T_{(n+1)/2}}{n}$$

centered on T_0.

In general, using Laplace notation:

$$T_{AVE}(s) = \frac{T_0(1/s-a(s))(e^{(n+1)sT/2}+..e^{sT/2}+1+e^{-sT/2}+..e^{-(n+1)sT/2})}{n}$$

In the steady state when a(w) is a sine wave a(sin wt), the magnitude of the resultant as a function of time may be obtained by replacing s by jw

So T_{AVE} =

$$T_{AVE} = \frac{T_0(e^{j(n-1)wT/2}+..e^{jwT/2}+1+e^{-jwT/2}+..e^{-j(n-1)wT/2})}{n}$$

For n odd, the exponentials may be taken in pairs and added.

In general: $e^{njwT} + e^{-njwT} = 2 \cos nwT$

$$\text{Hence } T_{AVE} = \frac{T_0(1+2\cos(wT)+2\cos(2wT)+\ldots2\cos(n-1)wT/2)}{n}$$

A similar analysis can be made for n even, but it involves choosing a center point half way between two samples simply as a mathematical convenience.

A graph of the transmission characteristic of this function is shown for 127 bit cells and is essentially flat up to 1kHz at 30 ips, 10,000 ftpi. This means that ISV in the range up to 1KHz must as a first requirement, be less than 7%.
The number of samples (126 to 130) was chosen for several reasons.

a) The same number of samples (128) is used in the proposed IMFM Recorded Standard.

b) 126-130 is necessary since there may be two zeroes at each end of any given sample.

c) Since, in actual data patterns, peak shift can occur, the error in computing average cell time is reduced by having a large number of samples. For example, a 35% peak shift changes the 128-bit average by only .27%.

In attempting to specify short term effects, considerable thought was given to the need ~~to use~~ the information actually received off tape rather than using special test patterns to determine whether the equipment can create suitable tapes.

It would be possible as in the unrecorded standard to specify the use of a standard PLL which would tend to follow ISV. The PLL would create the reference bit cells and the deviation from cell center caused by residual time displacement error, peak shift and asymmetry would be specified.

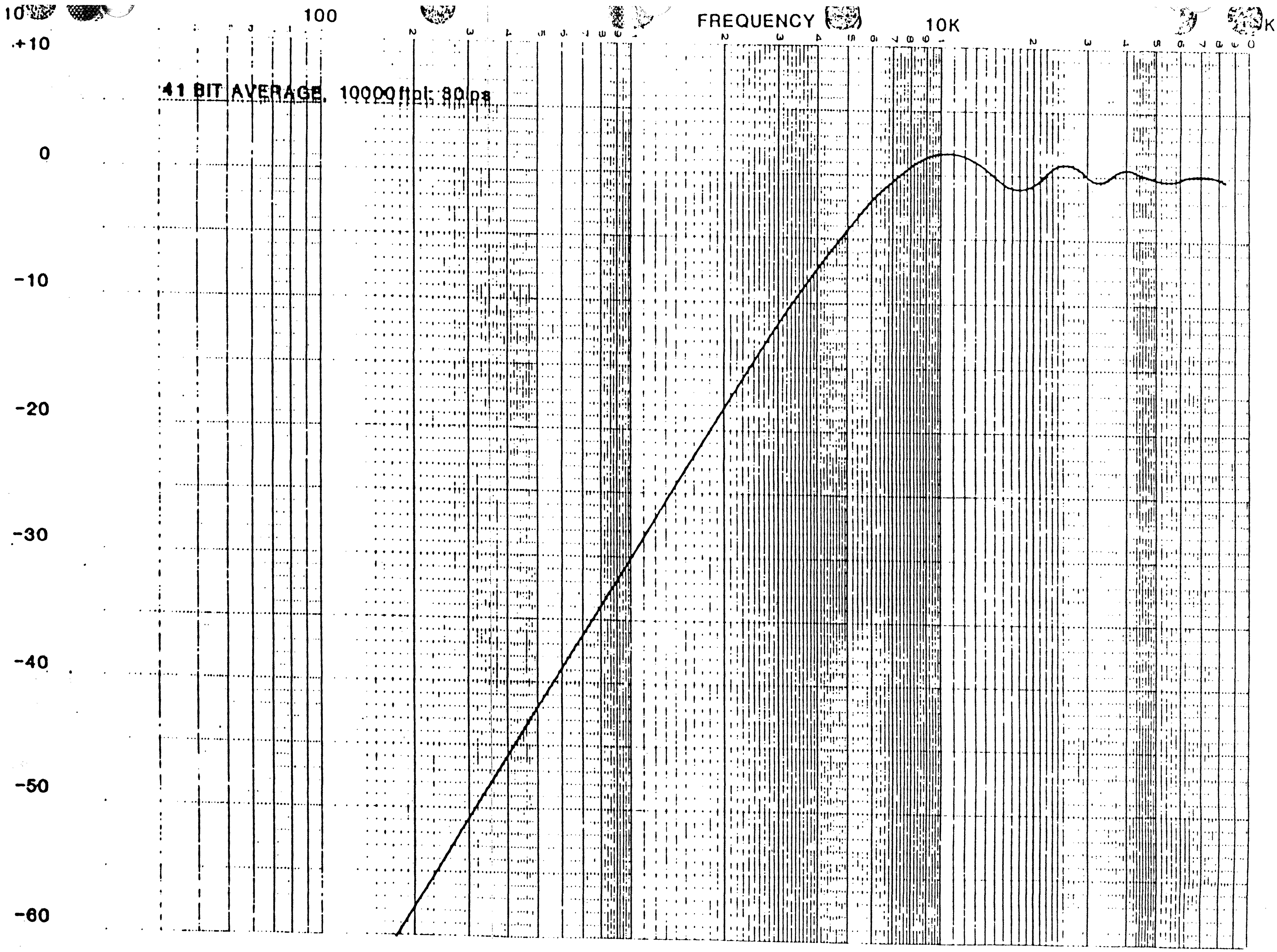
However, the 6400 ftpi IMFM standard has not used the PLL but has called out an averaging method. An attempt was made to find an averaging method having an effective frequency response (or suppression function) very similar to that of the PLL. This turns out to be a 41 bit average at 10,000 ftpi (see Figure A2).

As stated previously, residual TDE will be

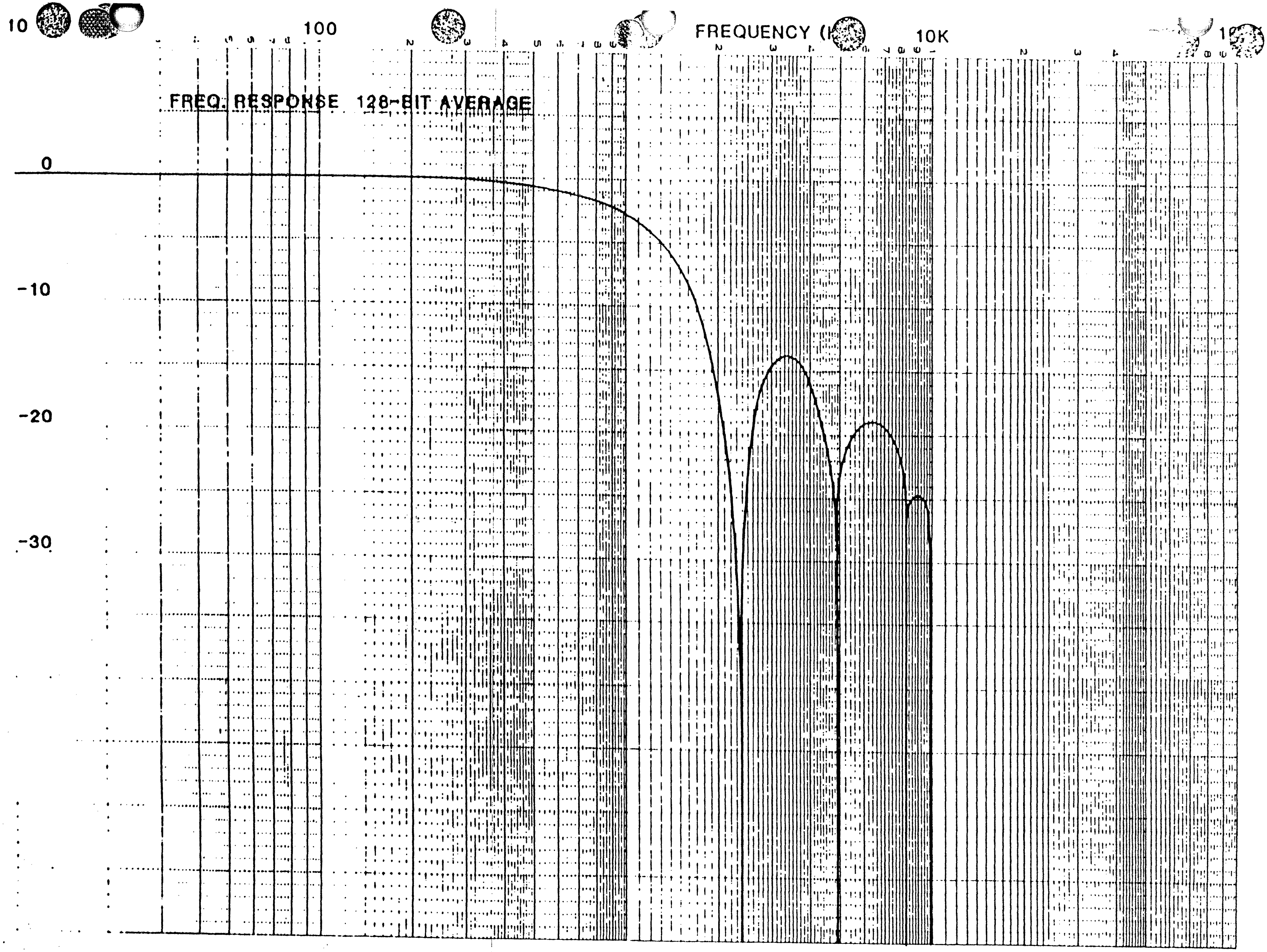
TDER = (a/w) X (Suppression Function)

Since the suppression function for the 41-bit average is very close to that of the standard PLL proposed in the unrecorded standard, the two methods will handle ISV in a similar manner. Additional peak shift and asymmetry will add to give the total bit shift that a practical system might expect to see off tape.

A figure of 70% of a bit cell(total) was chosen with zero azimuth error, since it has been determined empirically that much of the remaining 30% will be used up when the tape is read with an azimuthal error of up to 16 minutes of arc.



