INTERNATIONAL STANDARD

ISO/IEC 20563

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Information technology — 80 mm (1,23 Gbytes per side) and 120 mm (3,95 Gbytes per side) DVD-recordable disk (DVD-R)

Technologies de l'information — Disque enregistrable DVD (DVD-R) de 80 mm *(*1,23 Gbytes *par face) et* 120 mm *(*3,95 Gbytes *par face) de diamètre*

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

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.

Attention is drawn to the possibility that some of the elements of this International Standard may be the subject of patent rights. ISO and IEC shall not be held responsible for identifying any or all such patent rights.

International Standard ISO/IEC 20563 was prepared by JISC (as Standard JIS X.6245:1999) with document support and contribution from ECMA and was adopted under a special "fast-track procedure", by Joint Technical Committee JTC 1, *Information technology*, in parallel with its approval by national bodies of ISO and IEC.

Annexes A to N form a normative part of this International Standard. Annexes P to T are for information only.

Information technology — 80 mm (1,23 Gbytes per side) and 120 mm (3,95 Gbytes per side) DVD-recordable disk (DVD-R)

Section 1 — General

1 Scope

This International Standard specifies the mechanical, physical and optical characteristics of an 80 mm and a 120 mm DVD - Recordable disk to enable the interchange of such disks. It specifies the quality of the pre-recorded, unrecorded and the recorded signals, the format of the data, the format of the information zone, the format of the unrecorded zone, and the recording method, thereby allowing for information interchange by means of such disks. This disk is identified as a DVD - Recordable (DVD-R) disk. Once data has been recorded on a DVD-R disk it cannot be modified. It can be read many times. Further data may be appended.

This International Standard specifies

- 80 mm and 120 mm nominal diameter disks that may be either single or double sided,
- the conditions for conformance,
- the environments in which the disk is to be operated and stored,
- the mechanical and physical characteristics of the disk, so as to provide mechanical interchange between data processing systems,
- the format of the pre-recorded information on an unrecorded disk, including the physical disposition of the tracks and sectors, the error correcting codes and the coding method used,
- the format of the data and the recorded information on the disk, including the physical disposition of the tracks and sectors, the error correcting codes and the coding method used,
- the characteristics of the signals from pre-recorded and unrecorded areas on the disk, enabling data processing systems to read the pre-recorded information and to write to the disks,
- the characteristics of the signals recorded on the disk, enabling data processing systems to read the data from the disk.

This International Standard provides for interchange of disks between disk drives. Together with a standard for volume and file structure, it provides for full data interchange between data processing systems.

2 Conformance

2.1 Optical Disk

A claim of conformance shall specify the type of the disk, i.e. its size and whether it is single-sided or double sided. An optical disk shall be in conformance with this International Standard if it meets the mandatory requirements specified for this type.

2.2 Generating system

A generating system shall be in conformance with this International Standard if the optical disk it generates is in accordance with 2.1.

2.3 Receiving system

A receiving system shall be in conformance with this International Standard if it is able to handle an optical disk according to 2.1.

3 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

IEC 60950 *Safety of information technology equipment*

ISO 105-B02 *Textiles - Tests for colour fastness - Part B02: Colour fastness to artificial light: Xenon arc fading lamp test*

4 Terms and definitions

For the purpose of this International Standard, the following terms and definitions apply.

4.1 **Adhesive layer:** A layer of adhesive material bonding together the two parts of the disk.

4.2 **Channel bit:** The elements by which, after modulation, the binary values ZERO and ONE are represented on the disk by marks.

4.3 **Clamping Zone:** The annular part of the disk within which a clamping force is applied by a clamping device.

4.4 **Digital Sum Value (DSV):** The arithmetic sum obtained from a bit stream by allocating the decimal value 1 to bits set to ONE and the decimal value –1 to bits set to ZERO.

4.5 **Disk Reference Plane:** A plane defined by the perfectly flat annular surface of an ideal spindle onto which the Clamping Zone of the disk is clamped, and which is normal to the axis of rotation.

4.6 **Dummy substrate:** A layer which may be transparent or not, that is provided for the mechanical support of the disk and/or of a recorded layer.

4.7 **Entrance surface:** The surface of the disk onto which the optical beam first impinges.

4.8 **Groove:** A trench-like feature of the disk, applied before the recording of any information, and used to define the track location. The groove is located nearer to the entrance surface than the land. The recording is made on the centre of the groove.

4.9 **Land:** The area between the grooves.

4.10 **Optical disk:** A disk that accepts and retains information in the form of recorded marks in a recording layer and that can be read by an optical beam.

4.11 **Physical sector number:** A serial number allocated to the physical sectors on the disk.

4.12 **Read-only disk:** An optical disk in which the information has been recorded during manufacture of the disk. The information cannot be modified and can only be read from the disk.

4.13 **Recording layer:** A layer of the disk on, or in, which data is recorded.

4.14 **Reed-Solomon code:** An error detection and/or correction code for the correction of errors.

4.15 **Reserved field:** A field set to all ZEROs unless otherwise stated, and reserved for future standardization.

4.16 **Sector:** The smallest addressable part of a track in the information zone of a disk that can be accessed independently of other addressable parts.

4.17 **Space:** The area in a track between successive marks

4.18 **Substrate:** A transparent layer of the disk, provided for mechanical support of the recording or recorded layer, through which the optical beam accesses the recording or recorded layer.

4.19 **Track:** A 360° turn of a continuous spiral.

4.20 **Track pitch:** The distance between adjacent average physical track centrelines of the wobbled grooves for the unrecorded disk, or between adjacent physical track centrelines of the train of recorded marks for the recorded disk, measured in the radial direction.

4.21 **Zone:** An annular area of the disk.

5 Conventions and notations

5.1 Representation of numbers

A measured value is rounded off to the least significant digit of the corresponding specified value. For instance, it implies that a specified value of 1,26 with a positive tolerance of + 0,01 and a negative tolerance of - 0,02 allows a range of measured values from 1,235 to 1,275.

Numbers in decimal notations are represented by the digits 0 to 9.

Numbers in hexadecimal notation are represented by the hexadecimal digits 0 to 9 and A to F in parentheses.

The setting of bits is denoted by ZERO and ONE.

Numbers in binary notations and bit patterns are represented by strings of digits 0 and 1, with the most significant bit shown to the left.

Negative values of numbers in binary notation are given as Two’s complement.

In each field the data is recorded so that the most significant byte (MSB), identified as Byte 0, is recorded first and the least significant byte (LSB) last. In a field of 8*n* bits, bit $b_{(8n-1)}$ shall be the most significant bit (msb) and bit b_0 the least significant bit (lsb). Bit $b_{(8n-1)}$ is recorded first.

5.2 Names

The names of entities, e.g. specific tracks, fields, areas, zones, etc. are given a capital initial.

6 List of acronyms

6.1 General

BP	Byte Position
BPF	Band Pass Filter
CLV	Constant Linear Velocity
CPR_MAI	Copyright Management Information
DSV	Digital Sum Value
ECC	Error Correction Code
EDC	Error Detection Code
HF	High Frequency
ID	Identification Data
IED	ID Error Detection (code)
LPF	Low-Pass Filter
LSB	Least Significant Byte
MSB	Most Significant Byte
NRZI	Non Return to Zero Inverted
OPC	Optimum Power Control
PBS	Polarizing Beam Splitter
PCA	Power Calibration Area
PI	Parity (of the) Inner (code)
PO	Parity (of the) Outer (code)
PUH	Pick-Up Head
RMA	Recording Management Area
RMD	Recording Management Data
RS	Reed-Solomon (code)
SYNC Code	Synchronization Code
lsb	least significant bit
msb	most significant bit

7 General description

The 80 mm and 120 mm optical disks that are the subject of this International Standard consist of two substrates bonded together by an adhesive layer, so that the recording layer (single-sided disk) or recording layers (double-sided disk) are on the inside. The centring of the disk is performed on the edge of the centre hole of the assembled disk on the side currently read. Clamping is performed in the Clamping Zone. The DVD-Recordable Disk (DVD-R) may be either double-sided or single-sided with respect to the number of recording layers. A double-sided disk has a recording layer on the inside of each substrate. A single-sided disk has one substrate with the recording layer on the inside and a dummy substrate without a recording layer. An unrecorded DVD-R disk provides for the data to be irreversibly written by a drive. A recorded disk provides for the data to be read many times by an optical beam of a drive. A recorded DVD-R disk is equivalent to a DVD-Read-Only Disk. Figure 1 shows schematically a double-sided and a single-sided disk.

Type 1S consists of a substrate, a single recording layer, an adhesive layer, and a dummy substrate. The recording layer can be accessed from one side only. The nominal capacity is 1,23 Gbytes for an 80 mm disk and 3,95 Gbytes for a 120 mm disk.

Type 2S consists of two substrates, two recording layers, and an adhesive layer. From one side of the disk only one recording layer can be accessed. The nominal capacity is 2,26 Gbytes for an 80 mm disk and 7,9 Gbytes for a 120 mm disk.

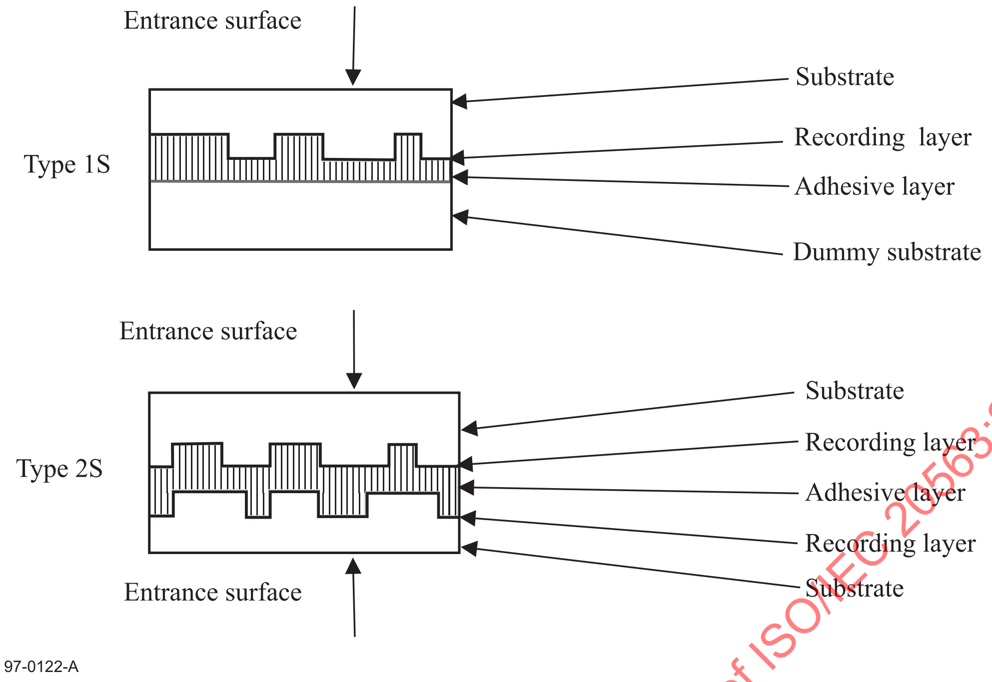


Figure 1 — Disk outline

8 General requirements

8.1 Environments

8.1.1 Test environment

The test environment is the environment where the air immediately surrounding the disk has the following properties.

	a) For dimensional measurements	b) For other measurements
temperature :	23 °C ± 2 °C	15 °C to 35 °C
relative humidity:	45 % to 55 %	45 % to 75 %
atmospheric pressure:	86 kPa to 106 kPa	86 kPa to 106 kPa

Unless otherwise stated, all tests and measurements shall be made in this test environment.

8.1.2 Operating environment

8.1.2.1 Recorded and unrecorded disk

This International Standard requires that an optical disk which meets all mandatory requirements of this International Standard in the specified test environment provides data interchange over the specified ranges of environmental parameters in the operating environment.

Disks used for data interchange shall be operated under the following conditions, when mounted in the drive supplied with voltage and measured on the outside surface of the disk.

The disk exposed to storage conditions shall be conditioned in the operating environment for at least two hours before operating.

temperature:	-25 °C to 70 °C
relative humidity:	3 % to 95 %
absolute humidity:	0,5 g/m^3 to 60 g/m^3
temperature gradient:	15 °C/h max.
relative humidity gradient:	10 %/h max.

There shall be no condensation of moisture on the disk.

8.1.2.2 Unrecorded disk environmental conditions during recording

The disk exposed to storage conditions shall be conditioned in the recording environment for at least two hours before operating.

temperature:	-5 °C to 55 °C
relative humidity:	10 % to 95 %
absolute humidity:	0,5 g/m^3 to 30 g/m^3

There shall be no condensation of moisture on the disk.

8.1.3 Storage environment

The storage environment is the environment where the air immediately surrounding the optical disk shall have the following properties.

temperature:	-20 °C to 50 °C
relative humidity:	5 % to 90 %
absolute humidity:	1 g/m^3 to 30 g/m^3
atmospheric pressure:	75 kPa to 106 kPa
temperature variation:	15 °C /h max.
relative humidity variation:	10 %/h max.

Recorded and unrecorded disks shall be in conformance to clauses 12 and 14 after being subjected to the light fastness test. See annex L.

8.1.4 Transportation

This International Standard does not specify requirements for transportation; guidance is given in annex T.

8.2 Safety requirements

The disk shall satisfy the requirements of Standard IEC 60950, when used in the intended manner or in any foreseeable use in an information system.

8.3 Flammability

The disk shall be made from materials that comply with the flammability class for HB materials, or better, as specified in Standard IEC 60950.

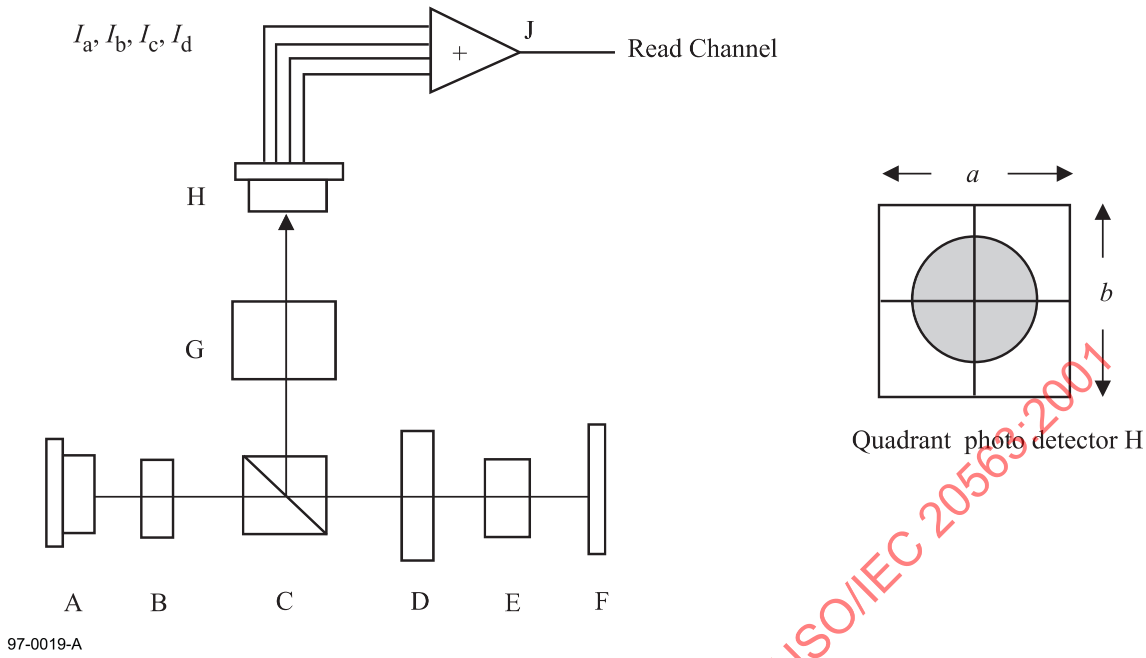
9 Reference measurement devices

The reference measurement devices for recorded disks and for unrecorded disks shall be used for the measurements of optical parameters for conformance with this International Standard. The critical components of these devices have specific properties defined in this clause.

9.1 Pick Up Head (PUH)

9.1.1 PUH for measuring recorded disks

The optical system for measuring the optical parameters is shown in figure 2. It shall be such that the detected light reflected from the entrance surface of the disk is minimized so as not to influence the accuracy of measurement. The combination of the polarizing beam splitter C with the quarter-wave plate D separates the incident optical beam and the beam reflected by the optical disk F. The beam splitter C shall have a p-s intensity/reflectance ratio of at least 100. Optics G generates an astigmatic difference and collimates the light reflected by the recorded layer of the optical disk F for astigmatic focusing and read-out. The position of the quadrant photo detector H shall be adjusted so that the light spot becomes a circle the centre of which coincides with the centre of the quadrant photo detector H when the objective lens is focused on the recorded layer. An example of such a photo detector H is shown in figure 2.



A Laser diode
B Collimator lens
C Polarizing beam splitter
D Quarter-wave plate
E Objective lens
F Optical disk
G Optics for the astigmatic focusing method
H Quadrant photo detector
I_a, I_b, I_c, I_d Output currents from the quadrant photo detector
J d.c. coupled amplifier

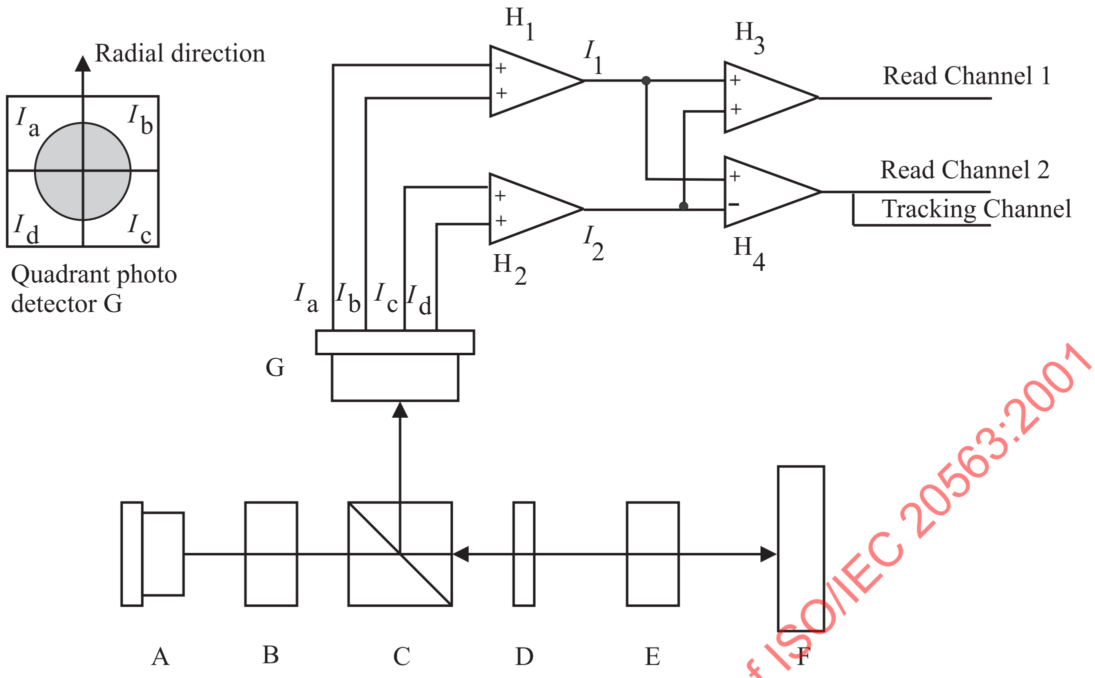
Figure 2 — Optical system of PUH for measuring Recorded disk

The characteristics of the PUH shall be as follows.

Wavelength (λ)	650 nm ± 5 nm
Polarization	circularly polarized light
Polarizing beam splitter	shall be used unless otherwise stated
Numerical aperture	0,60 ± 0,01
Light intensity at the rim of the pupil of the objective lens	60 % to 70 % of the maximum intensity level in radial direction, and over 90 % of the maximum intensity level in the tangential direction
Wave front aberration	0,033 λ rms max.
Relative intensity noise (RIN) 10 log [(a.c. light power density / Hz) / d.c. light power]	-134 dB/Hz max.

9.1.2 PUH for measuring unrecorded disks

The optical system for measuring the parameters is shown in figure 3. The optical system shall be used to measure the unrecorded disk specifications and for the recordings that are necessary for disk measurements. Different components and locations of the components are permitted, provided that the performance remains the same as the set-up in figure 3. The optical system shall be such that the detected light reflected from the entrance surface of the disk is minimized so as not to influence the accuracy of the measurements.



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A	Laser diode	F	Optical disk
B	Collimator lens	G	Quadrant photo detector
C	Polarizing beam splitter	H_1, H_2, H_3, H_4	d.c.-coupled amplifier
D	Quarter-wave plate	I_a, I_b, I_c, I_d	Output currents from the quadrant photo detector
E	Objective lens		

Figure 3 — Optical system of PUH for measuring unrecorded disks

The combination of polarizing beam splitter C and a quarter-wave plate D shall separate the entrance optical beam from a laser diode A and the reflected optical beam from an optical disk F. The beam splitter C shall have a p-s intensity reflectance ratio of at least 100.

