
**Identification cards — Recording
technique —**

Part 7:

**Magnetic stripe: High coercivity, high
density**

Cartes d'identification — Technique d'enregistrement —

Partie 7: Bandeau magnétique: Haute coercivité, haute densité

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Contents

	Page
Foreword	iv
1 Scope	1
2 Normative references	1
3 Terms, definitions, symbols and abbreviated terms	2
3.1 Terms and definitions.....	2
3.2 Symbols and abbreviated terms.....	4
4 Conformance	4
5 Physical characteristics of the identification card	4
5.1 General.....	4
5.2 Magnetic stripe area warpage.....	4
5.3 Surface distortions.....	4
6 Physical characteristics of the magnetic stripe	5
6.1 Height and surface profile of the magnetic stripe area.....	5
6.1.1 Surface profile of the magnetic stripe area.....	6
6.1.2 Height of the magnetic stripe area.....	7
6.2 Surface roughness.....	7
6.3 Adhesion of stripe to card.....	7
6.4 Wear of magnetic stripe from read/write head.....	8
6.5 Resistance to chemicals.....	8
7 Performance characteristics for the magnetic material	8
7.1 General.....	8
7.2 Testing and operating environment.....	8
7.3 Signal amplitude requirements for magnetic media.....	8
8 Data structure	10
9 Encoding specification	11
9.1 Angle of recording.....	11
9.2 Nominal bit density.....	12
9.3 Flux transition spacing variation.....	12
9.4 Signal amplitude requirements.....	12
9.5 Bit configuration.....	12
9.6 Direction of recording.....	13
9.7 Leading and trailing clock bits.....	13
10 Data structure	13
10.1 Track format.....	13
10.1.1 Track layout.....	13
10.1.2 FSC.....	14
10.1.3 Data frame.....	15
10.2 Coding for error detection and correction.....	15
10.2.1 Track CRC.....	16
10.2.2 Column parity.....	17
10.2.3 Frame CRC.....	17
11 Decoding	18
12 Location of encoded tracks	18
Annex A (informative) Compatibility of magnetic stripes (ISO/IEC 7811-6, ISO/IEC 7811-7)	20
Annex B (informative) Magnetic stripe abrasivity	21
Annex C (informative) Static magnetic characteristics	22
Annex D (informative) Reed-Solomon code references	24

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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO and IEC shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

This document was prepared by ISO/IEC JTC 1, *Information technology, SC 17, Cards and personal identification*.

This third edition cancels and replaces the second edition (ISO/IEC 7811-7:2014), which has been technically revised.

Major changes from the previous edition are as follows:

- the primary standard cards held by Q-Card are used to calibrate the manufacture of secondary reference cards; other primary standard cards held by PTB and Card Testing International (CTI) are used as backup to replace cards held by Q-Card as they wear out;
- deleted reference to character sets in the Scope since none are used in this document;
- list of major differences has been moved from the Introduction to [Annex A](#);
- the supplier of secondary reference cards has changed from PTB to Q-Card.

Notes in this document are only used for giving additional information intended to assist in the understanding or use of the document. They do not contain provisions or requirements to which it is necessary to conform in order to be able to claim compliance with this document.

A list of all the parts in the ISO/IEC 7811 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Identification cards — Recording technique —

Part 7:

Magnetic stripe: High coercivity, high density

1 Scope

This document is one of a series of standards describing the characteristics for identification cards as defined in the definitions clause and the use of such cards for international interchange.

This document specifies requirements for a high coercivity magnetic stripe (including any protective overlay) on an identification card and encoding technique. It takes into consideration both human and machine aspects and states minimum requirements.

Coercivity influences many of the quantities specified in this document but is not itself specified. The main characteristic of the high coercivity magnetic stripe is its improved resistance to erasure. This is achieved with minimal probability of damage to other magnetic stripes by contact while retaining read compatibility with magnetic stripes as defined in ISO/IEC 7811-2.

This document provides for a card capacity of approximately 10 times that of a card conforming to ISO/IEC 7811-6. The number of tracks has been increased to 6, each track being approximately half the width of tracks conforming to ISO/IEC 7811-6, located so that readers designed to read these high density tracks will also be able to read cards conforming to ISO/IEC 7811-2 and ISO/IEC 7811-6. Data is encoded in 8 bit bytes using the MFM encoding technique. Data framing is used to limit error propagation and error correction techniques further improve reliability of reading.

It is the purpose of the ISO/IEC 7811 series of standards to provide criteria to which cards shall perform. No consideration is given within these standards to the amount of use, if any, experienced by the card prior to test. Failure to conform to specified criteria is negotiated between the involved parties.

ISO/IEC 10373-2 specifies the test procedures used to check cards against the parameters specified in this document.

NOTE Numeric values in the SI and/or Imperial measurement system in this document may have been rounded off and are consistent with, but not exactly equal to each other. Using either system is correct but intermixing or reconverting values can result in errors. The original design was made using the Imperial measurement system.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 4287, *Geometrical Product Specifications (GPS) — Surface texture: Profile method — Terms, definitions and surface texture parameters*

ISO/IEC 7810, *Identification cards — Physical characteristics*

ISO/IEC 10373-1, *Identification cards — Test methods — Part 1: General characteristics*

ISO/IEC 10373-2, *Identification cards — Test methods — Part 2: Cards with magnetic stripes*

3 Terms, definitions, symbols and abbreviated terms

For the purposes of this document, the terms and definitions given in ISO/IEC 7810 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at <http://www.electropedia.org/>
- ISO Online browsing platform: available at <http://www.iso.org/obp>

3.1 Terms and definitions

3.1.1

primary standard

set of reference cards established by Physikalisch-Technische Bundesanstalt (PTB) and maintained by PTB, Q-Card, and Card Testing International that represent the values of U_R and I_R designated RM7811-6

3.1.2

secondary standard

reference card designated RM7811-6 that is related to the primary standard as stated in the calibration certificate supplied with each card

Note 1 to entry: Secondary standards can be ordered from Q-Card, 301 Reagan St., Sunbury, PA 17801, USA. The source of secondary standards will be maintained at least until 2018.

3.1.3

unused un-encoded card

card possessing all the components required for its intended purpose, which has not been subjected to any personalization or testing operation, and which has been stored in a clean environment with no more than 48 hour exposure to day-light at temperatures between 5 °C to 30 °C and humidity between 10 % to 90 % without experiencing thermal shock

3.1.4

unused encoded card

card according to 3.1.3 that has only been encoded with all the data (magnetic, embossing, electronic etc) required for its intended purpose

3.1.5

returned card

card according to 3.1.4 after it has been issued to the card holder and returned for the purpose of testing

3.1.6

flux transition

location of the greatest rate of change with distance of the magnetization

3.1.7

reference current

I_R
minimum recorded current amplitude under the given test conditions that causes, on the reference card, a readback signal amplitude equal to 80 % of the reference signal amplitude U_R , at a density of 20 flux transitions per millimetre (508 flux transitions per inch) as shown in [Figure 6](#)

3.1.8

reference flux level

F_R
flux level in the test head that corresponds to the reference current I_R

3.1.9

test recording currents

two recording currents defined by:

I_{\min} = Recording current corresponding to $2,2 F_R$

I_{\max} = Recording current corresponding to $2,5 F_R$

3.1.10

individual signal amplitude

U_i

base-to-peak amplitude of a single readback voltage signal

3.1.11

average signal amplitude

U_A

sum of the absolute values of the amplitude of each signal peak (U_i) divided by the number of signal peaks (n) for a given track over the length of the magnetic stripe area