41 BIT AVERAGE, 10000 fpl; 80 ps
FREQUENCY
100
10K
+10
0
-10
-20
-30
-40
-50
-60


FREQUENCY (Hz)
FREQ. RESPONSE 128-BIT AVERAGE
10
100
10K
0
-10
-20
-30

Part 4

QIC-02
REVISION D
9-23-82

PROPOSED 1/4 INCH CARTRIDGE TAPE DRIVE

INTELLIGENT INTERFACE STANDARD

September 23, 1982

TABLE OF CONTENTS

1.0 SCOPE

2.0 DEFINITIONS

3.0 INTERFACE

- 3.1 INPUT/OUTPUT SIGNAL CONNECTOR AND CABLE
- 3.2 INTERFACE SIGNAL LEVELS
- 3.3 SIGNAL TERMINATIONS
- 3.4 SIGNAL LOADING
- 3.5 INPUT/OUTPUT PIN ASSIGNMENTS & SIGNAL DESCRIPTIONS
- 3.6 INTERFACE TIMING
  - 3.6.1 READ STATUS COMMAND TIMING
  - 3.6.2 RESET TIMING
  - 3.6.3 SELECT COMMAND TIMING
  - 3.6.4 BOT, CARTRIDGE INITIALIZATION, OR ERASE COMMAND TIMING
  - 3.6.5 WRITE DATA TIMING
  - 3.6.6 READ DATA TIMING
  - 3.6.7 WRITE-FILE-MARK TIMING
  - 3.6.8 READ-FILE-MARK TIMING

4.0 COMMANDS

- 4.1 COMMAND SUMMARY
- 4.2 STANDARD COMMAND DESCRIPTIONS
  - 4.2.1 POWER ON/RESET
  - 4.2.2 SELECT COMMAND
  - 4.2.3 READ STATUS COMMAND
  - 4.2.4 BOT COMMAND
  - 4.2.5 CARTRIDGE INITIALIZATION COMMAND
  - 4.2.6 ERASE COMMAND
  - 4.2.7 WRITE COMMAND
  - 4.2.8 READ COMMAND
  - 4.2.9 WRITE-FILE-MARK COMMAND
  - 4.2.10 READ-FILE-MARK COMMAND

- 4.3 OPTIONAL COMMAND DESCRIPTIONS
  - 4.3.1 SELECT, LOCK CARTRIDGE COMMAND
  - 4.3.2 SELECT AUTO CARTRIDGE INITIALIZATION COMMAND
  - 4.3.3 WRITE WITHOUT UNDERRUNS COMMAND
  - 4.3.4 ENTER 6 BYTE PARAMETER BLOCK COMMAND
  - 4.3.5 WRITE N FILE MARKS COMMAND
  - 4.3.6 SPACE FORWARD COMMAND
  - 4.3.7 READ REDUCED TRACK DENSITY COMMAND
  - 4.3.8 SPACE FORWARD REDUCED TRACK DENSITY COMMAND
  - 4.3.9 READ REVERSE COMMAND
  - 4.3.10 SPACE REVERSE COMMAND
  - 4.3.11 READ REVERSE REDUCED TRACK DENSITY COMMAND
  - 4.3.12 SPACE REVERSE REDUCED TRACK DENSITY COMMAND

4.3.13 SEEK EOD (END OF DATA) COMMAND
4.3.14 READ FILE MARK REDUCED TRACK DENSITY COMMAND
4.3.15 SEEK EOD REDUCED TRACK DENSITY COMMAND
4.3.16 READ FILE MARK REVERSE COMMAND
4.3.17 READ FILE MARK REVERSE REDUCED TRACK DENSITY
4.3.18 READ N FILE MARKS COMMAND
4.3.19 READ EXTENDED STATUS 1 COMMAND
4.3.20 RUN SELF TEST 1 COMMAND
4.3.21 READ EXTENDED STATUS 2 COMMAND
4.3.22 RUN SELF TEST 2 COMMAND
4.3.23 READ EXTENDED STATUS 3 COMMAND

5.0 STANDARD STATUS

5.1 STATUS BYTE SUMMARY
5.2 STATUS BYTE DESCRIPTION
5.3 EXCEPTION STATUS SUMMARY
5.4 EXCEPTION STATUS DESCRIPTION

ADDENDUM TO:
QIC-02
REVISION D

ADDENDUM DATED
3-29-83

QIC ADDENDUM

SUBJECT: Proposed Optional ~~Partial Block command~~.

PURPOSE: An additional optional command is proposed to provide partial block capability for the QIC-02 interface. The proposed command allows the host to transfer a data block which is less than 512 bytes. The device will add the required pad characters and record a full 512 byte data block on tape.

PROPOSED COMMAND:

WRITE PARTIAL BLOCK (0100 0010)

This command will transfer one command byte, two parameter bytes, and a partial data block from the Host to the Device. ONLINE and READY must be asserted prior to command transfer. Command and parameter bytes are transferred by the REQUEST/READY handshake protocol and data is transferred via XFER/ACK protocol. The two parameter bytes define the length in bytes of the partial data block transfer. Transfer sequence will be command byte, followed by the MSB of the byte count, followed by the LSB of the byte count, followed by data transfer. After receiving the partial data block, the device will assert READY, add the required padding characters, and write the block on tape (An optional control block as defined by QIC-24 may preceed the partial block on tape). The device will underrun and stop after completion of the data block. When READY is asserted, it will be permissible to issue any of the WRITE type commands (WRITE, WRITE WITHOUT UNDERRUNS, WRITE PARTIAL BLOCK, WRITE FILEMARK, or WRITE N FILE MARKS).

Devices which do not implement this optional feature will assert EXCEPTION after the transfer of the command byte. Device will also set Status Byte 1, bit 6, illegal command. The Host will not attempt to transfer the two parameter bytes.

Devices which implement this option will verify that the byte count as specified by the two parameter bytes is within the count of 1 and 511 bytes (inclusive). If the count is outside this range the device will assert EXCEPTION with Status Byte 1, bit 6, illegal command, and abort the operation.

F11.1.1 - RESET

This command is used by the host system to initialize the device.
When a reset command is detected by the device, the exception line will be asserted.
The exception line must be cleared by a READ STATUS sequence.

PROGRAMMING

The tape is interfaced through a set of registers, whose address have been specified in section F.3. In particular, the CRW and CRR registers are used to issue commands and report status, and DRW and DRR are used to exchange data.
-The layout of the CRW register is the following:

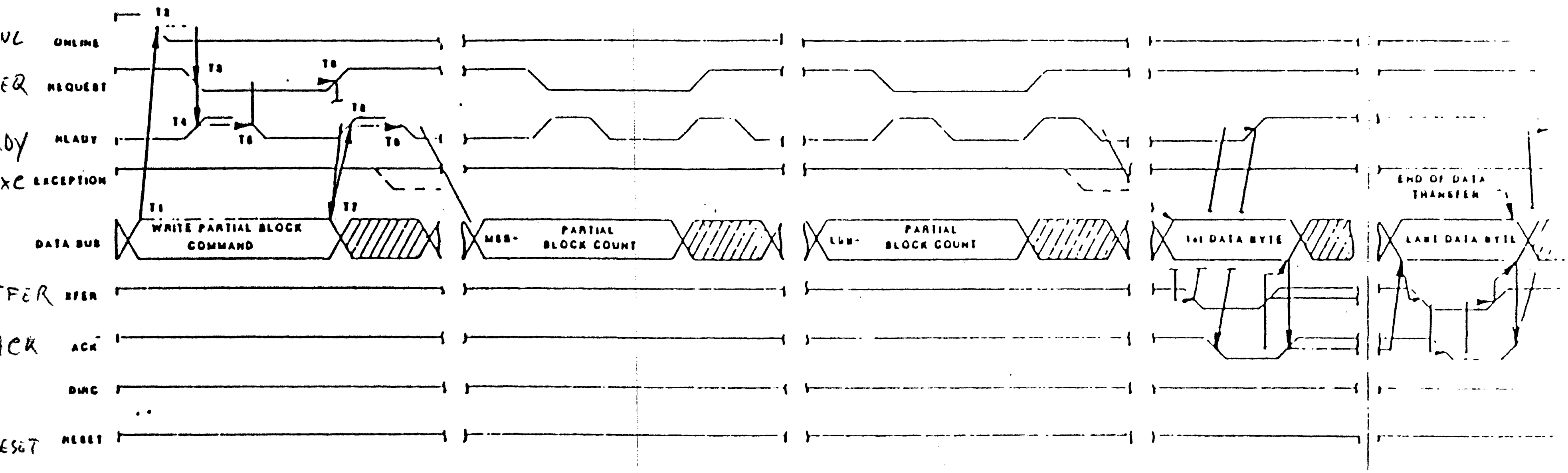
```
         ______________________________________________________________________________
         |       |       |       |       |       |       |       |       |
C.R.W. | BIT 7 | BIT 6 | BIT 5 | BIT 4 | BIT 3 | BIT 2 | BIT 1 | BIT 0|
         |_______|_______|_______|_______|_______|_______|_______|_______|
             |       |       |       |       |       |       |       |
             |       |       |       |       |       |       |     DXFER
             |       |       |       |       |       |            REQUEST

             |       |       |       |       |     ONLINE
             |       |       |       |     RESET
             |       |       |     R.F.U.
             |       |     R.F.U.
             |     R.F.U.
           R.F.U.
```

-The layout of the CRR register is the following:

```
         ______________________________________________________________________________
         |       |       |       |       |       |       |       |       |
C.R.R. | BIT 7 | BIT 6 | BIT 5 | BIT 4 | BIT 3 | BIT 2 | BIT 1 | BIT 0|
         |_______|_______|_______|_______|_______|_______|_______|_______|
             |       |       |       |       |       |       |       |
             |       |       |       |       |       |       |     R.F.U.
             |       |       |       |       |       |     R.F.U.
             |       |       |       |       |     R.F.U.
             |       |       |       |     R.F.U.
             |       |       |     DIR .
             |       |     EXCEP.
             |     READY.
          DTENBL
```

ADDENDUM TO:
QIC-02
REVISION D
ADDENDUM DATED
3-29-83



WRITE PARTIAL BLOCK COMMAND

TIMING PARAMETERS ARE TYPICAL HOST INTERFACE SPECIFICATIONS AS DESCRIBED FOR WRITE DATA COMMAND. SEE PAGE 12 OF QIC-02 REV.D.