The focused optical beam used for writing and reading data shall have the following properties:

Wavelength (λ)	635 nm ± 5 nm
Polarization	circularly polarized light
Numerical aperture	0,60 ± 0,01
Light intensity at the rim of the pupil of the objective lens	Over 35 % of the maximum intensity level in the radial direction and over 50 % of the maximum intensity level in the tangential direction
Wave front aberration	0,033 λ rms max.
Relative intensity noise (RIN) of the laser diode 10 log [(a.c. light power density /Hz) / d.c. light power]	- 130 dB/Hz max.

9.2 Measurement conditions

9.2.1 Recorded and unrecorded disk

Scanning velocity at a Channel bit rate of 26,15625 Mbit/s	3,84 m/s ± 0,03 m/s
Clamping force	2,0 N ± 0,5 N
Clamping Zone	See 10.5 and annex A.
Tapered cone angle	40,0°± 0,5° see annex E

9.2.2 Recorded disk

The measuring conditions for the recorded disk operational signals shall be as specified in annex F.

9.2.3 Unrecorded disk

The measuring conditions for the unrecorded disk operational signals shall be as specified in annex N

9.3 Normalized servo transfer function

In order to specify the servo system for axial and radial tracking, a function H_s is used (equation I). It specifies the nominal values of the open-loop transfer function H of the Reference Servo(s) in the frequency range 23,1 Hz to 10 kHz.

$$H_s(\mathrm{i}\omega) = \frac{1}{3} \times \left(\frac{\omega_o}{\mathrm{i}\omega}\right)^2 \times \frac{1+\frac{3\mathrm{i}\omega}{\omega_o}}{1+\frac{\mathrm{i}\omega}{3\omega_o}} \qquad \text{(I)}$$

where

$\omega = 2\pi f$

$\omega_o = 2\pi f_o$

$\mathrm{i} = \sqrt{-1}$

f_o is the 0 dB crossover frequency of the open loop transfer function. The crossover frequencies of the lead-lag network of the servo are given by

lead break frequency: $f_1 = f_o \times 1/3$

lag break frequency $f_2 = f_o \times 3$

9.4 Reference servo for axial tracking

For an open loop transfer function H of the Reference Servo for axial tracking, $|1+H|$ is limited as schematically shown by the shaded surface of figure 4.

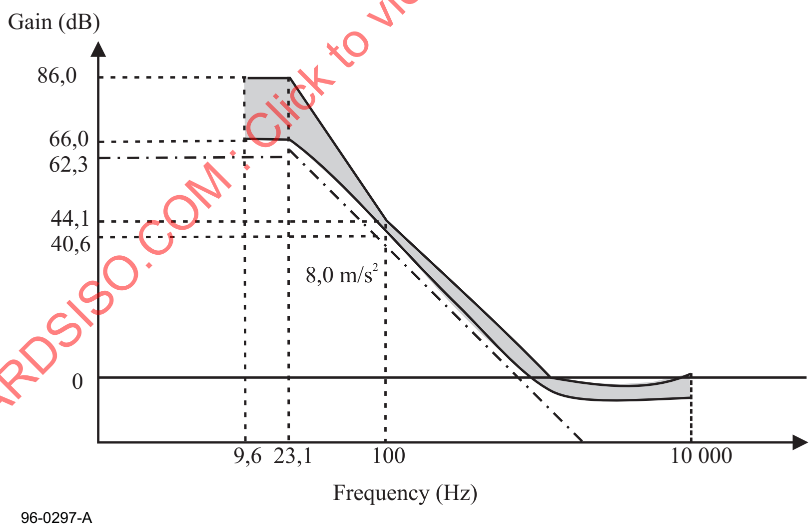

Figure 4 — Reference servo for axial tracking

Bandwidth 100 Hz to 10 kHz

$|1 + H|$ shall be within 20 % of $|1+H_s|$.

The crossover frequency $f_o = \omega_o / 2\pi$ shall be specified by equation (II), where α_{max} shall be 1,5 times larger than the expected maximum axial acceleration of 8 m/s^2. The tracking error e_{max} shall not exceed 0,23 µm. Thus, the crossover frequency f_o shall be

$$f_0 = \frac{1}{2\pi}\sqrt{\frac{3\,\alpha_{max}}{e_{max}}} = \frac{1}{2\pi}\sqrt{\frac{8 \times 1{,}5 \times 3}{0{,}23 \times 10^{-6}}} = 2{,}0 \text{ kHz} \qquad \text{(II)}$$

The axial tracking error e_{max} is the peak deviation measured axially above or below the 0 level.

Bandwidth 23,1 Hz to 100 Hz

| 1 + H | shall be within the limits defined by the following four points.

40,6 dB at 100 Hz	(| 1 + Hs | - 20% at 100 Hz)
66,0 dB at 23,1 Hz	(| 1 + Hs | - 20% at 23,1 Hz)
86,0 dB at 23,1 Hz	(| 1 + Hs | - 20% at 23,1 Hz add 20 dB)
44,1 dB at 100 Hz	(| 1 + Hs | + 20% at 100 Hz)

Bandwidth 9,6 Hz to 23,1 Hz

| 1 + H | shall be between 66,0 dB and 86,0 dB.

9.5 Reference servo for radial tracking

For an open-loop transfer function, H, of the Reference servo for radial tracking, | 1+ H | shall be limited within the shaded area shown in figure 5.

The radial track deviation is the peak deviation measured radially inward or outward from the 0 level.

Bandwidth from l00 Hz to 10k Hz

| 1 + H | shall be within 20 % of | 1+H_S |.

The crossover frequency $f_0 = \omega_o / (2\pi)$ shall be given by the equation (III), where α_{max} shall be 1,5 times as large as the expected radial acceleration of 1,1 m/s^2 and e_{max} shall not exceed 0,022 µm. Thus the crossover frequency f_0 shall be :

$$f_0 = \frac{1}{2\pi}\sqrt{\frac{\alpha_{max} \times c}{e_{max}}} = \frac{1}{2\pi}\sqrt{\frac{1{,}1 \times 1{,}5 \times 3}{0{,}022 \times 10^{-6}}} = 2{,}4 \text{ kHz} \qquad \text{(III)}$$

Bandwidth from 23,1 Hz to 100Hz

| 1+ H | shall be within the limits enclosed by the following four points.

43,7 dB at 100 Hz	(| 1 + Hs | - 20 % at 100 Hz)
69,2 dB at 23,1 Hz	(| 1 + Hs | - 20 % at 23,1 Hz)
89,2 dB at 23,1 Hz	(| 1 + Hs | - 20 % at 23,l Hz add 20 dB)
47,3 dB at 100 Hz	(| 1 + Hs | + 20 % at 100 Hz)

Bandwidth from 9,6 Hz to 23,1 Hz

|1 + H | shall be between 69,2 dB and 89,2 dB.

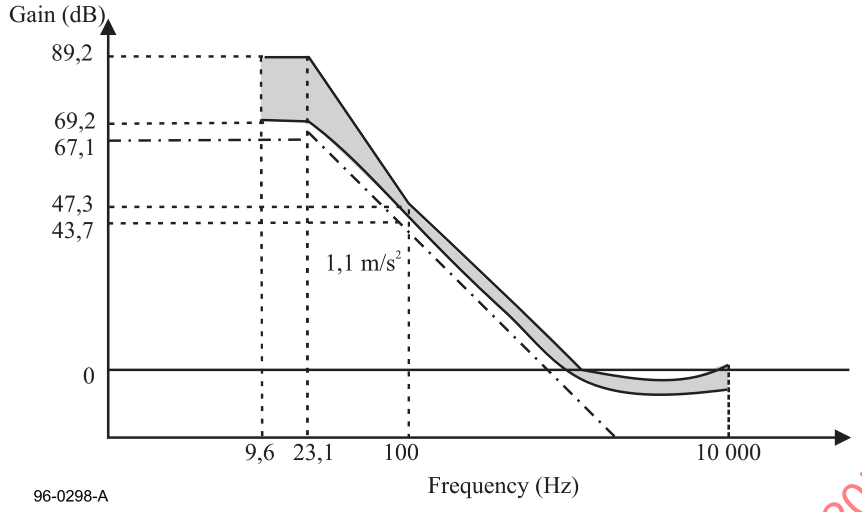

Figure 5 — Reference servo for radial tracking

Section 2 — Dimensional, mechanical and physical characteristics of the disk

10 Dimensional characteristics (figures 6, 7, and 8)

Dimensional characteristics are specified for those parameters deemed mandatory for interchange and compatible use of the disk. Where there is freedom of design, only the functional characteristics of the elements described are indicated. Figures 6, 7 and 8 show the dimensional requirements in summarized form. The different parts of the disk are described from the centre hole to the outside rim.

The dimensions are referred to two Reference Planes P and Q.

Reference Plane P is the primary Reference Plane. It is the plane on which the bottom surface of the Clamping Zone (see 10.4) rests.

Reference Plane Q is the plane parallel to Reference Plane P at the height of the top surface of the Clamping Zone.

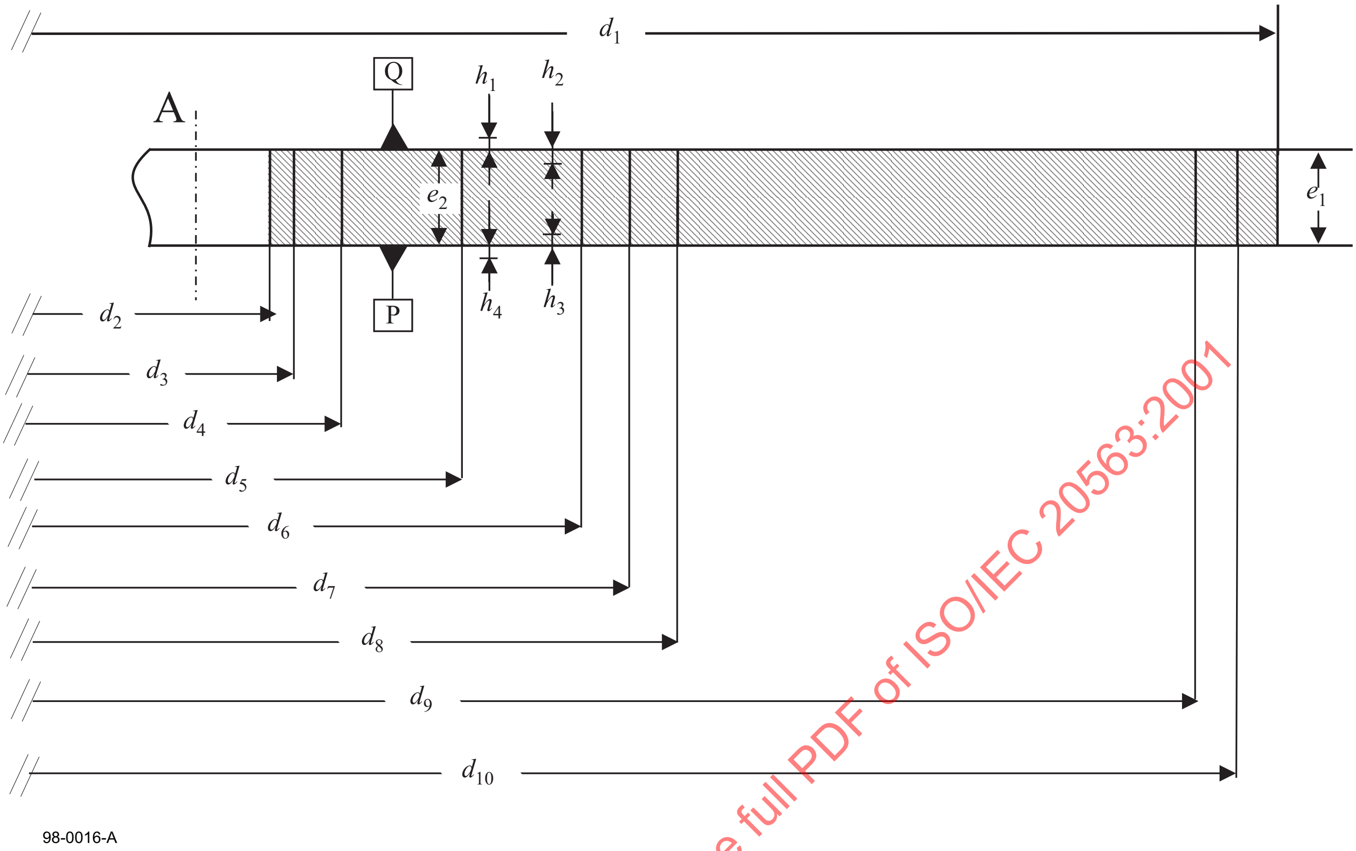

Figure 6 — Areas of the disk

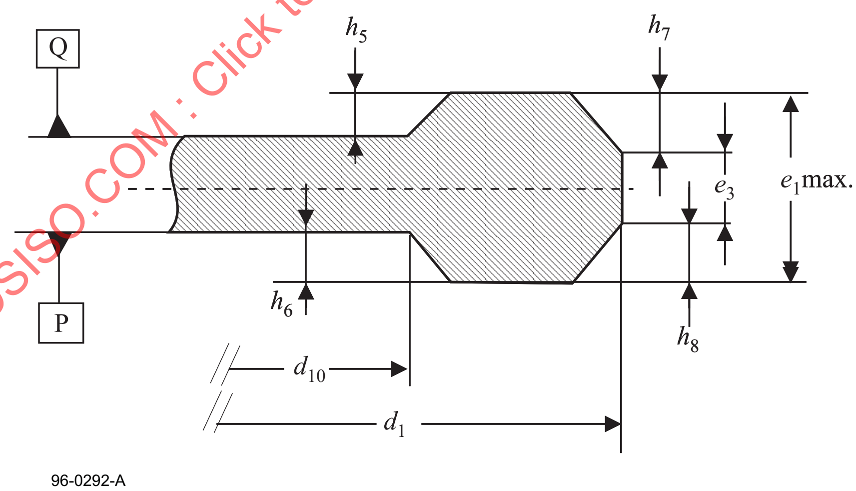

Figure 7 — Rim area

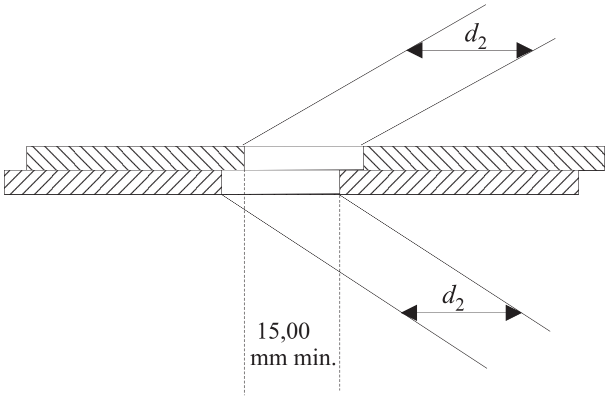

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Figure 8 — Hole of the assembled disk

10.1 Overall dimensions (figure 6)

The 120 mm disk shall have an overall diameter

d_1 = 120,00 mm ± 0,30 mm

The 80 mm disk shall have an overall diameter

d_1 = 80,00 mm ± 0,30 mm

The centre hole of a substrate or a dummy substrate shall have a diameter

$$d_2 = 15{,}00\ \text{mm}\ {}^{+\,0{,}15\ \text{mm}}_{-\,0{,}00\ \text{mm}}$$

The diameter of the hole of an assembled disk, i.e. with both parts bonded together, shall be 15,00 mm min. See figure 8. There shall be no burr on both edges of the centre hole.

The edge of the centre hole shall be rounded off or chamfered. The rounded radius shall be 0,1 mm max. The chamfer shall extend over a height of 0,1 mm max.

The thickness of the disk, including adhesive layer and label(s), shall be

$$e_1 = 1{,}20\ \text{mm}\ {}^{+\,0{,}30\ \text{mm}}_{-\,0{,}06\ \text{mm}}$$

10.2 First transition area (figure 6)

In the area defined by d_2 and

d_3 = 16,0 mm min.

the surface of the disk is permitted to be above the Reference Plane P and/or below Reference Plane Q by 0,10 mm max.

10.3 Second transition area (figure 6)

This area shall extend between diameter d_3 and diameter

d_4 = 22,0 mm max.

In this area the disk may have an uneven surface of burrs up to 0,05 mm max. beyond Reference Planes P and/or Q.

10.4 Clamping Zone (figure 6)

This zone shall extend between diameter d_4 and diameter

d_5 = 33,0 mm min.

Each side of the Clamping Zone shall be flat within 0,1 mm. The top side of the Clamping Zone, i.e. that of Reference Plane Q shall be parallel to the bottom side, i.e. Reference Plane P within 0,1 mm.

In the Clamping zone the thickness e_2 of the disk shall be

$$e_2 = 1{,}20 \text{ mm} \begin{matrix} +0{,}20 \text{ mm} \\ -0{,}10 \text{ mm} \end{matrix}$$

10.5 Third transition area (figure 6)

This area shall extend between diameter d_5 and diameter

d_6 = 44,0 mm max.

In this area the top surface is permitted to be above the Reference Plane Q by

h_1 = 0,25 mm max.

or below Reference Plane Q by

h_2 = 0,10 mm max.

The bottom surface is permitted to be above Reference Plane P by

h_3 = 0,10 mm max.

or below Reference Plane P by

h_4 = 0,25 mm max.

10.6 R-Information Zone

The R-Information Zone shall extend from the beginning of the Power Calibration Area to the beginning of the Lead-in Zone as specified in clause 28.

In the R-Information Zone the thickness of the disk shall be equal to e_1 specified in 10.1

The R-Information Zone shall be accessed for recording only

10.6.1 Sub-divisions of the R-Information Zone

The main parts of the R-Information Zone are

- the Power Calibration Area (PCA)
- the Recording Management Area (RMA)

10.7 Information Zone (figure 6)

The Information Zone shall extend from the beginning of the Lead-in Zone to diameter d_{10} the value of which is specified in table 1.

In the Information Zone the thickness of the disk shall be equal to e_1 specified in 10.1.

10.7.1 Sub-divisions of the Information zone

The main parts of the Information Zone are

- the Lead-in Zone
- the Data Zone
- the Lead-out Zone

10.7.1.1 Lead-in Zone (figure 6)

The Lead-in Zone shall start at d_7 = 45,2 mm max. and end at d_8.

10.7.1.2 Data Zone (figure 6)

The Data Zone shall start at

$$d_8 = 48{,}0 \text{ mm} \begin{matrix} +0{,}0 \text{ mm} \\ -0{,}4 \text{ mm} \end{matrix}$$

and shall end at

d_9 = 116,0 mm max. for the 120 mm diameter disk and

d_9 = 76,0 mm max. for the 80 mm diameter disk.

10.7.1.3 Lead-out Zone (figure 6)

The Lead-out Zone shall start at d_9 and shall end at d_{10}. The value of d_{10} depends on the length of the Data Zone as shown in table 1.

Table 1 — End of the Information Zone

Outer diameter d_9 of the Data Zone	**Value of diameter d_{10} for the 120 mm disk**	**Value of diameter d_{10} for the 80 mm disk**
Less than 68,0 mm	70,0 mm min.	
68,0 mm to 115,0 mm	Outer diameter of the Data Zone + 2,0 mm min.	
115,0 mm to 116,0 mm	117,0 mm min.	
Less than 68,0 mm		70,0 mm min.
68,0 mm to 75,0 mm		Outer diameter of the Data Zone + 2,0 mm min.
75,0 mm to 76,0 mm		77,0 mm min.

10.8 Track geometry

In the R-Information Zone and Information Zone tracks are constituted by a 360° turn of a spiral.

The track pitch averaged over the data zone shall be 0,80 ± 0,01 µm.

The maximum deviation of the track pitch from 0,80 µm shall be ± 0,04 µm.

10.9 Channel bit length

The R-Information Zone and Information Zone shall be recorded in CLV mode. The Channel bit length averaged over the Data Zone shall be 146,7 nm ± 1,5 nm.

10.10 Rim area (figure 7)

The rim area shall be that area extending from diameter

d_{11} = 118,0 mm min. for the 120 mm disk or

d_{11} = 78,0 mm min. for the 80 mm disk

to diameter d_1. In this area the top surface is permitted to be above Reference Plane Q by

h_5 = 0,1 mm max.

and the bottom surface is permitted to be below Reference Plane P by

h_6 = 0,1 mm max.

The total thickness of this area shall not be greater than 1,50 mm, i.e. the maximum value of e_1. The thickness of the rim proper shall be

e_3 = 0,6 mm min.

The outer edges of the disk shall be either rounded off with a rounding radius of 0,2 mm max. or be chamfered over

h_7 = 0,2 mm max.

h_8 = 0,2 mm max.

10.11 Remark on tolerances

All heights specified in the preceding clauses and indicated by h_i are independent from each other. This means that, for example, if the top surface of the third transition area is below Reference Plane Q by up to h_2, there is no implication that the bottom surface of this area has to be above Reference Plane P by up to h_3. Where dimensions have the same - generally maximum - numerical value, this does not imply that the actual values have to be identical.

10.12 Label

The label shall be placed on the side of the disk opposite the entrance surface for the information to which the label is related. The label shall be placed either on an outer surface of the disk or inside the disk bonding plane. In the former case, the label shall not extend over the Clamping Zone. In the latter case, the label may extend over the Clamping Zone. In both cases, the label shall not extend over the rim of the centre hole nor over the outer edge of the disk. The label should not affect the performance of the disk. Labels shall not be attached to either of the read out surfaces of a double sided disk.

11 Mechanical parameters

11.1 Mass

The mass of the 120 mm disk shall be in the range 13 g to 20 g.

