INTERNATIONAL STANDARD

ISO/IEC 11694-4

Third edition
2008-07-01

Identification cards — Optical memory cards — Linear recording method —

Part 4: Logical data structures

Cartes d'identification — Cartes à mémoire optique — Méthode d'enregistrement linéaire —

Partie 4: Structures de données logiques

Reference number
ISO/IEC 11694-4:2008(E)

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Published in Switzerland

Contents

Page

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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of the joint technical committee is to prepare International Standards. 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.

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.

ISO/IEC 11694-4 was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 17, *Cards and personal identification*.

This third edition cancels and replaces the second edition (ISO/IEC 11694-4:2001), which has been technically revised.

ISO/IEC 11694 consists of the following parts, under the general title *Identification cards — Optical memory cards — Linear recording method*:

— *Part 1: Physical characteristics*

— *Part 2: Dimensions and location of the accessible optical area*

— *Part 3: Optical properties and characteristics*

— *Part 4: Logical data structures*

— *Part 5: Data format for information interchange for applications using ISO/IEC 11694-4, Annex B*

— *Part 6: Use of biometrics on an optical memory card*

Introduction

ISO/IEC 11694 defines the parameters for optical memory cards and the use of such cards for the storage and interchange of digital data.

ISO/IEC 11694 recognizes the existence of different methods for recording and reading information on optical memory cards, the characteristics of which are specific to the recording method employed. In general, these different recording methods will not be compatible with each other. Therefore, ISO/IEC 11694 is structured to accommodate the inclusion of existing and future recording methods in a consistent manner.

This part of ISO/IEC 11694 is specific to optical memory cards using the linear recording method. Characteristics which apply to other specific recording methods are defined in separate standards documents.

This part of ISO/IEC 11694 defines the logical data structures and the extent of compliance with, addition to, and/or deviation from the relevant base document ISO/IEC 11693.

Identification cards — Optical memory cards — Linear recording method —

Part 4: Logical data structures

1 Scope

This part of ISO/IEC 11694 defines the logical data structures for optical memory cards necessary to allow compatibility and interchange between systems using the linear recording method.

2 Normative references

The following referenced documents are indispensible for the application 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/IEC 11693, *Identification cards — Optical memory cards — General characteristics*

ISO/IEC 11694-1, *Identification cards — Optical memory cards — Linear recording method — Part 1: Physical characteristics*

ISO/IEC 11694-2, *Identification cards — Optical memory cards — Linear recording method — Part 2: Dimensions and location of the accessible optical area*

ISO/IEC 11694-3, *Identification cards — Optical memory cards — Linear recording method — Part 3: Optical properties and characteristics*

ISO/IEC 10373-5, *Identification cards — Test methods — Part 5: Optical memory cards*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/IEC 11693, ISO/IEC 11694-1, ISO/IEC 11694-2, ISO/IEC 11694-3 and the following apply.

3.1
data bit
area which represents data on an optical memory card

NOTE It is usually a mark which has a different reflectivity and/or phase difference from the background reflectivity.

3.2
data track
area located between adjacent track guides where data are written and/or read

3.3
error correction code
ECC
code designed to correct certain kinds of errors in data

3.4
error detection and correction
EDAC
family of methods in which redundancy is added to a message block, at the time the message block is recorded, in known fashion, and in which, upon read back, a decoder removes the redundancy and uses the redundant information to detect and correct erroneous channel symbols

3.5
modulation code
system for coding which transforms information bits into some physical representation for recording onto the optical memory card

3.6
data pitch
distance between corresponding points on adjacent data spots

3.7
sector
minimum unit of data that can be accessed on a card for any read and/or write command

3.8
address
character or group of characters that identifies a register, a particular part of storage, or some other data source or destination

3.9
BEST code
Burst and random-Error correction-System for-Teletext code
272,190 majority-logic decodable cyclic error detection and correction code

3.10
code word
fixed length sequence of bits resulting from encoding a message block using some error detection and correction method

3.11
data area
portion of the accessible optical area that can be written and/or read under the control of the application software

3.12
error detection code
EDC
set of code words in which elements conform to specific rules

NOTE If errors occur, the resulting presentation will not conform to the rules, indicating that errors are present.

3.13
error message
message returned by a card drive unit to indicate that the card inserted in the drive cannot be processed

3.14
information
totality of data present on the card including service, system and user data for interchange independent of the method of recording

NOTE Information can be replicated or written by means of an optical beam.

