American National Standard

Adopted for Use by the Federal Government

FIPS 25

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recorded magnetic tape for information interchange (1600 CPI, PE)

american national standards institute, inc.
1430 broadway, new york, new york 10018

X3.39-1973

With minor exception, this standard was approved as a Federal Information Processing Standard by the Office of Management and Budget on April 2, 1973.

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American National Standard Recorded Magnetic Tape for Information Interchange (1600 CPI, PE)

Secretariat

Computer and Business Equipment Manufacturers Association

Approved March 7, 1973

American National Standards Institute, Inc

American National Standard

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Foreword

(This Foreword is not a part of American National Standard Recorded Magnetic Tape for Information Interchange (1600 CPI, PE), X3.39-1973.)

This American National Standard presents the technique for recording the American National Standard Code for Information Interchange (ASCII), X3.4-1968, on magnetic tape at 1600 characters per inch (CPI) using phase-encoded (PE) recording techniques. It is one of a series of standards implementing the ASCII in media.
Related standards specify higher densities and define more fully the physical and magnetic properties of magnetic tape, and specify a standard record format and labels. Work is continuing on definitions, higher performance, and future requirements.

The X3B1 Technical Committee which developed this document consists of a group of experienced and qualified specialists on recording of digital information on magnetic tape. In the development of this standard careful consideration was given to current practices, existing equipment and supplies, and the broadest possible acceptance, while providing a basis for future improvement in the use of the medium.

This standard was approved as an American National Standard by ANSI on March 7, 1973.

Suggestions for improvement of this standard will be welcome. They should be sent to the American National Standards Institute, 1430 Broadway, New York, N.Y. 10018.

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Contents

American National Standard Recorded Magnetic Tape for Information Interchange (1600 CPI, PE)

1. Scope

This standard provides specifications for format and recording for a 1/2-inch, 9-track magnetic tape to be used for information interchange among information processing systems, communications systems, and associated equipment utilizing the American National Standard Code for Information Interchange (ASCII), X3.4-1968. This standard deals solely with recording on magnetic tape and supports and complements American National Standard Unrecorded Magnetic Tape for Information Interchange (9-Track 200 and 800 CPI, NRZI, and 1600 CPI, PE), X3.40-1973, where the following sections are dealt with in detail: general requirements, definitions, tape physical and magnetic requirements, tape reel, and write-enable ring. Compliance with the standard for unrecorded tape 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 connection 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.

2. Definitions

beginning-of-tape (BOT) marker. A photoreflective marker placed on the tape for the purpose of indicating the beginning of the permissible recording area.

block. A group of contiguous recorded characters considered and transported as a unit containing one or more logical records. Blocks are separated by an interblock gap.

density. The nominal distribution per unit length of recorded information; usually expressed in characters per inch.

end-of-tape (EOT) marker. A photoreflective marker placed on the tape for the purpose of indicating the end of the permissible recording area.

flux reversal. The position of a flux reversal is defined as that point which exhibits the maximum free-space surface flux density normal to the tape surface.

interblock gap. A dc-erased section of tape separating blocks of information.

postamble. A group of special signals recorded at the end of each block on phase-encoded tapes for the purpose of electronic synchronization.

preamble. A group of special signs recorded at the beginning of each block on phase-encoded tapes for the purpose of electronic synchronization.

skew. The deviation of bits within a tape character from the intended or ideal placement, which is perpendicular to the reference edge.

tape mark. A special control block recorded on magnetic tape to serve as a separator between files and file labels.