The mass of the 80 mm disk shall be in the range 6 g to 9 g.

11.2 Moment of inertia

The moment of inertia of the 120 mm disk, relative to its rotation axis, shall not exceed 0,040 g·m^2 .

The moment of inertia of the 80 mm disk, relative to its rotation axis, shall not exceed 0,010 g·m^2 .

11.3 Dynamic imbalance

The dynamic imbalance of the 120 mm disk, relative to its rotation axis, shall not exceed 0,010 g·m.

The dynamic imbalance of the 80 mm disk, relative to its rotation axis, shall not exceed 0,0045 g·m.

11.4 Sense of rotation

The sense of rotation of the disk shall be counterclockwise as seen by the optical system.

11.5 Runout

11.5.1 Axial runout

When measured by the PUH with the Reference Servo for axial tracking, the disk rotating at the scanning velocity, the deviation of the recorded layer from its nominal position in the direction normal to the Reference Planes shall not exceed 0,3 mm for the 120 mm disk and 0,2 mm for the 80 mm disk.

The residual tracking error below 10 kHz, measured using the Reference Servo for axial tracking, shall be less than 0,23 µm. The measuring filter shall be a Butterworth LPF, fc (-3dB): 10 kHz, slope : -80 dB/decade.

11.5.2 Radial runout

The runout of the outer edge of the disk shall be less than 0,3 mm, peak-to-peak.

The radial runout of tracks at the rotational frequency determined by the scanning velocity shall be less than 70 µm, peak-to-peak.

The residual tracking error below 1,1 kHz, measured using the Reference Servo for radial tracking, shall be less than 0,022 µm. The measuring filter shall be a Butterworth LPF, fc (-3dB) : 1,1 kHz, slope : -80 dB/decade.

The rms noise value of the residual error signal in the frequency band from 1,1 kHz to 10 kHz, measured with an integration time of 20 ms, using the Reference Servo for radial tracking, shall be less than 0,016 µm. The measuring filter shall be a Butterworth BPF, frequency range (-3dB) : 1,1 kHz, slope :+80 dB/decade to 10 kHz, slope : - 80 dB/decade.

12 Optical parameters

12.1 Recorded and unrecorded disk parameters

12.1.1 Index of refraction

The index of refraction of the transparent substrate shall be 1,55 ± 0,10

12.1.2 Thickness of the transparent substrate

The thickness of the transparent substrate shall be determined by its index of refraction as specified in figure 9.

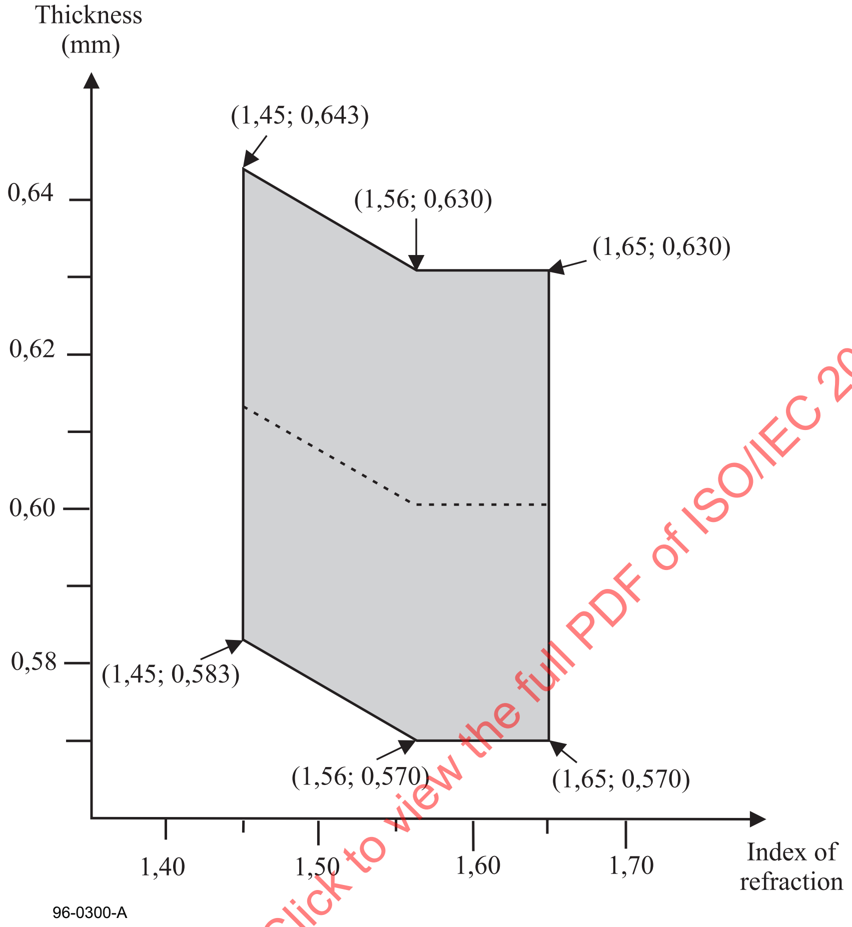


Figure 9 — Substrate thickness as a function of the index of refraction

12.1.3 Angular deviation

The angular deviation is the angle α between a parallel incident beam and the reflected beam. The incident beam shall have a diameter in the range 0,3 mm to 3,0 mm. This angle includes deflection due to the entrance surface and to unparallelism of the recorded layer, see annex A, figure A.1. It shall meet the following requirements when measured according to annex A.

In radial direction: α = 0,80° max.
In tangential direction: α = 0,30° max.

12.1.4 Birefringence of the transparent substrate

The birefringence of the transparent substrate shall be 100 nm max. when measured according to annex B.

12.2 Recorded disk reflectivity

When measured according to annex D and annex K**,** the reflectivity of the recorded layer(s) shall be

45 % to 85 % (PUH with PBS)
60 % to 85 % (PUH without PBS and with circular polarized light)

12.3 Unrecorded disk parameters

12.3.1 Polarity of reflectivity modulation

The reflectivity is high in unrecorded areas and changes to low in the recorded marks.

12.3.2 Recording power sensitivity variation

The variation in optimum recording power P_0 over the surface of the disk shall be $P_0 \pm 0{,}05\ P_0$.

Section 3 — Operational signals

13 Operational signals for recorded disk

13.1 Measurement conditions

The Pick Up Head (PUH) shall be as specified in 9.1.1.

The measurement conditions shall be as specified in 9.2.1 and 9.2.2

The HF signal equalizing for jitter measurement shall be as specified in annex F.

The reference servo for axial tracking shall be as specified in 9.3.

The reference servo for radial tracking shall be as specified in 9.4.

13.2 Read conditions

The power of the read spot shall not exceed 1,0 mW (continuous wave in the central spot).

13.3 Recorded disk high frequency (HF) signals

The HF signal is obtained by summing the currents of the four elements of the photo detector. These currents are modulated by diffraction of the light beam at the recorded marks representing the information on the recorded layer. Recording power conditions are specified in annex J. All measurements, except Jitter are executed on the HF signal before equalizing.

13.3.1 Modulated amplitude (figure 10)

The peak-to-peak value generated by the longest recorded mark and space is I_{14}.

The peak value corresponding to the HF signal before high-pass filtering is I_{14H}.

The peak-to-peak value generated by the shortest recorded mark and space is I_3.

The zero level is the signal level obtained when no disk is inserted.

These parameters shall satisfy following requirements.

I_{14} / I_{14H} = 0,60 min.

I_3 / I_{14} = 0,15 min.

The maximum value of $(I_{14H\ max.} - I_{14H\ min.}) / I_{14H\ max.}$ shall be as specified in table 2.

Table 2 — Maximum value of $(I_{14H\ max.} - I_{14H\ min.}) / I_{14H\ max.}$

	Within one disk	Within one revolution
PUH with PBS	0,33	0,15
PUH without PBS	0,20	0,10

13.3.2 Signal asymmetry

The value of asymmetry shall satisfy the following requirements when a DVD-R disk is recorded at the optimum recording power P_0 (see figure 10).

$- 0,05 \le [(I_{14H} + I_{14L}) / 2 - (I_{3H} + I_{3L}) / 2] / I_{14} \le 0,15$

where

$(I_{14H} + I_{14L}) / 2$ is the centre level of I_{14}

$(I_{3H} + I_{3L}) / 2$ is the centre level of I_3 .

13.3.3 Cross-track signal

The cross-track signal is derived from the HF signal when low pass filtered with a cut off frequency of 30 kHz when the light beam crosses the tracks (see figure 11). The low pass filter is a lst-order filter.

The cross-track signal shall meet the following requirements.

$I_T = I_H - I_L$

$I_T/I_H = 0{,}10$ min.

where I_H is the peak value of this signal and I_T is the peak-to-peak value.

13.4 Quality of signals

13.4.1 Jitter

Jitter is the standard deviation σ of the time variation of the digitized data passed through the equalizer. The jitter of the leading and the trailing edges is measured relative to the clock of the phase-lock loop and normalized by the Channel bit clock interval.

Jitter shall be less than 9,0 % of the Channel bit clock period, when measured according to annex F.

13.4.2 Random errors

A row of an ECC Block (see clause 18) that has at least 1 byte in error constitutes a PI error. In any 8 consecutive ECC Blocks the total number of PI errors before correction shall not exceed 280.

13.4.3 Defects

The maximum diameter of local defects shall meet the following requirements

- for air bubbles it shall not exceed 100 µm,
- for black spots causing birefringence it shall not exceed 200 µm,
- for black spots not causing birefringence it shall not exceed 300 µm.

In addition, over a distance of 80 mm in scanning direction of tracks, the following requirements shall be met

- the total length of defects larger than 30 µm shall not exceed 300 µm,
- there shall be at most 6 such defects.

13.5 Servo signals

The output currents of the four quadrants of the quadrant photo detector shown in figure 12 are identified by I_a, I_b, I_c and I_d.

13.5.1 Differential phase tracking error signal

The differential phase tracking error signal shall be derived from the phase difference between diagonal pairs of detectors elements when the light beam crosses the tracks : Phase ($I_a + I_c$) - Phase ($I_b + I_d$) , see figure 13. The differential phase tracking error signal shall be low-pass filtered with a cut-off frequency of 30 kHz, see annex C. This signal shall meet the following requirements.

Amplitude

At the positive 0 crossing $\overline{\Delta t}$ /T shall be in the range 0,5 to 1,1 at 0,10 µm radial offset, where $\overline{\Delta t}$ is the average time difference derived from the phase difference between diagonal pairs of detector elements, and T is the Channel bit clock period.

Asymmetry (figure 13)

The asymmetry shall meet the following requirement.

$$\frac{|T_1 - T_2|}{|T_1 + T_2|} \leq 0{,}2$$

where

- T_1 is the positive peak value of $\overline{\Delta t}$ / T
- T_2 is the negative peak value of $\overline{\Delta t}$ / T.

13.5.2 Tangential push-pull signal

This signal shall be derived from the instantaneous level of the differential output ($I_a + I_d$) - ($I_b + I_c$). It shall meet the following requirement, see figure 14.

$$0 \leq \frac{\left[(I_a + I_d) - (I_b + I_c)\right]_{pp}}{I_{14}} \leq 0{,}9$$

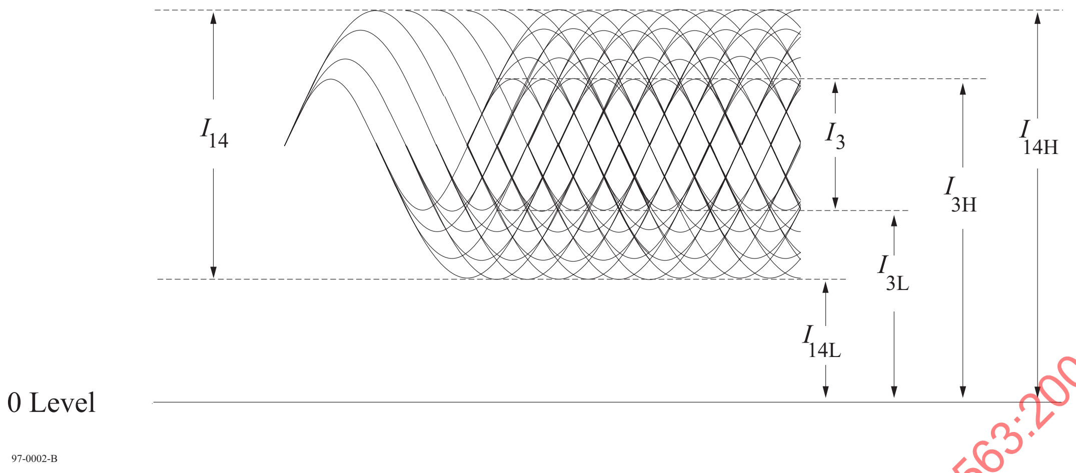


Figure 10 — Modulated amplitude

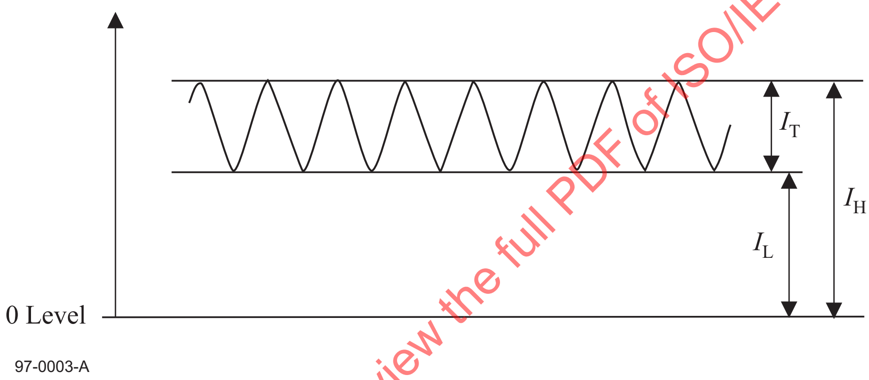


Figure 11 — Cross-track signal

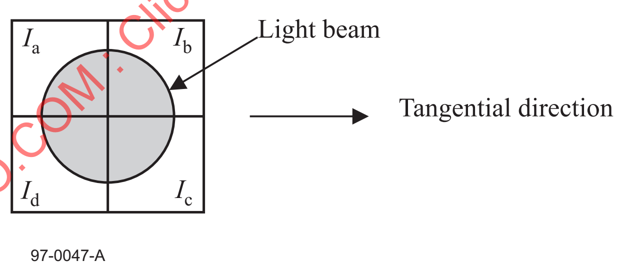


Figure 12 — Quadrant photo detector

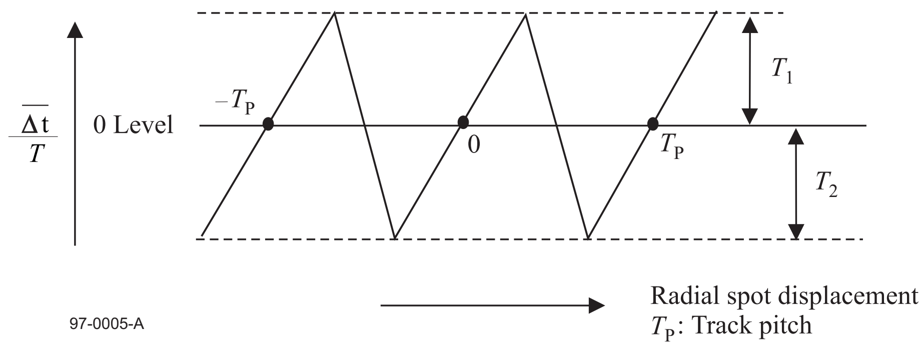


Figure 13 — Differential phase tracking error signal

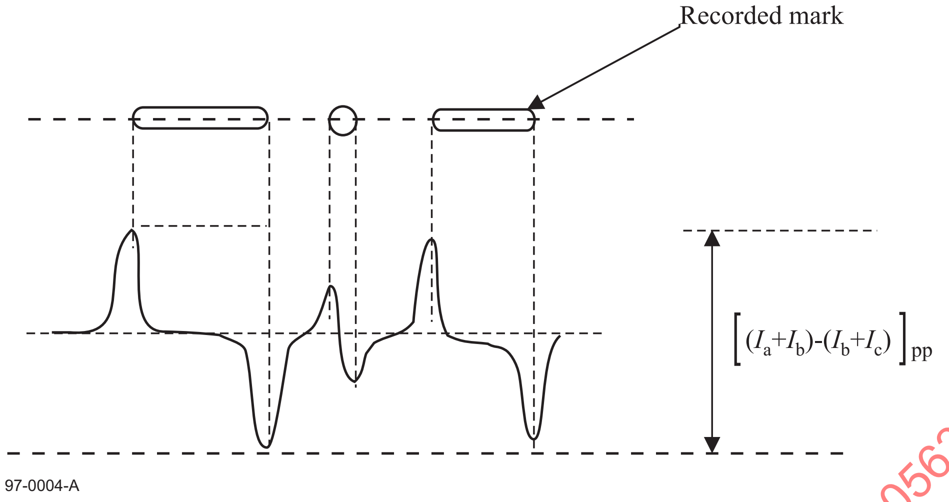


Figure 14 — Tangential push-pull signal

14 Operational signals for the unrecorded disk

14.1 Measurement conditions

- The drive optical Pick Up Head (PUH) for measurement of the unrecorded disk parameters and for making the recordings necessary for disk measurements shall be as specified in 9.1.2.
- The measurement conditions shall be as specified in 9.2.1 and 9.2.3
- The reference servo for axial tracking shall be as specified in 9.3.
- The reference servo for radial tracking shall be as specified in 9.4.

14.2 Recording conditions

- General recording strategy : In groove
- Optimum recording power : Determined by OPC specified in annex J
- Optimum recording power range of all disks : 6,0 mW $\leq P_0 \leq$ 12,0 mW
- Bias power : $P_b \leq$ 0,7 mW
- Recording power window : $P_0 \pm$ 0,25 mW

14.3 Basic write strategy for media testing

During the recordings necessary for disk measurements (using the PUH specified in 9.1.2) the laser power is modulated according to the basic write strategy (see figure 15).

Each write pulse of length 4T to 11T and 14T consists of two parts, a top pulse and a multiple-pulse train with T representing the length of one clock period.

The write pulse of length 3T uses the top pulse only.

The top pulse is generated by reducing the recording data width from its leading edge and ending it 3T from the leading edge time of the recording data. The top pulse width (Ttop) shall be selected according to the recording data length (Twd), as specified below.

The multiple-pulse train starts at 3T from the leading edge time of the recording data and ends at the trailing edge time of the recording data. Its width (Tmp) shall be independent of the recording data length.

The recommended value of each parameter is

Ttop = 1,25T when Twd = 3T

Ttop = 1,20T when Twd ≥ 4T

Tmp = 0,65T

Refer to annex P for recommended variations in write strategy.

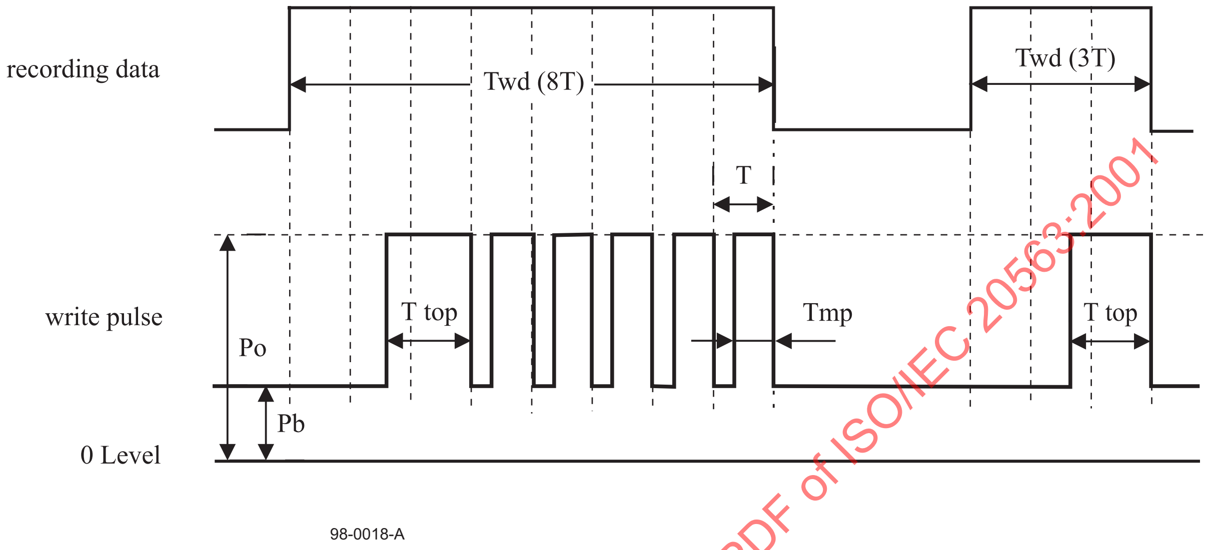


Figure 15 — Basic write strategy

14.4 Servo signals

The output currents of the four quadrants of the quadrant photo detector are I_a, I_b, I_c, and I_d shown in figure 16.

14.4.1 Radial push-pull tracking error signal

The radial push-pull tracking error signal is derived from the differential output of the detector elements when the light beam crosses the tracks and shall be $[(I_a + I_b) - (I_c + I_d)]$. The radial push-pull tracking error signal shall be measured with the PUH specified in 9.1.2 before and after recording and is low pass filtered with a cut-off frequency 30 kHz.

