INTERNATIONAL STANDARD

# ISO/IEC 3788

Second edition
1990-08-01

# Information processing — 9-track, 12,7 mm (0,5 in) wide magnetic tape for information interchange using phase encoding at 126 ftpmm (3 200 ftpi) — 63 cpmm (1 600 cpi)

*Traitement de l'information — Bande magnétique à 9 pistes, large de 12,7 mm (0,5 in), pour l'échange d'information, codée en modulation de phase à 126 ftpmm (3 200 ftpi) — 63 cpmm (1 600 cpi)*



Reference number
ISO/IEC 3788:1990(E)

## Foreword

ISO (the International Organization for Standardization) and IEC (the International Electrotechnical Commission) form the specialized system for worldwide standardization. National bodies that are members of ISO or IEC participate in the development of International Standards through technical committees established by the respective organization to deal with particular fields of technical activity. ISO and IEC technical committees collaborate in fields of mutual interest. Other international organizations, governmental and non-governmental, in liaison with ISO and IEC, also take part in the work.

In the field of information technology, ISO and IEC have established a joint technical committee, ISO/IEC JTC 1. Draft International Standards adopted by the joint technical committee are circulated to national bodies for voting. Publication as an International Standard requires approval by at least 75 % of the national bodies casting a vote.

International Standard ISO/IEC 3788 was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*.

Annex A forms an integral part of this International Standard. Annexes B and C are for information only.





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# Information processing — 9-track, 12,7 mm (0,5 in) wide magnetic tape for information interchange using phase encoding at 126 ftpmm (3 200 ftpi) — 63 cpmm (1 600 cpi)



## 1 Scope

This International Standard specifies a format and recording standard for 9-track, 12,7 mm (0,5 in) magnetic tape to be used for data interchange between information processing systems, communication systems, and associated equipment utilizing the 7-bit coded character set (see ISO 646), its extension in ISO 2022 where required, or an 8-bit coded character set (see ISO 4873). Magnetic labelling for use on magnetic tape is the subject of ISO 1001. The magnetic tape and reel to be used shall conform to ISO 1864 and/or ISO 8064.

NOTE 1 Numeric values in the SI and/or Imperial measurement system in this International Standard may have been rounded off and therefore are consistent with, but not exactly equal to, each other. Either system may be used, but the two should be neither intermixed nor reconverted. The original design was made using the Imperial measurement system.

## 2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 646:1983, *Information processing — ISO 7-bit coded character set for information interchange.*

ISO 1001:1986, *Information processing — File structure and labelling of magnetic tapes for information interchange.*

ISO 1864:1985, *Information processing — Unrecorded 12,7 mm (0,5 in) wide magnetic tape for information interchange — 32 ftpmm (800 ftpi) NRZ1, 126 ftpmm (3 200 ftpi) phase encoded and 356 ftpmm (9 042 ftpi) NRZ1.*

ISO 2022:1986, *Information processing — ISO 7-bit and 8-bit coded character sets — Coded extension techniques.*

ISO 4873:1986, *Information processing — ISO 8-bit code for information interchange — Structure and rules for implementation.*

ISO 8064:1985, *Information processing — Reels for 12,7 mm (0,5 in) wide magnetic tapes — Sizes 16, 18 and 22.*

## 3 Definitions

For the purposes of this International Standard, the following definitions apply.

**3.1 magnetic tape:** A tape which will accept and retain magnetic signals intended for input, output and storage purposes on computers and associated equipment.

**3.2 reference tape:** A tape which has been selected for given properties for use in calibration.

**3.3 Master Standard Reference Tape:** A reference tape selected as a standard for signal amplitude.

NOTE 2 A Master Standard Reference Tape has been established by the US National Institute of Standards and Technology (NIST).

**3.4 Secondary Standard Reference Tape:** A tape the performance of which is known and stated in relation to that of the Master Standard Reference Tape.

NOTE 3 Secondary Standard Reference Tapes are available from NIST (Office of Standard Reference Materials, Room B311, Chemistry Building, NBS, Gaithersburg, Md 20899, USA) under part number SRM 3200.