1.0 SCOPE

This document specifies an interface to an intelligent streaming 1/4 inch cartridge tape drive. The specification includes hardware interface, bus timing, commands and status.

2.0 DEFINITIONS

block - a group of consecutive bytes transferred as a unit
BOT - beginning of tape marker indicating beginning of tape
bus - a circuit over which data is transmitted
byte - a group of 8 binary bits operated on as a unit
cartridge - a four by six inch enclosure containing 1/4 inch magnetic tape wound on two coplanar hubs and driven by an internal belt which is coupled by an internal belt capstan to the external drive (ref ANSI X3.55-1977)
cartridge initialization - an operation which restores normal tension by wind and rewind of the cartridge
continuable - a type of error after which an operation can be continued by issuing another command
command - the portion of an instruction word which specifies the operation to be performed
device - that which is devised, invented, or formed by design; used interchangeably with drive
drive - a device that moves tape past a recording/playback head
early warning - early warning marker indicating the approaching end of permissible recording area
EOT - end of tape marker indicating the end of tape
erase - to remove all magnetically recorded information from the tape
fatal - a type of error which causes an operation to be aborted, operation must be started over
file mark - an identification mark following the last block in a file
load point - load point marker indicating the beginning of the permissible recording area
status - bytes transmitted indicating status of the device
underrun - condition developed when host transmits or receives data at a rate less than that required by the device for streaming operation

3.0 INTERFACE

This section describes the proposed 1/4 inch cartridge tape drive interface. Data and commands are transferred to and from the device on an 8 bit bi-directional data bus using asynchronous handshaking techniques to eliminate rigorous timing contraints. Up to four devices are supported on the interface.

3.1 INPUT/OUTPUT SIGNAL CONNECTOR AND CABLE

The signal connector on the Device shall be a 50 conductor edge connector. Mating connector 3M type 3415-0001 or equivalent shall be used.

The signal cable shall be a 50 conductor flat ribbon cable. 3M type 3365/50 or equivalent flat cable shall be used.

3.2 INTERFACE SIGNAL LEVELS

All signals to the Host shall be standard TTL levels as follows:

FALSE, Logic 0 (high)	=2.4 to 5.25 VDC
TRUE, Logic 1 (low)	=0 to 0.55 VDC

All signals to each Device shall be standard TTLlevelsas follows:

FALSE, Logic 0 (high)	=2.0 to 5.25 VDC
TRUE, Logic 1 (low)	=0 to 0.8 VDC

Voltages shall be measured at each Device connector. This interface shall support a total cable length of 3 meters maximum.

3.3 SIGNAL TERMINATIONS

The standard termination shall be 220 ohms to +5VDC 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 Host to the Device shall be terminated at the Device unless daisy-chained in which case the last device on the daisy shall provide terminations. The Host shall terminate the bi-directional data bus and the four control signals from the Devices to the Host at the Host.

3.4 SIGNAL LOADING

No signal on the interface shall be loaded by Devices by more than 2.0 mA plus required terminations. No signal on the interface shall be loaded by the Host by more than 2.0 mA plus required terminations.

3.5 INPUT/OUTPUT SIGNAL PIN ASSIGNMENTS AND SIGNAL DESCRIPTION

PIN#	NAME	TO	DESCRIPTION	
02	NUS-	X	NOT USED - unconnected signal lines	
04	NUS-	X		
06	NUS-	X		
08	NUS-	X		
10	HBP-	B	HOST BUS ODD PARITY - reserved for optional odd bus parity	
12	HB7-	B	HOST BUSBIT7 - most significant bit of 8-bit host bi-directional data bus	
14	HB6-	B	HOST BUS BIT 6	
16	HB5-	B	HOST BUS BIT 5	
18	HB4-	B	HOST BUS BIT 4	
20	HB3-	B	HOST BUS BIT 3	
22	HB2-	B	HOST BUS BIT 2	
24	HB1-	B	HOST BUS BIT 1	
26	HB0-	B	HOST BUS BIT 0 - least significant bit of 8-bit host bi-directional data bus	
28	ONL-	D	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	Set/Reset da FW
	REQ-	D	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, shall be asserted by host only when RDY- OR EXC- is asserted by device	set FW Reset Ready→$\overline{\text{Ready}}$
32	RST-	D	RESET - causes device initialization to be performed, default selection to device 0, EXCEPTION asserted.	Set/Reset da FW
34	XFR-	D	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	Set/Reset da FW
36	ACK-	H	ACKNOWLEDGE - device generated signal which indicates that data has been taken from the data bus in WRITE MODE or that data has been placed on the data bus in READ MODE	leggibile da FW

PIN#	NAME	TO	DESCRIPTION	
38	RDY-	H	READY - device generated signal which indicates one of 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 BOT, CARTRIDGE INITIALIZATION or ERASE COMMAND is completed following issuance (4) the device is ready to receive the next block or ready to receive a WRITE or WFM Command from the host in WRITE mode (5) a WFM command is completed in WRITE FILE MARK mode (6) the device is ready to transmit the next block to the host or ready to receive a READ or REM command from the host in READ MODE (7) OTHERWISE, device is ready to receive a new command	
40	EXC-	H	EXCEPTION - device generated signal which indicates that an exception condition exists in the device, that host MUST issue STATUS COMMAND and perform a STATUS INPUT to determine cause	leggibile da FW setta INT (per fine con Eccezione)
42	DIR-	H	DIRECTION - device generated signal which when false causes host data bus drivers to assert their data bus levels and device data bus drivers to assume high impedence states, when true causes host data bus drivers to assume high impedence states and device data bus drivers to assert their data bus levels	leggibile da FW 20lox Diafu. Abilitaz. 4W transrec
44	NUS-	I	NOT USED - unconnected signal line	
46	NUS-	I	NOT USED - unconnected signal line	
48	NUS-	I	NOT USED - unconnected signal line	
50	NUS-	I	NOT USED - unconnected signal line	

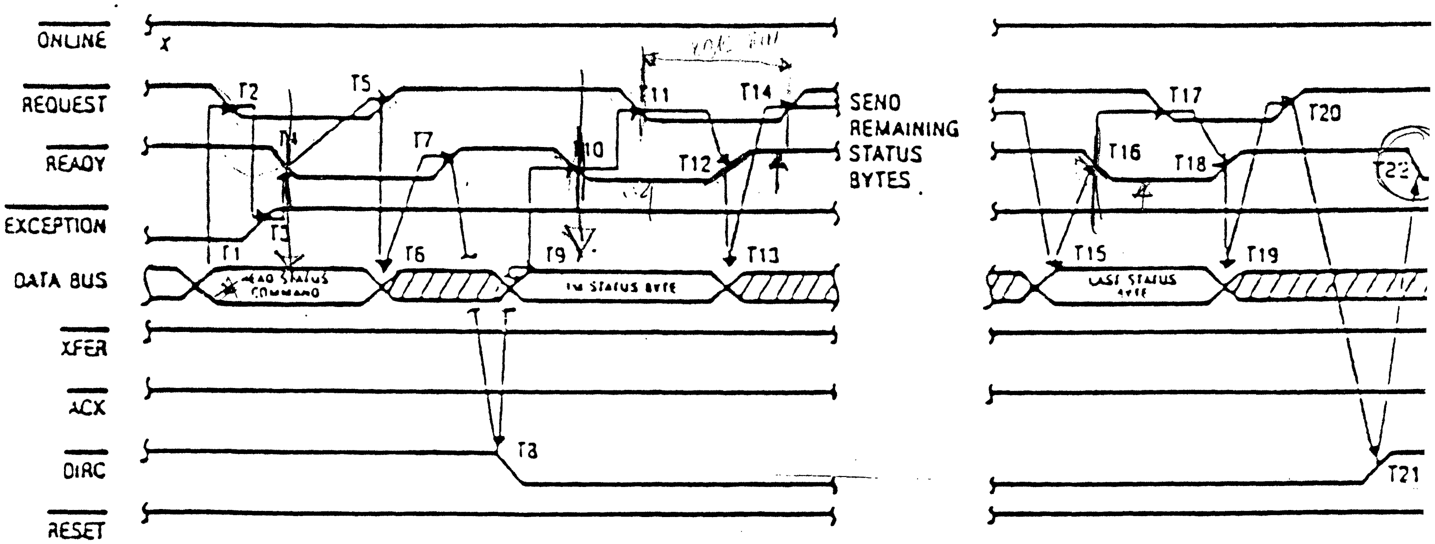
All odd pins shall be connected to signal GND at the Host. The "TO" nomenclature above shall be as follows:

I = UNDEFINED
B = BI-DIRECTIONAL
D = DEVICE
H = HOST

3.6 INTERFACE TIMING

Interface signal timing shall be as specified in the following timing diagrams.

3.6.1 READ STATUS COMMAND TIMING



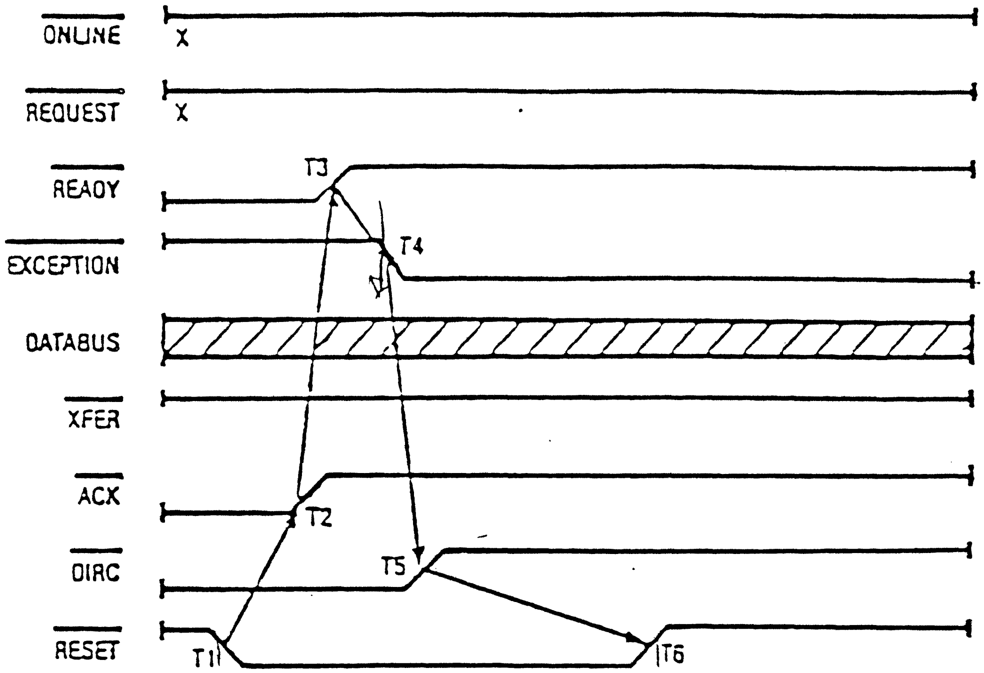
READ STATUS COMMAND

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.	T2—T4>20 Usec. (500 Usec. Nominal)
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	N/A
T10-CONTROLLER SETS READY	T7—T10>20 U sec.
T11-HOST SETS REQUEST	N/A
T12-CONTROLLER RESETS READY	T11—T12< 1 U sec.
T13-BUS DATA INVALID	T11—T13>0 U sec.
T14-HOST RESETS REQUEST	T11—T14>20 Usec.
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
T22-CONTROLLER SETS READY	T20—T21 >0
X-DON'T CARE	T21—T22 >0