The radial push-pull amplitude before recording (PPb) and after recording (PPa) shown in figure 17 are defined as :

$$\text{PPb, PPa} = \left| (I_a + I_b) - (I_c + I_d) \right|_{\text{a.c.}} / \left| (I_a + I_b + I_c + I_d) \right|_{\text{d.c.}}$$

The radial push-pull ratio (PPr) is defined as

PPr = PPb / PPa.

The above parameters must meet the following requirements.

- PPb signal amplitude: $0{,}18 < \text{PPb} < 0{,}36$
- Push Pull ratio: $0{,}5 < \text{PPr} < 1{,}0$
- Variation in PPb signal: $\Delta\text{PPb} < 15\ \%$

where ΔPPb = [(PPb) max. - (PPb) min.] / [(PPb) max.+ (PPb) min.]

- ΔPPb shall be measured over the entire disk surface (from 22 mm to 58,5 mm radii).

14.4.2 Cross-track signal before recording (Radial Contrast = RC)

The cross track signal for the recorded disk is specified in 13.3.3

The cross track signal before recording (Radial Contrast = RC) shown in figure 18 is defined as follows for the servo electronics: $RC = 2\times(I_{hb}-I_{lb}) / (I_{hb} + I_{lb})$ and shall be greater than 0,05

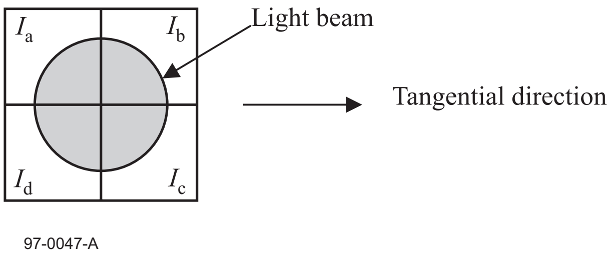


Figure 16 — Quadrant photo detector

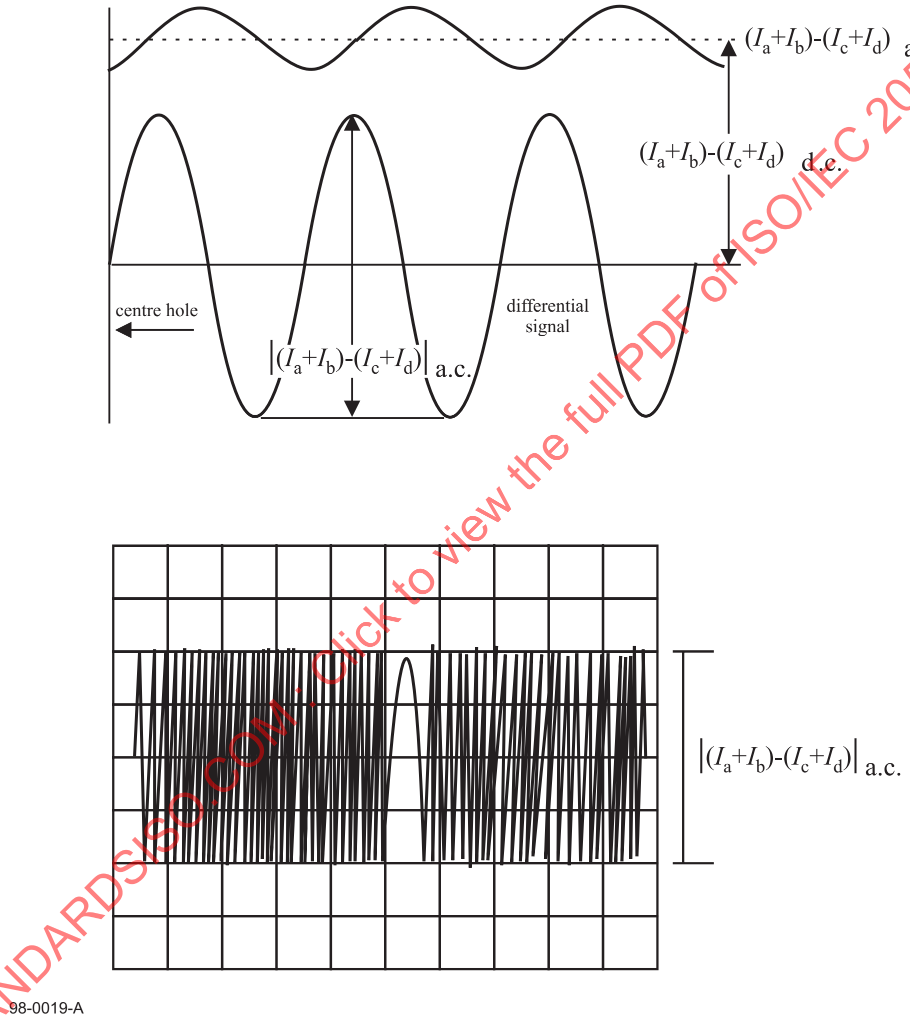


Figure 17 — Radial push-pull tracking error signal

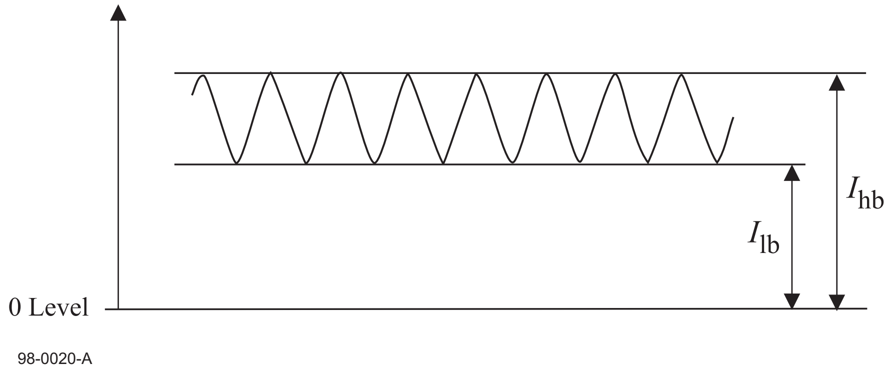


Figure 18 — Cross-track signal before recording (radial contrast)

14.4.3 Defects

The requirements are the same as for 13.4.3.

14.5 Addressing signals

The output currents of the four quadrants of the split photo detector are I_a, I_b, I_c, and I_d as shown in figure 16.

14.5.1 Land Pre-pit signal

The Land Pre-pit signal is derived from the instantaneous level of the differential output when the light beam is following a track and shall be $[(I_a + I_b) - (I_c + I_d)]$. This differential signal shall be measured by the PUH specified in 9.1.2 before and after recording.

The Land Pre-pit signal amplitude before recording (LPPb) and after recording (LPPa) are defined as:

LPPb, LPPa = $|(I_a + I_b) - (I_c + I_d)|$ o-p / $|(I_a + I_b + I_c + I_d)|$ d.c.

$|(I_a + I_b) - (I_c + I_d)|$ o-p shall be measured at the average point of maximum and minimum signals.

See figure 19 and annex Q.

The above parameters shall meet the following requirements.

- LPPb signal amplitude: LPPb = 0,18 ± 0,04
- LPPa signal amplitude: LPPa > 0,14
- Block error ratio of LPPb: BER < 3 %
- Block error ratio of LPPa: BER < 5 %

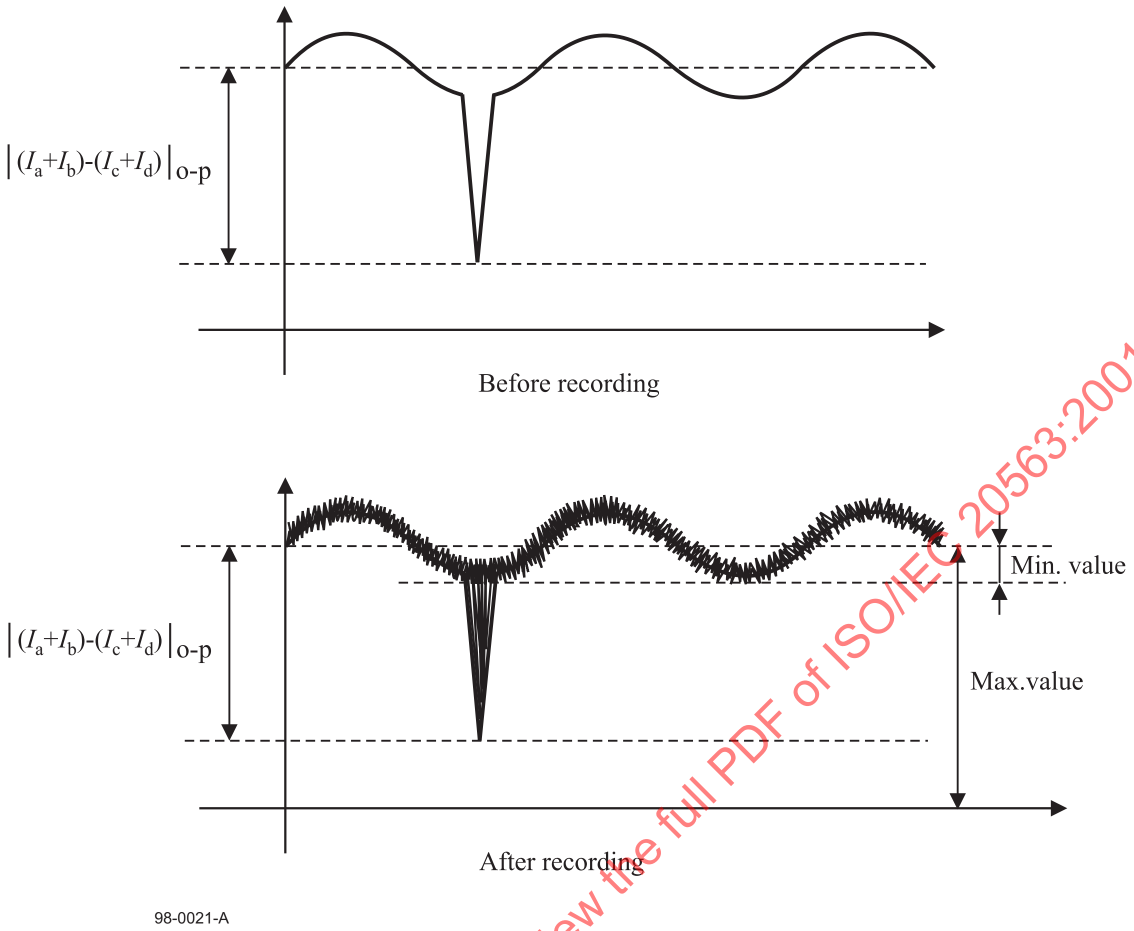


Figure 19 — Land Pre-pit signal

14.5.2 Groove wobble signal

The groove wobble signal is derived from the differential output when the light beam is following a track and is $[(I_a+ I_b) - (I_c+ I_d)]$. The groove wobble signal shall be measured by the PUH specified in 9.1.2 before and after recording.

The groove wobble signal amplitudes before recording (WOb) and after recording (WOa) are defined as:

WOb, WOa = $[(I_a + I_b) - (I_c + I_d)]$ pp

The above parameters shall meet the following requirements.

The locking frequency for the groove wobble shall be 8 times the SYNC frame frequency.

CNR of Wob shall be greater than 35 dB (RBW = 1 kHz)

CNR of Woa shall be greater than 31 dB (RBW = 1 kHz)

The CNR of WOb and WOa shall be measured for the average value.

The normalized Wobble signal (NWO) is defined to derive the wobble amplitude in nanometres.

NWO = WOb / RPS and its value shall be 0,08 < NWO < 0,12 where RPS is the peak to peak value of the radial push-pull signal amplitude $[(I_a+ I_b) - (I_c+ I_d)]$ before recording, when the light spot crosses the tracks and is low pass filtered with a cut-off frequency 30 kHz (see annex M).

14.5.3 Relation in phase between wobble and Land Pre-pit

The groove wobble signal and Land Pre-pit signal are derived from the differential output currents

[(I_a+ I_b) - (I_c+I_d)]. Therefore, when the photo detector elements (I_a, I_b) are located at the outer side of the disk and groove wobble is regarded as a sine wave, the relation in phase between groove wobble and Land Pre-pit (PWP) shall meet the following requirement (see figure 20).

PWP = -90° ± 10°

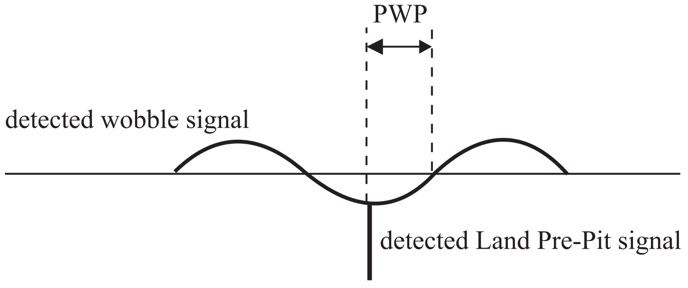


Figure 20 — Relation in phase between wobble and Land Pre-pit

Section 4 — Data format

15 General

The data received from the host, called Main Data, is formatted in a number of steps before being recorded on the disk. It is transformed successively into

- a Data Frame,
- a Scrambled Frame,
- an ECC Block,
- a Recording Frame,
- a Physical Sector

These steps are specified in the following clauses.

16 Data Frames (figure 21)

A Data Frame shall consist of 2 064 bytes arranged in an array of 12 rows each containing 172 bytes (see figure 21). The first row shall start with three fields, called Identification Data (ID), the check bytes of an ID Error Detection Code (IED), and Copyright Management Information (CPR_MAI), followed by 160 Main Data bytes. The next 10 rows shall each contain 172 Main Data bytes and the last row shall contain 168 Main Data bytes followed by four bytes for recording the check bits of an Error Detection Code (EDC). The 2 048 Main Data bytes are identified as D_0 to $D_{2\,047}$.

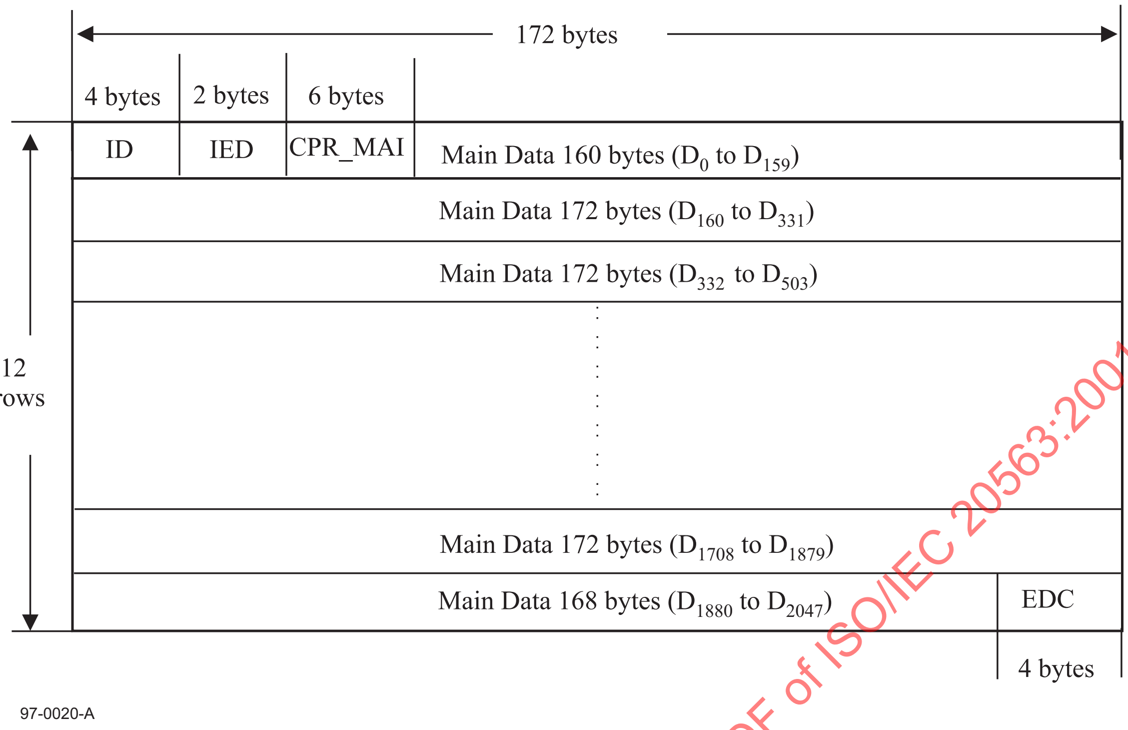


Figure 21 — Data Frame

16.1 Identification Data (ID)

This field shall consist of four bytes the bits of which are numbered consecutively from b_0 (lsb) to b_{31} (msb), see figure 22.

b_{31} ... b_{24}	b_{23} ... b_0
Sector Information	Sector Number

Figure 22 — Identification Data (ID)

b_{31}	b_{30}	b_{29}	b_{28}	b_{27} and b_{26}	b_{25}	b_{24}
Sector Format type	Tracking method	Reflectivity	Reserved	Zone type	Data type	Layer number

Figure 23 — Sector Information of the Identification Data (ID)

The least significant three bytes, bits b_0 to b_{23}, shall specify the sector number in binary notation. The sector number of the first sector of an ECC Block of 16 sectors shall be a multiple of 16.

The bits of the most significant byte shown in figure 23, the Sector information, shall be set as follows.

a) Sector format type bit b_{31} shall be set to ZERO, indicating the CLV format type specified for Read-only disk and Recordable disk.

b) Tracking method bit b_{30} shall be set to ZERO, indicating Pit tracking.

c) Reflectivity bit b_{29} shall be set to ZERO, indicating the reflectivity is greater than 40% measured with PBS PUH.

d) Reserved	bit b_{28}	shall be set to ZERO.
e) Zone type	bit b_{27} and bit b_{26}	shall be set to ZERO ZERO in the Data Zone.
		shall be set to ZERO ONE in the Lead-in Zone.
		shall be set to ONE ZERO in the Lead-out Zone.
f) Data type	bit b_{25}	shall be set to ZERO, indicating Read-Only data.
		shall be set to ONE, indicating Linking data.
g) Layer number	bit b_{24}	shall be set to ZERO, indicating that through an entrance surface only one recording layer can be accessed.

Other settings are prohibited by this International Standard.

16.2 ID Error Detection Code

When identifying all bytes of the array shown in figure 21 as C i,j for i = 0 to 11 and j = 0 to 171, the check bytes of the ID Error Detection Code are represented by $C_{0,j}$ for j = 4 to 5. Their setting shall be obtained as follows.

$$IED(x) = \sum_{j=4}^{5} C_{0,j}\, x^{5-j} = I(x)\, x^2 \mod G_E(x)$$

where

$$I(x) = \sum_{j=0}^{3} C_{0\,j} \cdot x^{3-j}$$

$$G_E(x) = \prod_{k=0}^{1} \left(x + \alpha^k\right)$$

α represents the primitive root of the primitive polynomial

$$P(x) = x^8 + x^4 + x^3 + x^2 + 1$$

16.3 Copyright Management Information (CPR_MAI)

This field shall consist of 6 bytes. Their setting is application dependent, for instance a video application. If this setting is not specified by the application, the default setting shall be to set to all ZEROs.

Within a link sector (see clause 23.1) the CPR_MAI shall be set to all ZEROs.

16.4 Error Detection Code

This 4-byte field shall contain the check bits of an Error Detection Code computed over the preceding 2 060 bytes of the Data Frame. Considering the Data Frame as a single bit field starting with the most significant bit of the first byte of the ID field and ending with the least significant bit of the EDC field, then this msb will be $b_{16\,511}$ and the lsb will be b_0. Each bit b_i of the EDC shall be as follows for i = 31 to 0 :

$$EDC(x) = \sum_{i=31}^{0} b_i x^i = I(x) \bmod G(x)$$

where

$$I(x) = \sum_{i=16\,511}^{32} b_i x^i$$

$$G(x) = x^{32} + x^{31} + x^4 + 1$$

17 Scrambled Frames

The 2 048 Main Data bytes shall be scrambled by means of the circuit shown in figure 24 which shall consist of a feedback bit shift register in which bits r_7 (msb) to r_0 (lsb) represent a scrambling byte at each 8-bit shift. At the beginning of the scrambling procedure of a Data Frame, positions r_{14} to r_0 shall be pre-set to the value(s) specified in table 3. The same pre-set value shall be used for 16 consecutive Data Frames. After 16 groups of 16 Data Frames, the sequence is repeated. The initial pre-set number is equal to the value represented by bits b_7 (msb) to bit b_4 (lsb) of the ID field of the Data Frame. Table 3 specifies the initial pre-set value of the shift register corresponding to the 16 initial pre-set numbers.