It is intended that these be used for calibration of tertiary tapes for use in routine calibration.

**3.5 Typical Field:** In the plot of Average Signal Amplitude against recording field at the specified flux transition density, the Typical Field is the minimum field that causes an Average Signal Amplitude equal to 95 % of the maximum Average Signal Amplitude.

**3.6 Reference Field:** The Typical Field of the Master Standard Reference Tape at the specified recording density.

**3.7 Standard Reference Amplitude:** The average peak-to-peak signal amplitude derived from the Master Standard Reference Tape in the NIST measurement system under the recording conditions specified in 5.6.1.

**3.8 reference edge:** The edge further from an observer, when a tape is lying flat with the magnetic surface uppermost and the direction of movement for recording is from left to right (see figure 1).

**3.9 in-contact:** An operating condition in which the magnetic surface of a tape is in contact with a magnetic head.

**3.10 track:** A longitudinal area on a tape along which a series of magnetic signals may be recorded.

**3.11 row:** Nine transversely related locations (one in each track) in which bits are recorded.

**3.12 physical recording density:** The number of recorded flux transitions per unit length of track, [ftpmm (ftpi)].

**3.13 data density:** The number of data characters stored per unit length of tape, [cpmm (cpi)].

**3.14 skew:** Within a row, the maximum displacement of any location from any other location measured as the distance between two perpendiculars to the reference edge through said locations.

**3.15 position of a flux transition:** The point which exhibits the maximum free-space flux density normal to the tape surface.

## 4 General requirements

### 4.1 Operating environment

Tapes used for data interchange shall be operated under the following conditions:

- temperature: 16 °C to 32 °C (60 °F to 90 °F);
- relative humidity: 20 % to 80 %;
- wet bulb temperature: not greater than 25 °C (78 °F).

Conditioning before operating: If a tape has been exposed during storage and/or transportation to conditions outside the above values, it should be conditioned for a period of 2 h to 12 h depending upon the extent of exposure.

### 4.2 Storage and transportation

The recommendations for storage and transportation environment are specified in annex C.

Responsibility for ensuring that adequate precautions against damage are taken during shipment shall be with the sender (see annex C).

### 4.3 Wind tension

For interchange, the tape winding tension shall be between 2,0 N and 3,6 N (7 ozf to 13 ozf).

## 5 Recording

### 5.1 Method of recording

The recording method shall be phase encoding, described as follows:

**5.1.1** A ONE is represented by a flux transition to the polarity of the interblock gap, when reading in the forward direction.

**5.1.2** A ZERO is represented by a flux transition to the polarity opposite to that of the interblock gap, when reading in the forward direction.

**5.1.3** Additional flux transitions shall be written at the nominal midpoint between bit flux transitions, as defined in 5.1.1 and 5.1.2, if required to establish the proper polarity for the succeeding bits. These flux transitions shall be called phase flux transitions.

**5.1.4** Interblock gaps shall be of the same polarity as erase (see 5.7).

## 5.2 Density of recording

The nominal physical recording density shall be 126 ftpmm (3 200 ftpi). The resulting nominal flux transition spacing is 7,935 µm (312,5 µin). A density of 63 ftpmm (1 600 ftpi) is also used for specific measurements.

## 5.3 Average flux transition spacing

The following requirements shall be measured by reading a tape that has been continuously and evenly recorded at 63 ftpmm (1 600 ftpi) in phase in all tracks. The resulting nominal bit flux transition spacing is 15,87 µm (625 µin).

**5.3.1** The long-term average (static) flux transition spacing shall be within ± 4 % of the nominal spacing. This average shall be measured over a minimum of $5 \times 10^5$ successive flux transitions.

**5.3.2** The short-term average (dynamic) flux transition spacing, when referred to a particular flux transition spacing, is defined as the average of that flux transition spacing and the preceding three flux transition spacings.

The short-term average flux transition spacing shall be within ± 10 % of the long-term average flux transition spacing.