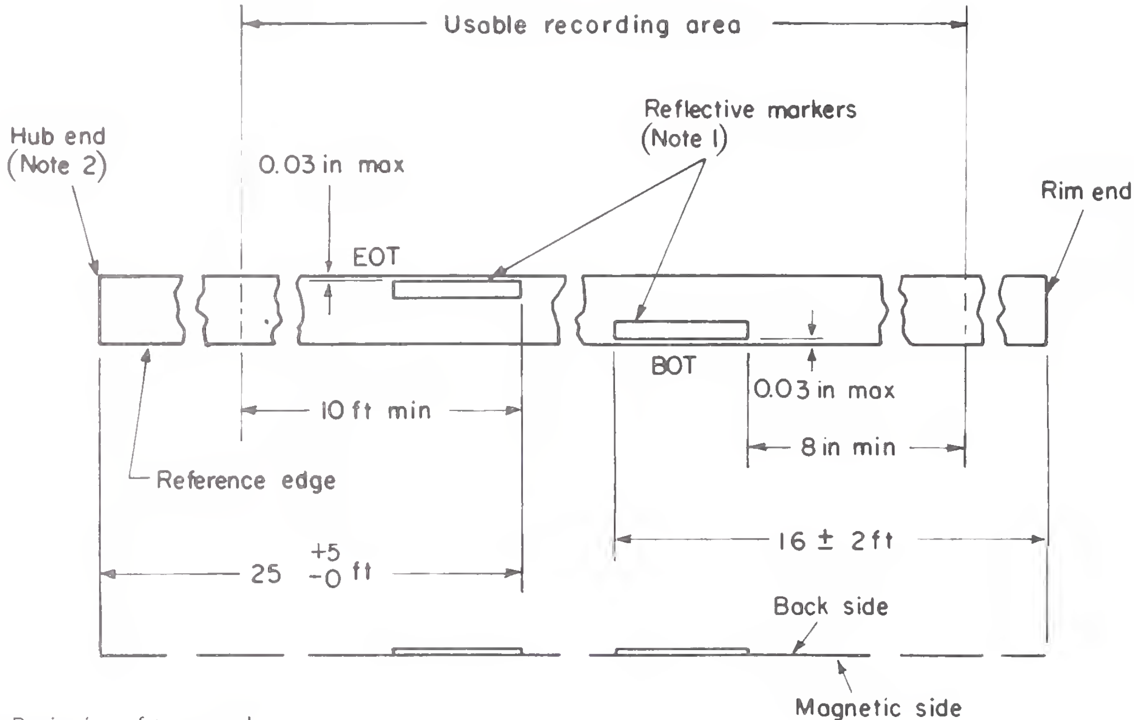
total character skew. The deviation, during reading, from time coincidence (converted to apparent length) of the bits within a recorded character.

3. Recording Area Markers

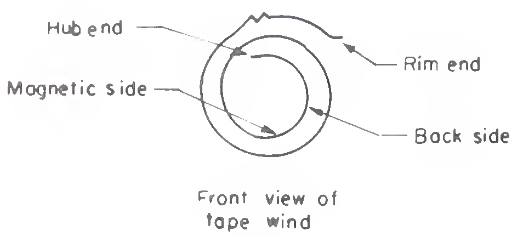
Each reel of tape shall be furnished with two photoreflective markers, beginning-of-tape (BOT) and end-of-tape (EOT), as shown in Fig. 1.

4. Recording

4.1 Method. The recording method shall be phase encoding, as described in 4.1.1 through 4.1.3.



BOT: Beginning-of-tape marker
EOT: End-of-tape marker



NOTES:
(1) Photoreflective markers shall not protrude beyond the edge of the tape and shall be free of wrinkles and excessive adhesive. Marker dimensions: length, 1.1 inch ± 0.2 inch; width, 0.19 inch ± 0.02 inch; thickness, 0.0008 inch maximum.
(2) Tape shall not be attached to the hub.

Fig. 1
Usable Recording Area

4.1.1 A "1" data bit is defined as a flux reversal to the polarity (see 4.5.1) of the interblock gap, when reading in the forward direction.

4.1.2 A "0" data bit is defined as a flux reversal to the polarity opposite to that of the interblock gap, when reading in the forward direction.

4.1.3 A flux reversal shall be written at the nominal midpoint between successive "1" bits or between successive "0" bits, to establish proper polarity. This flux reversal shall be called a phase flux reversal.

4.2 **Density of Recording.** The recording density shall be 1600 characters per inch nominal. The nominal character spacing, exclusive of phase flux reversals, shall be 625 μin (microinches) subject to the variations specified in 4.2.1 and 4.2.2.

NOTE: Density statements in CPI (characters per inch) are always exclusive of phase flux reversals.

4.2.1 Long-term average (static) character spacing shall be within ± 4% of the nominal spacing. This average shall be measured over a minimum of 240 000 successive characters.

4.2.2 Short-term (dynamic) character spacing, excluding the effects of 4.3, shall be within ± 10% of the long-term average character spacing. The short-term character spacing shall change at a rate not to exceed 0.5% per character averaged over the three preceding characters.

4.3 Flux Reversal Spacing. To determine the instantaneous spacing between any two flux reversals, 4.3.1 and 4.3.2 must be taken together.

4.3.1 Spacing

4.3.1.1 The spacing between successive data bits without an intervening phase flux reversal shall be between 85% and 108% of the short-term character spacing.

4.3.1.2 The spacing between successive data bits with an intervening phase flux reversal shall be between 93% and 112% of the short-term character spacing.

4.3.1.3 The spacing between a data bit and any adjacent phase flux reversal shall be between 44% and 62% of the short-term character spacing.

4.3.2 Procedure. The equipment used for recording tapes at 1600 characters per inch and the magnetic tape to be used for interchange must meet the specifications given in 4.3.1.1 through 4.3.1.3 when tested under the conditions specified in the reference read chain. (See Appendix B.)