Table 3 — Initial value of shift register

Initial pre-set number	**Initial value**	**Initial pre-set number**	**Initial value**
(0)	(0001)	(8)	(0010)
(1)	(5500)	(9)	(5000)
(2)	(0002)	(A)	(0020)
(3)	(2A00)	(B)	(2001)
(4)	(0004)	(C)	(0040)
(5)	(5400)	(D)	(4002)
(6)	(0008)	(E)	(0080)
(7)	(2800)	(F)	(0005)

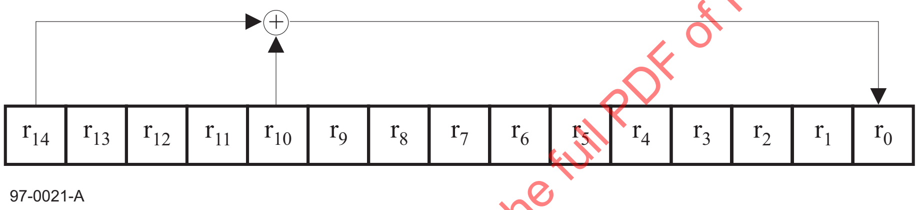


Figure 24 — Feedback shift register for generating scramble data

The part of the initial value of r_7 to r_0 is taken out as scrambling byte S_0. After that, 8-bit shift is repeated 2 047 times and the following 2 047 bytes shall be taken from r_7 to r_0 as scrambling bytes S_1 to $S_{2\,047}$. The Main Data bytes D_k of the Data Frame become scrambled bytes D'_k where

$D'_k = D_k \oplus S_k$ for $k = 0$ to $2\,047$

$\oplus$ stands for Exclusive OR.

18 ECC Block configuration

An ECC Block is formed by arranging 16 consecutive Scrambled Frames in an array of 192 rows of 172 bytes each (figure 25). To each of the 172 columns, 16 bytes of Parity of Outer Code are added, then, to each of the resulting 208 rows, 10 byte of Parity of Inner Code are added. Thus a complete ECC Block comprises 208 rows of 182 bytes each. The bytes of this array are identified as $B_{i,j}$ as follows, where i is the row number and j the column number.

$B_{i,j}$ for i = 0 to 191 and j = 0 to 171 are bytes from the Scrambled Frames

$B_{i,j}$ for i = 192 to 207 and j = 0 to 171 are bytes of the Parity of Outer Code

$B_{i,j}$ for i = 0 to 207 and j = 172 to 181 are bytes of the Parity of Inner Code

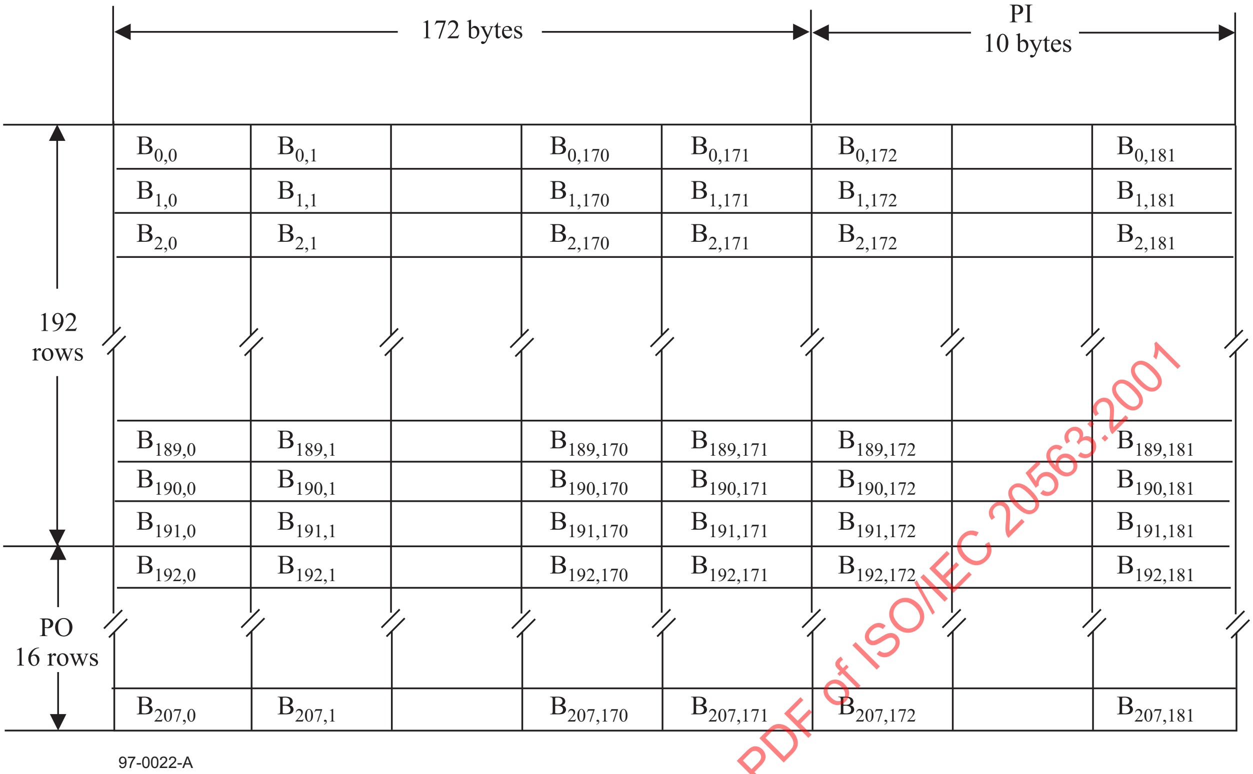


Figure 25 — ECC block

The PO and PI bytes shall be obtained as follows.

In each of columns j = 0 to 171, the 16 PO bytes are defined by the remainder polynomial $R_j(x)$ to form the outer code RS (208,192,17).

$$R_j(x) = \sum_{i=192}^{207} B_{i,j} x^{207-i} = I_j(x) x^{16} \bmod G_{PO}(x)$$

where

$$I_j(x) = \sum_{i=0}^{191} B_{i,j} x^{191-i}$$

$$G_{PO}(x) = \prod_{k=0}^{15} \left(x + \alpha^k\right)$$

In each of rows i = 0 to 207, the 10 PI bytes are defined by the remainder polynomial $R_i(x)$ to form the inner code RS (182,172,11).

$$R_i(x) = \sum_{j=172}^{181} B_{i,j} x^{181-j} = I_i(x) x^{10} \bmod G_{PI}(x)$$

where

$$I_i(x) = \sum_{j=0}^{171} B_{i,j} x^{171-j}$$

$$G_{PI}(x) = \prod_{k=0}^{9} \left(x + \alpha^k\right)$$

α is the primitive root of the primitive polynomial $P(x) = x^8 + x^4 + x^3 + x^2 + 1$

19 Recording Frames

Sixteen Recording Frames shall be obtained by interleaving one of the 16 PO rows at a time after every 12 rows of an ECC Block (figure 26). This is achieved by re-locating the bytes $B_{i,j}$ of the ECC Block as $B_{m,n}$ for

$m = i + int\,[i / 12]$ and $n = j$ for $i \leq 191$

$m = 13\,(i - 191) - 1$ and $n = j$ for $i \geq 192$

where *int* [x] represents the largest integer not greater than *x*.

Thus the 37 856 bytes of an ECC Block are re-arranged into 16 Recording Frames of 2 366 bytes. Each Recording Frame consists of an array of 13 rows of 182 bytes.

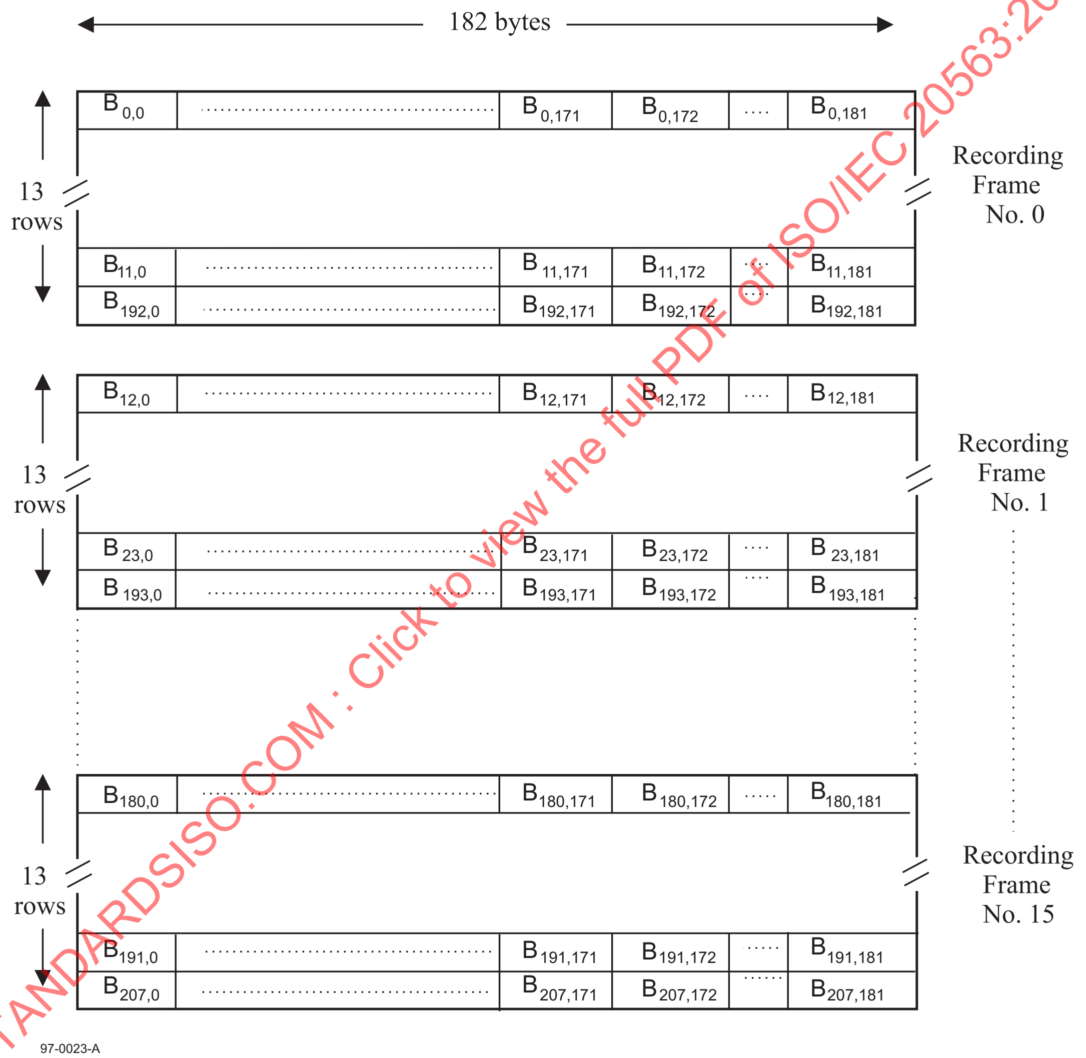
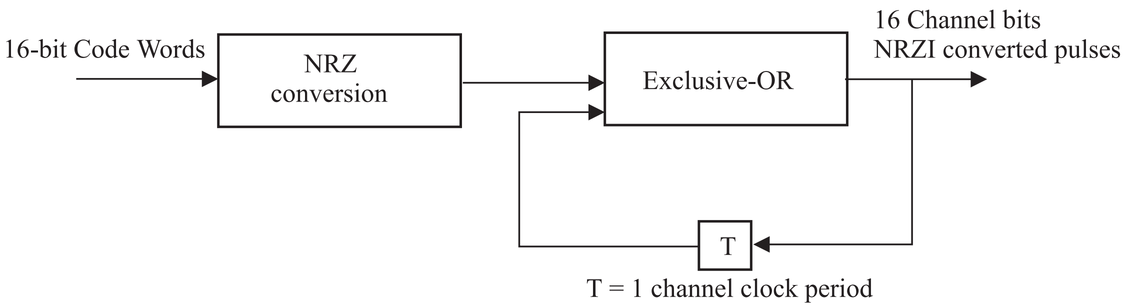


Figure 26 — Recording Frames obtained from an ECC Block

20 Modulation

The 8-bit bytes of each Recording Frame shall be transformed into 16-bit Code Words with the run length limitation that between 2 ONEs there shall be at least 2 ZEROs and at most 10 ZEROs (RLL 2,10). Annex G specifies the conversion tables to be applied. The Main Conversion table and the Substitution table specify a 16-bit Code Word for each 8-bit bytes with one of 4 States. For each 8-bit byte, the tables indicate the corresponding Code Word, as well as the State for the next 8-bit byte to be encoded.

The 16-bit Code Words shall be NRZI-converted into Channel bits before recording on the disk (figure 27).

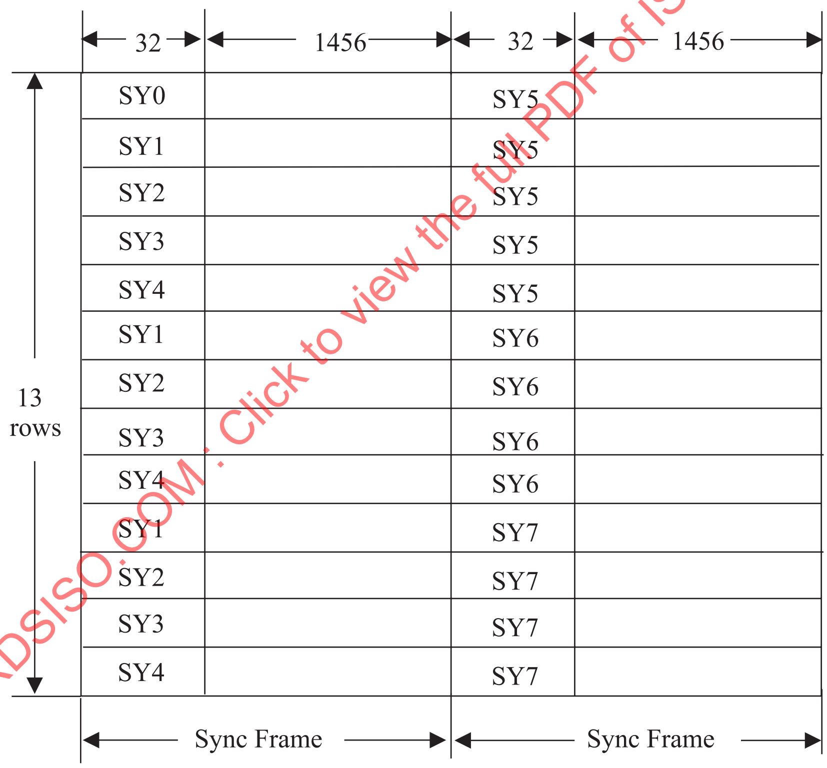


97-0024-A

Figure 27 — NRZI conversion

21 Physical Sectors

The structure of a Physical Sector is shown in figure 28. It shall consist of 13 rows, each comprising two Sync Frames. A Sync Frame shall consist of a SYNC Code from table 4 and 1 456 Channel bits representing the first, respectively the second 91 8-bit bytes of a row of a Recording Frame. The first row of the Recording Frame is represented by the first row of the Physical Sector, the second by the second, and so on.



97-0025-A

Figure 28 — Physical sector

Recording shall start with the first Sync Frame of the first row, followed by the second Sync Frame of that row, and so on row-by-row.

Table 4 — SYNC Codes

	Primary SYNC codes (msb) … (lsb)		Secondary SYNC codes (msb) … (lsb)
State 1 and State 2			
SY0 =	0001001001000100 0000000000010001	/	0001001000000100 0000000000010001
SY1 =	0000010000000100 0000000000010001	/	0000010001000100 0000000000010001
SY2 =	0001000000000100 0000000000010001	/	0001000001000100 0000000000010001
SY3 =	0000100000000100 0000000000010001	/	0000100001000100 0000000000010001
SY4 =	0010000000000100 0000000000010001	/	0010000001000100 0000000000010001
SY5 =	0010001001000100 0000000000010001	/	0010001000000100 0000000000010001
SY6 =	0010010010000100 0000000000010001	/	0010000010000100 0000000000010001
SY7 =	0010010001000100 0000000000010001	/	0010010000000100 0000000000010001
State 3 and State 4			
SY0 =	1001001000000100 0000000000010001	/	1001001001000100 0000000000010001
SY1 =	1000010001000100 0000000000010001	/	1000010000000100 0000000000010001
SY2 =	1001000001000100 0000000000010001	/	1001000000000100 0000000000010001
SY3 =	1000001001000100 0000000000010001	/	1000001000000100 0000000000010001
SY4 =	1000100001000100 0000000000010001	/	1000100000000100 0000000000010001
SY5 =	1000100100000100 0000000000010001	/	1000000100000100 0000000000010001
SY6 =	1001000010000100 0000000000010001	/	1000000001000100 0000000000010001
SY7 =	1000100010000100 0000000000010001	/	1000000010000100 0000000000010001

The physical sector is a sector after the modulation by 8/16 conversion which adds a SYNC code to the head of every 91 bytes in the Recording Frame.

22 Suppress control of the d.c. component

To ensure a reliable radial tracking and a reliable detection of the HF signals, the low frequency content of the stream of Channel bit patterns should be kept as low as possible. In order to achieve this, the Digital Sum Value (DSV, see 4.4) shall be kept as low as possible. At the beginning of the modulation, the DSV shall be set to 0.

The different ways of diminishing the current value of the DSV are as follows.

a) Choice of SYNC Codes between Primary or Secondary SYNC Codes.

b) For the 8-bit bytes in the range 0 to 87, the Substitution table offers an alternative 16-bit Code Word for all States.

c) For the 8-bit bytes in the range 88 to 255, when the prescribed State is 1 or 4, then the 16-bit Code Word can be chosen either from State 1 or from State 4, so as to ensure that the RLL requirement is met.

In order to use these possibilities, two data streams, Stream 1 and Stream 2, are generated for each Sync Frame. Stream 1 shall start with the Primary SYNC Code and Stream 2 with the Secondary SYNC Code of the same category of SYNC Codes. As both streams are modulated individually, they generate a different DSV because of the difference between the bit patterns of the Primary and Secondary SYNC Codes.

In the cases b) and c), there are two possibilities to represent a 8-bit byte. The DSV of each stream is computed up to the 8-bit byte preceding the 8-bit byte for which there is this choice. The stream with the lowest |DSV| is selected and duplicated to the other stream. Then, one of the representations of the next 8-bit byte is entered into Stream 1 and the other into Stream 2. This operation is repeated each time case b) or c) occurs.

Whilst case b) always occurs at the same pattern position in both streams, case c) may occur in one of the streams and not in the other because, for instance, the next State prescribed by the previous 8-bit byte can be 2 or 3 instead of 1 or 4. In that case the following 3-step procedure shall be applied.

1) Compare the |DSV| s of both streams.

2) If the |DSV| of the stream in which case c) occurs is smaller than that of the other stream, then the stream in which case c) has occurred is chosen and duplicated to the other stream. One of the representations of the next 8-bit byte is entered into this stream and the other into the other stream.

3) If the |DSV| of the stream in which case c) has occurred is larger than that of the other stream, then case c) is ignored and the 8-bit byte is represented according to the prescribed State.

In both cases b) and c), if the |DSV| s are equal, the decision to choose Stream 1 or Stream 2 is implementation-defined.

The procedure for case a) shall be as follows. At the end of a Sync Frame, whether or not case b) and or case c) have occurred, the DSV of the whole Sync Frame is computed and the stream with the lower |DSV| is selected. If this DSV is greater than + 63 or smaller than -64, then the SYNC Code at the beginning of the Sync Frame changed from Primary to Secondary or vice versa. If this yields a smaller |DSV| , the change is permanent, if the |DSV| is not smaller, the original SYNC Code is retained. During the DSV computation, the actual values of the DSV may vary between -1000 and +1000, thus it is recommended that the count range for the DSV be at least from -1 024 to +1 023.

23 Linking scheme

The Linking scheme shall be the specified method to append data in the Incremental Recording mode.

23.1 Linking sector

Linking shall be performed as shown in figure 29 between the 82nd and 87th bytes in the second SYNC frame of the first Physical sector within the first ECC block of a new recording. This sector shall be referred to as the Linking sector.

Incremental Recording using Linking shall terminate at the 86th byte in the second SYNC frame of the Linking sector and shall start between the 82nd and 87th bytes in the second SYNC frame of the Linking sector.

The Data type (see clause 16.1) of the Linking sector shall be set to ZERO.

23.2 Linking loss area

A Linking loss area shall be set aside to prevent any degradation of the data reliability due to the influence of linking. The minimum size of the Linking loss area shall be 2 048 bytes or 32 768 bytes. By choosing a Linking loss area of 2 048 bytes or 32 768 bytes, the user can obtain a greater user data capacity or higher reliability respectively.

A 32 768 bytes Linking loss area shall include the entire ECC block containing the Linking sector plus the Padding sectors of the prior ECC block. In a 32 768 bytes Linking loss area, the Data type bit (see clause 16.1) of the 14 sectors following the Linking sector shall be set to ONE.

A 2 048 bytes Linking loss area shall include only the Linking sector plus the padding sectors of the prior ECC block (see figure 30).

All Main data bytes within a Linking loss area shall be set to (00).

23.2.1 Padding sectors

All sectors after the last sector containing user data in the last full ECC block of an incremental recording shall be Padding sectors and shall be included in the Linking loss area. The Main Data bytes in these sectors shall be set to (00).

The Data type of each of the Padding sectors and the Data type of the last sector containing user data shall be set to ONE.