In addition, the rate of change of the short-term average flux transition spacing shall not exceed 0,5 %.

## 5.4 Instantaneous flux transition spacing

The instantaneous spacing between flux transitions may be influenced by the reading and writing process, the bit sequence recorded (pulse crowding effects) and other factors.

Instantaneous spacings between flux transitions shall meet the following five conditions, when tested on the reference read chain (see annex A):

a) The spacing between successive data flux transitions without an intervening phase flux transition shall be between 85 % and 108 % of the corresponding short-term average flux transition spacing.

b) The spacing between successive data flux transitions with an intervening phase flux transition shall be between 93 % and 112 % of the corresponding short-term average flux transition spacing.

c) The spacing between a data flux transition and any adjacent phase flux transition shall be between 44 % and 62 % of the corresponding short-term average flux transition spacing.

d) The average spacing between actual data flux transitions in a sequence of flux transitions at 63 per millimetre (1 600 per inch) and the predicted position of those data bits relative to flux transitions at 126 per millimetre (3 200 per inch) preceding or succeeding the sequence shall not exceed ± 6 % of the corresponding short-term average spacing.

e) The equipment used for recording tapes at 63 characters per millimetre (1 600 characters per inch) and the magnetic tape to be used for interchange shall fulfil the requirements of a) to d) when tested under the conditions specified in the reference read chain (see annex A).

## 5.5 Skew

The skew shall be less than 15,87 µm (625 µin). This condition is required to be satisfied for both flux transition polarities and for each row.

## 5.6 Signal amplitude

### 5.6.1 Standard Reference Amplitude

The Standard Reference Amplitude is the average peak-to-peak signal amplitude derived from the Master Standard Reference Tape on the qualified measurement system at the density of 126 ftpmm (3 200 ftpi) and the recording current, $I_r$, of $1{,}8 \times I_f$. The signal amplitude shall be averaged over 4 000 flux transitions, and shall be measured on the read-while-write pass. The reference current, $I_f$, is the current which produces the Reference Field.

### 5.6.2 Average signal amplitude

The average peak-to-peak signal amplitude of an interchanged tape at 126 ftpmm (3 200 ftpi) shall be between 65 % and 150 % of the Standard Reference Amplitude.

The average peak-to-peak signal amplitude at 63 ftpmm (1 600 ftpi) shall be less than 300 % of the Standard Reference Amplitude.

Averaging shall be done over a minimum of 4 000 flux transitions, which for the interchange tape, may be segmented into blocks. Averaging shall be done on the first read pass after interchange.

### 5.6.3 Minimum signal amplitude

An interchange tape shall contain no adjacent flux transitions the peak-to-peak signal amplitude of which is less than 20 % of the Standard Reference Amplitude on the first pass after interchange.

### 5.7 Erasure

#### 5.7.1 Erase direction

When erased, the rim end of the erased area of the tape shall be magnetized so that it is a North-seeking pole, and the hub end of the erased area is a South-seeking pole (see annex B).

#### 5.7.2 Erase width

The full width of the tape shall be d.c.-erased in the direction specified in 5.7.1.

#### 5.7.3 Residual signal

The tape shall be erased so that any residual signals, including NRZ1 at 32 ftpmm (800 ftpi) and 356 ftpmm (9 042 ftpi), and phase encoding at 126 ftpmm (3 200 ftpi) are less than 4 % of the Standard Reference Amplitude at 126 ftpmm (3 200 ftpi).

## 6 Track configuration

### 6.1 Number of tracks

There shall be nine tracks.

### 6.2 Track identification

Tracks shall be numbered consecutively beginning at the reference edge with track 1 (see figure 1).

### 6.3 Track positions

The distance from the centrelines of the tracks to the reference edge shall be

Track 1: 0,74 mm (0,029 in)
Track 2: 2,13 mm (0,084 in)
Track 3: 3,53 mm (0,139 in)
Track 4: 4,93 mm (0,194 in)
Track 5: 6,32 mm (0,249 in)
Track 6: 7,72 mm (0,304 in)
Track 7: 9,12 mm (0,359 in)
Track 8: 10,52 mm (0,414 in)
Track 9: 11,91 mm (0,469 in)

The tolerance shall be ± 0,08 mm (0,003 in) for all tracks.