4.3.3 Downstream Shift. The average distance between actual data bits in a sequence of flux reversals of 1600 per inch and the predicted position of the data bits relative to flux reversals of 3200 per inch preceding or succeeding the sequence shall not exceed ± 6% of the corresponding short-term average spacing.

4.4 Total Character Skew. No data bit in a character shall be displaced more than 625 μin from any other data bit in the same tape character when measured in a direction parallel to the reference edge.

4.5 Erase

4.5.1 Erase Direction. The tape shall be magnetized so that the rim end of the tape is a north-seeking pole.

4.5.2 Erase Width. The full width of the tape is de erased in the direction specified in 4.5.1.

4.5.3 Erase Function. The erase function, whether by the write head or the erase head, shall ensure that the level of the read-back signal amplitude is below 4% of the Standard Reference Amplitude at 3200 frpi (flux reversals per inch).

4.6 Standard Reference Amplitude. The Standard Reference Amplitude is the average peak-to-peak output signal amplitude derived from the NBS Amplitude Reference Tape (SRM 3200) on a measurement system at the density of 3200 frpi and the recording current of $1.8 \times I_r$. The signal amplitude shall be averaged over a minimum of 4000 flux reversals.

The Standard Reference Current (I_r) is the minimum current applied to the Amplitude Reference Tape which causes an output signal amplitude equal to 95% of the maximum output signal.

4.7 Signal Amplitude

4.7.1 Average Signal Amplitude. The average peak-to-peak signal amplitude of an interchanged tape at 3200 frpi shall deviate no more than + 50%, – 35% from the Standard Reference Amplitude. Averaging shall be done over a minimum of 4000 flux reversals, which for the interchange tape may be segmented into groups of 70 flux reversals each.

4.7.2 1600 frpi Signal Amplitude. The peak-to-peak signal amplitude shall be less than three times the Standard Reference Amplitude.

4.7.3 Minimum Signal Amplitude. An interchanged tape shall contain no adjacent flux reversals whose peak-to-peak signal amplitude is less than 0.2 times the Standard Reference Amplitude.

5. Format

See Fig. 2.

5.1 Track Format. The track format shall consist of nine parallel tracks.

5.2 Track Dimensions

5.2.1 Track width on tape is 0.043 inch minimum.

5.2.2 Centerline distance between tracks is 0.055 inch nominal.

5.2.3 Centerline of track 1 is to be 0.029 inch ± 0.003 inch from the reference edge.

5.3 Reference Edge. The reference edge of the tape shall be the top edge when viewing the oxide-coated side of the tape with the rim end of the tape to the observer's right.

5.4 Track Identification. Tracks shall be numbered consecutively, beginning at the reference edge with track No. 1, and assigned as follows:

Track:	1	2	3	4	5	6	7	8	9
Environment:	E3	E1	E5	P	E6	E7	E8	E2	E4
Binary weight:	2^2	2^0	2^4	P	2^5	2^6	2^7	2^1	2^3
ASCII bits:	b_3	b_1	b_5	P	b_6	b_7	Z	b_2	b_4