3.15
interleaving
process of distributing the physical location of code words to render the data more immune to clustered bit errors

3.16
message block
fixed length sequence of data bits which is encoded using error detection and correction methods to form a code word

3.17
MFM-RZ
modified-frequency-modulation-return-to-zero
modification of MFM encoding with a return to zero so that a flux reversal is used to indicate a 1 bit and the lack of a flux reversal is used to indicate a 0 bit

NOTE Also referred to as 1,3 RLL.

3.18
NRZI-RZ
non-return-to-zero-inverted, return to zero
encoding similar to MFM-RZ (3.17) except that a transition does not occur between adjacent zeros

3.19
sector code word
sector data block encoded using an error detection and correction code

3.20
sector data block
block of data containing user data and system information

4 Format structure

This section details information which makes up the accessible optical area and is placed on cards during manufacture and/or at the time of card initialization.

Area	Subsets
Accessible optical area	Guard tracks and data area.
Data area	Format description tracks, test tracks, application description tracks and application area.
Application area	Application data and user data.

5 Track layout

Track layout information shall be preformatted on cards during manufacture and/or written to cards prior to use.

Tracks shall be arranged in reverse order beginning with the reference track, the last bottom guard track located nearest the reference edge.

The track layout is outlined below. Because the total number of tracks can vary, the numbers of all tracks located between the last user data track and the reference track are given in parametric form where *n* is the nominal number of tracks and *n+9* is the number of the last bottom guard track, the reference track.

Track Description	Track #	Hex
Guard track (last bottom)	*n*+9	
:	:	
Guard track (first bottom)	*n*	
Format description track	*n*-1 [a]	
Test track 1 (bottom)	*n*-2 [a]	
:	:	
Test track 4 (bottom)	*n*-5 [a]	
Application description track	*n*-6 [a,b]	
Last user data track	*n*-7 [a,b]	
:	:	
First user data track	6 [a,b]	0006
Application description track	5 [a,b]	0005
Test track 4 (top)	4 [a]	0004
:	:	:
Test track 1 (top)	1 [a]	0001
Format description track	0 [a]	0000
Guard track (last top)	-1	3FFF
:	:	:
Guard track (first top)	-10	3FF6

[a] Data area
[b] Application area

5.1 Track layout examples

This section provides information concerning data structures that support the optional card layouts described in ISO/IEC 11694-2.

5.1.1 Cards with moderate data capacity

NOTE These layouts support the inclusion of a magnetic stripe and/or signature panel.

5.1.1.1 Normal density mode

Nominal number of tracks 2583. This layout shall contain 2603 tracks, of which 2571 shall be user data tracks. Tracks shall be numbered sequentially, in reverse order, beginning with track 2592, the reference track.

5.1.1.2 High density mode

Nominal number of tracks 4144. This layout shall contain 4164 tracks, of which 4132 shall be user data tracks. Tracks shall be numbered sequentially, in reverse order, beginning with track 4153, the reference track.

5.1.2 Cards with small data capacity

NOTE These layout options support the inclusion of a magnetic stripe, IC chip with contacts, embossing and/or signature panel.

5.1.2.1 Normal density mode

Nominal number of tracks 1000. This layout shall contain 1020 tracks, of which 988 shall be user data tracks. Tracks shall be numbered sequentially, in reverse order, beginning with track 1009, the reference track.

5.1.2.2 High density mode

Nominal number of tracks 1612. This layout shall contain 1632 tracks, of which 1600 shall be user data tracks. Tracks shall be numbered sequentially, in reverse order, beginning with track 1621, the reference track.

5.1.3 Cards with maximum data capacity

NOTE These layouts support the inclusion of a magnetic stripe and/or signature panel.

5.1.3.1 Normal density mode

Nominal number of tracks 3425. This layout shall contain 3445 tracks, of which 3413 shall be user data tracks. Tracks shall be numbered sequentially, in reverse order, beginning with track 3434, the reference track.

5.1.3.2 High density mode

Nominal number of tracks 5492. This layout shall contain 5512 tracks, of which 5480 shall be user data tracks. Tracks shall be numbered sequentially, in reverse order, beginning with track 5501, the reference track.

The total number of tracks may vary dependent on the application requirements; however, in all cases, tracks shall be arranged in order, and numbered sequentially, beginning with the reference track.

6 Track guides

Track guides shall be uniformly spaced across the card and shall extend the length of the accessible optical area. The accumulated tolerances across the width of all track guides shall be less than or equal to 0,01 % at 25 °C.

The width of the track guides shall be 2,2 µm ± 0,5 µm. The distance from the centre of one track guide to the centre of an adjacent track guide shall be 12,0 µm ± 0,1 µm in the normal density mode and 7,5 µm ± 0,1 µm in the high density mode.