### 6.4 Track width

The width of a written track shall be

1,09 mm min. (0,043 in min.)

## 7 Data representation

### 7.1 Coded representation of characters

Characters shall be represented by means of the 7-bit coded character set (see ISO 646), the 8-bit coded character set (see ISO 4873) or, where required, of an extension of the 7-bit coded character set (see ISO 2022).

The bit-to-track allocation shall be as follows:

#### 7.1.1 7-bit coded characters

| Binary weight | $2^0$ | $2^1$ | $2^2$ | $2^3$ | $2^4$ | $2^5$ | $2^6$ | — | — |
|---|---|---|---|---|---|---|---|---|---|
| Bit designation | b1 | b2 | b3 | b4 | b5 | b6 | b7 | — | P |
| Track | 2 | 8 | 1 | 9 | 3 | 5 | 6 | 7 | 4 |

Track 7 shall always be recorded with bit ZERO. Bit P in track 4 shall be the parity bit. The parity shall be odd.

#### 7.1.2 8-bit coded characters

| Binary weight | $2^0$ | $2^1$ | $2^2$ | $2^3$ | $2^4$ | $2^5$ | $2^6$ | $2^7$ | — |
|---|---|---|---|---|---|---|---|---|---|
| Bit designation | b1 | b2 | b3 | b4 | b5 | b6 | b7 | b8 | P |
| Track | 2 | 8 | 1 | 9 | 3 | 5 | 6 | 7 | 4 |

Bit P in track 4 shall be the parity bit. The parity shall be odd.

### 7.2 Representation of binary data

When the coding method requires it, the coded representations recorded in data rows shall be regarded as a set of bit positions, each containing a bit, which can be either a ZERO or a ONE.

The binary weights, bit designations and track allocation shall be as given in 7.1.

## 8 Format of the tape

### 8.1 Identification burst

The phase-encoded recording method shall be identified by a burst of recording at the BOT marker. This burst shall consist of 63 ftpmm (1 600 ftpi) on track 4 and erasure on all other tracks. The identification burst shall begin at least 43,2 mm (1,7 in) before the hub end of the BOT marker and continue past the hub end of the BOT marker, but shall end at least 12,7 mm (0,5 in) before the first block.

## 8.2 Block structure

All data blocks shall consist of a preamble, a data portion and a postamble.

## 8.3 Preamble

The preamble, preceding the data portion of a data block shall consist of 40 rows containing only ZEROs followed by one row containing only ONEs.

## 8.4 Length of the data portion

The data portion of a data block shall consist of at least 18 data rows and at most 2 048 data rows. However, larger blocks may be used by agreement between the interchanging parties.

## 8.5 Postamble

The postamble, following the data portion of a data block shall consist of one row containing only ONEs followed by 40 rows containing only ZEROs.

## 8.6 Gaps

### 8.6.1 Initial gap

Between the hub end of the BOT marker and the first recorded row of the preamble of the first block there shall be a gap with a length of 76 mm min. (3 in min.) and 7 600 mm max. (300 in max.). This gap shall be erased in accordance with 5.7 with the exception of the identification burst.