5.4.1 Bits b_1–b_7 correspond to the bit assignment in ASCII.

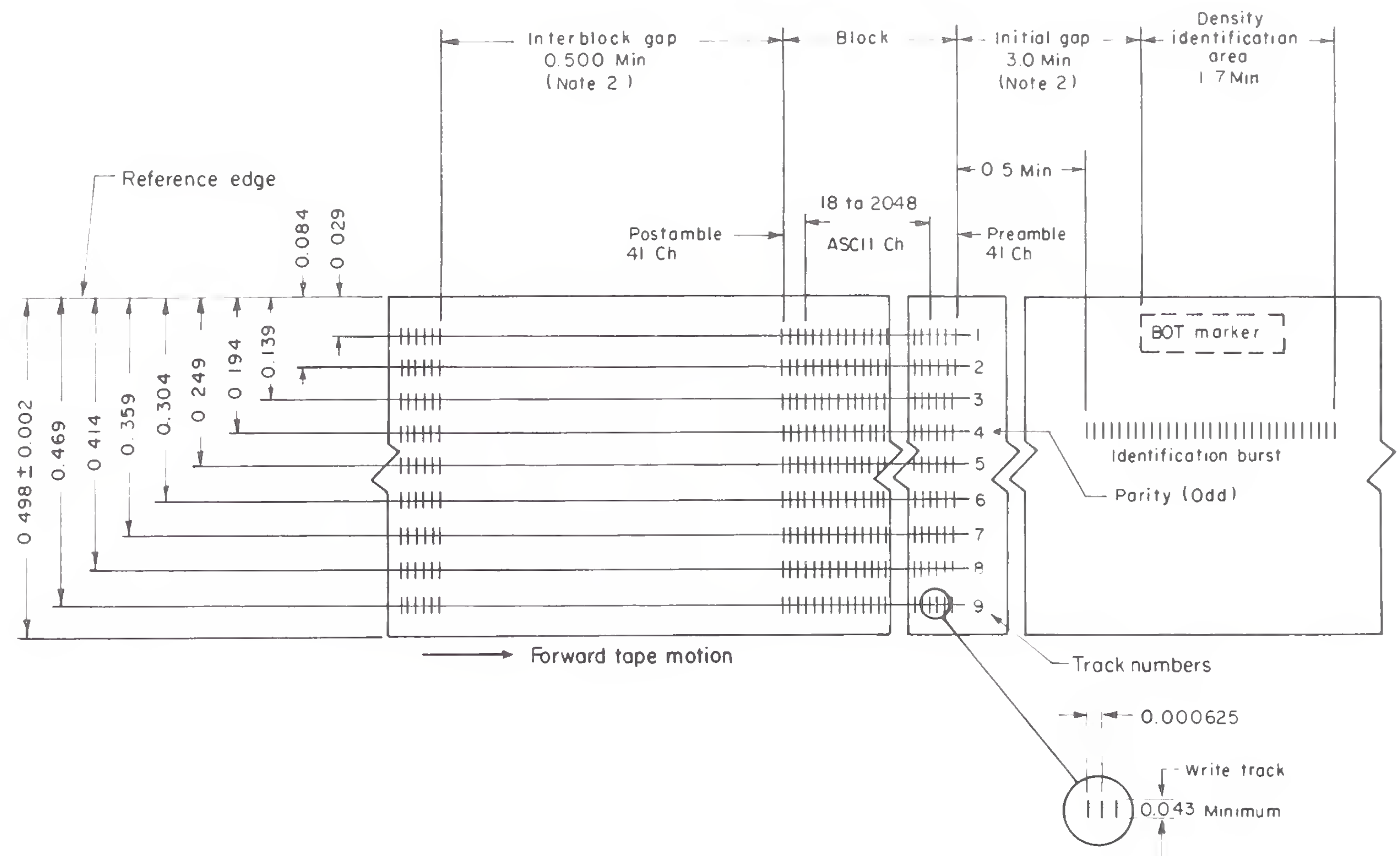
5.4.2 Bit P is the parity bit. Character parity is odd.

5.4.3 Bit Z shall be zero and treated as a bit of higher order than the ASCII bits.

5.5 Block Length (See Fig. 2)

5.5.1 Minimum Block Length. The data portion of a block shall contain a minimum of 18 ASCII characters.

5.5.2 Maximum Block Length. The data portion of



Legend

BOT: Beginning of tape
Ch: Characters
CPI: Characters per inch
Min: Minimum

NOTES:

(1) Tape is shown with oxide side up, Read/Write head on same side as oxide.
(2) Tape to be fully saturated in the erased direction in the interblock gap and the initial gap.
(3) The identification burst extends past the trailing edge of the BOT marker.
(4) All dimensions are given in inches.
(5) There is a track placement tolerance of ± 0.003 inch for each track.

Fig. 2
Recording Format (1600 CPI)

a block shall contain a maximum of 2048 ASCII characters.

5.5.3 Preamble. Preceding data in each block, a preamble shall be written consisting of 41 characters, of which the first 40 characters shall contain "0" bits in all tracks, followed by a single character containing "1" bits in all tracks.

5.5.4 Postamble. Following data in each block, a postamble shall be written consisting of 41 characters, of which the first character shall contain "1" bits in all tracks, followed by 40 characters containing "0" bits in all tracks.

5.6 Density Identification Area. The phase-encoding recording methods shall be identified by a burst of recording in the area of the BOT marker. This burst shall consist of 1600 frpi on track 4 and erasure on all other tracks. The identification burst shall begin 1.7 inches minimum before the trailing edge of the BOT marker, continue past the trailing edge of the BOT marker, and end at least 0.5 inch before the first block.

5.7 Gaps (See Fig. 2)

5.7.1 Interblock Gap. The interblock gap, in addition to preambles and postambles, shall be as follows:

(1) Nominal – 0.6 inch
(2) Minimum – 0.5 inch
(3) Maximum – 25 feet

(Gap depends upon the number of consecutive erase instructions.)

5.7.2 Initial Gap. The gap between the trailing edge of the BOT marker and the first recorded character shall be 3 inches minimum, 25 feet maximum.