3.1.12

reference signal amplitude

U_R

maximum value of the average signal amplitude of a reference card corrected to the primary standard

3.1.13

physical recording density

number of flux transitions per unit length recorded on a track

3.1.14

bit density

number of data bits stored per unit of length

3.1.15

bit cell

distance for a data bit nominally the reciprocal of the bit density as shown in [Figure 8](#)

3.1.16

average bit cell

B_a

product of bit cell length and sum of the actual distances for all flux transition intervals on a track divided by the sum of the nominal distances for all flux transition intervals on the track

3.1.17

local average bit cell

B_{a6}

comparison reference for a given flux transition interval equal to the nominal L1 distance multiplied by the sum of the actual distances for the previous six flux transition intervals divided by the sum of the nominal distances for the previous six flux transition intervals ($L1 * (\Sigma \text{ actual}) / (\Sigma \text{ nominal})$)

3.1.18

demagnetization current

I_d

D.C. current value that reduces the average signal amplitude to 80 % of the reference signal amplitude (U_R) on a secondary reference card that has been encoded at a density of 40 ft/mm (1 016 ftpi) at a current of I_{\min}

3.1.19

U_F

magnitude of the individual element at 20 flux transitions per mm frequency of the Fourier spectrum for a given track over the length of the magnetic stripe area

3.2 Symbols and abbreviated terms

CRC	cyclic redundancy check
CP	column parity
FSC	frame synchronization character
L_1	short distance between adjacent flux transitions nominally equal to 1 times the bit cell
L_2	medium distance between adjacent flux transitions nominally equal to 1,5 times the bit cell
L_3	long distance between adjacent flux transitions nominally equal to 2 times the bit cell

4 Conformance

A prerequisite for conformance with this document is conformance with ISO/IEC 7810. An identification card is in conformance with this document if it meets all mandatory requirements specified herein. Default values apply if no others are specified.

5 Physical characteristics of the identification card

5.1 General

The identification card shall conform to the specification given in ISO/IEC 7810.

WARNING — The attention of card issuers is drawn to the fact that information held on the magnetic stripe may be rendered ineffective through contamination by contact with dirt and certain commonly used chemicals including plasticizers. It should also be noted that any printing or screening placed on top of the magnetic stripe must not impair the function of the magnetic stripe.

5.2 Magnetic stripe area warpage

Application of a 2,2 N (0.5 lbf) load evenly distributed on the front face opposite the magnetic stripe shall bring the entire stripe within 0,08 mm (0.003 in) of the rigid plate.

5.3 Surface distortions

There shall be no surface distortions, irregularities or raised areas on both the front and the back of the card in the area shown in [Figure 1](#) that might interfere with the contact between the magnetic head and magnetic stripe.

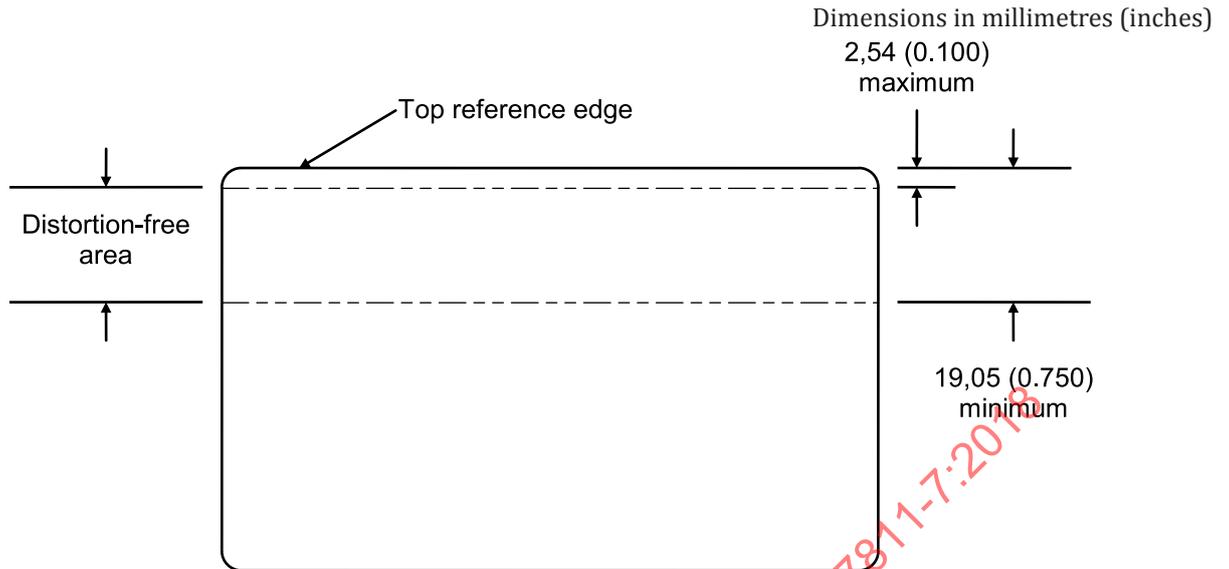


Figure 1 — Distortion-free area on card with magnetic stripe

If a raised signature panel area is located on the front or back of the card, then it shall be no closer to the top edge of the card than 19,05 mm (0.750 in).

NOTE Raised areas and distortions on other areas of the card can cause card transport problems with magnetic stripe processing equipment resulting in reading or writing errors.

6 Physical characteristics of the magnetic stripe

6.1 Height and surface profile of the magnetic stripe area

The magnetic stripe area is located on the back of the card as shown in [Figure 2](#).

NOTE In the case of the magnetic stripe area used for track 1 and 2, the dimension a as shown in [Figure 2](#) of the magnetic media could be less than the maximum dimension b as shown in [Figure 11](#) for the location of track 2 data on the card. It is desirable that the magnetic stripe area extend beyond the limits of the encoded track.