### 8.6.2 Interblock gap

The length of the interblock gaps shall be

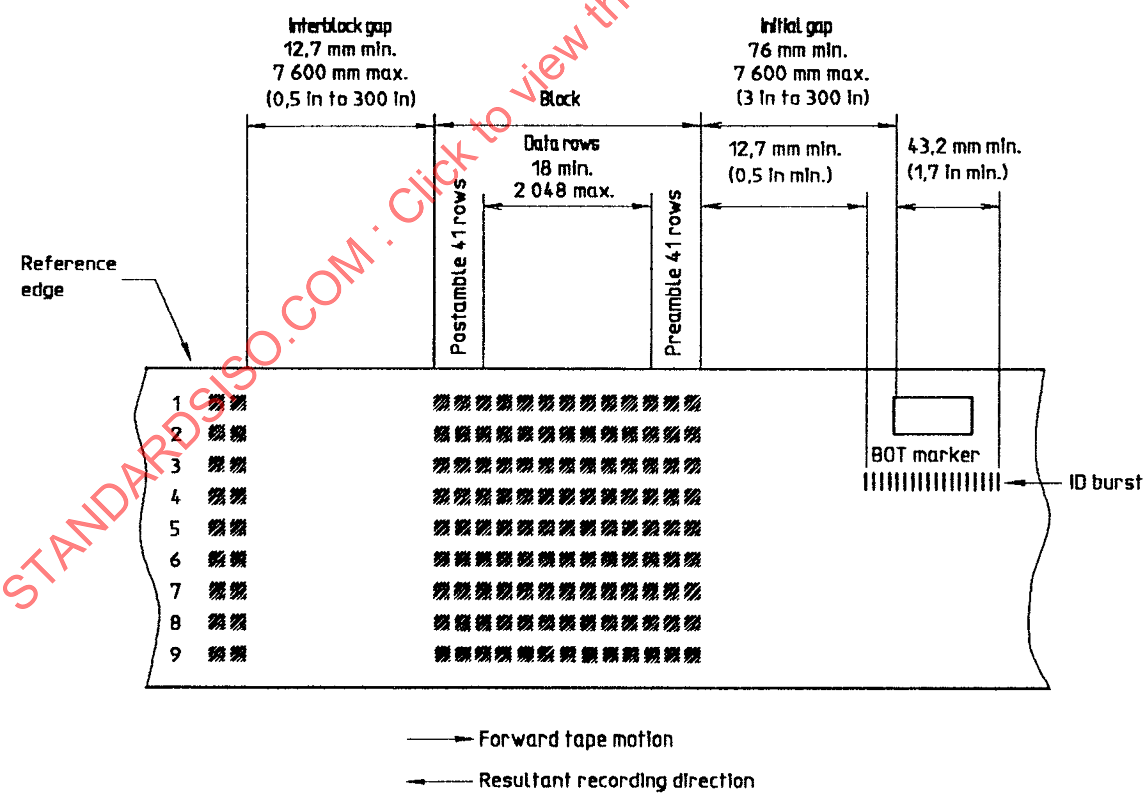
— 15 mm nom. (0,6 in nom.)

— 12,7 mm min. (0,50 in min.)

— 7 600 mm max. (300 in max.)

This gap shall be erased in accordance with 5.7. The actual gap length depends upon the number of consecutive erase instructions.






Note – Tape is shown with magnetic surface towards observer. Read-write head on same side as magnetic surface.

**Figure 1 — Track layout**

### 8.7 Tape Mark

The Tape Mark shall be a control block characterized by:

— d.c.-erasure in tracks 3, 6 and 9;

— bit pattern (1111...), over 64 to 256 transitions in tracks 2, 5 and 8;

— tracks 1, 4 and 7, in any combination, may be d.c.-erased or recorded in the manner stated for tracks 2, 5 and 8. All eight possible combinations shall be considered as a Tape Mark.

A Tape Mark shall be separated from other blocks by an interblock gap.

The use of Tape Marks is specified in ISO 1001.

## 9 Quality of recording for data interchange

Tapes shall not be employed for data interchange where the number of gaps which have been elongated due to erase instructions,

either: exceeds 2 when the total number of blocks written is less than, or equal to, 400;

or: is greater than 0,5 % of the total number of blocks written in any other case.

No permanent parity errors whilst writing are permissible in the data to be interchanged.

# Annex A
(normative)

## Procedure and instrumentation for measuring flux transition spacing

### A.1 Format

The equipment used for recording tapes (see tape transport, A.2.1) at 63 cpmm (1 600 cpi) shall record on the magnetic tape to be used for interchange using the format described in the following subclauses.