A maximum of ten track guides can have breaks exceeding 100 µm; no breaks shall exceed 500 µm.

7 Guard tracks

There shall be 20 guard tracks, ten located directly above and ten directly below the user data area to enable the optics to locate the user data tracks and prevent the optical head from over running the accessible optical area if auto-tracking is lost.

Guard tracks *-1* to *-10* and *n* to *n+9* shall contain a copy of the card manufacturing information from sector 0 of the format description track formatted using sector type 13. The excess bytes shall be filled with zeros.

8 Format description tracks

There shall be two format description tracks, one located at the top and the other at the bottom of the data area, that shall be preformatted with information that permits the card drive to automatically switch between formats and allows later generations of card formats to be introduced alongside earlier generations. To achieve this upward compatibility, the format description track must be of identical format and location on all generations of card formats.

Format description tracks shall be created when an optical card is manufactured. Card drives shall be unable to write to this track and an optical card shall be deemed invalid unless the format description track is present.

8.1 Content

Each format description track shall contain six sectors of 162 bytes. Sectors 0, 2, and 4 shall contain data formats and card manufacturing information; sectors 1, 3, and 5 shall contain the error message to be returned in case of improper use of the card.

Each format description track shall contain the required fields as described below and as shown in Tables 1 and 2. All distance measurements are in the units of microns unless otherwise specified.

— **data format identifier:** A format identifier unique to each variation in format.

— **track pitch:** The distance from the centre of one track guide to the centre of an adjacent track guide.

— **nominal number of data tracks:** The number of data tracks contained in the data area. See section 5.

— **usable track length:** The maximum track length available for written information and preformatted data.

— **type of preformat data:** The method of coding the preformat data.

— **data encoding identifier:** An encoding scheme identifier defining the encoding scheme used.

— **max. sectors per track:** The maximum number of sectors per track allowable.

— **preformatted data bit size:** The nominal size of the preformatted data bits.

— **written data bit size:** The nominal size of the written data bits.

— **written data pitch:** The minimum spacing from the centre of one written bit to the centre of an adjacent written bit.

— **sector type identifier:** An identifier code indicating the type of card sector.

— **EDAC scheme identifier:** An identifier code indicating the EDAC scheme used.

— **media type identifier:** An identifier code indicating the type of media used.

— **card type identifier:** An identifier code indicating the type of card used.

— **manufacturing plant identifier:** An identifier code used to indicate where the card was made.

— **master identifier:** A four character identifier indicating the master used to make the cards.

— **serial number of master:** A four character identifier indicating the serial number of the master used to make the cards.

— **reserved for future use:** Area reserved for future usage.

In Tables 1 and 2 fields marked *Std* shall be controlled by the standards body which will assign values and keep a control register of the values assigned. Fields marked *Mfg* shall be assigned values by the individual manufacturers of the cards in cooperation with the card issuer.

9 Test tracks

There shall be eight test tracks, four at the top and four at the bottom of the data area, for card drive autodiagnosis and calibration purposes.

9.1 Content - Test track 1 (top and bottom)

The first test track shall consist of one sync marker, four leadins, six BOS (see 14.2.3), a continuous high frequency pattern (0000) 12784 bits long, 24 sector padding bits, one sync marker, six BOS and ending with four leadins.

9.2 Content - Test track 2 (top and bottom)

The second test track shall consist of one sync marker, four leadins, six BOS, a continuous low frequency pattern (0101) 12784 bits long, 24 sector padding bits, one sync marker, six BOS and ending with four leadins.

9.3 Content - Test track 3 (top and bottom)

The third test track shall consist of one long sector containing random data generated using the generator polynomial defined in 16.1.2 according to the following algorithm (*x* is an unsigned 16-bit number):

Step 0: If first generated value, set *x*=8000 hex, go to step 4.

Step 1: Set *x* to the last generated value.

Step 2: Shift *x* by one position to the left, that is, multiply by 2 modulo 2^{16}.

Step 3: If bit 15 of the last generated value is set, take the bit by bit exclusive *OR* of *x* with 1021 hex and put the result in *x*.

Step 4: Return *x*.

The series of random numbers begin with hex 8000, 1021, 2042, 4084, 8108, 1231, 2462, 48C4, 9188, 3331, 6662, CCC4, 89A9, etc.

9.4 Content - Test track 4 (top and bottom)

The fourth test track shall consist of 15 type 0 sectors containing incremental data 00, 01, 02, ...FF, 00, 01, 02, ...FF, 00, 01, 02, ...84 hex.