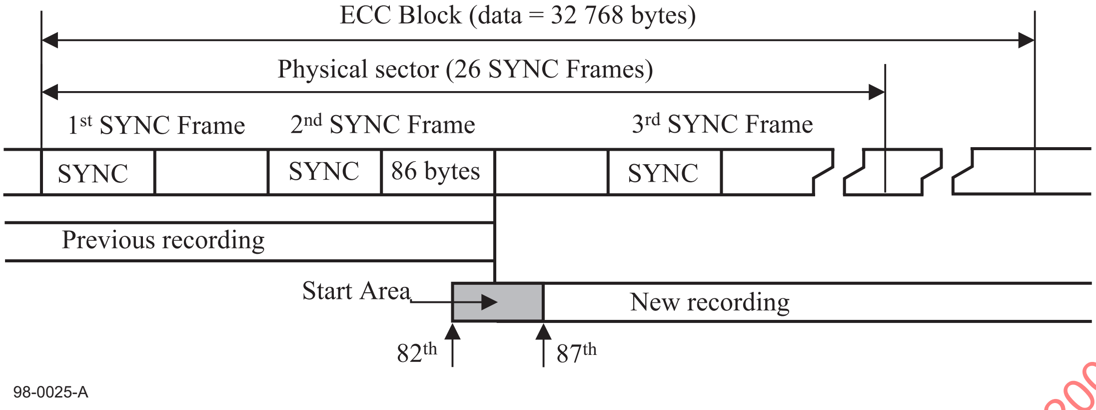


Figure 29 — Structure of Linking

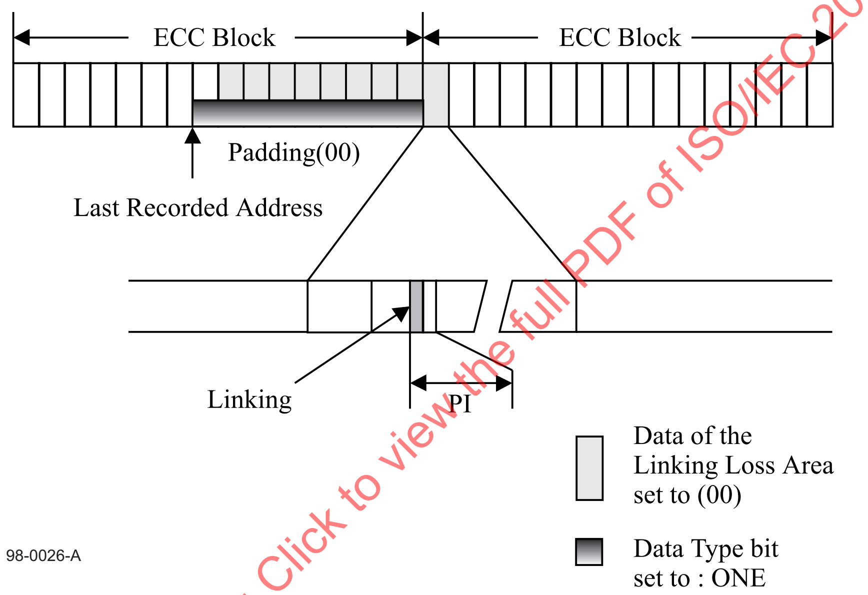


Figure 30 — The structure of ECC block with Linking Loss Area of 2 048 bytes

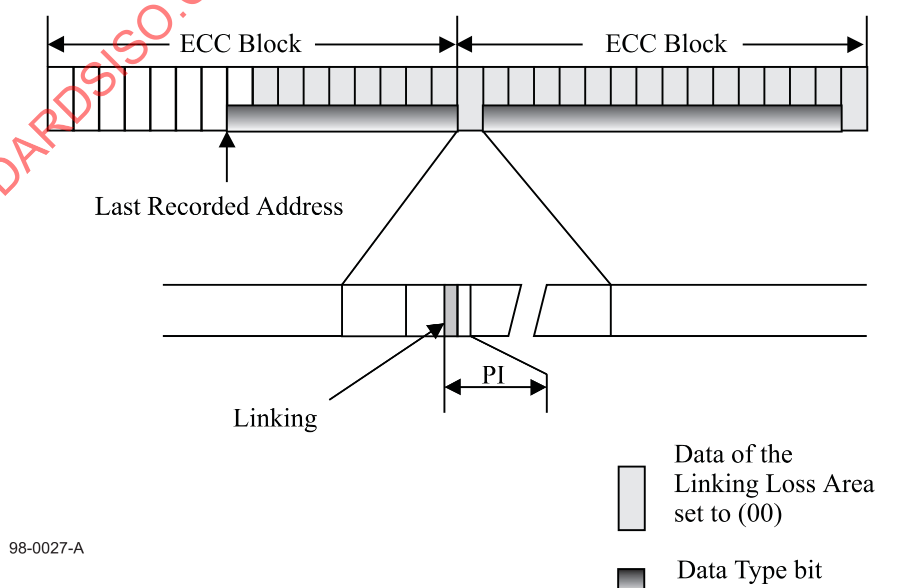


Figure 31 — The structure of ECC block with Linking Loss Area of 32 768 bytes

Section 5 — Format of the Information Zone

24 General description of the Information Zone

The Information Zone shall be divided in three parts : the Lead-in Zone, the Data Zone and the Lead-out Zone. The Data Zone is intended for the recording of Main Data. The Lead-in Zone contains control information. The Lead-out Zone allows for a continuous smooth read-out.

24.1 Layout of the Information Zone

The Information Zone shall be sub-divided as shown in table 5. The value of the radii indicated are nominal values for the first Physical Sector and that of the last track of the last Physical Sector of a zone.

Table 5 — Layout of the Information Zone

	Nominal radius in mm			Sector Number of the first Physical Sector	Number of Physical Sectors
Lead-in Zone Initial Zone	22,6 max. to 24,0				
Reference Code Zone				(02F000)	32
Buffer Zone 1				(02F020)	480
Control Data Zone				(02F200)	3 072
Buffer Zone 2				(02FE00)	512
Data Zone	24,0 to r_1			(030000)	
Lead-out Zone for 120 mm disk	r_1 to 35,0 min. when $r_1 < 34{,}0$	r_1 to $(r_1+1{,}0)$ when $34{,}0 \le r_1 \le 57{,}5$	r_1 to 58,5 when $57{,}5 < r_1 < 58{,}0$		
Lead-out Zone for 80 mm disk	r_1 to 35,0 min. when $r_1 < 34{,}0$	r_1 to $(r_1+1{,}0)$ when $34{,}0 \le r_1 \le 37{,}5$	r_1 to 58,5 when $37{,}5 < r_1 < 38{,}0$		

24.2 Physical sector numbering

The first physical sector of the Data Zone shall have the sector number (030000).

Physical sectors do not comprise gaps. They follow each other continuously from the beginning of the Lead-in Zone to the end of the Lead-out Zone.

The physical sector number increases continuously from the beginning of the Lead-in Zone to the end of the Lead-out Zone. See figure 32.

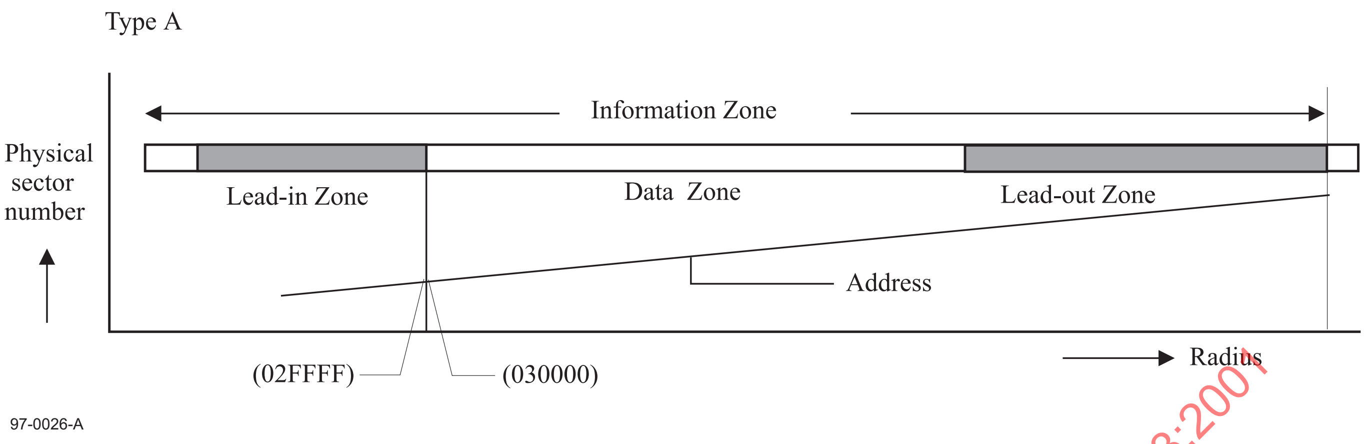


Figure 32 — Physical sector numbering

25 Lead-in Zone and Lead-out Zone

25.1 Lead-in Zone

The Lead-in Zone is the innermost zone of the Information Zone. It shall consist of the following parts (figure 33).

- Initial Zone,
- Reference Code Zone,
- Buffer Zone 1,
- Control Data Zone,
- Buffer Zone 2.

The Sector Number of the first Physical Sector of each part is indicated in figure 33 in hexadecimal and in decimal notation.

In the case of incremental recording the Lead-in Zone shall be recorded sequentially without using the linking scheme except the last ECC block (Linking Loss Area) in Lead-in Zone.

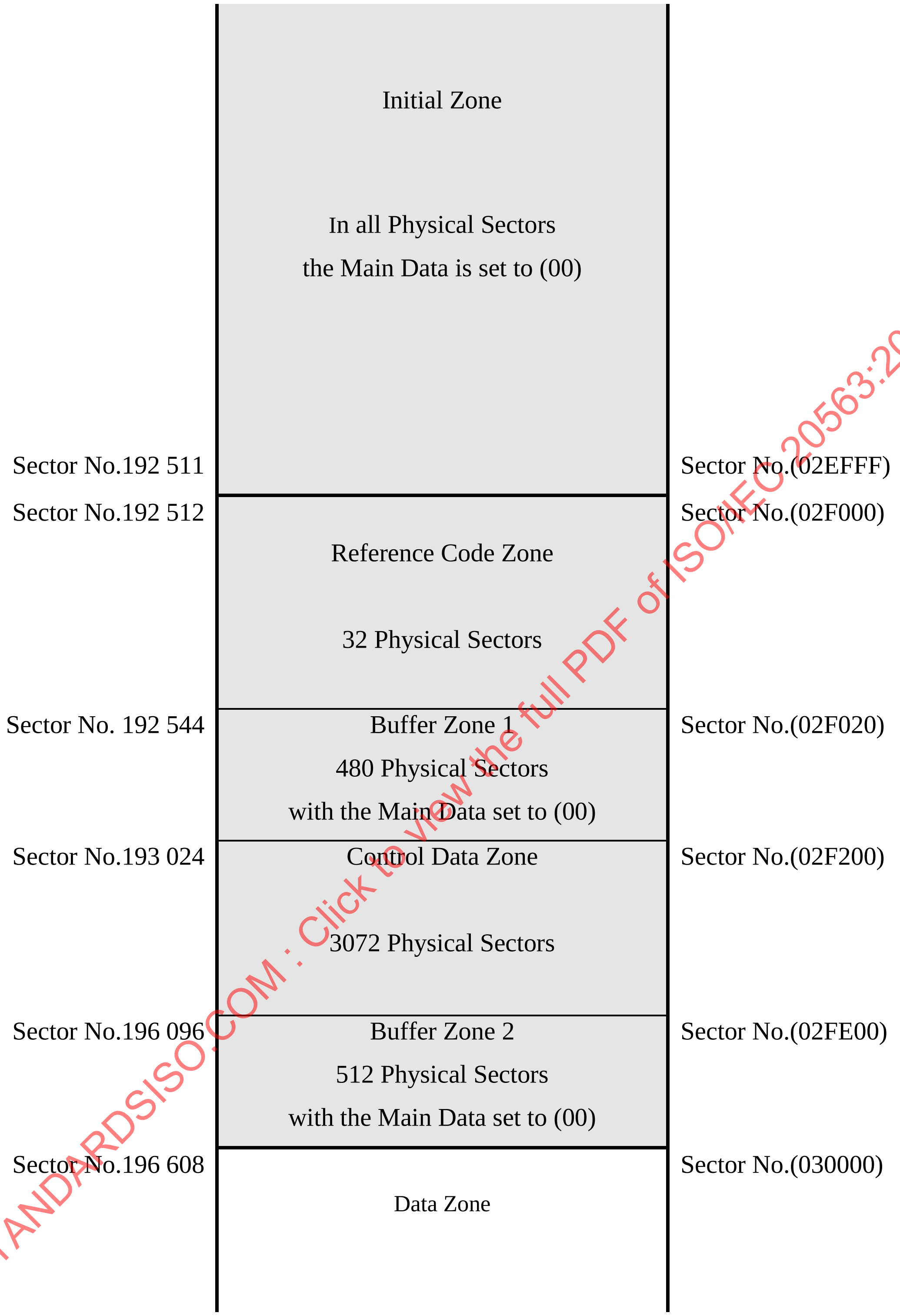


Figure 33 — Lead-in Zone

25.1.1 Initial Zone

The Main Data of the Data Frames eventually recorded as Physical Sectors in the Initial Zone shall have been set to (00). This International Standard does not specify the number of Physical Sectors in the Initial Zone. However, the Sector Number of the first Physical Sector of the Data Zone is large enough so as to prevent a Sector Number 0 to occur in the Initial Zone.

25.1.2 Reference Code Zone

The Reference Code Zone shall consist of the 32 Physical Sectors from two ECC Blocks which generate a specific Channel bit pattern on the disk. This shall be achieved by setting to (AC) all 2 048 Main Data bytes of each corresponding Data Frame.

Moreover, no scrambling shall be applied to these Data Frames, except to the first 160 Main Data bytes of the first Data Frame of each ECC Block (see annex R).

25.1.3 Buffer Zone 1

This zone shall consist of 480 Physical Sectors from 30 ECC Blocks. The Main Data of the Data Frames eventually recorded as Physical Sectors in this zone shall have been set to (00).

25.1.4 Buffer Zone 2

This zone shall consist of 512 Physical Sectors from 32 ECC Blocks. The Main Data of the Data Frames eventually recorded as Physical Sectors in this zone shall have been set to (00).

25.2 Control Data Zone

This zone shall consist of 3 072 Physical Sectors from 192 ECC Blocks. The content of the 16 Physical Sectors of each ECC Block is repeated 192 times. The structure of a Control Data Block shall be as shown in figure 34.

Physical format information 2 048 bytes
Disk manufacturing information 2 048 bytes
Reserved 14 × 2 048 bytes

Figure 34 — Structure of a Control Data Block

25.2.1 Physical format information

This information shall comprise the 2 048 bytes shown in table 6 and described below.

Table 6 — Physical format information

BP	Content	Number of bytes
0	Disk Category and Version Number	1
1	Disk size and maximum transfer rate	1
2	Disk structure	1
3	Recording density	1
4 to 15	Data Zone allocation	12
16 to 31	Set to (00)	16
32 to 39	Start sector number of Border zone	8
40 to 2 047	Set to (00)	2 008

Byte 0 - Disk Category and Version Number

Bits b_0 to b_3 shall specify the Version Number.
They shall be set to 0001, indicating this International Standard.

Bits b_4 to b_7 shall specify the Disk Category.
These bits shall be set to 0010, indicating a recordable disk.

Other settings are prohibited by this International Standard.

Byte 1 - Disk size and maximum transfer rate

Bits b_0 to b_3 shall specify the maximum transfer rate:

if set to 0000, they specify a maximum transfer rate of 2,52 Mbits/s
if set to 0001, they specify a maximum transfer rate of 5,04 Mbits/s
if set to 0010, they specify a maximum transfer rate of 10,08 Mbits/s

Bits b_4 to b_7 shall specify the disk size:

If the diameter of the disk is 120 mm ,they shall be set to 0000.
If the diameter of the disk is 80 mm, they shall be set to 0001.

Other settings are prohibited by this International Standard.

Byte 2 - Disk structure

Bits b_0 to b_3 specify the Layer type.

They shall be set to 0010, indicating that the disk contains Recordable user data Zone(s).

Bit b_4 shall specify the track path. It shall be set to ZERO.

Bits b_5 and b_6 shall be set to (00), indicating that through an entrance surface only one layer can be accessed.

Bit b_7 shall be set to ZERO.

Other settings are prohibited by this International Standard.

Byte 3 - Recording density

Bits b_0 to b_3 shall specify the average track pitch.
They shall be set to 0001, indicating the average track pitch of 0,80 µm.

Bits b_4 to b_7 shall specify the average Channel bit length.
They shall be set to 0001, indicating 0,147 µm.

Bytes 4 to 15 - Data Zone allocation

Byte 4 shall be set to (00).

Bytes 5 to 7 shall be set to (030000) to specify the Sector Number 196 608 of the first Physical Sector of the Data Zone

Byte 8 shall be set to (00).

Bytes 9 to 11 shall specify the Sector Number of the last Rzone in the Bordered Area.

Byte 12 shall be set to (00)

Bytes 13 to 15 shall be set to (00)

Other settings are prohibited by this International Standard.

Bytes 16 to 31

These bytes shall be set to (00).

Bytes 32 to 39 - Start sector number of Border Zone

Bytes 32 to 35 shall specify the Sector Number of the first sector of the current Border Out (see annex H).

Bytes 36 to 39 shall specify the Sector Number of the first sector of the next Border In (see annex H).

When the Lead-in is recorded in the disk at once mode or in the Incremental Recording mode without BorderZone, these bytes shall be set to (00).

Bytes 40 to 2 047

These bytes shall be set to (00).

25.2.2 Disk manufacturing information

This International Standard does not specify the format and the content of these 2 048 bytes. They shall be ignored in interchange.

25.2.3 Reserved

These bytes shall be set to all ZEROs.

25.3 Lead-out Zone

The Main Data of the Data Frames eventually recorded as Physical Sectors in the Lead-out Zone shall have been set to (00). This International Standard does not specify the number of Physical Sectors in the Lead-out Zone.

Section 6 — Format of the Unrecorded Zone

26 General description of the Unrecorded Zone

The track of the Unrecorded Zone is formed by a continuous spiral pre-groove that extends from the inner part of the disk to the outer diameter of the disk. The track is wobbled at a specified frequency to control the drive functions. The precise address information for an unrecorded disk is embossed on the land between adjacent grooved regions.

The Unrecorded Zone shall be divided into two parts; the R-Information Zone and the Information Zone.

The R-Information Zone shall be divided into two parts; the Power Calibration Area and the Recording Management Area.

The Information Zone shown in figure 35 shall be divided as shown in 10.7.1 into three parts which have the same configuration as a Read-only disk. Starting from the inner radius, these zones are the Lead-in Zone, Data Recordable Zone, and Lead-out Zone. These three zones are essential and identical in principle to those same zones on a DVD-Read-Only disk. The sequence of recording these three areas depends on the specific recording mode.

The Recording Data shall be recorded in the pre-groove guided by the wobble and Pre-pit Information that is embossed in the land.

The accurate start address before recording shall be determined by decoding the Pre-pit Information on the land.

26.1 Layout of the Unrecorded Zone

The Unrecorded Zone shall be sub-divided as shown in table 7. The first ECC block address (see clause 26.2) for some of the zones are shown in table 7.

Table 7 — Layout of Unrecorded Zone

	ECC block address of the first block of the zone	Number of blocks
R-Information Zone Power Calibration Area	(002080)	443
Recording Management Area	(00223C)	701
Lead-In Zone		
Data Zone	(003000)	
Lead-out Zone		

26.2 ECC block address (see 27.3.2)

The ECC block address shall be the absolute physical address of the track.
The start and stop positions of each zone shall be defined using the ECC block address.
The address shall increase from the inside to outside diameter of the disk.
The address shall be embossed on the land as the Pre-pit Information.

26.3 ECC block numbering

The ECC block address increases continuously from the inner radius to the outer radius of the disk. The ECC block address is calculated by letting the ECC block address (see 27.3.2) of the block placed at the beginning of the Data Zone be (003000). This first block of the Data Zone shall be located after the Lead-in Zone.

The Power Calibration Area and Recording Management Area shown in figure 35 shall be located before the Lead in Zone.

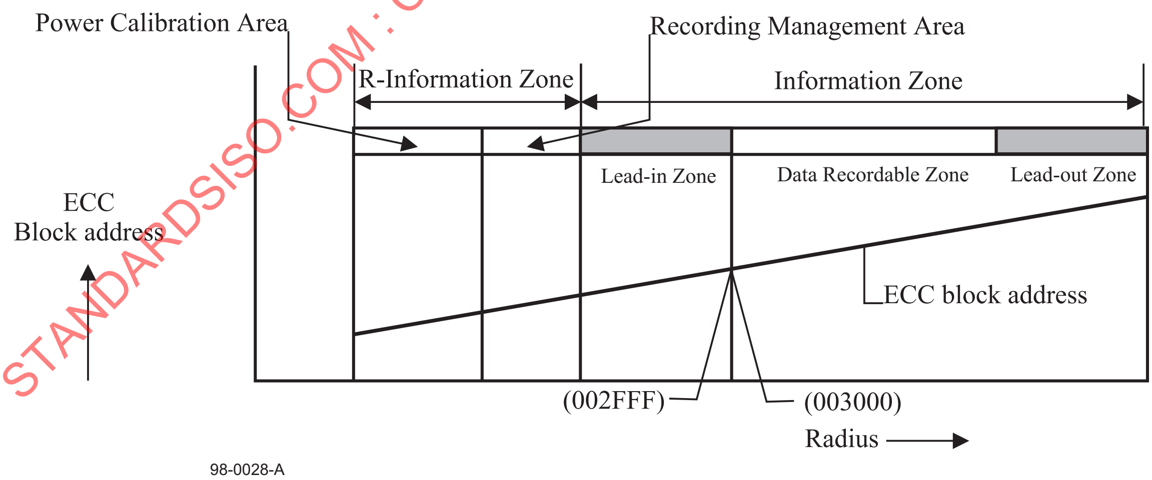


Figure 35 — Pre-pit sector layout and ECC block numbering

27 Pre-pit Data format

27.1 General description

The Pre-pit Data is embossed as a sequence of Pre-pits on the land. The Pre-pit Data sequence corresponds to 16 sectors of the same physical size as 1 ECC block to be recorded in the groove.