#### A.1.1 Worst case patterns

**Test patterns**

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

These test patterns shall be used in the following sequence as specified in A.1.3.1.1 and A.3.2.1:

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.

#### A.1.2 Writing

The tape shall be written in any start-stop mode of operation compatible with system operation.

#### A.1.3 Block format

Two block formats shall be generated. Each block format shall be repeated 800 times together with interblock gaps. All tracks shall be recorded simultaneously, each to meet the format specified as follows:

**A.1.3.1 Format A**

**A.1.3.1.1** Tracks 1, 2, 4, 6, 8 and 9 shall each contain the preamble, three times the test pattern sequence defined in A.1.1 and the postamble.

**A.1.3.1.2** Track 5 shall contain the preamble, 816 ONEs, and the postamble. This track is written to provide a record of speed variations.

**A.1.3.1.3** Tracks 3 and 7 shall each contain the preamble, 51 times the pair test pattern No. 1 followed by test pattern No. 2, and the postamble. These tracks are written to provide a means for locating any test pattern in a block defined in A.1.3.1.1.

**A.1.3.2 Format B**

**A.1.3.2.1** Tracks 1, 3, 5, 7, 8 and 9 shall each contain the preamble, three times the test pattern sequence defined in A.1.1 and the postamble.

**A.1.3.2.2** Track 4 shall contain the preamble, 816 ONEs, and the postamble. This track is written to provide a record of speed variations.

**A.1.3.2.3** Tracks 2 and 6 shall each contain the preamble, 51 times the pair test pattern No. 1 followed by test pattern No. 2, and the postamble. These tracks are written to provide a means for locating any test pattern in a block defined in A.1.3.2.1.

NOTE 4 On using the formats described in A.1.3.1 and A.1.3.2, odd parity is preserved in each row on the recorded tape.

### A.2 Instrumentation

#### A.2.1 Tape transport

**A.2.1.1** Nominal tape speeds shall be between 380 mm/s and 480 mm/s (15,0 in/s and 18,9 in/s), ± 1 %, constant speed.

**A.2.1.2** The equipment shall accept 266,7 mm (10,5 in) reels.

**A.2.1.3** The start-stop mode is not used; therefore, start-stop parameters are irrelevant.

## A.2.2 Read chain

### A.2.2.1 Read head

NOTE 5 The length of gap is defined as the dimension parallel to the tape movement.

**A.2.2.1.1** Voltage output parameters are irrelevant.

**A.2.2.1.2** The head mechanical dimensions should be such as to meet the specifications in 6.3. The length of the physical read gap shall be less than 2,8 µm (110 µin) but greater than 1,9 µm (75 µin).

### A.2.2.1.3 Transfer function

#### A.2.2.1.3.1 Test

Test the amplitude and phase response relative to the magnetic field induced by a wire placed at right angles to the length of the gap. The position of the wire shall be such as to maximize the head output. The current in the wire shall be constant at all frequencies of the test.

#### A.2.2.1.3.2 Specification

In the frequency range from 6 kHz to 45 kHz, the amplitude frequency characteristic shall be within 1 dB from a + 6 dB per octave line.

### A.2.2.2 Impedance match

Head-to-amplifier: The loading effect of the input impedance of the amplifier shall not cause the head output to change by more than $^{+0,0}_{-0,1}$ dB in the range of frequencies from 0 kHz to 200 kHz.

### A.2.2.3 Amplifier-differentiator

**A.2.2.3.1** The frequency response of the amplifier alone shall be flat within a total variation of 0,1 dB in the frequency range from 1 kHz to 100 kHz, and not more than 3 dB down at 30 Hz and 1 MHz.

**A.2.2.3.2** The frequency limiting lumped components within the amplifier shall be designed to produce the following transfer function[1].