10 Application description tracks

Two application description tracks, one at the top and the other at the bottom of the data area, contain a description of the card application along with any error message to be returned if there is a conflict between card and application.

These tracks are optional and can be created either during card manufacture and/or written to the card using an application program. Each application description track shall contain 1 sector of 1112 bytes (sector type 4). If application description tracks are not required, these tracks shall be left blank.

11 Data tracks

Written and/or preformatted data shall be located within data tracks and centred between adjacent track guides to a tolerance of ± 0,5 µm in the y-axis. Each data track can contain a maximum of 69,64 mm of written and/or preformatted data.

12 Data bits

Written and/or preformatted data bits shall be 2,2 µm ± 0,5 µm in size and the minimum distance from the centre of one data bit to the centre of an adjacent data bit shall be 5,0 µm ± 0,3 µm.

13 Reference points

The reference track and reference edges defined in ISO/IEC 11694-2 apply unless otherwise specified.

13.1 First data bit

The first data bit shall be located on the reference track and is part of the track ID. The first data bit closest the right edge of the card shall be located at 77,4 mm ± 0,7 mm in the x-axis.

14 Track components

14.1 Track ID

Written and/or preformatted track ID shall identify the physical address of each data track and sector. The preformatted track ID is contained in the preformatted track header. The written track ID is contained in the sector structure for sector types 0 to 5 and at the end of the track for sector types 7 to 15.

14.2 Preformatted track header

The preformatted track header shall consist of 488 bits beginning with one sync marker followed by four leadins (two minimum) and six BOS where the sector number of the track sector address is zero.

NOTE A track is written by scanning the preformatted track header first. A written track can be read in either direction, that is from right to left or left to right.

14.2.1 Sync marker

A unique 8-bit pattern which cannot be reproduced by any other data using the current modulation code. See Figure 2.

NOTE When loss of synchronization occurs during reading, data can be resynchronized after sync marker detection.

14.2.2 Leadin

A series of 48 bits beginning with 40 bits all set to 1 followed by an 8-bit sync marker.

14.2.3 Beginning of sector (BOS)

A series of 48 bits beginning with a 20-bit track sector address field, followed by a 4-bit position field which counts the repetition of the BOS, 16 bits of EDC and terminating with a sync marker. The argument of the EDC polynomial is given by the track sector address and the position field. See Figure 1.

14.2.3.1 Track sector address (TSA)

The track sector address shall consist of 20-bits beginning with 14-bits specifying the track address followed by 6-bits specifying the sector address.

14.2.3.2 Position field

Four bits which count the repetition of identical BOS data. Counting is done with negative numbers ending at -1 expressed in two's complement. Since data are repeated six times, the position fields contain respectively -6, -5, -4, -3, -2 and -1.

EXAMPLE (-1) is expressed as 1111 and (-5) as 1011.

14.2.3.3 Error detection code (EDC)

A code computed using the generator polynomial found in 16.1.2.

14.3 Sectors

Sectors are defined by the amount of user data in bytes and the number of sectors which can be written to a single data track. The type and size of each sector, the respective auxiliary field and the number of padding bits are shown in Table 3.

14.3.1 Sector types 0 to 5

The structure of a sector is shown in Figure 8. Each sector shall consist of:

— User data, auxiliary fields and system data encoded with EDAC (except for type-5 which shall contain only user data bytes) as described in section 16.1.3 and 16.1.4.

— Sync marker.

— Six BOS containing the address of the sector which follows.

14.3.2 Sector types 7 to 15

These sector types shall be written with the maximum possible interleaving factor (48). There shall be one sync marker within each frame and all sync markers shall be written simultaneously at the first write to a track containing these type sectors. For a track containing these types of sectors, the portion located between the two preformat track header and written track header shall consist of 272 frames of 48 bits each. See Figure 7.

The frame number *i* shall consist of a sync marker and 40 bits containing the bit number *i* of each code word contained in the track. See Figure 9.

These sector types are defined by the number *m* of message blocks which are written within the sector and the interleaving factor used to write the sector. The amount s_d of user data written in a given sector is expressed in bytes as:

$$s_d = \text{floor}\,(190\,m/8) - 4$$

The size s_a of the auxiliary field available is the sector data is expressed in bits as:

$$s_a = (190\,m) \bmod 8$$

14.3.3 Sector type 7

The number of message blocks written in one sector can vary such that sectors on the same track may have different sizes. However, the sum of the message blocks of all type-7 sectors contained within one full track must be equal to 40.

14.3.4 Sector types 8 to 15

The maximum number of sectors per track, n, is obtained from the number m of message blocks as:

$$n = 40/m$$

All sectors on a given track shall have the same length.