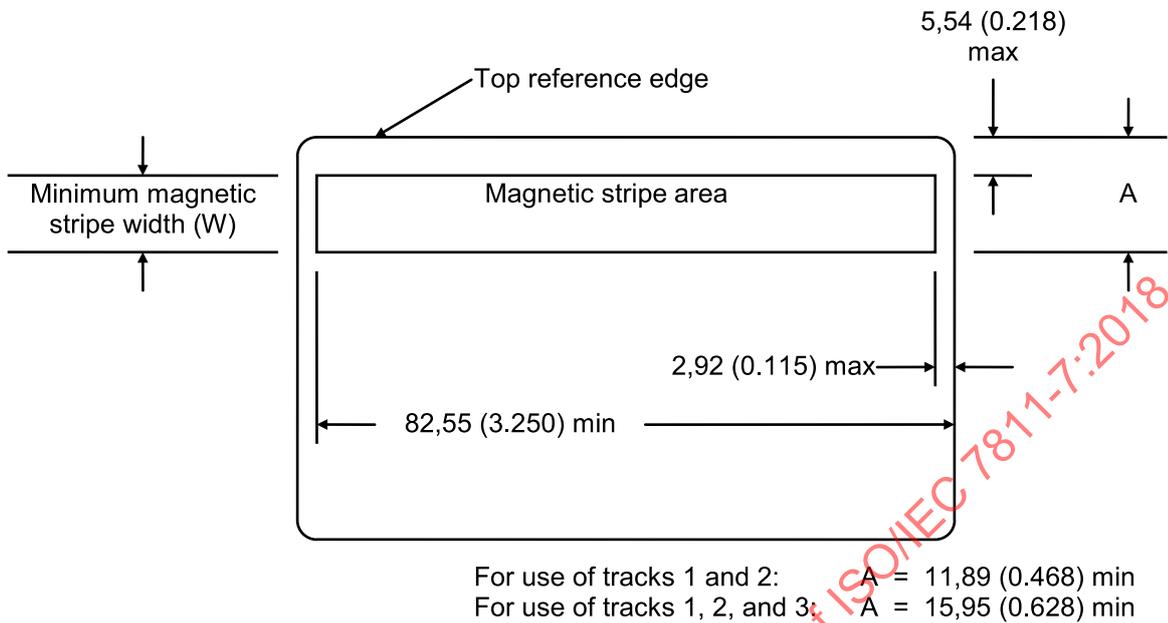


Figure 2 — Location of magnetic material

6.1.1 Surface profile of the magnetic stripe area

The maximum vertical deviation (a) of the transverse surface profile of the magnetic stripe area is shown below. See Figure 3, Figure 4, and Figure 5. The slope of the surface profile curve shall be limited to: $-4a/W < \text{slope} < 4a/W$.

When the bending stiffness value (see ISO/IEC 7810) for the card is 20 mm or more then the surface profile limits are:

Minimum stripe width	As shown in Figure 3A	As shown in Figure 3B
$W = 6,35 \text{ mm (0.25 in)}$	$a \leq 9,5 \mu\text{m (375 } \mu\text{in)}$	$a \leq 5,8 \mu\text{m (225 } \mu\text{in)}$
$W = 10,28 \text{ mm (0.405 in)}$	$a \leq 15,4 \mu\text{m (607 } \mu\text{in)}$	$a \leq 9,3 \mu\text{m (365 } \mu\text{in)}$

When the bending stiffness value (see ISO/IEC 7810) for the card is less than 20 mm then the surface profile limits are:

Minimum stripe width	As shown in Figure 3A	As shown in Figure 3B
$W = 6,35 \text{ mm (0.25 in)}$	$a \leq 7,3 \mu\text{m (288 } \mu\text{in)}$	$a \leq 4,5 \mu\text{m (175 } \mu\text{in)}$
$W = 10,28 \text{ mm (0.405 in)}$	$a \leq 11,7 \mu\text{m (466 } \mu\text{in)}$	$a \leq 7,3 \mu\text{m (284 } \mu\text{in)}$

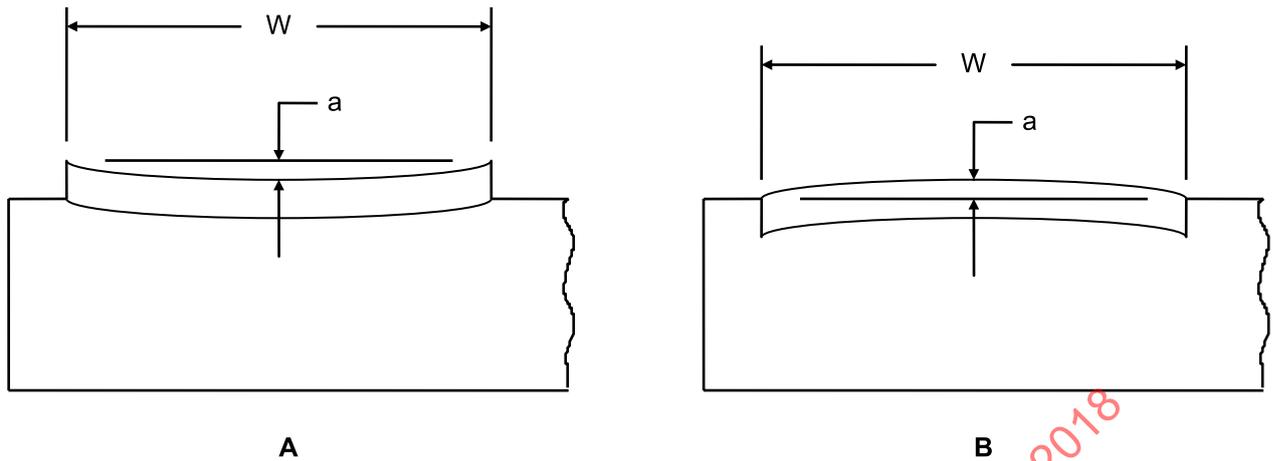


Figure 3 — Surface profile

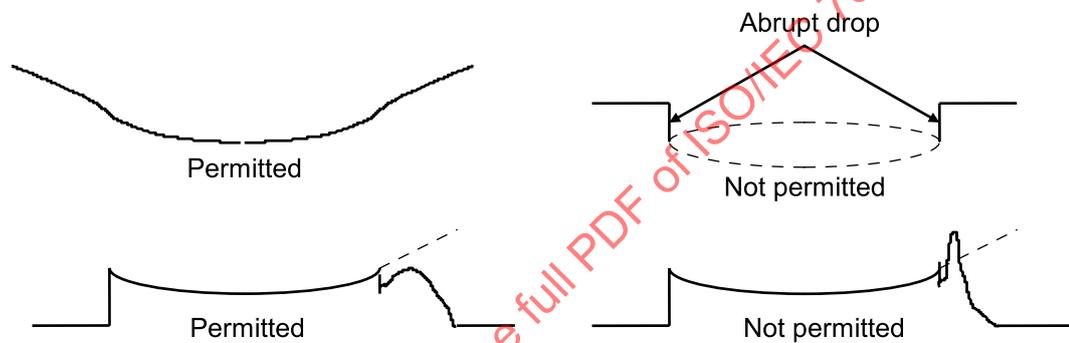
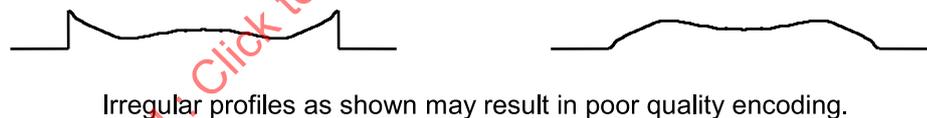


Figure 4 — Surface profile examples



Irregular profiles as shown may result in poor quality encoding.

Figure 5 — Irregular surface profile examples

6.1.2 Height of the magnetic stripe area

The vertical deviation (h) of the magnetic stripe area relative to the adjacent surface of the card shall be:

$$-0,005 \text{ mm } (-200 \text{ } \mu\text{in}) \leq h \leq 0,038 \text{ mm } (1500 \text{ } \mu\text{in})$$

Spiking in the profile caused by the material “squirt out” in hot stamping is not part of the stripe. It shall not extend above the magnetic stripe area height (h) as defined above.

6.2 Surface roughness

The average surface roughness (R_a) of the magnetic stripe area shall not exceed $0,40 \text{ } \mu\text{m}$ ($15,9 \text{ } \mu\text{in}$) in both the longitudinal and transverse directions. Refer to ISO/IEC 4287.

6.3 Adhesion of stripe to card

The stripe shall not separate from the card under normal use.