One set of Pre-pits shall be given by 3 bits (b_2,b_1,b_0) every two SYNC frames. The first set of Pre-pits in a Pre-pit physical sector is the Pre-pit SYNC code . The first bit of the first set of bits is called the SYNC frame code bit. The first bit of the 3 bits shall be located at the special position of the recorded SYNC code of the 16-bit Code Words in the groove. The assignment of these bits shall be as shown in table 8.

Table 8 — Assignment of Land Pre-pit

	b_2	b_1	b_0
Pre-pit SYNC code in Even position	1	1	1
Pre-pit SYNC code in Odd position	1	1	0
Pre-pit data ONE	1	0	1
Pre-pit data ZERO	1	0	0

The assigned position of Pre-pits and the SYNC pattern of 16-bit Code words shall be as shown in figures 36 and 37. The relation in phase between wobble and Land Pre-pit also shall be as specified in clause 14.5.3.

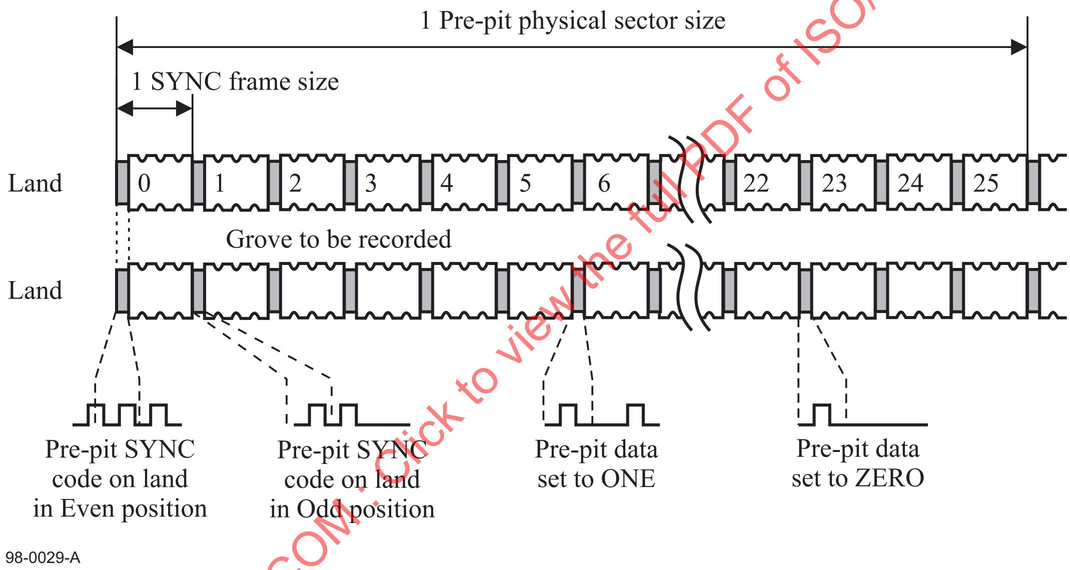


Figure 36 — Track formation

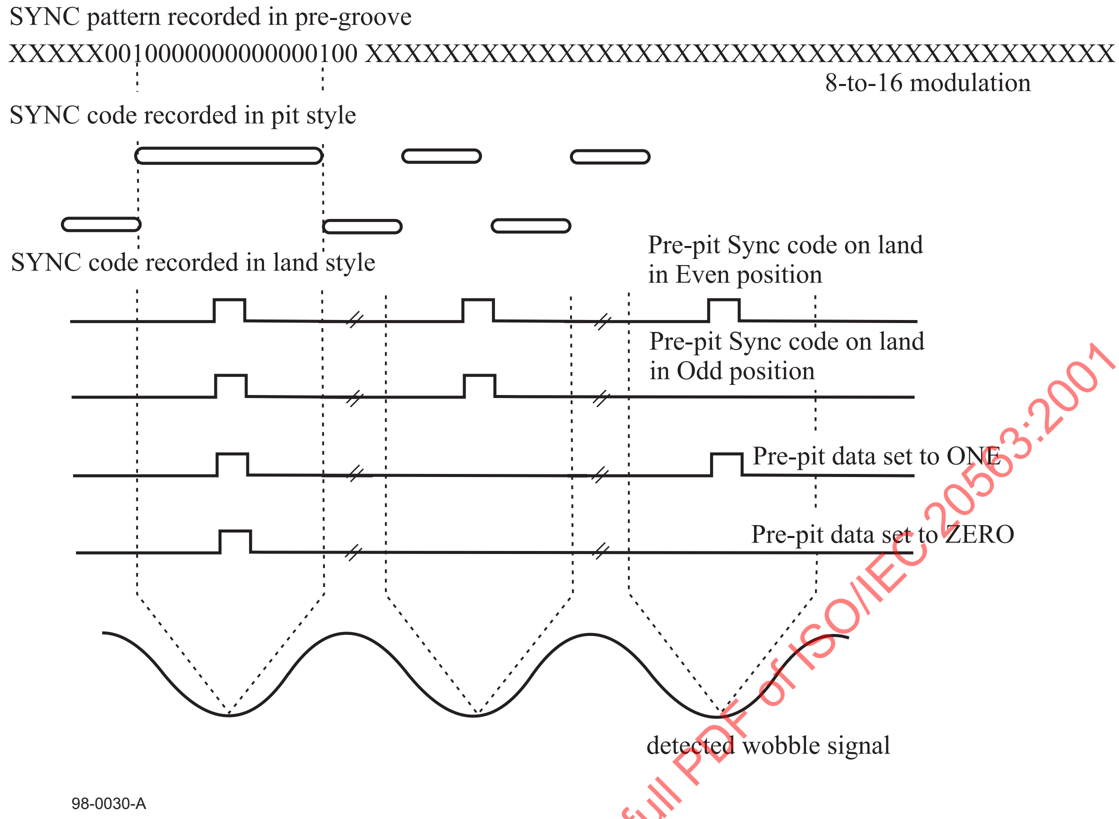


Figure 37 — Relationship of signals recorded in groove and land

There are two cases of Pre-pit position in two SYNC frames called Even position and Odd position. Normally the Pre-pit should be recorded at the Even position. In mastering, when there is already a Pre-pit on the neighbouring land, the position of the Pre-pits shall be shifted to the Odd position sequence. Such a case is described in figure 38.

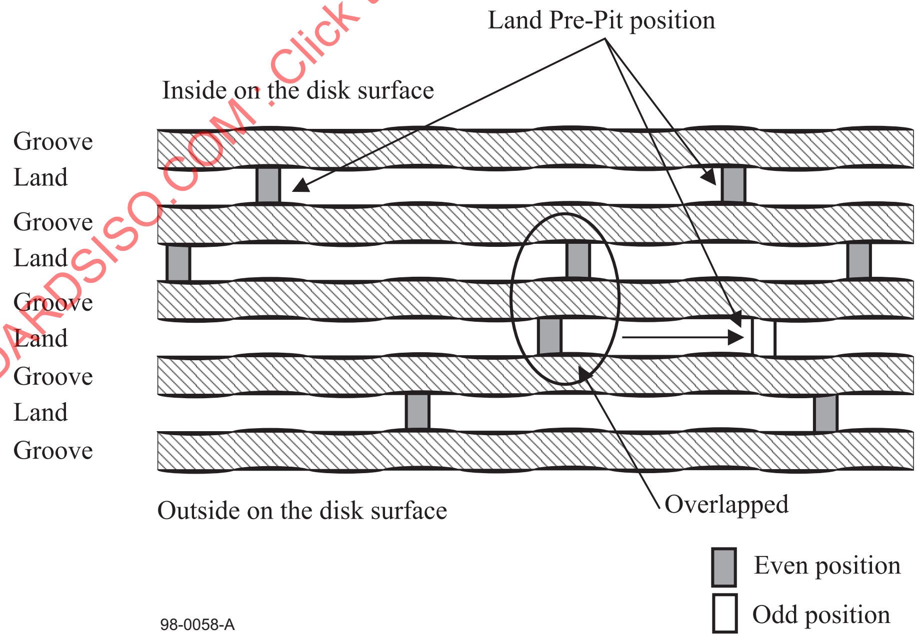


Figure 38 — Layout of land Pre-pit positioning

The Pre-pit physical sector shall be the minimum unit for constructing the Pre-pit block. The Pre-pit block shall be formed with 16 Pre-pit physical sectors.

The Pre-pit data frame shall consist of 4 bits of relative address specified in 27.3.1 and 8 bits of user data.

Pre-pit data shall be recorded in the user data area of the Pre-pit data frame. The Pre-pit data frame shall be as shown in figure 39.

The Pre-pit physical sector shall be a Pre-pit data frame after transforming 1 bit into 3 bits and adding Pre-pit SYNC code. The Pre-pit physical sector shall be recorded on the land as part of the land Pre-pit recording. See figure 40 and table 8.

Relative address 4 bits	User data 8 bits

Figure 39 — Pre-pit data frame structure

Pre-pit SYNC code 3 bits	Transformed relative address 12 bits	Transformed user data 24 bits

Figure 40 — Pre-pit physical sector structure

27.2 Pre-pit block structure

A Pre-pit data block shall be constructed with 16 Pre-pit data frames

The Pre-pit data block shall have two data parts, part A and part B.

Part A shall consist of 3 bytes of ECC block address (see clause 27.3.2) and 3 bytes of parity A (see clause 27.3.3), and relative address 0000 to 0101 (see clause 27.3), thus Part A is constructed with 6 Pre-pit data frames.

Part B shall consist of 1 byte of Field ID, 6 bytes of disk information and 3 bytes of parity B and relative address 0110 to 1111. Thus Part B is constructed with 10 Pre-pit data frames.

The Pre-pit physical block shall be constructed with 16 Pre-pit physical sectors which are constructed by transforming each 1 bit of Pre-pit data block to 3 bits and adding the Pre-pit SYNC code.

This signal processing shall be as shown in figure 41.

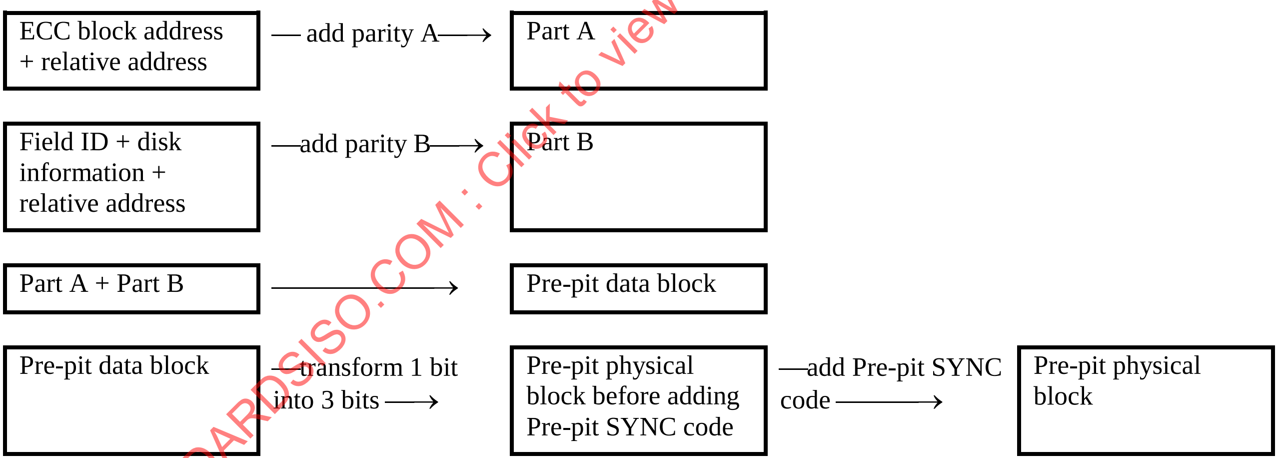


Figure 41 — Processing order to construct a Pre-pit block

The Pre-pit block structure shall be as shown in figure 42.

<table>
<tr><td></td><td colspan="3">Pre-pit physical block (using transformed Pre-pit data block (see table 8))</td></tr>
<tr><td></td><td colspan="3">Pre-pit data block</td></tr>
<tr><td rowspan="4">Pre-pit SYNC code</td><td rowspan="2">Relative address
0000 to 0101</td><td>ECC block address [3 bytes]</td><td rowspan="2">Part A</td></tr>
<tr><td>Parity A [3 bytes]</td></tr>
<tr><td rowspan="2">Relative address
0110 to 1111</td><td>Pre-pit field ID and disk information
[7 bytes]</td><td rowspan="2">Part B</td></tr>
<tr><td>Parity B [3 bytes]</td></tr>
</table>

Figure 42 — Pre-pit block structure

A Pre-pit physical block shall be as shown schematically in figure 43.

←--26 SYNC frames ---→

←--------Pre-pit SYNC code and relative address-------------→ ←-----Pre-pit part A and part B information---→

	E	O	E	O	E	O	E	O	E	O	E	O	E	O	E	O	E	O	E	O	E	O	E	O	E	O		
G																											A	#0
L	111		100		100		100		100		←	—	—	—	—	a	d	d	r	e	s	s	—	—	—	→		
G																												#1
L	111		100		100		100		101		←	—	—	—	—	a	d	d	r	e	s	s	—	—	—	→		
G																												#2
L	111		100		100		101		100		←	—	—	—	—	a	d	d	r	e	s	s	—	—	—	→		
G																												#3
L	111		100		100		101		101		←	—	—	—	p	a	r	i	t	y		A	—	—	—	→		
G																												#4
L	111		100		101		100		100		←	—	—	—	p	a	r	i	t	y		A	—	—	—	→		
G																												#5
L	111		100		101		100		101		←	—	—	—	p	a	r	i	t	y		A	—	—	—	→		
G																											B	#6
L	111		100		101		101		100						f	i	e	l	d		I	D						
G																												#7
L	111		100		101		101		101		d	i	s	k		i	n	f	o	r	m	a	t	i	o	n		
G																												#8
L	111		101		100		100		100		d	i	s	k		i	n	f	o	r	m	a	t	i	o	n		
G																												#9
L	111		101		100		100		101		d	i	s	k		i	n	f	o	r	m	a	t	i	o	n		
G																												#10
L	111		101		100		101		100		d	i	s	k		i	n	f	o	r	m	a	t	i	o	n		
G																												#11
L	111		101		100		101		101		d	i	s	k		i	n	f	o	r	m	a	t	i	o	n		
G																												#12
L	111		101		101		100		100		d	i	s	k		i	n	f	o	r	m	a	t	i	o	n		
G																												#13
L	111		101		101		100		101		←	—	—	—	p	a	r	i	t	y		B	—	—	—	→		
G																												#14
L	111		101		101		101		100		←	—	—	—	p	a	r	i	t	y		B	—	—	—	→		
G																												#15
L	111		101		101		101		101		←	—	—	—	p	a	r	i	t	y		B	—	—	—	→		

Legend:

a) G means groove, L means land, E means even position, O means odd position.

b) Pre-pits SYNC code is shown in even position in this representation. Relative address Pre-pit Data ONE is represented by 101 and Pre-pit Data ZERO is represented by 100 in this representation. The assignment of land Pre-pits is specified in table 8.

c) Last column is the Pre-pit physical sector number in a Pre-pit physical block.

d) Second from last column denotes the part A and part B of the Pre-pit physical block structure.

Figure 43 — Pre-pit physical block

27.3 Pre-pit data block configuration

Data of Part A and Part B is called Pre-pit information. Pre-pit information of Part A shall be the ECC block address. Pre-pit information of Part B shall be recorded in the disk information fields of Part B.

The contents of the disk information in Part B are classified and shall be distinguished by Field ID. Therefore each Pre-pit data block including the classified Part B shall be distinguished by a Field ID.

The classification and the location of the Pre-pit data block shall be as shown in table 9.

Table 9 — Classification and location of Pre-pit data blocks

Field ID	Contents of disk-information in Part B	Location
0	ECC block address	All Zones
1	Application code / Physical data	Lead-in Zone
2	Recording information	Lead-in Zone
3	Manufacturer ID (1)	Lead-in Zone
4	Manufacturer ID (2)	Lead-in Zone
5	Manufacturer ID (3)	Lead-in Zone

In the Lead-in Zone, Pre-pit data blocks of Field ID 1 to 5 shall be recorded as shown in figure 44.

Field ID	Location	ECC block address
Field ID 1	Start of the Lead-in Zone	(024FA)
Field ID 2		
Field ID 3		
Field ID 4		
Field ID 5		
Field ID 1		
Field ID 2		
Field ID 3		
Field ID 4		
Field ID 5		
Field ID 1		
•		
•		
•		
Field 4		
Field 5		
Field 0		(02FFE)
Field 0	End of the Lead-in Zone	(02FFF)

Figure 44 — Layout of Pre-pit data blocks in the Lead- in Zone

27.3.1 Relative address

The Pre-pit data frame contains a relative address. The relative address shows the position of 16 Pre-pit data frames (one Pre-pit data block). Four bits shall be used to specify the relative address.

0000 First Pre-pit data frame
0001 Second Pre-pit data frame

.

.

.

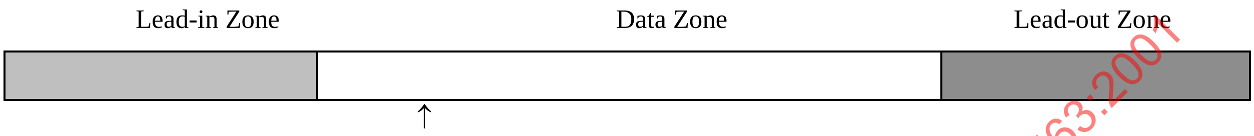
1111 Last Pre-pit data frame

The relative address number shall be equal to the decimal value represented by the least significant 4 bits of the physical sector number recorded in the groove. The relative address shall not have error detection and error correction code.

27.3.2 ECC block address data configuration

The ECC block address shall be equal to the decimal value represented by b_{23} to b_4 of the physical sector number recorded in the groove. The ECC block address at the start of Data Zone shall be (003000) as shown in figure 45.

The ECC block address shall have parity. Therefore error correction is possible.



Groove: Physical sector number (030000)

Land: ECC block address (003000)

Figure 45 — The relation between physical sector number and ECC block address

27.3.3 Parity A and Parity B

In figure 45, suppose each byte allocated in the matrix is C_j (j = 0 to 15). Then each byte for parity;
C_j (j = 3 to 5 and j= 13 to 15) shall be as follows.

Parity A:

$$\text{Parity A}(x) = \sum_{j=3}^{5} c_j x^{5-j} = \mathrm{I}(x)x^3 \mod G_E(x)$$

where

$$\mathrm{I}(x) = \sum_{j=0}^{2} c_j x^{2-j}$$

$$G_E(x) = \prod_{k=0}^{2} \left(x + \alpha^k\right)$$

$$G_p(x) = x^8 + x^4 + x^3 + x^2 + 1$$

Parity B:

$$\text{Parity B}(x) = \sum_{j=13}^{15} c_j x^{15-j} = \mathrm{I}(x)x^3 \mod G_E(x)$$

where

$$\mathrm{I}(x) = \sum_{j=6}^{12} c_j x^{12-j}$$

$$G_E(x) = \prod_{k=0}^{2} \left(x + \alpha^k\right)$$

α represents the primitive root of the primitive polynomial.

$$G_p(x) = x^8 + x^4 + x^3 + x^2 + 1$$

27.3.4 Field ID0

The Pre-pit data block configuration of Field ID0 shall be as shown in figure 46.

Pre-pit data frame number	Bit position 0	1 to 4	5 (msb) to 12 (lsb)	
0	Pre-pit SYNC code*	0000	First byte of ECC block address 2	Part A
1		0001	Second byte of ECC block address 1	
2		0010	Third byte of ECC block address 0	
3		0011	First byte of Parity A	
4		0100	Second byte of Parity A	
5		0101	Third byte of Parity A	
6		0110	Field ID (00)	Part B
7		0111	First byte of ECC block address	
8		1000	Second byte of ECC block address	
9		1001	Third byte of ECC block address	
10		1010	Reserved	
11		1011	Reserved	
12		1100	Reserved	
13		1101	First byte of Parity B	
14		1110	Second byte of Parity B	
15		1111	Third byte of Parity B	

* The Pre-pit SYNC code is added to the Pre-pit data block to construct the Pre-pit physical block

Figure 46 — Pre-pit data block configuration of Field ID0

27.3.5 Field ID1

The Pre-pit block configuration of Field ID1 shall be as shown in figure 47.