NOTE Additional sector types are allowed. However, it is intended that every card drive support at least those sector types specified in Table 3. Applications which use additional sector types must indicate this in the application description track. Using additional sector types may eliminate the possibility of interchange of cards in other card drives.

All sectors within a given track shall be identical in type and partially written tracks shall only be appended with sectors of the same type as those previously written on the track.

NOTE Sector types/sizes have been defined to maximize the efficiency of data storage on a track and may vary by modulation code.

14.3.5 Auxiliary field

Since the EDAC scheme uses a message block 190 bits long and the sector data consists of an integral number of bytes, bits must be added to form an integral number of message blocks. These additional bits, called auxiliary fields, are processed by the EDAC scheme and are available to the application. The size of the auxiliary field (s_d) can be computed from the number (m) of message blocks contained in the sector:

$$s_d = (190\ m) \bmod 8$$

NOTE If m is a multiple of 4, the size of the auxiliary field is zero. Such sectors have no auxiliary fields. See Table 3.

14.3.6 Sector padding bits

Continuous zero bits which are added to each sector to make the sector length equal to an integral number of 48-bit data frames. Since these bits are not processed by the EDAC, they are not available to the application.

14.3.7 Data frame

A 48 bit long data structure. For sector types 7 to 15 the data frames contain 40 user data bits terminated by an 8-bit sync marker. See Figure 3.

14.4 Track structure

The structure of a track allows the track to be read from either direction, that is from right to left or left to right.

14.4.1 Structure of a full track, sector types 0 to 5

A full track of sector types 0 to 5 shall consist of a preformatted track header, at least one sector, and a termination sequence composed of four leadins maximum (two minimum). The track structure shall be symmetric and shall always be terminated by a sync marker. See Figure 5.

14.4.2 Structure of a full partially filled track, sector types 0 to 5

A partially filled track shall consist of a preformatted track header and at least one sector of data and shall be terminated by the six BOS written at the end of the last filled sector. Data added to the track shall be written immediately after the sync marker contained in the last BOS, no gap shall be left between the sync marker and the beginning of the next sector. See Figure 6.

14.4.3 Structure of a full track, sector types 7 to 15

A full track of maximum interleave sectors, types 7 to 15, shall consist of a preformatted track header, 272 data frames, a written track header, and shall be terminated by at least four leadins maximum (two minimum). The first data frame shall contain the first bit of each code word (a track shall contain a maximum of 40 code words), the second data frame shall contain the second bit of each code word, ..., the 272nd data frame will contain the last data bit of each code word. The end of each data frame shall contain a 8-bit sync marker. The sector number of the written track header is set to one.

The structure of a track filled with sector types 7 to 15 is shown in Figure 7.

14.4.4 Structure of a partially filled track, sector types 7 to 15

A partially filled track of maximum interleave sectors, types 7 to 15, shall be identical to that of a filled track. In case of a track which is partially filled, the bits corresponding to the sectors which have not yet been written are missing in every frame. The sync markers for each data frame, written track header and termination leadins shall be written with the first sector. Sectors with maximum interleave can be written in any order after the first sector has been written. See Figure 7.

15 Measurement

The reading/writing test conditions outlined in ISO/IEC 11694-3 apply, unless otherwise specified, when observing the optical characteristics.

15.1 Preformatted data measurement

Track pitch, track guide width, and preformatted data bit size shall be measured. The average of a minimum of ten measurements each shall fall within the specified range.

15.2 Preformatted data characteristics

The following characteristics shall be achieved when scanning a preformatted portion of the accessible optical area containing high frequency data (5 µm bit pitch), and low frequency data (10 µm bit pitch).

To achieve the expected results, tests shall be conducted in accordance with the procedures described in ISO/IEC 10373-5.

15.2.1 Low frequency recovery

The low frequency recovery value shall be greater than or equal to 0,7. See ISO/IEC 11694-3.

15.2.2 Amplitude comparison

The amplitude comparison value shall be greater than or equal to 0,4. See ISO/IEC 11694-3.

15.2.3 Signal overlap

The signal overlap (S_O) divided by the high frequency amplitude (A_{HF}) shall be greater than or equal to 0,5. See ISO/IEC 11694-3.

15.3 Written data characteristics

The following characteristics shall be achieved when scanning a written portion of the accessible optical area containing high frequency data (5 µm bit pitch), and low frequency data (10 µm bit pitch).

To achieve the expected results, tests shall be conducted in accordance with the procedures described in ISO/IEC 10373-5.

15.3.1 Low frequency recovery

The low frequency recovery value shall be greater than or equal to 0,7. See ISO/IEC 11694-3.