6.4 Wear of magnetic stripe from read/write head

Average signal amplitude (U_A) and individual signal amplitude (U_i) are measured before and after 2 000 wear cycles and shall result in:

$$U_{A \text{ after}} \geq 0,60 U_{A \text{ before}} \quad \text{and} \quad U_{i \text{ after}} \geq 0,80 U_{A \text{ after}}$$

6.5 Resistance to chemicals

Average signal amplitude (U_A) and individual signal amplitude (U_i) are measured before and after short term exposure (as defined in the referenced Test Method document) shall result in:

$$U_{A \text{ after}} \geq 0,90 U_{A \text{ before}} \quad \text{and} \quad U_{i \text{ after}} \geq 0,90 U_{A \text{ after}}$$

Average signal amplitude (U_A) and individual signal amplitude (U_i) are measured before and after long term exposure (24 h) to acid and alkaline artificial perspiration, as defined in the referenced Test Method document.

$$U_{A \text{ after}} \geq 0,90 U_{A \text{ before}} \quad \text{and} \quad U_{i \text{ after}} \geq 0,90 U_{A \text{ after}}$$

7 Performance characteristics for the magnetic material

7.1 General

The purpose of this clause is to enable magnetic interchangeability between card and processing systems. Media coercivity is not specified. The media's performance criteria, regardless of coercivity, is specified in [7.3](#).

This method uses a reference card whose material is traceable to the primary standard (see [Clause 3](#)). All signal amplitude results from the use of the secondary reference card must be corrected by the factor supplied with the secondary reference card.

7.2 Testing and operating environment

The testing environment for signal amplitude measurements is $23 \text{ °C} \pm 3 \text{ °C}$ ($73 \text{ °F} \pm 5 \text{ °F}$) and 40 % to 60 % relative humidity. When tested under otherwise identical conditions, the average signal amplitude measured at 40 ft/mm (1 016 ftpi) shall not deviate from its value in the above test environment by more than 15 % after 5 min exposure over the following operating environment range:

temperature	-35 °C to 50 °C (-31 °F to 122 °F)
relative humidity	5 % to 95 %

7.3 Signal amplitude requirements for magnetic media

The requirements for recording characteristics of the card are shown in [Table 1](#), [Figure 6](#), and [Figure 7](#). The media's performance requirements specified in [7.3](#) shall be met in order to achieve improved resistance to erasure, and to enable magnetic interchange between card and processing systems. The properties in [Annex C](#) are intended as guidelines for magnetic material. [Annex C](#) is informative and shall not be used as performance criteria for cards.

Table 1 — Signal amplitude requirements for unused unencoded cards

Description	Density ft/mm (ftpi)	Test recording current	Signal amplitude result	Requirement
Signal amplitude	20 (508)	I_{min}	U_{A1}	$0,8 U_R \leq U_{A1} \leq 1,2 U_R$
Signal amplitude	20 (508)	I_{min}	U_{i1}	$U_{i1} \leq 1,26 U_R$
Signal amplitude	20 (508)	I_{max}	U_{A2}	$U_{A2} \geq 0,8 U_R$
Signal amplitude	40 (1016)	I_{max}	U_{i2}	$U_{i2} \geq 0,65 U_R$
Resolution	40 (1016)	I_{max}	U_{A3}	$U_{A3} \geq 0,8 U_{A2}$
Erasure	0	I_{min} , DC	U_{A4}	$U_{A4} \leq 0,03 U_R$
Extra pulse	0	I_{min} , DC	U_{i4}	$U_{i4} \leq 0,05 U_R$
Demagnetisation	0	I_d , DC	U_{A5}	$U_{A5} \geq 0,64 U_R$
Demagnetisation	0	I_d , DC	U_{i5}	$U_{i5} \geq 0,54 U_R$
Overwrite	20 (508)	I_{max}	U_{F6}	$U_{F7} \leq 0,03 U_{F6}$
	40 (1016)	I_{min}	U_{F7}	

The slope of the saturation curve shall never be positive between I_{min} and I_{max} .
It is not permissible to combine the above requirements mathematically.

NOTE 1 The density of 20 ft/mm converts to 508 ftpi in this document and to 500 ftpi in ISO/IEC 7811-2 and ISO/IEC 7811-6. These 2 are not different in principle. To ensure compatibility at the higher recording density the more accurate conversion is used in this document.

NOTE 2 It has been observed that low resolution as measured per Table 1 can correlate with high flux transition spacing variation as measured per Table 2.

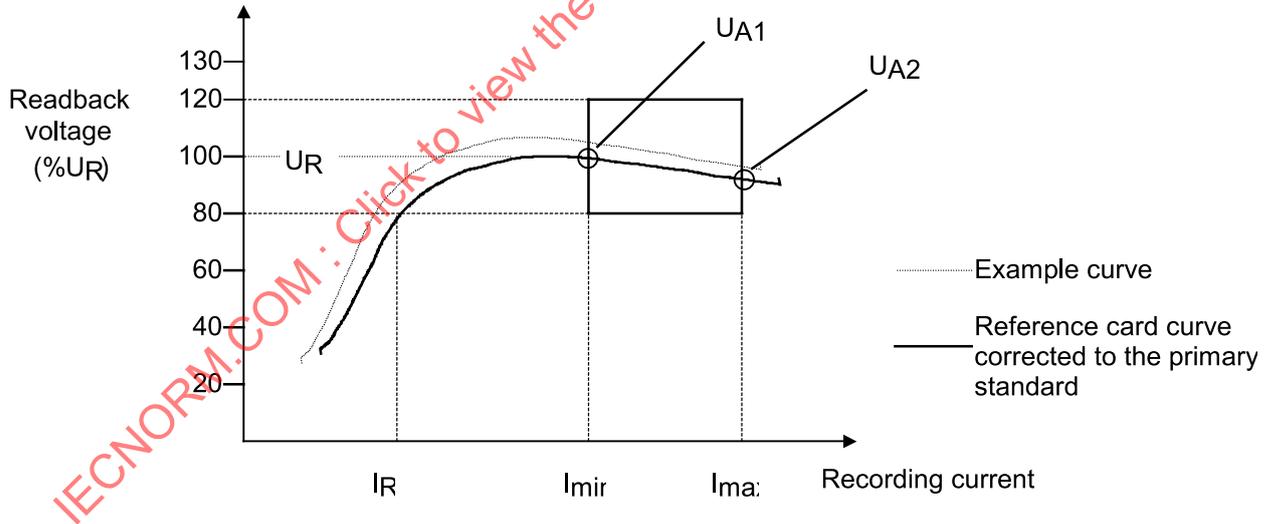


Figure 6 — Saturation curve example showing tolerance area

NOTE The curve defines the primary standard response (on a card). The window parameters define a card that will be functional in the machine readable environment.