20 µs

1 - 6 - 1

3.6.2 RESET TIMING

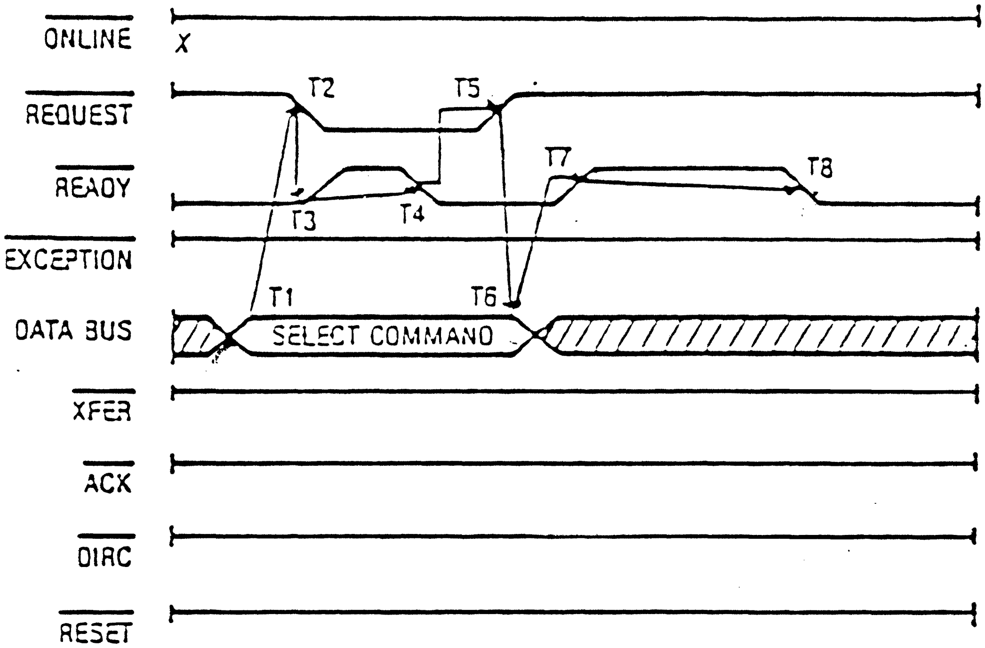


RESET TIMING

ACTIVITY	CRITICAL TIMING
T1-HOST ASSERTS RESET	NA
T2-CONTROLLER DISABLES ACK	T1—T2<1 U sec.
T3-CONTROLLER DISABLES READY	T1—T3<1 U sec.
T4-CONTROLLER ASSERTS EXCEPTION	T1—T4<3 U sec.
T5-CONTROLLER DISABLES DIRC	T1—T5≤1 U sec.
T6-HOST DISABLES RESET	T1—T6>25U sec.

X-DON'T CARE

3.6.3 SELECT COMMAND TIMING

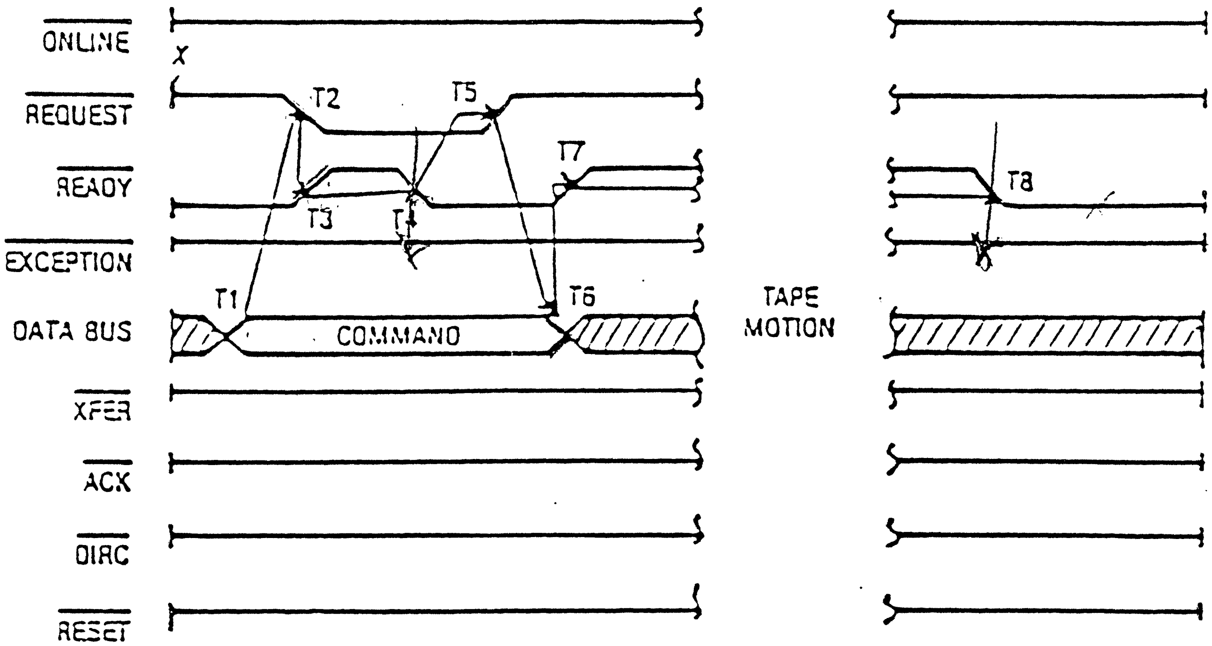


SELECT COMMAND

ACTIVITY	CRITICAL TIMING
T1-HOST COMMAND TO BUS	N/A
T2-HOST SETS REQUEST	T1—T2>0 U sec.
T3-CONTROLLER RESETS READY	T2—T3<1 U sec.
T4-CONTROLLER SETS READY	T3—T4> 50 U sec. (500 U sec. nominal)
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 SETS READY	T7—T8>20 U sec.

X-DON'T CARE

3.6.4 BOT, CARTRIDGE INITIALIZATION, OR ERASE TIMING

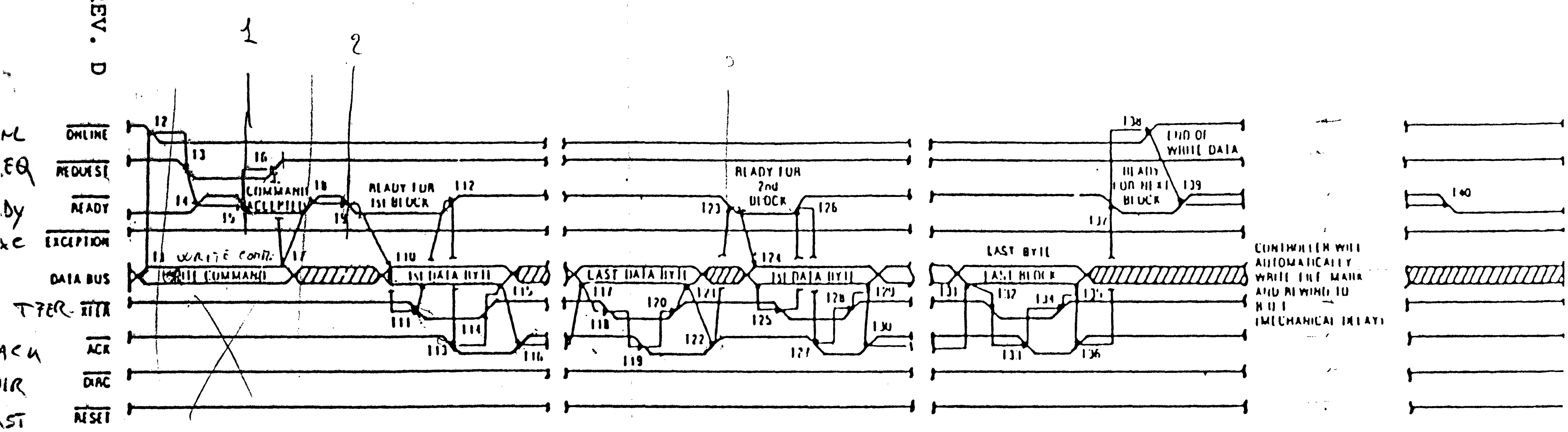


BOT, INITIALIZATION OR ERASE COMMAND

ACTIVITY	CRITICAL TIMING
T1-HOST BUS DATA VALID	N/A
T2-HOST SETS REQUEST	T1—T2 = >0 U sec.
T3-CONTROLLER RESETS READY	T2—T3 = ≤1 U sec.
T4-CONTROLLER SETS READY	T3—T4> 20 U sec. (500 U sec. nominal)
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 SETS READY	T7—T8 = >20 U sec.