15.3.2 Amplitude comparison

The amplitude comparison value shall be greater than or equal to 0,4. See ISO/IEC 11694-3.

15.3.3 Signal overlap

The signal overlap (S_O) divided by the high frequency amplitude (A_{HF}) shall be greater than or equal to 0,5. See ISO/IEC 11694-3.

16 Data encoding

This section describes the method for encoding and storing data on optical cards using the various sector types.

16.1 Error detection and correction

Two levels of error control shall be applied before data are written to a sector of an optical card. Data shall first be collected into a block containing user data and certain system information. A first level EDC shall be applied this block to form a sector data block. The sector data block shall be further encoded using an interleaved EDAC coding scheme.

The degree of interleaving shall depend on the sector type. Sector code words, which are generated from sector data blocks, contain data plus parity-check bits which allow the detection of bit-errors and the eventual correction of some of these bit-errors during decoding.

The final code word shall be written to the optical card using a modulation code to represent the binary bits of the code word.

An EDAC coding scheme shall be written, in addition to user data, to all sector types except type-5 which shall be written without EDAC.

16.1.1 Structure of sector data block

16.1.1.1 Length

The length of the sector data block shall be a multiple of 190 bits. The multiple shall depend on the sector type as given in Table 3 and the value shall be equal to the interleaving factor of the EDAC code to be applied later. The block shall be filled with user data and shall end with the lower 16 bits of the track sector address, the auxiliary field, if any, and 16 bits of EDC resulting from the application to the three items above. See Figure 10.

16.1.1.2 Construction

For all sector types, except type-5 sectors, the sector data block shall be constructed in the following manner.

- The lower 16 bits of the track sector address shall be appended to the user data block, most significant bit first.
- Data shall be divided into 190-bit message blocks with the last block having auxiliary bits added after the track sector address to bring it up to 174 bits; adding 16 bits of EDAC to these 174 bits equals a complete 190-bit message block.
- The first level EDC is calculated across all the 190-bit message blocks with the 16 EDC parity-check bits appended to the last message block after the auxiliary bits, if any, most significant bit first. This makes the last block 190 bits.

16.1.2 First level error detection code

The first level EDC shall be computed using the generator polynomial:

$$G(x) = x^{16} + x^{12} + x^5 + 1$$

16.1.3 Second level sector block encoding

The sector data block shall be encoded using the EDAC described in 16.1.4 to form a sector code word of length *n* x 272 bits where *n* is the interleaving factor which is equal to the number of 190-bit message blocks in the sector data block. See Figure 12.

16.1.4 Error detection and correction code

Each sector data block shall be encoded using an interleaved code based on the BEST EDAC code generated by the polynomial:

$$g(x) = x^{82} + x^{77} + x^{76} + x^{71} + x^{67} + x^{66} + x^{56} + x^{52} + x^{48} + x^{40} + x^{36} + x^{34} + x^{24} + x^{22} + x^{18} + x^{10} + x^4 + 1$$

The basic code word for a message block of 190 bits has a length of 272 bits and forms the basis for the different interleaved codes used for each sector type as described in 16.1.5

16.1.5 Interleaving for sector types 0 to 5

The interleaved sector code word for a given sector type shall be constructed by encoding 190-bit message blocks forming the sector block. The resulting 272-bit code words shall be arranged in a rectangular matrix array, an interleaving frame, with dimensions *n* rows by 272 columns, where *n* is the interleaving factor. The value of *n* will depend on the sector type as given in Table 3. The interleaving frame shall be filled in by row and written to the optical card, column by column, with each column starting at row 1 as shown in Figures 12 and 13. The code word shall be written to the optical card using MFM-RZ encoding.

16.1.6 Type-5 sectors

For type-5 sectors, the sector data block shall consist of only user data bytes. See Figure 11. No track sector address or auxiliary bits shall be added nor shall the first level EDC be applied. The data shall be arranged in 272-bit blocks and interleaved as described in 16.1.5. See Figure 14.

16.1.7 Interleaving for sector types 7 to 15

The interleaved sector code word for a given sector type with maximum interleave is constructed by encoding 190-bit message blocks forming the sector block to obtain 82 parity bits which are appended to the 190 bit message block to form a 272 bit code word. The resulting 272 bit code words are inverted and are placed in a rectangular matrix array, an interleaving frame, with dimensions 40 rows by 272 columns.

The row at which the first message block is placed corresponds to the position of the sector along the track. Unused rows are set to zero.

EXAMPLE If the second sector of type 9 is written, only rows 3 and 4 will be filled with code words. The remaining rows are filled with zeroes.