**A.2.2.3.2.1** Function for a 475 mm/s (18 3/4 in/s) drive:

$$H(S) = \frac{AS}{(S + 1{,}0 \times 10^6)(S^2 + 1{,}59 \times 10^6 S + 1{,}2 \times 10^{12})}$$

$A$ being the gain to be adjusted to produce a 2 V peak-to-peak output at 126 ftpmm (3 200 ftpi);

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 in the frequency range from 0 kHz to 90 kHz.

**A.2.2.3.2.2** Function for a 380 mm/s (15 in/s) drive:

$$H(S) = \frac{AS}{(S + 6{,}61 \times 10^5)(S^2 + 1{,}04 \times 10^6 S + 5{,}25 \times 10^{11})}$$

$A$ being the gain to be adjusted to produce a 2 V peak-to-peak output at 126 ftpmm (3 200 ftpi);

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 80 kHz and a constant delay of 3,48 µs, with less than 1 % deviation in the frequency range from 0 kHz to 60 kHz.



1) The symbol, $S$, represents the complex frequency variable arising in the Laplace Transform. The symbol, $p$, is also often used.

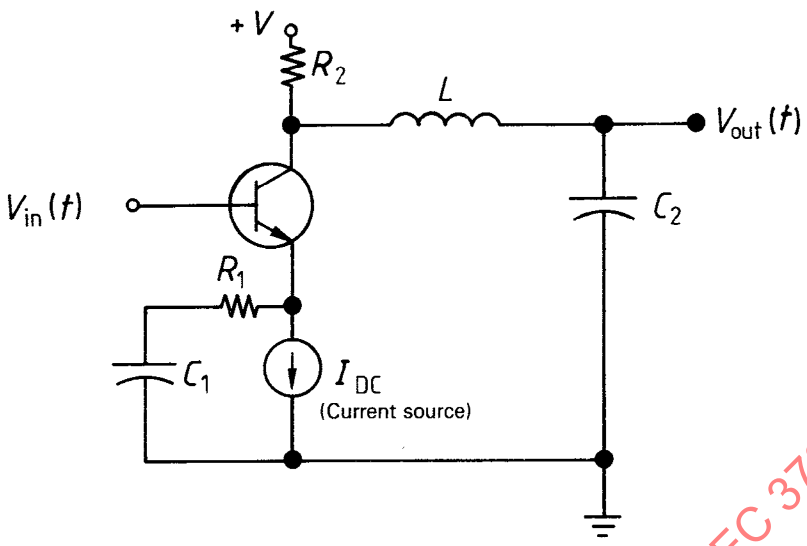



**Figure A.1 — Example of amplifier differentiator**



**A.2.2.3.3** Generalized equation for a 3-pole filter with differentiation (see figure A.1):

$$\frac{V_{out}(S)}{V_{in}(S)} = \frac{AS}{(S+a)(S^2+bS+c)}$$

where

$$V_{out}(S) = L[V_{out}(t)]$$

$$V_{in}(S) = L[V_{in}(t)]$$

Solution to the equation

$$A = R_2/R_1LC_2$$

$$a = 1/R_1C_1$$

$$b = R_2/L$$

$$c = 1/LC_2$$

When selecting the gain $A$, the value of one of the passive components in the above circuit, and the proper values for $a$, $b$ and $c$ from either A.2.2.3.2.1 or A.2.2.3.2.2, the solution for the other passive components is determinated. The bias current "$I_{d.c.}$" is selected for convenience and does not affect the transfer function.

**A.2.2.4 Amplifier-limiter**

The gain of the limiter shall be such as to produce at the output a minimum slope of 0,025 V/ns with a 30 kHz, 2 V peak-to-peak sinewave. With the same input, the limiter shall introduce less than a 20 ns asymmetry.

**A.2.2.5 Overall response from head gap to output of amplifier-limiter**

**A.2.2.5.1 Equipment required**

A 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.

A time-interval counter able to measure 5 µs with a resolution of 10 ns.

NOTE 6 The required resolution may be obtained by any convenient means; for example, an average of 100 or more independent measurements, each of 100 ns resolution, may be used.

**A.2.2.5.2 Equipment setup**

The setup of the equipment shall be as shown in figure A.2.