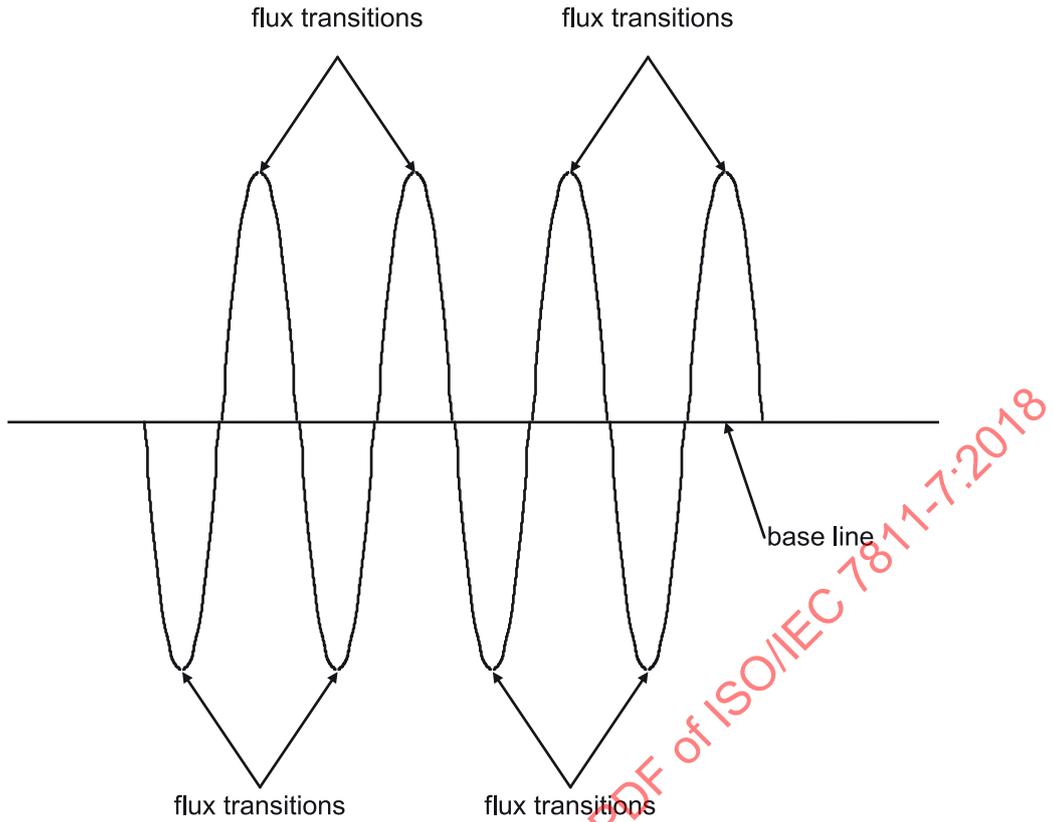


Figure 7 — Waveform example

8 Data structure

The encoding technique for each track shall be Modified Frequency Modulation (MFM) recording for which the conditions are:

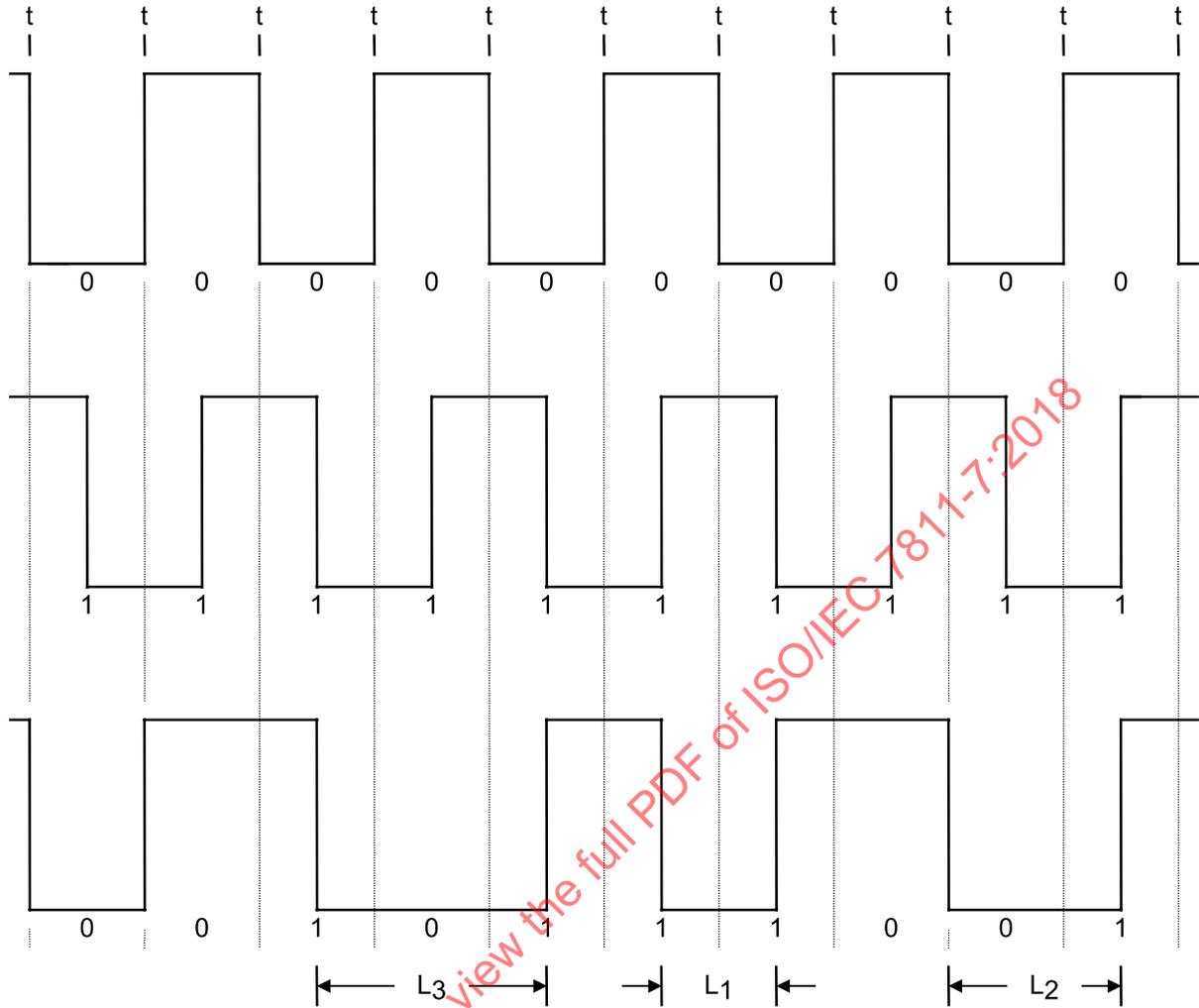
- a flux transition shall be written at the centre of each bit cell containing a ONE;
- a flux transition shall be written at each cell boundary between adjacent bit cells containing ZEROS.

The data shall be recorded as a synchronous sequence of characters without intervening gaps.

NOTE 1 Recording with a write current which is less than I_{min} can result in poor quality encoding.

NOTE 2 MFM is the same as the FM technique described in ISO/IEC 7811-6 except that clocking flux transitions for 1 bits have been removed. This results in a loss of some of the self-clocking feature with FM encoding and requires more accuracy for flux transition intervals. With this technique there may not be a flux transition at the bit cell boundary.

See [Figure 8](#).



Key
 t bit cell boundaries

Figure 8 — Examples of MFM encoding

9 Encoding specification

9.1 Angle of recording

The angle of recording shall be normal to the nearest edge of the card parallel to the magnetic stripe with a tolerance of ± 20 min. The angle of recording (α) is determined by measuring the angle of the head gap when the reading amplitude is maximum (see [Figure 9](#)).