X-DON'T CARE

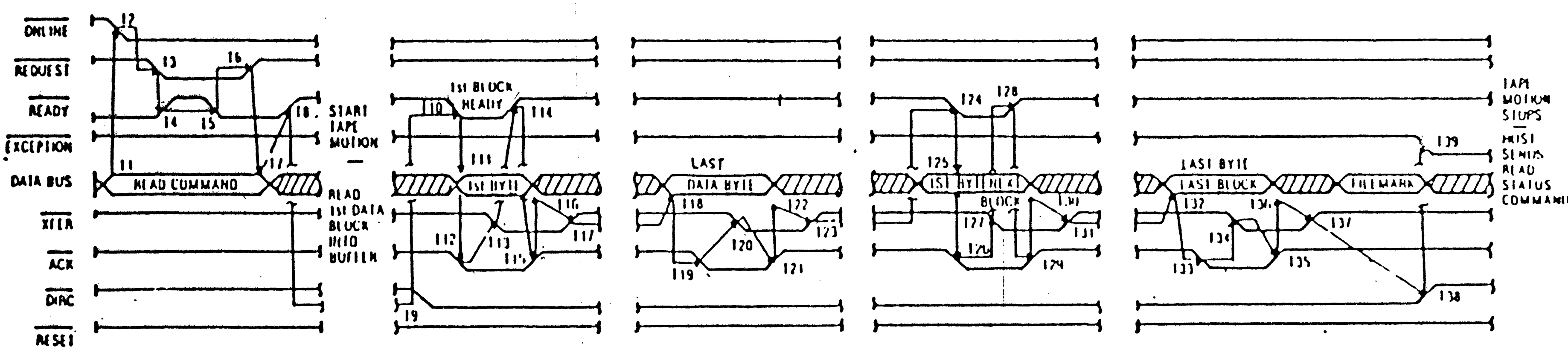
3.6.5 WRITE DATA TIMING



WRITE DATA COMMAND

ACTIVITY	CRITICAL TIMING
T1 HOST COMMAND TO BUS	N/A
T2 HOST SETS ONLINE	N/A
T3 HOST SETS REQUEST	T2 - T3 > 0 U sec
T4 CONTROLLER RESETS READY	T3 - T4 < 1 U sec
T5 CONTROLLER SETS READY	T4 - T5 > 20 U sec (500 Usec nominal)
T6 HOST RESETS REQUEST	T5 - T6 > 0 U sec
T7 BUS DATA INVALID	T5 - T7 > 0 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 < 1 Usec.~~
T13 CONTROLLER SETS ACK	0.5 < T11 - T13 < 100 Usec.
T14 HOST RESETS XFER	T13 - T14 > 0 U sec
T15 BUS DATA INVALID	T13 - T15 > 0 U sec
T16 CONTROLLER RESETS ACK	0 < T14 - T16 < 3 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
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

3.6.6 READ DATA TIMING

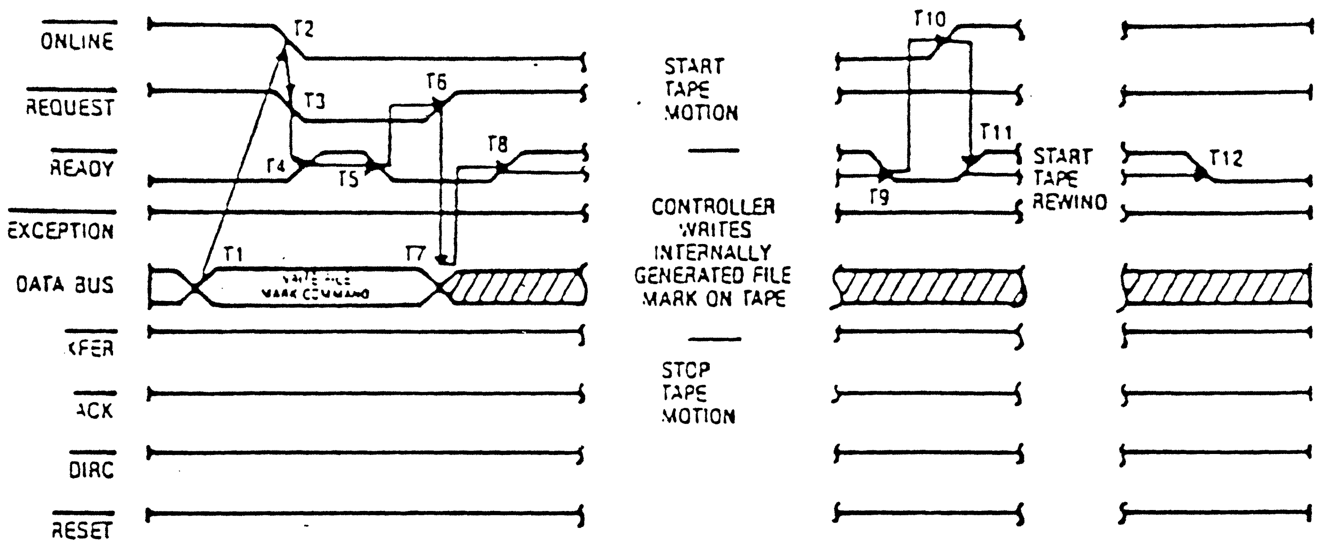


READ DATA COMMAND

ACTIVITY	CRITICAL TIMING
T1 HOST COMMAND TO BUS	N/A
T2 HOST SETS ONLINE	N/A
T3 HOST SETS REQUEST	T2→T3>0 U sec
T4 CONTROLLER RESETS READY	T3→T4<1 Usec
T5 CONTROLLER SETS READY	T4→T5>20 Usec (500 Usec nom)
T6 HOST RESETS REQUEST	T5→T6>0 U sec
T7 BUS DATA INVALID	T5→T7>0 U sec
T8 CONTROLLER RESETS READY	20<T6→T8<100 U sec
T9 CONTROLLER CHANGES DIRC	N/A
T10 1ST DATA BYTE TO BUS	N/A
T11 CONTROLLER SETS READY	N/A
T12 CONTROLLER SETS ACK	T11→T12>-40 NANO sec
T13 HOST SETS XFER	T12→T13>0 U sec
T14 CONTROLLER RESETS READY	T13→T14<1 Usec.
T15 CONTROLLER RESETS ACK	.5<T13→T15<3 Usec.
T16 BUS DATA INVALID	T13→T16>0 U sec
T17 HOST RESETS XFER	T15→T17>0 U sec
T18 BUS DATA VALID	N/A
T19 CONTROLLER SETS ACK	SAME AS T12
T20 HOST SETS XFER	SAME AS T13
T21 CONTROLLER RESETS ACK	SAME AS T15
T22 BUS DATA INVALID	SAME AS T16
T23 HOST RESETS XFER	SAME AS T17
T24 CONTROLLER SETS READY	N/A
T25 1ST BYTE TO BUS	N/A
T26 CONTROLLER SETS ACK	SAME AS T12
T27 HOST SETS XFER	SAME AS T13
T28 CONTROLLER RESETS READY	SAME AS T14
T29 CONTROLLER RESETS ACK	SAME AS T15
T30 BUS DATA INVALID	SAME AS T16
T31 HOST RESETS XFER	SAME AS T17
T32 LAST BYTE TO BUS	N/A
T33 CONTROLLER SETS ACK	SAME AS T12
T34 HOST SETS XFER	SAME AS T13
T35 CONTROLLER RESETS ACK	SAME AS T15
T36 BUS DATA INVALID	SAME AS T16
T37 HOST RESETS XFER	SAME AS T17
T38 CONTROLLER SETS EXCEPTION	N/A
T39 CHANGE BUS DIRECTION	N/A

NOTE: T12 CAN PRECEDE T11 BY 40 NANOSEC.

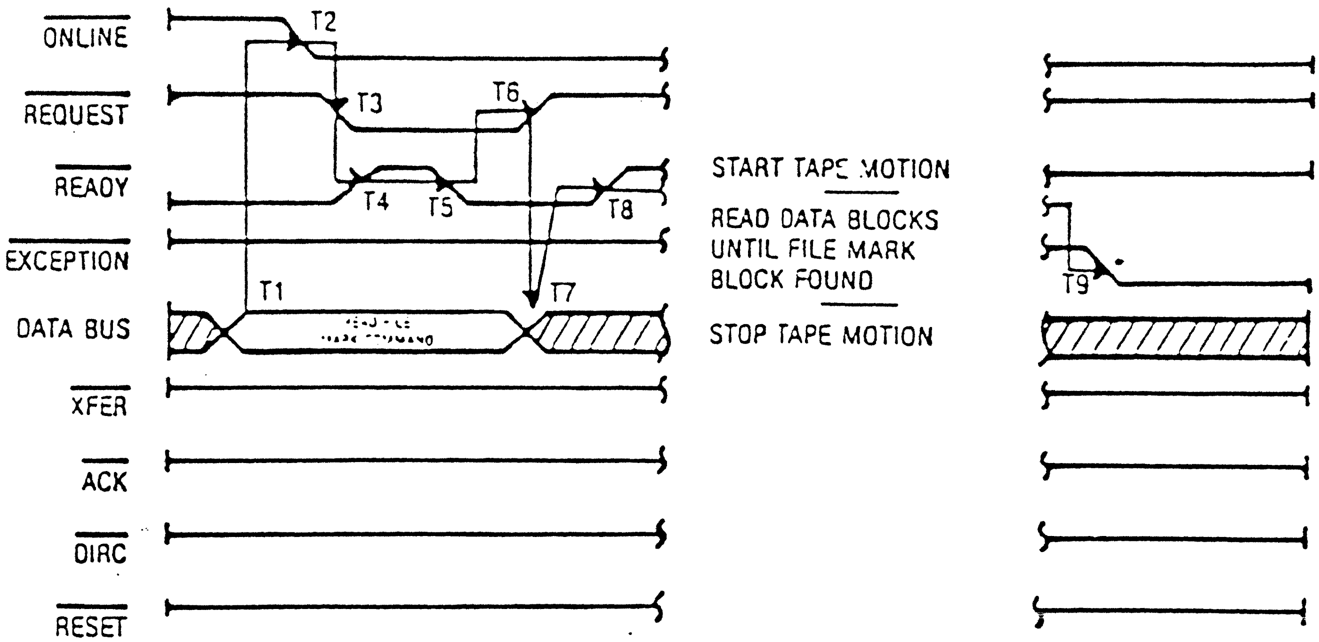
3.6.7 WRITE-FILE-MARK TIMING



WRITE FILE MARK COMMAND

ACTIVITY	CRITICAL TIMING
T1-HOST COMMAND TO BUS	N/A
T2-HOST SETS ONLINE	T1—T2>0 U sec.
T3-HOST SETS REQUEST	T2—T3>0 U sec.
T4-CONTROLLER RESETS READY	T3—T4<1 U sec.
T5-CONTROLLER SETS READY	T4—T5>20 U sec (500 U sec nominal)
T6-HOST RESETS REQUEST	T5—T6>0 U sec.
T7-BUS DATA INVALID	T5—T7>0 U sec.
T8-CONTROLLER RESETS READY	20<T6—T8<100 U sec.
T9-CONTROLLER SETS READY	N/A
T10-HOST RESETS ONLINE	T9—T10>0 U sec.
T11-CONTROLLER RESETS READY	N/A
T12-CONTROLLER SETS READY (AT B.O.T.)	N/A

3.6.8 READ-FILE-MARK TIMING



READ FILE MARK COMMAND

ACTIVITY	CRITICAL TIMING
T1-HOST COMMAND TO BUS	N/A
T2-HOST SETS ONLINE	T1—T2>0 U sec.
T3-HOST SETS REQUEST	T2—T3>0 U sec.
T4-CONTROLLER RESETS READY	T3—T4<1 U sec.
T5-CONTROLLER SETS READY	T4—T5>20 Usec. (500 Usec. nominal)
T6-HOST RESETS REQUEST	T5—T6>0 U sec.
T7-BUS DATA INVALID	T4—T7>0 U sec.
T8-CONTROLLER RESETS READY	20<T6—T8<100 U sec.
T9-CONTROLLER SETS EXCEPTION	N/A

**SYSTEM MUST ISSUE READ STATUS COMMAND*

4.0 COMMANDS

All device commands are single byte commands as defined in the COMMAND SUMMARY (4.1). Devices shall implement all standard (S) commands in order to meet the minimum requirements of this standard. Optional (O) commands, if implemented, shall be implemented as specified in this standard. Reserved (R) commands are reserved for future use. Vendor unique (V) commands may be used for any purpose. All unimplemented commands shall return illegal command status from a device.