The 272 frames are then read and sent to the modulation unit, one column corresponding to one data frame as shown in Figure 15. Data frames are written using the NRZI-RZ encoding which ensures that positions corresponding to the unused rows are not written on the card. If the track is empty, sync markers are written at the end of each data frame. If the track was partially filled, sync markers are not written. Figure 9 shows a frame resulting from the interleaving process.

With the sync marker located at the end of each data frame, a track with sector types 7 to 15 can be read using the MFM-RZ decoding used for sector types 0 to 5.

Right Edge

Track address (14 bits)	Sector address (6 bits)	Pos. field (4 bits)	EDC (16 bits)	Sync marker (8 bits)

Figure 1 — Structure of the beginning of sector

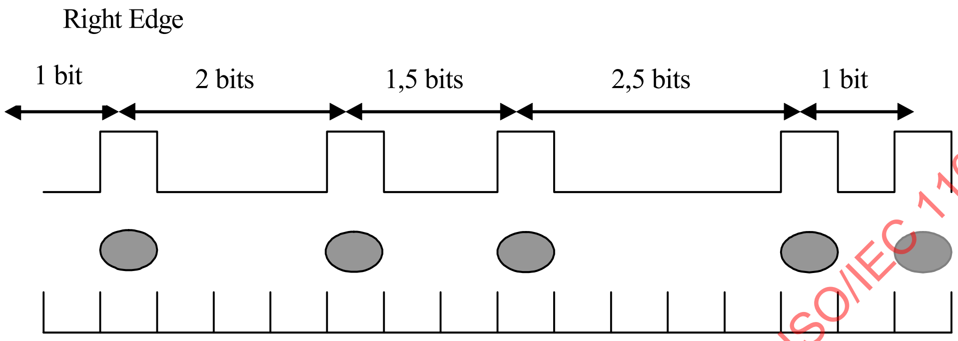

Figure 2 — Structure of the sync marker

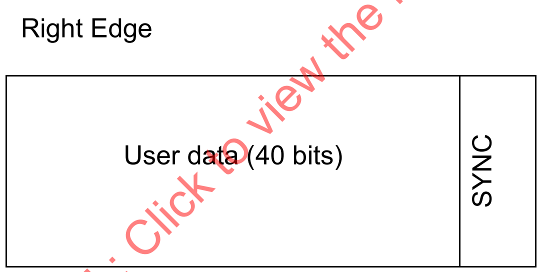

Figure 3 — Structure of a data frame

Right Edge (Bit)

19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}
Track number														Sector number					

Figure 4 — Track sector address format

Right Edge

SYNC	Leadin (2 min 4 max)	6x BOS	Sector 0	Sector 1	Other Sectors	Sector n	Leadin (2 min 4 max)

Preformat data (SYNC, Leadin, 6x BOS)

Figure 5 — Structure of a full track, sector types 0 to 5

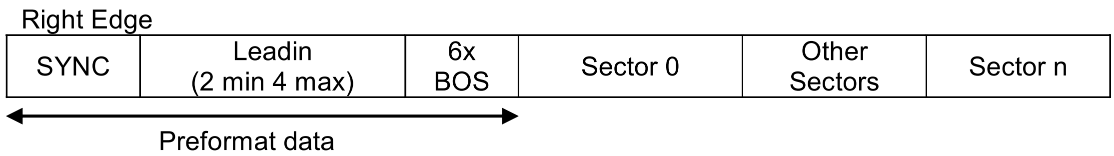

Figure 6 — Structure of a partially written track, sector types 0 to 3

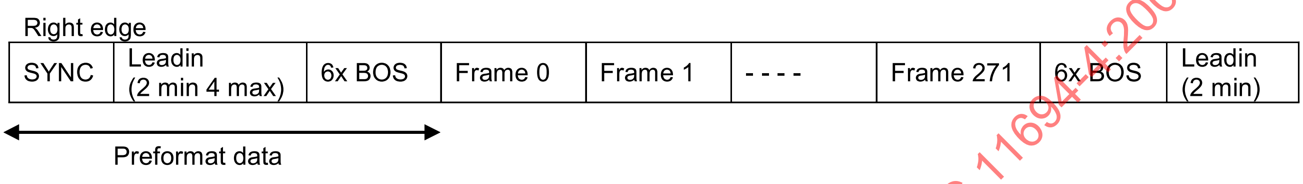

Figure 7 — Structure of a track with maximum interleave sectors, types 7 to 15 (full and partially written)