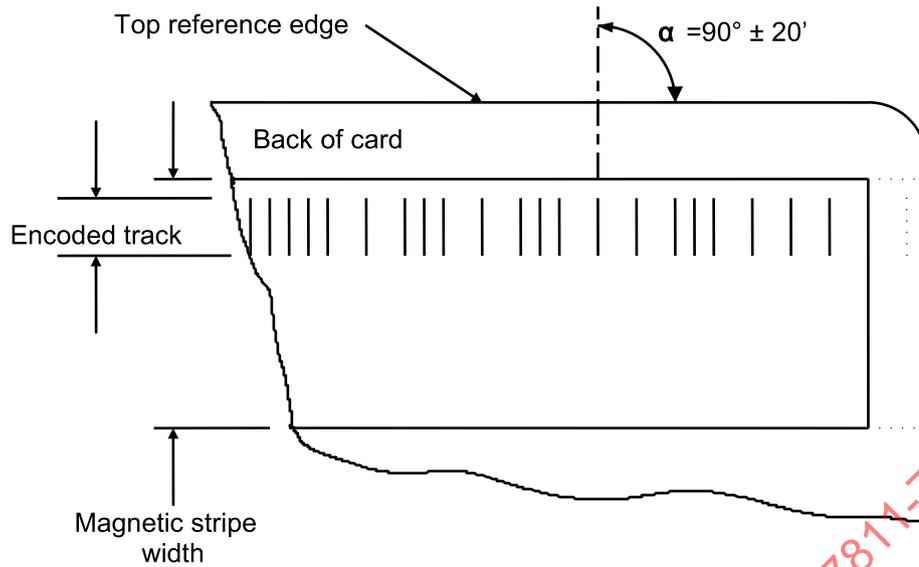


Figure 9 — Angle of recording

9.2 Nominal bit density

The nominal bit density for each of the tracks shall be 40 bits/mm (1016 bpi).

9.3 Flux transition spacing variation

Flux transition spacing variations for all tracks are given in [Table 2](#).

Table 2 — Flux transition spacing variation

Term	Description	Requirement	Variation
B_a	Average bit cell	$23 \mu\text{m} (906 \mu\text{in}) \leq B_a \leq 25,3 \mu\text{m} (994 \mu\text{in})$	-8 % to +1 %
B_{a6}	Local average bit cell	$0,92 B_a \leq B_{a6} \leq 1,08 B_a$	$\pm 8 \%$ of B_a
L_1	Short interval	$0,80 B_{a6} \leq L_1 \leq 1,20 B_{a6}$	$\pm 20 \%$ of B_{a6}
L_2	Medium interval	$1,30 B_{a6} \leq L_2 \leq 1,70 B_{a6}$	$\pm 13,3 \%$ of $1,5 B_{a6}$
L_3	Long interval	$1,80 B_{a6} \leq L_3 \leq 2,25 B_{a6}$	$\pm 10 \%$ of $2 B_{a6}$

NOTE It has been observed that low resolution as measured per [Table 1](#) can correlate with high flux transition spacing variation as measured per [Table 2](#).

9.4 Signal amplitude requirements

The requirements for signal amplitude on all tracks shall be as follows:

- unused encoded cards: $0,64 U_R \leq U_i \leq 1,36 U_R$;
- returned cards: $0,52 U_R \leq U_i \leq 1,36 U_R$.

NOTE The requirements above specify the interchange signal amplitude limits for each of the encoded track locations at the specified bit densities. Signal amplitude requirements specified in [Table 1](#) reflect the magnetic media limits at the specified recording frequency and recording test currents.

9.5 Bit configuration

Data shall be recorded with the least significant bit (2^0) first.

9.6 Direction of recording

The encoding shall begin from the right-hand side viewed from the side with the magnetic stripe and with the stripe at the top.

9.7 Leading and trailing clock bits

The lead-in up to the first FSC shall be recorded with ones and the space after the last FSC shall also be recorded with ones. Ones encoded from the edge of the card to 3,30 mm (0.130 in) in from the edge of the card are not required to meet the specifications given herein.

10 Data structure

User data to be written on the card shall be divided among the tracks used. Each track used shall be of a fixed length depending on the type of card used requiring the user data to be padded with binary zero bytes if it does not fill the available space on the track(s) used. Data structure on each track is independent of other tracks. The general process for structuring of the data is shown in [Table 3](#), see also [Figure 11](#).

Table 3 — Data structure process steps

Step	Process
1	Determine number of tracks needed based on data capacity for card type used.
2	Divide card data into data for each track and pad end of card data with binary zero bytes if necessary such that all frames on every track used are filled. Padding may be done before dividing onto tracks or after. More error correction is obtained if data is divided equally among the tracks used and then each track padded.
3	Generate CRC for track data and append to end of track data.
4	Divide track data into frames.
5	Generate Reed-Solomon column parity.
6	Add frame ID number.
7	Generate CRC for each frame.
8	Arrange for writing on card: add lead/trail clock transitions, convert frame ID from 8 bit to 5 bit string, and add FSC's.

NOTE No coded character set is defined by this document. Most uses for the high density format will be for non-text applications.

10.1 Track format

10.1.1 Track layout

Each track shall consist of leading clock transitions, a FSC, data frames each separated by a FSC, a FSC, and trailing clock transitions as shown below.

Leading clock transitions
FSC
Frame identifier 1
Data
Frame CRC
FSC
Frame identifier 2
Data
Frame CRC
FSC
Frame identifier 3
Data
Frame CRC
FSC
:
:
:
FSC
Frame identifier 18
Data
Frame CRC
FSC
Trailing clock transitions

10.1.2 FSC

The FSC is used to determine direction and identify the edge of the data frame. A FSC shall occur before and after each data frame but only one FSC shall occur between adjacent data frames. The FSC has the representation shown in [Figure 10](#).

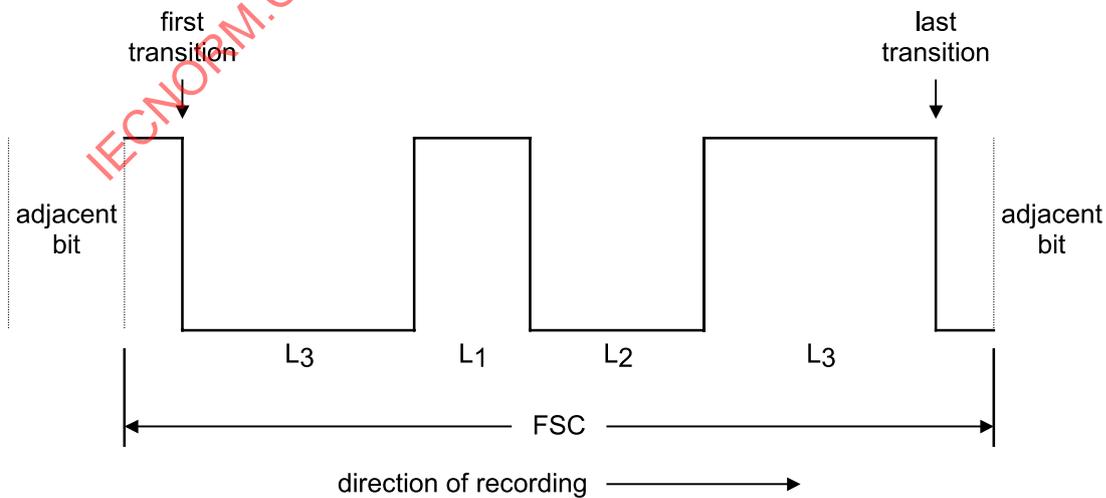


Figure 10 — FSC representation

NOTE The FSC occupies a space of 7,5 bits and is a series of flux transition intervals where the edges are like 1 bits (transition in middle of bit boundary). It is not a series of 1 and 0 bits since this pattern of flux transition intervals is unique and will never occur with MFM encoding rules. Therefore, the FSC can be found even if character synchronisation within the data frame has been lost, and synchronisation begins with the next data frame.