4.1 COMMAND SUMMARY

7654 3210	SOR	V(N)	DESCRIPTION
0000 0000		V(1)	
0000 0001	S		SELECT DRIVE 1
0000 0010	S		SELECT DRIVE 2
0000 0011		V(1)	
0000 0100	S		SELECT DRIVE 3
0000 0101		V(1)	
0000 011X		V(2)	
0000 1000	S		SELECT DRIVE 4
0000 1001		V(1)	
0000 101X		V(2)	
0000 11XX		V(4)	
0001 0000		V(1)	
0001 0001	O		SELECT DRIVE 1, LOCK CARTRIDGE
0001 0010	O		SELECT DRIVE 2, LOCK CARTRIDGE
0001 0011		V(1)	
0001 0100	O		SELECT DRIVE 3, LOCK CARTRIDGE
0001 0101		V(1)	
0001 011X		V(2)	
0001 1000	O		SELECT DRIVE 4, LOCK CARTRIDGE
0001 1001		V(1)	
0001 101X		V(2)	
0001 11XX		V(4)	
0010 0000		V(1)	
0010 0001	S		POSITION TO BEGINNING OF TAPE
0010 0010	S		ERASE THE ENTIRE TAPE
0010 0011		V(1)	
0010 0100	S		INITIALIZE CARTRIGE
0010 0101	O		SELECT AUTO CARTRIDGE INITIALIZATION
0010 011X		V(2)	

7654	3210	SOR	V(N)	DESCRIPTION
0010	1XXX		V(8)	
0011	XXXX		V(16)	
0100	0000	S		WRITE
0100	0001	O		WRITE WITHOUT UNDERRUNS
0100	001X		V(2)	
0100	01XX		V(4)	
0100	1000	O		ENTER 6 BYTE PARAMETER BLOCK
0100	1001		V(1)	
0100	101X		V(2)	
0100	11XX		V(4)	
0101	XXXX		V(16)	
0110	0000	S		WRITE FILE MARK
0110	0001	R		
0110	001X		V(2)	
0110	01XX		V(4)	
0110	1XXX		V(8)	
0111	NNNN	O		WRITE N FILE MARKS
1000	0000	S		READ
1000	0001	O		SPACE FORWARD
1000	001X		V(2)	
1000	0100	O		READ REDUCED TRACK DENSITY
1000	0101	O		SPACE FORWARD REDUCED DENSITY
1000	011X		V(2)	
1000	1000	O		READ REVERSE
1000	1001	O		SPACE REVERSE
1000	101X		V(2)	
1000	1100	O		READ REVERSE REDUCED TRACK DENSITY
1000	1101	O		SPACE REVERSE REDUCED TRACK DENSITY
1000	111X		V(2)	
1001	XXXX		V(16)	
1010	0000	S		READ FILE MARK
1010	0001		V(1)	
1010	0010		V(1)	
1010	0011	O		SEEK EOD (END OF DATA)
1010	0100	O		READ FILE MARK REDUCED TRACK DENSITY
1010	0101		V(1)	
1010	0110		V(1)	
1010	0111	O		SEEK EOD REDUCED TRACK DENSITY
1010	1000	O		READ FILE MARK REVERSE
1010	1001		V(1)	
1010	101X		V(2)	
1010	1100	O		READ FILE MARK REVERSE REDUCED TRACK DENSITY

7654	3210	SOR	V(N)	DESCRIPTION
1010	1101		V(1)	
1010	111X		V(2)	
1011	NNNN	O		READ N FILE MARKS
1100	0000	S		READ STATUS
1100	0001	O		READ EXTENDED STATUS 1
1100	0010	O		RUN SELF TEST 1
1100	0011		V(1)	
1100	0100	O		READ EXTENDED STATUS 2
1100	0101		V(1)	
1100	011X		V(2)	
1100	100X		V(2)	
1100	1010	O		RUN SELF TEST 2
1100	1011		V(1)	
1100	11XX		V(4)	
1101	XXXX		V(16)	
1110	0000	O		READ EXTENDED STATUS 3
1110	0001		V(1)	
1110	001X		V(2)	
1110	01XX		V(4)	
1110	1XXX		V(8)	
1111	XXXX		V(16)	

4.2 STANDARD COMMAND DESCRIPTIONS

This section describes the standard commands which shall be implemented by all devices.

4.2.1 POWER-ON/RESET

The POWER-ON/RESET sequence provides the host with the information on power-on occurrences in the device. It also provides a convenient mechanism for initializing the device during hardware and software debugging of the host interface.

The host applies power to the device or applies a pulse on the device reset line. Device circuitry shall be reset. EXCEPTION shall be asserted. When the power-on reset times out or when the reset pulse terminates, the device initializes operating parameters and defaults to drive 0 for subsequent commands. Each device waits for the host to issue a command. If the command issued was a READ STATUS command, the selected device now executes the command by transferring the six required status bytes, byte 1 (the second byte) bit 0 of which shall be set to indicate that a power-up or a reset occurred.

4.2.2 SELECT COMMAND (0000 DRIVE)

The select command selects one of up to four drives. The drive shall remain selected until changed by another SELECT command or RESET (4.2.1).

4.2.3 READ STATUS COMMAND (1100 0000) S

The READ STATUS command provides host with information about the selected device. The host issues the READ STATUS command. The device transfers the standard six bytes to the host.

4.2.4 BOT COMMAND (0010 0001) S

The BOT command positions the tape in the cartridge in the selected device to BOT (beginning of tape).

4.2.5 INITIALIZATION COMMAND (0010 0100) S

The INITIALIZATION command shall be used in accordance with cartridge tape manufacturer's instructions. The INITIALIZATION command moves the tape in the selected device to BOT, then to EOT and then back to BOT.

4.2.6 ERASE COMMAND (0010 0010) S

The ERASE command completely erases the tape in the selected drive. The ERASE command moves the tape in the selected device to BOT, activates the erase head and moves to EOT, deactivates the erase head and moves the tape back to BOT. The ERASE command also fulfills the requirements of initialization.

4.2.7 WRITE COMMAND (0100 0000) S

The host asserts ONLINE and issues the WRITE command. The selected device requests and transfers data. The READY line is activated when the device is ready for a data block transfer. When the READY line is active, the host terminates transfer of write data by issuing a WRITE-FILE-MARK command. When the READY line is active, the host alternatively terminates transfer of write data by deactivating ONLINE. Deactivating ONLINE causes a File Mark to be written (if not preceded by a WRITE-FILE-MARK command) and the tape rewound to BOT. Note: A WRITE command following cartridge insertion or RESET shall commence recording at BOT end of tape, otherwise, recording shall commence at the current tape position. Note: if the host starts transfer between blocks before READY is asserted, READY may not be asserted.

When the early warning hole of the last track is detected by the device, the device ceases to transfer additional data blocks from the host. The device terminates the WRITE command and reports END OF MEDIA by means of an EXCEPTION and READ STATUS. Note: the device shall allow the transfer of up to 1024 bytes of data if a WRITE command is issued.

4.2.8 READ COMMAND (1000 0000)

The host asserts ONLINE and issues the READ command. The selected device transfers data. The READY line is 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 host is informed by means of an EXCEPTION and a READ STATUS sequence. When READY is asserted, the host may terminate the READ command by deactivating ONLINE. Deactivating ONLINE during READ also causes the tape to be rewound to BOT. When READY is true, the host may alternatively terminate the READ command by issuing a READ-FILE-MARK command. If a READ command is issued, the command is accepted and the drive continues reading. Note: a READ command following cartridge insertion or RESET shall commence at BOT, otherwise the read command commences from the current tape position. Note: if the host starts transfer between blocks before READY is asserted, READY may not be asserted.

4.2.9 WRITE-FILE-MARK COMMAND (0110 0000)

The WRITE-FILE-MARK (WFM) command causes a FILE MARK to be written on the tape in the selected drive. Note: a WFM command following cartridge insertion or RESET shall commence recording at BOT end of tape, otherwise, recording shall commence at the current tape position.

4.2.10 READ-FILE-MARK COMMAND (1010 0000)

The READ-FILE-MARK (RFM) command causes the tape in the selected drive to be moved to the next FILE MARK. Note: A RFM command following cartridge insertion or RESET shall commence reading at BOT, otherwise, reading shall commence at the current tape position.

4.3 OPTIONAL COMMAND DESCRIPTIONS

This section describes optional commands which if implemented shall be implemented as specified.

4.3.1 SELECT DRIVE, LOCK CARTRIDGE (0001 DRIVE)

This command is identical in function to the SELECT DRIVE command and additionally provides a soft (light) and/or hard lock on the cartridge. Execution of the SELECT command (0000 drive) or RESET unlocks the cartridge.

4.3.2 SELECT AUTO CARTRIDGE INITIALIZATION COMMAND (0010 0101)

This command will instruct the drive to perform a cartridge initialization each time a new cartridge is inserted. The drive will perform this operation for every cartridge insertion until the drive is reset or power is turned off.

4.3.3 WRITE WITHOUT UNDERRUNS COMMAND (0100 0001)

This command instructs the drive not to stop tape movement when a buffer underrun situation (no data available from the host) occurs in write mode. The drive will then proceed by writing an elongated preamble and/or redundant blocks until either the end of track is reached or data becomes available.