5.8 Tape Mark. The Tape Mark is a special control block consisting of 64 to 256 flux reversals, at 3200 frpi, in tracks 2, 5, and 8. Tracks 3, 6, and 9 are dc erased. Tracks 1, 4, and 7, in any combination, may be dc erased or recorded in the manner stated for tracks 2, 5, and 8. For interchange purposes, such as data transmission, all eight combinations of Tape Mark shall be treated as a DC3 character.

6. Revision of American National Standard Referred to in This Document

When the following American National Standard referred to in this document is superseded by a revision approved by the American National Standards Institute, Inc, the revision shall apply:

American National Standard Code for Information Interchange, X3.4-1968

Appendixes

(These Appendixes are not a part of American National Standard Recorded Magnetic Tape for Information Interchange (1600 CPI, PE), X3.39-1973, but are included for information purposes only.)

Appendix A
Design Considerations

A1. Introduction

A1.1 This recorded magnetic tape standard is intended to implement the American National Standard Code for Information Interchange (ASCII), X3.4-1968, on magnetic tape for interchange among information processing systems, communication systems, and associated equipment.

A1.2 A related standard has been prepared to specify unrecorded magnetic tape. The scope of the unrecorded magnetic tape standard covers the specification and testing of physical and magnetic properties and also the operation and storage environments, identification, control devices, and attachments.

A1.3 A related standard has been prepared to specify a standard format for blocks recorded on 1/2-inch, 9-track magnetic tape. The scope of the magnetic tape label standard covers the definition, content, functions, and interrelationships of blocks.

A2. Specification Support

A2.1 Tape

A2.1.1 The dimensions in the recorded tape standard are for reference and to facilitate the design and layout of the recording format.

A2.1.2 Additional signal level specifications are detailed in the unrecorded tape standard.

A2.1.3 The 1/2-inch tape width was selected due to its widespread and current usage throughout the industry and the large quantity in existence. Any changes would tend to obsolete this 1/2-inch tape and also discourage acceptance of the standard. (Similar consideration applies to existing tape transport designs.)

A2.1.4 Tape length must be agreed upon by the interchange parties. The maximum length is to be limited by the requirements for reel dimensions, tape thickness, "E" value, and moment of inertia as given in American National Standard Unrecorded Magnetic Tape for Information Interchange, (9-track 200 and 800 CPI, NRZI, and 1600 CPI, PE), X3.40-1973.

A2.1.5 Special leaders and trailers may be attached in order to meet special transport loading and control requirements wherever needed.

A2.1.6 The tape wind convention is specified to insure uniformity among all users.

A2.2 Recording Area Markers. The marker type and size have been provided in the recorded tape standard so that placement of BOT and EOT could be determined and set forth in the standard. The detail of the marker is set forth in the unrecorded tape standard.

A2.3 Recording Method

A2.3.1 Phase encoding is an accepted method of recording for the given density.

A2.3.2 DC erase of the full width of the tape is provided to insure that all previously recorded information is removed prior to recording new information.

A2.4 Format

A2.4.1 **Number of Tracks.** The 9-track format was selected for the following reasons:

(1) The de facto standard (7-track) is not capable of easily handling ASCII; a minimum of 8 tracks is desirable.

(2) The addition of the ninth track permits alternate, noninterchange uses of the same tape and equipment. (See Section A3 of this Appendix.)

A2.4.2 **Track Dimensions**

A2.4.2.1 The track locations (centerline of recorded data) are dimensioned from the reference edge of the tape. Tracks are numbered 1 through 9 starting at the reference edge. The track location tolerance of ± 0.003 inch is close enough to prevent undesirably wide deviation in track locations, thus allowing the widest possible read head track width. Wide read head track widths are desirable to provide adequate signal levels and enhance the freedom from defect-caused signal dropouts.

A2.4.2.2 The method of dimensioning allows equipment manufacturers to make distribution of design tolerances between the write head and the tape transport mechanism as desired.

A2.4.2.3 The minimum recorded track width was selected to provide maximum freedom from defect-caused signal dropouts consistent with reasonable head design practices.

A2.4.2.4 Width of read tracks is not specified. It is assumed that equipment manufacturers will select an optimum read track width for their particular equipment.

A2.4.3 Track Identification and Bit Assignment

A2.4.3.1 The track numbering is logically assigned 1 through 9, starting at the reference edge of the tape.

A2.4.3.2 The bit assignments were selected to agree with the 800 CPI, NRZI 9-track assignment.

A2.4.4 Parity

A2.4.4.1 Odd character parity was selected to agree with the 800 CPI, NRZI 9-track format.

A2.4.4.2 There are no longitudinal redundancy check characters or cyclic redundancy check characters defined for this recording method.