10.1.3 Data frame

Data frames shall consist of a frame number, data and a frame CRC character. The number of frames per track shall be 18.

10.1.3.1 Frame identifier

Each data frame shall be identified with a 5 bit character representing a number. Frames shall be numbered consecutively starting with 1 for the frame nearest the start of encoding and ending with 18 nearest the end of encoding. When performing data operations prior to writing on the card or during the decoding process after reading, the frame identifier shall be represented as an 8 bit string.

10.1.3.2 Data

Data shall be represented in 8 bit bytes and shall be user data, column parity, or track CRC information. The capacity and number of bytes per frame depends on the card size and shall be as shown in [Table 4](#). For each card size all the amounts are fixed (no variable lengths).

Table 4 — Track capacity

Card type	ID-1	ID-2	ID-3
Frame data capacity (bytes per frame)	17	22	28
Frame size (bits per frame)	156,5	196,5	244,5
Track data capacity (bytes per track)	306	396	504
Track size (bits per track)	2 824,5	3 544,5	4 408,5
Column parity (bytes)	68	88	112
Track CRC (bytes)	4	4	4
User data capacity (bytes)	234	304	388

NOTE The user data capacity shown in [Table 4](#) is based on the amount of error correction used. Frame size equals FSC+Frame ID+(bytes per frame*8)+CRC. Track size equals (bits per frame*18)+FSC.

10.1.3.3 Frame CRC character

Each frame shall include one 8 bit CRC character.

10.2 Coding for error detection and correction

Track data shall be located in frames as shown in [Figure 11](#) where N is 2 plus the number of bytes per track as specified in [Table 4](#). When written on the card, byte 1 of frame 1 is nearest the start of encoding and byte N of frame 18 is nearest the end of encoding (left to right, top to bottom).

Byte										
1	2	3	4		N-5	N-4	N-3	N-2	N-1	N
Frame ID	Data area									CRC
1	CP	CP	CP		CP	CP	CP	CP	CP	CRC ₁
2	CP	CP	CP		CP	CP	CP	CP	CP	CRC ₂
3	CP	CP	CP		CP	CP	CP	CP	CP	CRC ₃
4	CP	CP	CP		CP	CP	CP	CP	CP	CRC ₄
5	Data	Data	Data		Data	Data	Data	Data	Data	CRC ₅
6	Data	Data	Data		Data	Data	Data	Data	Data	CRC ₆
7	Data	Data	Data		Data	Data	Data	Data	Data	CRC ₇
8	Data	Data	Data		Data	Data	Data	Data	Data	CRC ₈
9	Data	Data	Data		Data	Data	Data	Data	Data	CRC ₉
10	Data	Data	Data		Data	Data	Data	Data	Data	CRC ₁₀
11	Data	Data	Data		Data	Data	Data	Data	Data	CRC ₁₁
12	Data	Data	Data		Data	Data	Data	Data	Data	CRC ₁₂
13	Data	Data	Data		Data	Data	Data	Data	Data	CRC ₁₃
14	Data	Data	Data		Data	Data	Data	Data	Data	CRC ₁₄
15	Data	Data	Data		Data	Data	Data	Data	Data	CRC ₁₅
16	Data	Data	Data		Data	Data	Data	Data	Data	CRC ₁₆
17	Data	Data	Data		Data	Data	Data	Data	Data	CRC ₁₇
18	Data	Data	Data		Data	Track CRC			CRC ₁₈	

Figure 11 — Track data structure

NOTE The frame CRC character is used for error detection and column parity is used for error correction.

10.2.1 Track CRC

The track shall include a CRC comprised of four 8 bit bytes generated as follows and added to the end of the track data. Highest order term for track CRC shall be in byte (N-4) frame 18:

$$CRC = [x^4M(x)] \text{ mod } g(x) \text{ over } GF(2^8)$$

where

M(x) = all user data for the track in polynomial form (length depends on card type used). Highest order term is in byte 2 frame 5 and lowest order term in byte N-5 frame 18. See [Figure 11](#);

g(x) = (x-α)(x-α²)(x-α³)(x-α⁴) = generator polynomial for the track CRC;

GF(2⁸) = a finite Galois field of 256 different 8 bit binary symbols generated by a primitive polynomial defined as: p(x) = 1 + x² + x³ + x⁴ + x⁸;

xⁱ = bit at position i.

NOTE 1 The track CRC will allow the detection of up to 4 errors with a probability of 1. For more than 4 errors the probability of detecting errors is equal to $1-1/(256)^4$.

NOTE 2 The track CRC is the remainder of $x^4M(x)$ divided by $g(x)$ using modulo operations. For more than 251 bytes of data, the CRC is technically not a cyclical check, it is a simple redundancy check although it is generated in the same way.

NOTE 3 Published tables exist showing the bit representations for the corresponding power for α for GF power of alpha corresponds to the number so that the term alpha raised to it's power is a unique bit pattern (8 bit binary string). Each byte of the user data needs to be converted from 8 bit binary into the corresponding power of α before carrying out the modulo operation. The term x is used to denote the position of the bit in the string for example, x^2 in the track data would be the third lowest order byte.

10.2.2 Column parity

Column parity shall be generated for each column of byte information across all user data frames on the track using a shortened Reed-Solomon code RS(255-237,251-237), also called RS(18,14). Highest order term for track CP shall be in frame 4 and lowest order term shall be in frame 1:

$$CP = [x^4M(x)] \text{ mod } g(x) \text{ over } GF(2^8)$$

where

$M(x)$ = user data for a column from frame 5 to frame 18 in polynomial form (length is fixed at 14). Highest order term is in frame 18 and lowest order term in frame 5. See [Figure 11](#);

$g(x) = (x-\alpha)(x-\alpha^2)(x-\alpha^3)(x-\alpha^4)$ = generator polynomial for the Reed-Solomon CP;

$GF(2^8)$ = a finite Galois field of 256 different 8 bit binary symbols generated by a primitive polynomial defined as: $p(x) = 1 + x^2 + x^3 + x^4 + x^8$;

x^i = bit at position i .

NOTE 1 The CP will allow the correction of up to 4 "erasures" with a probability of 1. More than 4 "erasures" on a track cannot be corrected. The term "erasure" is used in RS codes and denotes an area that is not readable, the decoding process then treats that sector as "erased" or not there.

NOTE 2 The CP is the remainder of $x^4M(x)$ divided by $g(x)$ using modulo operations. The term "shortened" before Reed-Solomon means that there are higher order terms with a value of 0 (237 in this case) which do not need to be considered in modulo operations.

NOTE 3 This code results in $100\% * 4/18 = 22,2\%$ error correction overhead.

10.2.3 Frame CRC

The frame shall include a CRC comprised of one 8 bit byte generated as follows and added to the end of the frame data:

$$CRC = [xM(x)] \text{ mod } g(x) \text{ over } GF(2^8)$$

where

$M(x)$ = user data for frame and frame ID number from byte 1 to byte N-1 in polynomial form (length depends on card type used). Highest order term is in byte 1 and lowest order term in byte N-1. See [Figure 11](#);

$g(x) = (x-\alpha)$ = generator polynomial for frame CRC;

$GF(2^8)$ = a finite Galois field of 256 different 8 bit binary symbols generated by a primitive polynomial defined as: $p(x) = 1 + x^2 + x^3 + x^4 + x^8$;

x^i = bit at position i.