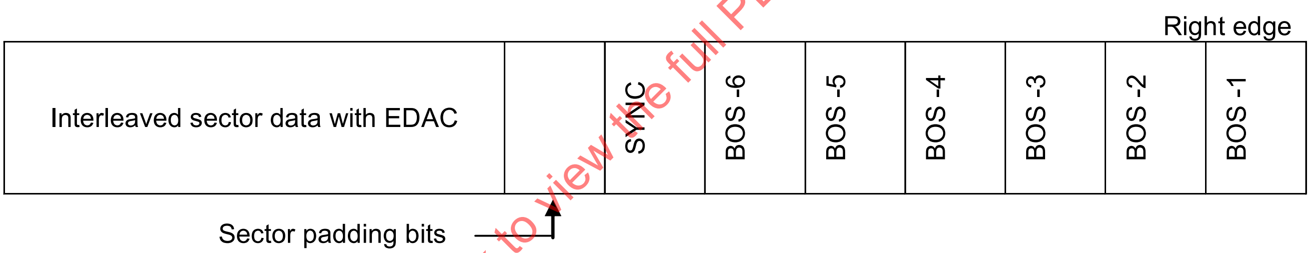

Figure 8 — Structure of a sector, types 0 to 5

Figure 9 — Structure of frame number *i* with maximum interleave sectors

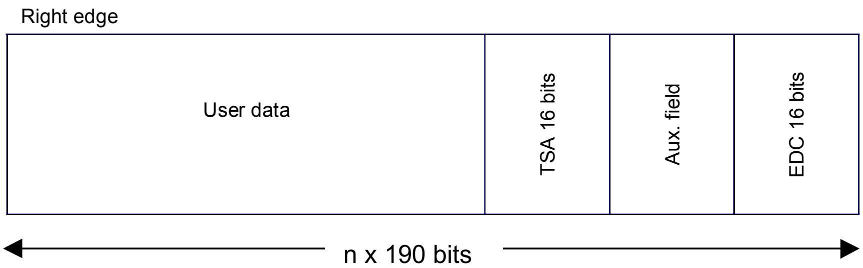

Figure 10 — Structure of a sector data block (type 5 sectors excepted)

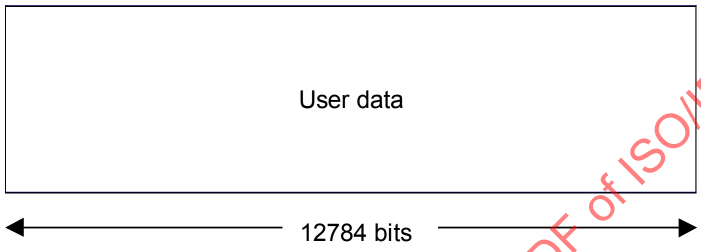

Figure 11 — Structure of a type 5 sector data block

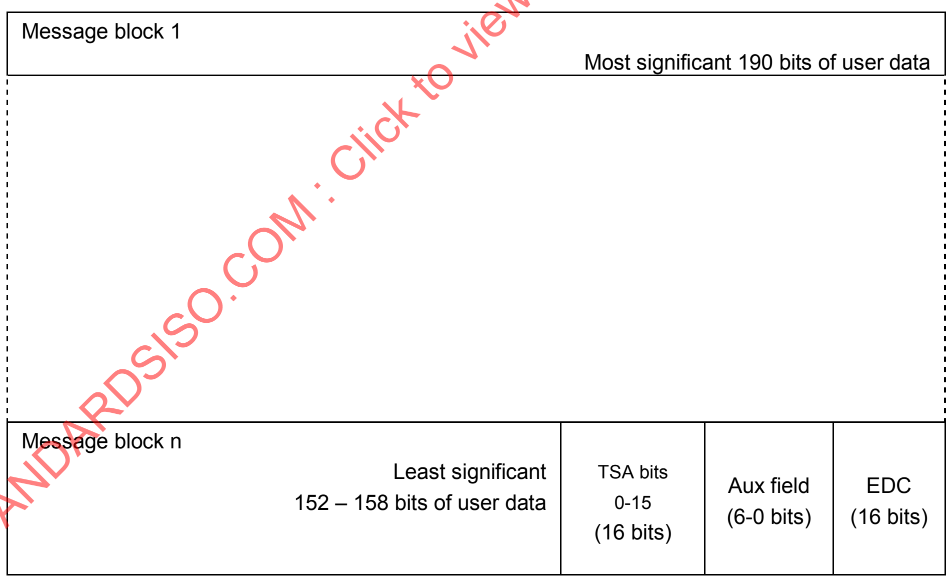

Figure 12 — Sector data before EDAC (all sector types except type 5)