A2.4.5 Block Length

A2.4.5.1 The minimum block length was selected to agree with the 800 CPI, NRZI 9-track format. There is no technical restriction in the phase encoding method which necessitates a minimum data length requirement.

A2.4.5.2 The maximum block length was selected to permit processing on the smallest systems and accommodation by reasonably sized buffers.

A2.4.6 **Gap Sizes.** Gap sizes are specified according to existing usage. The maximum gap is specified to permit corrective action when gaps of excessive length are encountered (successive erase instructions).

A2.4.7 **Tape Mark.** The Tape Mark was chosen to minimize the possibility of recognizing it as a data block, and vice versa. For noninterchange applications, similar control block combinations are possible, either across the width of tape or by segmenting the longer length of the control block to provide additional combinations.

A3. Additional Considerations

A3.1 **Introduction.** With the standard objective in mind, that is, to provide interchange between systems utilizing digital magnetic tapes, this standard provides sufficient specifications to facilitate such interchange, yet provides considerable flexibility for purposes inherent within any given systems design. The possibilities given in A3.2 and A3.3 are feasible.

A3.2 Noninterchange Applications

A3.2.1 Increased character transfer rate.

(1) Density: No restrictions on any other recording technique.

(2) Tape Speed: No restriction.

(3) Packing: Two numeric characters may be placed in one tape character, possibly by the use of track 7 for one of the bits in a numeric character.

A3.2.2 Further flexibilities allowed by 9 tracks, for example:

(1) Redundant recording.

(2) Search indices.

(3) Special control.

A3.3 Information Exchange Flexibility

A3.3.1 The ASCII concept does not prohibit a variety of inherent subsets and supersets. This American National Standard for recorded magnetic tape will accommodate such flexibility.

A3.3.2 Present equipment design and handling capability was given considerable weight in the choice of the particular attributes of this standard.

A3.3.3 Upon agreement between persons interchanging recorded tapes, nothing in this standard should be taken to prohibit the use of longer block lengths than that specified in this standard.

Appendix B
Recommended Procedure and Instrumentation for Measuring Flux Reversal Spacing

B1. Procedure

B1.1 The equipment used for recording tapes (tape transport) at 1600 CPI shall record on the magnetic tape to be used for interchange using the format described in B1.1.1 through B1.1.6.

B1.1.1 The worst-case test patterns are as given in Table B1. These test patterns are to be used in the following sequence: 1, 1, 1, 3, 2, 2, 2, 4, 6, 3, 4, 4, 6, 6, 3, 5, 5, 5, 7, 8, 7, 8, 7, 8, 9, 9, 9, 10, 10, 10, 12, 11, 14, 13.

This sequence is to be repeated three times to constitute each tape block.

B1.1.2 The tape is to be written in any start-stop mode of operation compatible with system operation.

B1.1.3 Two block formats will be generated. Each block format is to be repeated 800 times together with interblock gaps. All tracks shall be recorded simultaneously, each to meet the format specified in B1.1.3.1 and B1.1.3.2.

B1.1.3.1 Format A

(1) Each of tracks 1, 2, 4, 6, 8, and 9 shall contain a preamble, the 102 eight-bit test patterns defined in B1.1.1, and a postamble.

(2) Track 5 shall contain the preamble, 816 one bits, and postamble. This track is written to provide a record of speed variations.

(3) Each of tracks 3 and 7 shall contain a preamble, the sequence of test pattern No. 1 followed by test pattern No. 2 to be recorded 51 times, and postamble. These tracks are written to provide a means for locating any test pattern in a block as defined in B1.1.1.

B1.1.3.2 Format B

(1) Each of tracks 1, 3, 5, 7, 8, and 9 shall contain a preamble, the 102 eight-bit test patterns defined in B1.1.1, and a postamble.

Table B1
Worst-Case Test Patterns

Test Pattern		Test Pattern	
1	11111111	8	11101000
2	00000000	9	11001100
3	11110000	10	10101010
4	00001111	11	10101111
5	00010000	12	11110101
6	11101111	13	01010000
7	00010111	14	00001010

(2) Track 4 shall contain the preamble, 816 one bits, and postamble. This track is written to provide a record of speed variations.

(3) Each of tracks 2 and 6 shall contain a preamble, the sequence of test pattern No. 1 followed by test pattern No. 2 to be recorded 51 times, and postamble. These tracks are written to provide a means for locating any test pattern in a block as defined in B1.1.1.

NOTE: On using either format described in B1.1.3, odd parity is preserved in each character on the recorded tape.

B1.1.4 The interflux spacings in each of the tracks containing the test patterns are to be measured at the output of the amplifier-limiter.