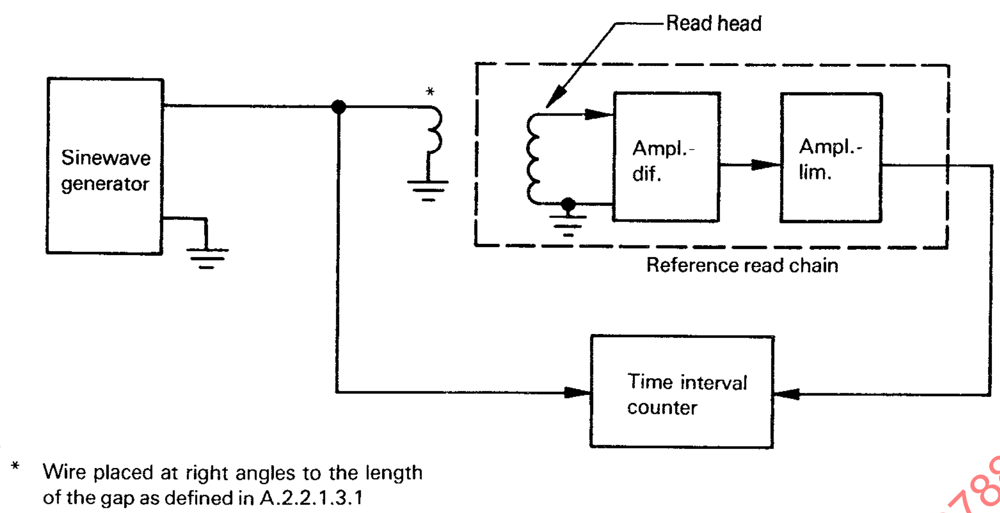



**Figure A.2 — Calibration equipment setup**



#### A.2.2.5.3 Procedure

With the generator output set to give 2 V peak-to-peak at the output amplifier-differentiator at each test frequency, vary the frequency of the generator from 6 kHz to 45 kHz. At each test frequency, measure the time displacement between the positive zero crossover of the current sinewave following through the gap wire and the positive transition at the output of the amplifier-limiter.

#### A.2.2.5.4 Specification for the calibration of the read chain

**A.2.2.5.4.1** For the filter in A.2.2.3.2.1 at 475 mm/s (18 3/4 in/s) 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 by more than $\pm$ (400 $\times$ 7 500/$f$)ns*), where $f$ is the test frequency, with respect to the time delay measured at 15 kHz, in the range of frequencies from 7,5 kHz to 45 kHz.

**A.2.2.5.4.2** For the filter in A.2.2.3.2.2 at 380 mm/s (15 in/s) 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 by more than $\pm$ (500 $\times$ 6 000/$f$)ns**), where $f$ is the test frequency, with respect to the time delay measured at 12 kHz, in the range of frequencies from 6 kHz to 36 kHz.

## A.3 Procedure for measuring flux transition spacing as defined in 5.4

### A.3.1 Equipment required

**A.3.1.1** The tape generated meeting the conditions specified in clause A.1.

**A.3.1.2** The tape drive and three read chains as specified in clause A.2.

**A.3.1.3** Time-measuring equipment suitable for measuring the time between flux transitions.

### A.3.2 A possible method of measurement

#### A.3.2.1 Assumptions

For the purposes of this equipment, the time-measuring equipment shall be a triple-trace oscilloscope, and the tape format shall be as specified in A.1.3.1.

#### A.3.2.2 Setup

Arrange the equipment as shown in figure A.3.

**A.3.2.2.1** The flux transition spacings shall be measured as the time between the transitions present at the output of the amplifier-limiter of track 4.

**A.3.2.2.2** The short-term average flux transition spacing as defined in 5.3.2 shall be measured at the output of the amplifier-limiter of track 5 simultaneously with the measurement on A.3.2.2.1.

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*) This value is equivalent to + 1 degree at 7,5 kHz

**) This value is equivalent to + 1 degree at 6 kHz.