4.3.4 ENTER 6 BYTE PARAMETER BLOCK COMMAND (0100 1000)

This command shall be used to enter information to the drive which allows drive operation to be configured remotely. Its use is not restricted and allows a method of implementing additional functions not covered in the specific command set. The 6 byte parameter block shall be transferred as a 6 byte write data block.

4.3.5 WRITE N FILE MARKS COMMAND (0111 NNNN)

This command is identical in function to the WRITE FILE MARK command (0110 0000) except that the number of file marks written is determined by the binary value of NNNN. A value of NNNN=0 shall cause no operation to be performed.

4.3.6 SPACE FORWARD COMMAND (1000 0001)

This command moves the tape forward over the subsequent block. No data is transferred to the host.

4.3.7 READ REDUCED TRACK DENSITY COMMAND (1000 0100)

This command instructs the drive to perform the read operation on tapes with reduced track density.

4.3.8 SPACE FORWARD REDUCED TRACK DENSITY COMMAND (1000 0101)

This command instructs the drive to perform the space forward operation on tapes with reduced track density.

4.3.9 READ REVERSE COMMAND (1000 1000)

This command is identical in function to the READ command (1000 0000) except that tape motion is logically reversed. The byte transfer sequence is in the order read. If the command is issued at beginning of media, an exception will result.

4.3.10 SPACE REVERSE COMMAND (1000 1001)

This command moves the tape in reverse over the subsequent block. No data is transferred to the host. If the command is issued at beginning of media, an exception will result.

4.3.11 READ REVERSE REDUCED TRACK DENSITY COMMAND (1000 1100)

This command instructs the drive to perform the read reverse operation on tapes with reduced track density.

4.3.12 SPACE REVERSE REDUCED TRACK DENSITY COMMAND (1000 1101)

This command instructs the drive to perform the space reverse operation of tapes with reduced track density.

4.3.13 SEEK END OF RECORDED DATA COMMAND (1010 0011)

This command instructs the drive to seek the end of recorded data. New data may then be appended to already existing data on the tape by issuing a write command.

4.3.14 READ FILE MARK REDUCED TRACK DENSITY COMMAND (1010 0100)

This command instructs the drive to perform the read file mark operation on tapes with reduced track density.

4.3.15 SEEK END OF RECORDED DATA REDUCED TRACK DENSITY (1010 0111)

This command instructs the drive to perform the seek end of recorded data operation on tapes with reduced track density.

4.3.16 READ FILE MARK REVERSE COMMAND (1010 1000)

This command is identical in function to the READ FILE MARK command except that the tape is moved in the logically reverse direction. If this command is issued at beginning of tape, an exception shall result.

4.3.17 READ FILE MARK REVERSE COMMAND REDUCED TRACK DENSITY (1010 1100)

This command instructs the drive to perform the read file mark reverse operation on tapes with reduced track density. If this command is issued at beginning of tape, an exception shall result.

4.3.18 READ N FILE MARKS COMMAND (1011 NNNN)

This command is identical in function to the READ FILE MARK command (1010 0000) except that number of file marks read is the binary value of NNNN. A value of NNNN=0 shall cause no operation to be performed.

4.3.19 READ EXTENDED STATUS 1 COMMAND (1100 0001)

This command instructs the drive to transfer the first 6 status bytes from the extended status register. These bytes are numbered from 6 to 11. The table below shows the use of these bytes for different kinds of operations.

Status Byte Number	0 Select Command	1 Position Command	2 Write Command	3 Write File Mark Command	4 Read Command	5 Read File Mark Command	6 Self Test Command
6	Not used	Not used	Not used	Last File Mark Number	Not used	Last File Mark Number	Not used
7	Not used	Not used	Number of Good Blocks MSB	Not used	Number of Good Blocks MSB	Not used	Not used
8	Not used	Not used	Number of Good Blocks	Not used	Number of Good Blocks	Not used	Not used
9	Not used	Not used	Number of Good Blocks LSB	Not used	Number of Good Blocks LSB	Not used	Not used
10	Not used	Not used	Remaining Data Blocks In Buffer	Not used	Not used	Not used	Not used
11	Not used	Not used	Not used	Not used	Not used	Not used	Not used

4.3.20 RUN SELF TEST 1 COMMAND (1100 0010)

This command instructs the drive to perform different kinds of selftest operations. The particular types of selftest operations performed are vendor unique. SELF TEST 1 does not allow writing on the cartridge in the permissible recording area. The result of the tests is given as a code which is available in status register 3. The code is vendor unique except that 0001 0001 always means selftest OK. A 0000 0000 result indicates that a selftest operation may not have been performed.

4.3.21 READ EXTENDED STATUS 2 COMMAND (1100 0100)

This command instructs the drive to transfer the following 6 status bytes:

0	current read file	MSB.
1	current read file	LSB.
2	current write file	MSB.
3	current write file	LSB.
4	diagnostic error code	.
5	track number	.

4.3.22 RUN SELF TEST 2 COMMAND (1100 1010)

This command is identical in function to the RUN SELF TEST 1 COMMAND (1100 0010) except that SELF TEST 2 allows writing on the cartridge in the permissible recording area. Note: user data will be destroyed.

4.3.23 READ EXTENDED STATUS 3 COMMAND (1110 0000)

The READ EXTENDED STATUS 3 command provides host with information for fault isolation of the selected device. The host issues the READ EXTENDED STATUS 3 command. The device transfers 64 bytes of vendor unique status information to the host.

5.0 STANDARD STATUS DESCRIPTION

ALL DEVICE STATUS shall be contained in 6 byte groups as defined in the STATUS BYTE SUMMARY (5.1).

5.1 STATUS BYTE SUMMARY

```
     BYTE 0            BYTE 1          EXS          DESCRIPTION
BIT 76543210          76543210
    ||||||||          |||||||+-------- POR   power on/reset occurred
    ||||||||          ||||||+--------- RES   reserved for end of re-
                                             corded media
    ||||||||          |||||+---------- RES   reserved for bus parity
                                             error
    ||||||||          ||||+----------- BOM   beginning of media
    ||||||||          |||+------------ MBD   marginal block detected
    ||||||||          ||+------------- NDT   no data detected
    ||||||||          |+-------------- ILL   illegal command
    ||||||||          +--------------- ST1   status byte 1 bits
    ||||||||
    |||||||+-------------------------- FIL   file mark detected
    ||||||+--------------------------- BNL   bad block not located
    |||||+---------------------------- UDA   unrecoverable data
                                             error
    ||||+----------------------------- EOM   end of media
    |||+------------------------------ WRP   write protected
                                             cartridge
    ||+------------------------------- USL   unselected drive
    |+-------------------------------- CNI   cartridge not in place
    +--------------------------------- STO   status byte 0 bits


      BYTE 2                BYTE 3     DEC   data error counter

      BYTE 4                BYTE 5     URC   underrun counter
```

5.2 STATUS BYTE DESCRIPTION

Bytes 0 and 1 contain exception status (EXS) to define the reason that the device asserted EXCEPTION. A description of each status bit follows:

STATUS BYTE 1

BIT 0: POR - The power on reset bit is set after the host asserts RESET or when the controller is powered up. The bit is reset by a Read Status Sequence.

BIT 1: RES - Reserved

BIT 2: RES - Reserved

BIT 3: BOM - Beginning of Media bit is set whenever the cartridge is logically at beginning of tape, track 0. The bit is reset when the tape moves away from beginning of tape. This is the only bit in this byte that does not set EXCEPTION when it goes true, nor is it reset by the Read Status Sequence. This bit is reset when the tape moves away from the logical end of media or a RESET occurs.

BIT 4: MBD - Marginal Block Detected bit is set when the device determines that a data block is marginal. This bit is reset by a Read Status Sequence.

BIT 5: NDT - No Data Detected bit is set when an unrecoverable data error occurs due to lack of recorded data. Absence of recorded data is the failure to detect a data block within a controller time-out. This bit is reset by a Read Status Sequence.

BIT 6: ILL - Illegal Command bit is set if any of the following occurs. The bit is reset by a Read Status Sequence.

a. SELECT command is issued with no drives or more than one drive indicated.

b. ONLINE not asserted when a WRITE, WRITE FILE MARK, READ ~~or READ FILE MARK command is issued.~~

c. A command other than WRITE or WRITE FILE MARK is issued during the execution of a Write Data Sequence.

d. A command other than READ or READ FILE MARK is issued during the execution of a Read Data Sequence.

e. A drive is deselected by another SELECT command when the cartridge in the currently selected drive is not at beginning of tape, track 0.

f. Any unimplemented command is issued.

BIT 7: ST1 - Status byte 1 bit is set if any other bit in Status byte 1 is set.

STATUS BYTE 0

BIT 0: FIL - File Mark Detected bit is set when a File Mark is detected during a Read Data or Read File Mark Sequence. The bit is reset by a Read Status Sequence.

BIT 1: BNL - Block in error Not Located bit is set when an unrecoverable read error occurs and the controller can not confirm that the last block transmitted was the block in error. The bit is reset by a Read Status Sequence.

BIT 2: UDA - Unrecoverable Data bit is set when the controller experiences a hard error during read or write operations. The bit is reset by a Read Status Sequence.

BIT 3: EOM - End of Media bit is set when the logical early warning hole of the last track 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 Sequence.

BIT 4: WRP - Write Protected bit is set if the cartridge write protect plug is set in the file protect "safe" position. Operator must change the write protect plug position before the status bit will reset.

BIT 5: USL - Drive Unselected bit is set if the selected drive is not physically connected or is not receiving power. Operator must correct the condition before the status bit will reset.

BIT 6: CNI - Cartridge not in Place bit is set if a cartridge is not fully inserted into the drive. Operator must correct the condition before the status bit will reset.

BIT 7: STO - Status Byte 0 bit is set if any other bit in Status Byte 0 is set.

Refer to EXCEPTION STATUS SUMMARY and EXCEPTION STATUS DESCRIPTION for further explanation.

Bytes 2 and 3 contain the data error counter (DEC) which accumulates the number of blocks rewritten for WRITE operations and the number of soft read errors during READ operations. These bytes shall be cleared by a Read Status Sequence.

Bytes 4 and 5 contain the underrun counter (URC) which accumulates the number of times that streaming was interrupted because host failed to maintain minimum through-put rate. These bytes shall be cleared by a Read Status Sequence.