B1.1.5 The spacing between data bits is to be measured in the all-ones track simultaneously with the measurement in B1.1.4. A minimum of one and a maximum of four contiguous spacings between data bits are to be averaged in order to qualify as the short-term character spacing as defined in 4.2.2.

B1.1.6 Each of the interflux spacings measured in B1.1.4 is to be compared with the simultaneous short-term character spacing between data bits measured in B1.1.5. The maximum deviation thus obtained, measured in percentage of the short-term character spacing between data bits, shall be within the limits set in 4.3 measured at less than one-half error per block averaged over one pass.

B2. Instrumentation

B2.1 Instrumentation shall be as described in B2.1.1 through B2.1.6.

B2.1.1 Tape Transport

(1) Tape speed is to be 18-3/4 inches per second, ± 1%, constant speed.

(2) The tape transport must accept 10-1/2-inch reels.

(3) There are no start-stop requirements.

B2.1.2 Head

B2.1.2.1 There are no voltage output specifications.

B2.1.2.2 Read element mechanical dimensions are according to specifications, with the added constraint that the physical gap be less than 110 microinches but greater than 75 microinches wide.

B2.1.2.3 Transfer function:

(1) Test the amplitude and phase response relative

to the magnetic field induced by a wire placed parallel and adjacent to the gap. The position of the wire must be such as to maximize the head output.

(2) Specification: In the frequency range of 7.5 kHz to 45 kHz, the magnitude characteristic shall be within 1 dB from a + 6-dB-per-octave line.

B2.1.3 Impedance Match (Head to Amplifier). The input impedance of the amplifier shall be such as not to load the head + 0 dB, – 0.1 dB in the range of frequencies from dc to 200 kHz.

B2.1.4 Amplifier-Differentiator

B2.1.4.1 The frequency response of the amplifier without the frequency-limiting lumped components shall be within the cutoff frequencies of: lower 3 dB frequency 30 Hz; upper 3 dB frequency 1 MHz.

The amplifier shall be flat within + 0 dB, – 0.1 dB in the frequency range of 1 kHz to 100 kHz.

B2.1.4.2 The frequency-limiting lumped components within the amplifier-differentiator shall be designed to produce the following transfer function:

$$H(s) = \frac{As}{(s + 1.00 \times 10^6)(s^2 + 1.59 \times 10^6 s + 1.21 \times 10^{12})}$$

where

A is the gain to be adjusted to produce 2 volts peak-to-peak output at 3200 frpi

In the numerator, s produces differentiation

In the denominator, the poles are designed for a 3-pole Bessel filter with a – 3-dB frequency of 120 kHz and a constant delay of 2.32 μs, with less than 1% deviation from the zero frequency value up to 90 kHz

B2.1.5 Amplifier-Limiter. The gain of the limiter shall be such as to produce at the output a minimum slope of 1 V/40 ns with a 30-kHz, 2 volts peak-to-peak input sinewave. With the same input, the limiter shall introduce less than a 20-ns asymmetry.

B2.1.6 Overall Response from Head Gap to Output of Amplifier-Limiter

B2.1.6.1 Equipment Needed

(1) Commercial sinewave generator able to generate frequencies in the range from 5 kHz to 50 kHz. The harmonic distortion content of the generator's sinewave output shall be such as to produce less than 1% harmonic distortion of the sinewave at the output of the amplifier-differentiator.

(2) Commercial time-interval counter able to measure 5 μs with a resolution of 100 ns.

B2.1.6.2 Setup. The equipment is to be set up as shown in Fig. B1.

B2.1.6.3 Experiment Procedure. With the generator's amplitude output set to give 2 volts peak-to-peak at the output of the amplifier-differentiator at each test frequency, vary the frequency of the generator from 7.5 kHz to 45 kHz. At each test frequency measure the time displacement between the positive zero crossover of current sinewave flowing through the gap wire and the positive transition at the output of the amplifier-limiter.

B2.1.6.4 Specification for Calibration of Read Chain. The time delay between the positive zero crossover of the current sinewave flowing through the gap wire and the positive transition at the output of the amplifier-limiter shall not vary more than ± 400 × (7500)/f ns, where f = test frequency, with respect to the time delay measured at 15 kHz, in the range of frequencies from 7.5 kHz to 45 kHz.

NOTE: The value 400 × (7500)/f ns is equivalent to ± 1 degree at 7.5 kHz.