NOTE 1 The frame CRC will allow the detection of up to 1 error with a probability of 1. For more than 1 error the probability of detecting errors is equal to 1-1/256.

NOTE 2 The CRC is the remainder of $xM(x)$ divided by $g(x)$ using modulo operations.

NOTE 3 The frame ID number is an 8 bit byte for all calculations but is written on the card as a 5 bit sequence.

11 Decoding

The general steps to follow for decoding data for each track after reading are shown in Table 5. Specific implementations are left to the user.

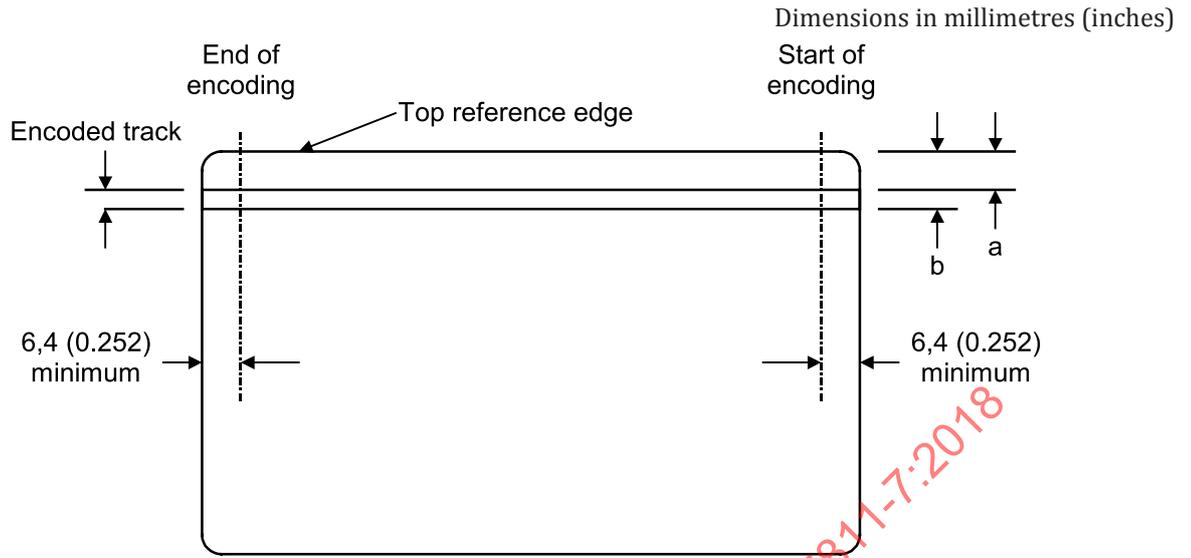
Table 5 — Decoding process

Step	Process
1	Read track data from card.
2	Expand frame ID to 8 bit size.
3	Create data structure as shown in Figure 11 .
4	Check track CRC (result of $[x4M(x) + CRC] \text{ mod } g(x)$ over $GF(28)$, (result 0 = no errors). If a track CRC error occurs, begin error correction.
5	Check CRC of each frame. Frame errors indicate an error location for all columns at that byte position.
6	If the quantity of frame errors is beyond the capability of the decoder, post a Media Error and quit. Otherwise, continue to the next steps.
7	Fill the frames at locations indicated by frame CRC errors with hexadecimal zero (00) bytes (data erasure is assumed).
8	Column parity is then used along with frame CRC error locations to reconstruct data byte values (Reed-Solomon code RS(18,14) is used). These byte values are inserted at column-positions indicated by corresponding frame errors.
9	Check track CRC (result of $[x4M(x) + CRC] \text{ mod } g(x)$ over $GF(28)$ must be all 0 bytes for no errors).
10	Process the corrected data for output.
11	Process all tracks in the same manner.

NOTE The simplest decode process assumes “data erasure”, but other extended processes are possible. Numerous references are available describing specific decoding implementations. See [Annex D](#).

12 Location of encoded tracks

Each encoded track shall be located between the two lines as shown in [Figure 12b](#). The start of encoding is located at the centreline of the first transition of the first FSC. The end of encoding is located at the centreline of the last transition of the last FSC.



Dimensions in mm (inches)

Track	Dimension		
Track H1	a	5,75 (0.226)	maximum
	b	6,75 (0.266)	minimum
Track H2	a	7,45 (0.293)	maximum
	b	8,45 (0.333)	minimum
Track H3	a	9,15 (0.360)	maximum
	b	10,15 (0.400)	minimum
Track H4	a	10,85 (0.427)	maximum
	b	11,85 (0.467)	minimum
Track H5	a	12,55 (0.494)	maximum
	b	13,55 (0.534)	minimum
Track H6	a	14,25 (0.561)	maximum
	b	15,25 (0.601)	minimum

Figure 12 — Location of encoded tracks

Annex A (informative)

Compatibility of magnetic stripes (ISO/IEC 7811-6, ISO/IEC 7811-7)

The purpose of this annex is to explain to users the limitations of the term 'read compatibility' as mentioned in the scope of this document, and applied to ISO/IEC 7811-6 and ISO/IEC 7811-7.

The high density tracks specified in this document are arranged such that a reader designed to read these tracks will also be able to read the normal tracks defined in ISO/IEC 7811-6. This also allows a combination of normal and high density tracks to coexist on the same magnetic stripe, for example normal tracks 1 and 2 with high density tracks H5 and H6. It is not possible to interchange write heads in the same way that read heads can be.

The increased density specified in this document will result in a lower signal amplitude compared to ISO/IEC 7811-6: approximately 40 % based on testing of PTB. The exact ratio between these two signal amplitude values will depend on the type of magnetic stripes used.

The following is an overview of the main differences between this document and ISO/IEC 7811-2 and ISO/IEC 7811-6.

- 1) The bit density has increased from 8,27 bits/mm (track 1,3) and 2,95 bits/mm (track 2) to 40 bits/mm for all tracks which results in 234 bytes of user data per track for an ID-1 size card.
- 2) The encoding technique referred to as MFM is used in place of F2F. This change doubles the data storage density for the same minimum transition spacing with only a small reduction in the self-clocking ability.
- 3) The 3 tracks have been replaced by 6 tracks that are approximately half the width so that they occupy the same space on the card. These are located so that readers designed to read the high density tracks will also be able to read cards conforming to ISO/IEC 7811-2 and ISO/IEC 7811-6.
- 4) Data is distributed in frames with synchronisation characters to aid in error recovery, and there is a CRC for each frame and a track CRC. Data recorded on each track is independent from other tracks (error detection and correction for each track is on the same track), even though it may be only part of the message on the card.
- 5) Error detection and correction is included using a shortened Reed-Solomon code. The amount of error correction is fixed for all card sizes.
- 6) The magnetic stripe area extends completely to the left and right edge of the card.
- 7) In [Table 1](#), test density values have changed, the resolution requirement has changed from 0,7 to 0,8, the test for Waveform has been deleted, and Overwrite has been added to the requirements.
- 8) The maximum coercivity in Table C.1 has been changed from 335 kA/m (4200 Oe) to 250 kA/m (3125 Oe).