5.3 EXCEPTION STATUS SUMMARY

	BYTE 0	BYTE 1		DESCRIPTION
	76543210	76543210		
1.	110X0000	00000000	-------	No cartridge
2.	11110000	00000000	-------	No drive
3.	10010000	X000X000	-------	Write Protected
4.	10001000	00000000	-------	End of Media
5.	100X0100	10001000	-------	Read or Write abort
6.	100X0100	00000000	-------	Read error, bad block xfer
7.	100X0110	00000000	-------	Read error, filler block xfer
8.	100X0110	10100000	-------	Read error, no data
9.	100X1110	10100000	-------	Read error, no data & EOM
10.	100X0110	101X1XX0	-------	Read error, no data & BOM
11.	100X0001	00000000	-------	Read a filemark
12.	XXXX0000	1100X000	-------	Illegal command
13.	XXXX0000	1000X001	-------	Power on/reset
14.	100X0001	00010000	-------	Marginal block detected

NOTE: X denotes "could be either 0 or 1" condition

5.4 EXCEPTION STATUS DESCRIPTION

1. NO CARTRIDGE - Selected drive did not contain a cartridge when BOT, RET, ERASE, WRITE, WFM, READ or RFM was issued or cartridge was removed while the drive is selected. FATAL.

2. NO DRIVE - Selected drive was not present when BOT, RET, ERASE, WRITE, WFM, READ or RFM was issued. FATAL.

3. WRITE PROTECTED - Selected drive contained write protected (safe) cartridge when ERASE, WRITE or WFM was issued. FATAL.

4. END OF MEDIA - Tape has passed the logical early warning hole of the last track during WRITE command, CONTINUABLE.

5. READ OR WRITE ABORT - The maximum limit of same block rewrites occurred during a WRITE or WFM command or unrecoverable reposition error occurred during a WRITE, WFM, READ or RFM command. Tape has returned to BOT. FATAL.

6. READ ERROR, BAD BLOCK XFER - The maximum limit of same block retries failed to recover block without CRC error, last block transferred contained data from the erroneous data block for off line reconstruction. CONTINUABLE.

7. READ ERROR, FILLER BLOCK XFER - The maximum limit of same block retries failed to recover block without CRC error, last block transferred contained filler data to keep total block count correct. CONTINUABLE.

8. READ ERROR, NO DATA - No recorded data found on tape. CONTINUABLE.

9. READ ERROR, NO DATA AND EOM - The maximum limit of same block retries failed to recover the next or subsequent blocks and the logical end of tape holes on the last track were encountered. CONTINUABLE.

10. READ ERROR, NO DATA & BOM - During a reverse motion command, the maximum limit of same block retries failed to recover the next or subsequent blocks and the logical beginning of tape holes on the first track were encountered. CONTINUABLE.

11. FILEMARK READ - A filemark block was read during a READ or RFM command. CONTINUABLE.

12. ILLEGAL COMMAND - One of the following events occurred:

a. Attempt to select other than one drive.
b. Attempt to change drive selection when tape has been moved away from BOT by a read or write operation.
c. Attempt to BOT, INITIALIZE CARTRIDGE, or ERASE simultaneously
d. Attempt to WRITE, WFM, READ or RFM with ONLINE off.
e. Attempt to issue a command other than WRITE or WFM during a WRITE command. FATAL.
f. Attempt to issue a command other than READ or RFM during a READ command. FATAL.
g. Attempt to issue any command not implemented.

13. POWER ON/RESET - A power on reset or a reset by the host has occurred - FATAL.

14. MARGINAL BLOCK DETECTED - A marginal data block was detected by the device. CONTINUABLE.

F.10 STREAMER TAPE OPERATION

The streamer tape controller is capable to execute a set of commands of the QIC-02 interface.
There are two types of commands:
- OFF LINE COMMANDS
- ON LINE COMMANDS

F10.1 OFF LINE COMMANDS

These kinds of commands don't require data transfer

COMMAND	HEX COMMAND VALUE ON DATA BUS
- RESET	DATA BUS NOT USED (HW command line)
- BOT	21
- CARTRIDGE INITIALIZATION	24
- ERASE	22
- WRITE FILE MARK	60
- READ FILE MARK	A0

F10.2 ON LINE COMMANDS

These kinds of commands require data transfer

COMMAND	HEX COMMAND VALUE ON DATA BUS
- READ STATUS	C0
- READ DATA	20
- WRITE DATA	40

F11 THEORY OF STREAMER OPERATION

The D.C.S. controller can operate in two ways:
- INTERRUPT MODE
- POLLING MODE

There are two different types of operation.

F11.1 INTERRUPT MODE

When the host wants to operate in interrupt mode it must program the register of the B.I.M.as shown below.
C.R.0. is not used
C.R.1. is reserved for I.M.D.C. use
C.R.2. is used for ready interrupt (tape)
C.R.3. is used for exception interrupt (tape)
H14 is the hexadecimal value that the host must put into the CR2 and CR3 registers for tape interrupt programming.
The interrupt vector register must also be properly setup.

The host must write into the C.R.W.(command register write) the hex value H08 and then wait for the exception interrupt, after that the host have to write H00 into the C.R.W.
The reset pulse window must be guaranted to be at least 25uS.
After a power on or a reset sequence the device will assert the EXC signal. If a RESET sequence occur while the EXC line is already asserted the host must test the EXC bit and, if the bit is active, finish the reset operation that is to be considered correct.

PROGRAMMING Host writes H08 into the CRW. After the exception interrupt the host writes H00 into the CRW.

F 11.1.2 BOT

Make the rewind of the tape at the beginning

F 11.1.3 CART. INIT

Repositioning the tape at the beginning after reading the end of tape mark.

F 11.1.4 ERASE

Erase the tape until the end. Repositioning the tape at the beginning. This command active a procedure like initialization.

PROGRAMMING The host must write into the DRW the hex value of the desidered command (H21,H22,H23).
The host writes H02 into the CRW to assert the request line. The host must then wait for a ready interrupt. When it is detected host writes H00 into the CRW in order to deassert the request line. At this point the tape begins the motion; host will wait for the next ready interrupt issued at the end of operation.

F 11.1.5 WRITE/READ FILE MARK

It is used to write a file mark on the current position of the tape.
Read file mark, instead, move the tape from the current position to next file mark.

PROGRAMMING The host writes the value of the requested off line command into the DRW. Then it writes H06 into the CRW to activate the REQUEST and ONLINE lines. Then it will wait for the first ready interrupt.It will then write H04 into the CRW in order to deactivate the request line, then it will wait for the next ready interrupt.
On the next interrupt the host can operate in two ways:

- it can begin a new operation without deactivate the ONLINE signal; that means the tape is not rewaund.
- it can begin a new operation deactivating the ONLINE signal; in this case the tape is rewound at the beginning and then a ready interrupt is sent to the host .

F 11.1.6 WRITE DATA

The host put on the data bus the WRITE COMMAND and it asserts the REQUEST and ONLINE lines. Then it wait for a ready interrupt. The device becomes ready after having decoded the command and another interrupt is generated. At this point the host can send the characters on the data bus in blocks of 512 bytes.Each block must be transferred in a period of at most 5.6 ms, otherwise the tape will stop. At each character transfer the software should poll the DTENBL signal: only if it is equal to zero the host can write a new data onto the bus. The transmission protocol carried on is this: the data transfer signal DXFER must be set to 1 by software. By a logic network we have automatic commutation of DXFER, when the devices, which respond with the ACKNOWLEDGE signal, take the data. At the end of the block the device return to the ready status and a ready interrupt is sent. If the host deactivates ONLINE signal the device make the rewind to bot and the device will be ready when the beginning of tape is reached.

F 11.1.7 READ DATA

The host puts on the data bus the command and the signals like before. When the device is ready, the device will change the DIR signal , put the data on the bus and assert ACK. Now the data transfer signal DXFER must be reset to zero by software. The software must poll the DTENBL and only if it is equal to zero the host can read the data. The reading of a file mark cause the issue of the EXCEPTION signal, that generates another interrupt request.

F 11.2 POLLING MODE

The differences of operation between interrupt mode and polling mode are shown below. When the host want to work in polling mode it must disable the BIM writing H00 into the registers CR2 and CR3, in order to deactivate the interrupts to the cpu. In this mode the signals READY and EXCEPTION will not generate the interrupt and for this rason the software must control the status of the devices.

F 11.2.1 RESET

First of all the host writes H08 into the CRW to generate the RESET command. The software then poll the EXC, which is the bit 5 of the CRR. When it goes to 0, the RESET pulse must be held for at least 25 us more.

F 11.2.3 BOT,CART. INIT,ERASE

After it activates the REQUEST, the s/w must test the READY signal and recognize the sequence:

READY = 1 goes to 0;
READY = 0 goes to 1

Only when ready turns on again, the host can deassert the request signal.Having detected the deassertion of the REQUEST, the device will set READY low and at the end of the operation it will turn the READY line on again.

F 11.2.4 READ STATUS COMM.

In this case, as in all on-line commands, a data transfer is needed. The host will issue the command code, assert the REQUEST line and then it will poll the READY line after the assertion of REQUEST line. When ready goes from 1 to 0, in 4 us the host must deassert the REQUEST. The device will be ready in 100 us max after the preparation of the status byte on the bus . At this point the host must read the status byte and then respond with REQUEST to confirm that the byte is taken. The READY signal must be recognized to 1. In any case the request pulse signal must be at least 20 us long.

F 11.2.5 WRITE FILE MARK

The host must issue the command code and then assert the ONLINE and REQUEST command lines.The S/W must then poll the READY signal to detect the transactions from 1 to 0 and then from 0 to 1 before removing the REQUEST. READY goes to 0 after 100 us and goes to 1 after execution of this command. At this moment the host can remove ONLINE and the tape will rewind to BOT.

F 11.2.6 READ FILE MARK

The host must issue the command code and then assert the ONLINE and REQUEST command lines. The S/W must then poll the READY signal to detect the transactions from 1 to 0 and then from 0 to 1 before removing the REQUEST. Ready remains at 0 after the esecution of the command. The EXCEPTION signal is activated when it goes to 1. The s/w must poll this signal.

F 11.2.7 WRITE/READ DATA

The host assert the request line and can deassert it only after that the s/w has tested the transition of ready from 1 to 0 and from 0 to 1. Inside the block, the data exchange protocol works as explained before The host must test the ready line between each block, before starting the next.

‹e software must control the EXCEPTION signal that can be asserted any time during the operations.