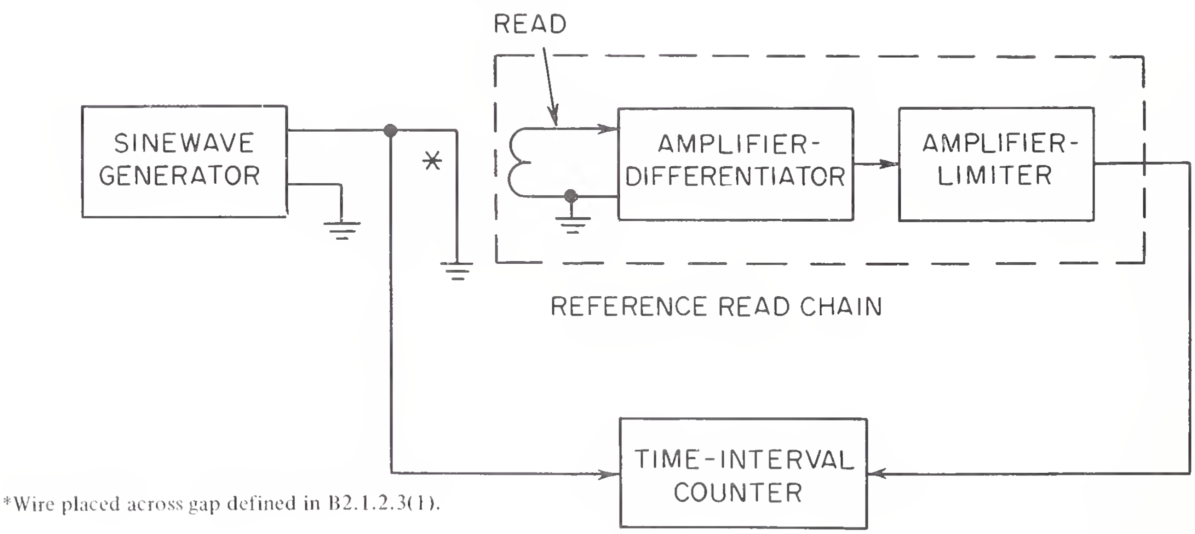


Fig. B1
Setup for Calibration of Read Chain

American National Standards on Computers and Information Processing

X3.1-1969 Synchronous Signaling Rates for Data Transmission

X3.2-1970 Print Specifications for Magnetic Ink Character Recognition

X3.3-1970 Bank Check Specifications for Magnetic Ink Character Recognition

X3.4-1968 Code for Information Interchange

X3.5-1970 Flowchart Symbols and Their Usage in Information Processing

X3.6-1965 Perforated Tape Code for Information Interchange

X3.9-1966 FORTRAN

X3.10-1966 Basic FORTRAN

X3.11-1969 Specifications for General Purpose Paper Cards for Information Processing

X3.12-1970 Vocabulary for Information Processing

X3.14-1973 Recorded Magnetic Tape for Information Interchange (200 CPI, NRZI)

X3.15-1966 Bit Sequencing of the American National Standard Code for Information Interchange in Serial-by-Bit Data Transmission

X3.16-1966 Character Structure and Character Parity Sense for Serial-by-Bit Data Communication in the American National Standard Code for Information Interchange

X3.17-1966 Character Set for Optical Character Recognition

X3.18-1967 One-Inch Perforated Paper Tape for Information Interchange

X3.19-1967 Eleven-Sixteenths Inch Perforated Paper Tape for Information Interchange

X3.20-1967 Take-Up Reels for One-Inch Perforated Tape for Information Interchange

X3.21-1967 Rectangular Holes in Twelve-Row Punched Cards

X3.22-1973 Recorded Magnetic Tape for Information Interchange (800 CPI, NRZI)

X3.23-1968 COBOL

X3.24-1968 Signal Quality at Interface Between Data Processing Terminal Equipment and Synchronous Data Communication Equipment for Serial Data Transmission

X3.25-1968 Character Structure and Character Parity Sense for Parallel-by-Bit Communication in the American National Standard Code for Information Interchange

X3.26-1970 Hollerith Punched Card Code

X3.27-1969 Magnetic Tape Labels for Information Interchange

X3.28-1971 Procedures for the Use of the Communication Control Characters of American National Standard Code for Information Interchange in Specified Data Communication Links

X3.29-1971 Specifications for Properties of Unpunched Oiled Paper Perforator Tape

X3.30-1971 Representation for Calendar Date and Ordinal Date for Information Interchange

X3.31-1973 Structure for the Identification of the Counties of the United States for Information Interchange

X3.34-1972 Interchange Rolls of Perforated Tape for Information Interchange

X3.38-1972 Identification of States of the United States (Including the District of Columbia) for Information Interchange

X3.39-1973 Recorded Magnetic Tape for Information Interchange (1600 CPI, PE)

X3.40-1973 Unrecorded Magnetic Tape for Information Interchange (9-Track 200 and 800 CPI, NRZI, and 1600 CPI, PE)

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