Pre-pit data frame number	Bit position 0	1 to 4	5 (msb) to 12 (lsb)	
0	Pre-pit SYNC code*	0000	First byte of ECC block address	Part A
1		0001	Second byte of ECC block address	
2		0010	Third byte of ECC block address	
3		0011	First byte of Parity A	
4		0100	Second byte of Parity A	
5		0101	Third byte of Parity A	
6		0110	Field ID (01)	Part B
7		0111	Application code	
8		1000	Disk physical code	
9		1001	First byte of Last address of Data Zone	
10		1010	Second byte of Last address of Data Zone	
11		1011	Third byte of Last address of Data Zone	
12		1100	Reserved	
13		1101	First byte of Parity B	
14		1110	Second byte of Parity B	
15		1111	Third byte of Parity B	

* The Pre-pit SYNC code is added to the Pre-pit data block to construct the Pre-pit physical block

Figure 47 — Pre-pit data block configuration of Field ID1

27.3.5.1 Application code

The Application code shall be specified as follows:

Bit Position 5	set to ZERO	
Bit Position 6	set to ZERO	: Disk for restricted use (disk may be used for either , but not both, of the following purposes).
Bit Position 7 to 12	set to 000000	: General purpose disk for use only in general purpose drives.
Bit Position 7 to 12	set to others	: Special purpose disk for use only in special drives.
Bit Position 6	set to ONE	: Disk for unrestricted use (disk may be used for both of the following purposes).
Bit Position 7 to 12	set to 000000	: For use in general purpose drives
Bit Position 7 to 12	set to others	: For use in general purpose drives and also for use in consumer drives for a specific registered application to be defined.

27.3.5.2 Disk physical code

Basic physical characteristics of the disk shall be specified in the Disk physical code field as shown in table 10.

Table 10 — Disk physical code

Bit position	Content	Bit settings and meaning	
5 (msb)	Track pitch	ZERO = 0,8 µm	ONE = 0,74 µm
6	Reference velocity	ZERO = 3,84 m/s	ONE = 3,49 m/s
7	Disk diameter	ZERO = 120 mm	ONE = 80 mm
8	Reflectivity(1)	ZERO = 45 % to 85 %	ONE = 18 % to 30%
9	Reflectivity(2)	Reserved	
10	Media type(1)	ZERO = Organic dye	ONE = others
11	Media type(2)	Reserved	
12 (lsb)	Reserved	Reserved	

27.3.5.3 Last address of Data Zone

The last ECC block address of the Data Zone shall be specified in hexadecimal notation in the Last Address of Data Zone field. The Last address of Data Zone does not indicate the maximum ECC block address of the disk but indicates the outer limit of the Data Zone. The Pre-pit physical block shall extend toward the outer diameter of the disk, beyond the zone indicated by the last address of Data Zone.

27.3.6 Field ID2

The Pre-pit data block configuration of Field ID2 shall be as shown in figure 48.

Pre-pit data frame	Bit position			
	0	1 to 4	5 (msb) to 12 (lsb)	
0	Pre-pit SYNC code*	0000	First byte of ECC block address	Part A
1		0001	Second byte of ECC block address	
2		0010	Third byte of ECC block address	
3		0011	First byte of Parity A	
4		0100	Second byte of Parity A	
5		0101	Third byte of Parity A	
6		0110	Field ID (02)	Part B
7		0111	OPC suggested code	
8		1000	Wavelength code	
9		1001	First byte of Write strategy code	
10		1010	Second byte of Write strategy code	
11		1011	Third byte of Write strategy code	
12		1100	Fourth byte of Write strategy code	
13		1101	First byte of Parity B	
14		1110	Second byte of Parity B	
15		1111	Third byte of Parity B	

* The Pre-pit SYNC code is added to the Pre-pit data block to construct the Pre-pit physical block

Figure 48 — Pre-pit data block configuration of Field ID2

27.3.6.1 OPC code

The OPC code field shall either specify a recommended recording power for the disk, or be set to (00). The OPC code shall be as shown in table 11.

Table 11 — OPC code

OPC code	Recording power in mW
(00)	not specified
(01)	6,0
(02)	6,5
(03)	7,0
(04)	7,5
(05)	8,0
(06)	8,5
(07)	9,0
(08)	9,5
(09)	10,0
(0A)	10,5
(0B)	11,0
(0C)	11,5
(0D)	12,0

Other settings are prohibited by this International Standard.

27.3.6.2 Wavelength code

The wavelength code field shall specify the wavelength of the laser for the recommended recording power as shown in Table 12. If the OPC code is set to (00), then all bytes of this field shall be set to (00).

Table 12 — Wavelength code

Wavelength code	Wavelength in nm
(00)	not specified
(01)	630
(02)	631
(03)	632
(04)	633
(05)	634
(06)	635
(07)	636
(08)	637
(09)	638
(0A)	639
(0B)	640

Other settings are prohibited by this International Standard.

27.3.6.3 Write Strategy code

The write strategy code field indicates the optimum Write Strategy for the disk. The Write Strategy code field consists of several fields which shall be as shown in table 13.

If the first byte in the Write Strategy code field in figure 48 is set to (00), the other Write Strategy code fields are invalid and all of the bytes of these fields (i.e. the second byte of the Write Strategy code field to the fourth byte) shall be set to (00). In the Tables 13 and 14 nT_{top} is the top pulse length of the write pulse when recording the nT data (n = 3 to 11 and 14) (see annex P).

Table 13 — Write Strategy code field

Pre-pit data frame	Content			
9	$3T_{top}$		$4T_{top}$	
10	$5T_{top}$ - $11T_{top}$, $14T_{top}$		T_{mp}	
11	3 - $3T_{ld}$	3 - $3T_{tr}$	3 - $4T_{ld}$	3 - $4T_{tr}$
12	4 - $3T_{ld}$	4 - $3T_{tr}$	4 - $4T_{ld}$	4 - $4T_{tr}$

The Write Strategy code shall consist of 4 bits of nT_{top} code, 4 bits of T_{mp} code, 2 bits of T_{ld} code and 2 bits of T_{tr} Code. The Write Strategy code shall be as shown in tables 14, 15, and 16.

Table 14 — nT_{top} code

Code	$3T_{top}$	$4T_{top}$	$5T_{top}$ to $11T_{top}$, $14T_{top}$	T_{mp}
0001	1,00T	1,00T	1,00T	0,30T
0010	1,05T	1,05T	1,05T	0,35T
0011	1,10T	1,10T	1,10T	0,40T
0100	1,15T	1,15T	1,15T	0,45T
0101	1,20T	1,20T	1,20T	0,50T
0110	1,25T	1,25T	1,25T	0,55T
0111	1,30T	1,30T	1,30T	0,60T
1000	1,35T	1,35T	1,35T	0,65T
1001	1,40T	1,40T	1,40T	0,70T
1010	1,45T	1,45T	1,45T	0,75T
1011	1,50T	1,50T	1,50T	0,80T
1100	1,55T	1,55T	1,55T	0,85T
1101	1,60T	1,60T	1,60T	0,90T
1110	1,65T	1,65T	1,65T	0,95T
1111	1,70T	1,70T	1,70T	1,00T

Table 15 — T_{ld} code

Code	T_{ld}
00	0,00T
01	0,05T
10	-0,05T
11	-0,10T

Table 16 — T_{tr} code

Code	T_{tr}
00	0,00T
01	0,05T
10	-0,05T
11	-0,10T

27.3.6.3.1 $3T_{top}$ field, $4T_{top}$ field, $5T_{top}$ to $11T_{top}$ and $14T_{top}$ field, T_{mp} field

Each code selected out of table 14 shall be specified in each field.

27.3.6.3.2 3-3T_{ld} field, 3-3T_{tr} field, 3- 4T_{ld} field, 3-4T_{tr} field, 4-3T_{ld} field, 4-3T_{tr} field, 4-4T_{ld} field, 4-4T_{tr} field

These fields shall specify T_{ld} code and T_{tr} code which are selected from table 15 and table 16 according to the combination of the preceding space length and the recording data length, see annex P. In the case that the preceding space length is mT and the recording data length is nT, T_{ld} shall be identified as m-nT_{ld} and T_{tr} shall be described as m-nT_{tr} (m = 3, 4 and n = 3, 4).

27.3.7 Field ID3 to Field ID5

The Pre-pit data block configuration of Field ID3 to Field ID5 shall be as shown in figures 49, 50 and 51.

This International Standard does not specify the format and the content of the 18 bytes designated as Manufacturer ID. They shall be ignored in interchange.

Pre-pit	Bit position			
data frame	0	1 to 4	5 (msb) to 12 (lsb)	
0	Pre-pit SYNC code*	0000	First byte of ECC block address	Part A
1		0001	Second byte of ECC block address	
2		0010	Third byte of ECC block address	
3		0011	First byte of Parity A	
4		0100	Second byte of Parity A	
5		0101	Third byte of Parity A	
6		0110	Field ID (03)	Part B
7		0111	First byte of Manufacturer ID	
8		1000	Second byte of Manufacturer ID	
9		1001	Third byte of Manufacturer ID	
10		1010	Fourth byte of Manufacturer ID	
11		1011	Fifth byte of Manufacturer ID	
12		1100	Sixth byte of Manufacturer ID	
13		1101	First byte of Parity B	
14		1110	Second byte of Parity B	
15		1111	Third byte of Parity B	

* The Pre-pit SYNC code is added to the Pre-pit data block to construct the Pre-pit physical block

Figure 49 — Pre-pit data block configuration of Field ID3

Pre-pit data frame	Bit position 0	1 to 4	5 (msb) to 12 (lsb)	
0	Pre-pit SYNC code*	0000	First byte of ECC block address	Part A
1		0001	Second byte of ECC block address	
2		0010	Third byte of ECC block address	
3		0011	First byte of Parity A	
4		0100	Second byte of Parity A	
5		0101	Third byte of Parity A	
6		0110	Field ID (04)	Part B
7		0111	Seventh byte of Manufacturer ID	
8		1000	Eighth byte of Manufacturer ID	
9		1001	Ninth byte of Manufacturer ID	
10		1010	Tenth byte of Manufacturer ID	
11		1011	Eleventh byte of Manufacturer ID	
12		1100	Twelfth byte of Manufacturer ID	
13		1101	First byte of Parity B	
14		1110	Second byte of Parity B	
15		1111	Third byte of Parity B	

* The Pre-pit SYNC code is added to the Pre-pit data block to construct the Pre-pit physical block

Figure 50 — Pre-pit data block configuration of Field ID4

Pre-pit data frame	Bit position			
	0	1 to 4	5 (msb) to 12 (lsb)	
0	Pre-pit SYNC code*	0000	First byte of ECC block address	Part A
1		0001	Second byte of ECC block address	
2		0010	Third byte of ECC block address	
3		0011	First byte of Parity A	
4		0100	Second byte of Parity A	
5		0101	Third byte of Parity A	
6		0110	Field ID (05)	Part B
7		0111	Thirteenth byte of Manufacturer ID	
8		1000	Fourteenth byte of Manufacturer ID	
9		1001	Fifteenth byte of Manufacturer ID	
10		1010	Sixteenth byte of Manufacturer ID	
11		1011	Seventeenth byte of Manufacturer ID	
12		1100	Eighteenth byte of Manufacturer ID	
13		1101	First byte of Parity B	
14		1110	Second byte of Parity B	
15		1111	Third byte of Parity B	

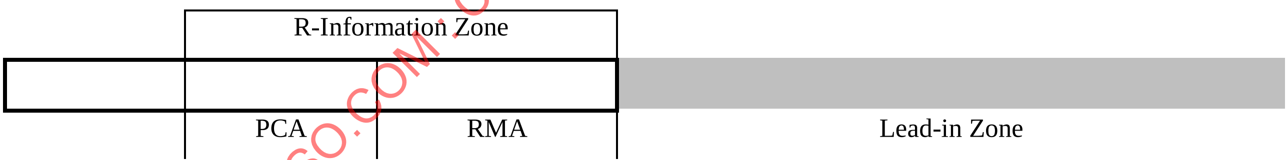
* The Pre-pit SYNC code is added to the Pre-pit data block to construct the Pre-pit physical block

Figure 51 — Pre-pit data block configuration of Field ID5

28 Data structure of R-Information Zone

28.1 Layout of Power Calibration Area and Recording Management Area

The Power Calibration Area and Recording Management Area shown in figure 52 are located in front of the Lead-in Zone.



Start address of R-Information Zone

ECC block address: (002080)……………………………………………………………………(002FFF)

Physical sector number (020800)……………………………………………………………………(02FFFF)

Figure 52 — Address layout of the R-Information Zone

28.2 Structure of the Power Calibration Area

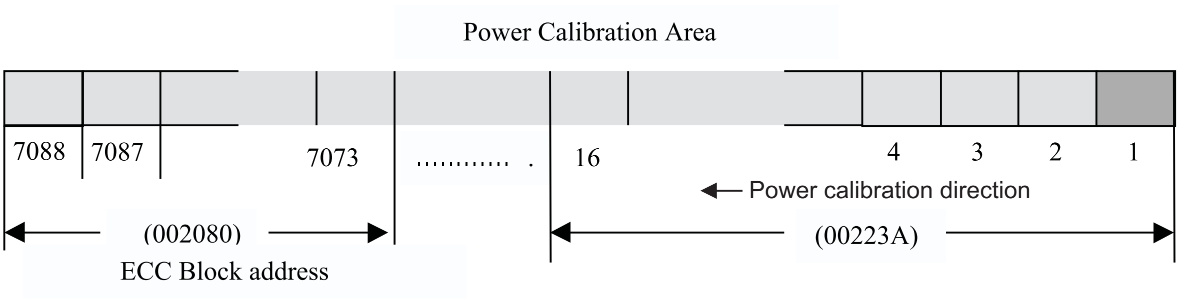
The Power Calibration Area shall be located from ECC block address (002080) to (00223A).

The minimum segment for a power calibration shall be one Pre-pit physical sector and is referred to as a power calibration sector.

The Power Calibration Area shall be constructed with 7 088 power calibration sectors.

The structure of the Power Calibration Area is shown in figure 53.

Power calibration shall be performed from the outside to the inside of the disk.



98-0017-A

Figure 53 — Structure of the Power Calibration Area

28.3 Data configuration of the Recording Management Area (RMA)

28.3.1 Sector format of the Recording Management Area (figure 54)

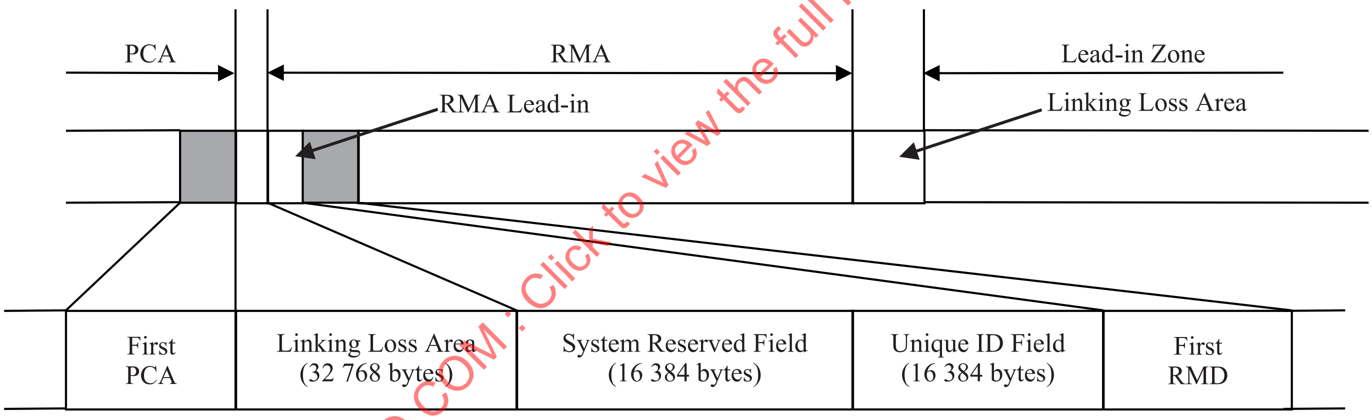
The Recording Management Area shall be located from ECC block address (00223C) to (0024F8).

The RMA shall be constructed with a RMA Lead-in and Recording Management Data (RMD).

The size in bytes of the RMA Lead-in is 32 768 bytes and is constructed with the System Reserved Field of size 16 384 bytes and the Unique Identifier (ID) Field of size 16 384 bytes.

The data in the System Reserved Field shall be set to (00).

The Unique ID Field shall be constructed with eight units which have the same 2 048 bytes size and contents. The byte assignment of each unit shall be as shown in table 17.



98-0059-A

Figure 54 — Layout of the Recording Management Area

Table 17 — Contents of Unique ID Field

BP	Content
0 to 31	Vendor ID
32 to 39	(00)
40 to 55	Serial Number
56 to 63	(00)
64 to 79	Model Number
80 to 87	(00)
88 to 105	Unique Disk ID
106 to 2047	(00)

Byte 0 to byte 31 - Vendor ID

This International Standard does not specify the format and the content of these 32 bytes. They shall be ignored in interchange.

Byte 32 to byte 39 - Reserved

These bytes shall be set to (00).

Byte 40 to byte 55 - Serial number

This International Standard does not specify the format and the content of these 16 bytes. They shall be ignored in interchange.

Byte 56 to byte 63 - Reserved

These bytes shall be set to (00).

Byte 64 to 79 - Model number

This International Standard does not specify the format and the content of these 16 bytes. They shall be ignored in interchange.

Byte 80 to byte 87 - Reserved

These bytes shall be set to (00).

Byte 88 to byte 105 - Unique Disk Identifier (ID)

This International Standard does not specify the format and the content of these 18 bytes. They shall be ignored in interchange.

Byte 106 to byte 2 047 - Reserved

These bytes shall be set to (00).

28.3.2 Recording Management Data (RMD)

Recording Management Data (RMD) shall contain the information about the recordings on the disk. The size of the RMD shall be 32 768 bytes. The data structure of the RMD shall be as shown in table 18.

Table 18 — Data structure of the Recording Management Data

Sector Number	Field
Sector 0	Linking Loss Area
Sector 1	RMD Field0
Sector 2	RMD Field1
Sector 3	RMD Field2
Sector 4	RMD Field3
Sector 5	RMD Field4
Sector 6	RMD Field5
Sector 7	RMD Field6
Sector 8	RMD Field7
Sector 9	RMD Field8
Sector 10	RMD Field9
Sector 11	RMD Field10
Sector 12	RMD Field11
Sector 13	RMD Field12
Sector 14	RMD Field13
Sector 15	RMD Field14

Each RMD field shall be 2 048 bytes of Main Data and shall be recorded through the signal processing according to section 4

In order to record RMD incrementally, a Linking Loss Area of 2 048 bytes shall be selected.

28.3.2.1 RMD Field 0

RMD Field 0 shall specify general information of the disk and the contents of this field shall be as specified in table 19.

Table 19 — RMD Field 0

BP	Contents	Number of bytes
0 and 1	RMD format	2
2	Disk status	1
3	Set to (00)	1
4 to 21	Unique disk identifier	18
22 to 85	Copy of Pre-recorded Information	64
86 to 2 047	Set to (00)	1 962

Bytes 0 and 1 - RMD format

These bytes shall be set to (0001).

Byte 2 - Disk status

This field shall specify the disk status as follows.

If set to (00), they specify that the disk is empty.
If set to (01), they specify that the disk is in the “Disk-at once” recording mode.
If set to (02), they specify that the disk is in the “incremental recording” mode.
If set to (03), they specify that the disk is a finalized disk (for the case of “incremental recording”).

Other settings are prohibited by this International Standard.

Byte 3 - Reserved

These bytes shall be set to (00).

Byte 4 to byte 21- Unique disk identifier

This International Standard does not specify the format and the content of these 18 bytes. They shall be ignored in interchange.

Byte 22 to byte 85 - Copy of Pre-pit Information

The copy of Pre-pit Information which is specified in 27.3 shall be recorded in this field. The recording format shall be as shown in table 20.

Table 20 — Copy of Pre-pit Information

BP	Contents
22	Field ID set to (01)
23	Application code
24	Disk physical code
25 to 27	Last address of Data Zone (see 27.3.5.3)
28 to 29	Set to (00)
30	Field ID set to (02)
31	OPC code
32	Wavelength code
33 to 36	Write strategy code
37	Set to (00)
38	Field ID set to (03)
39 to 44	Manufacturer ID
45	Set to (00)
46	Field ID set to (04)
47 to 52	Manufacturer ID
53	Set to (00)
54	Field ID set to (05)
55 to 60	Manufacturer ID
61 to 85	Set to (00)

Byte 86 to byte 2 047 - Reserved

These bytes shall be set to (00).

28.3.2.2 RMD Field1

RMD Field1 shall contain OPC related information. In RMD Field1 it is possible to record OPC related information for up to 4 drives that may coexist in a system.

In the case of a single drive system, OPC related information shall be recorded in field #1 and the other fields shall be set to (00). In every case, the unused fields of RMD Field1 shall be set to (00).

Table 21 — RMD Field1

BP	Contents		Number of bytes
0 to 79	#1	Power calibration information	80
80 to 83		Power calibration address	4
84 to 107		Running OPC information	24
108 to 127		Set to (00)	20
128 to 207	#2	Power calibration information	80
208 to 211		Power calibration address	4
212 to 235		Running OPC information	24
236 to 255		Set to (00)	20
256 to 335	#3	Power calibration information	80
336 to 339		Power calibration address	4
340 to 363		Running OPC information	24
364 to 383		Set to (00)	20
384 to 463	#4	Power calibration information	80
464 to 467		Power calibration address	4
468 to 491		Running OPC information	24
492 to 511		Set to (00)	20
512 to 2 047		Set to (00)	1 536

Bytes 0 to 79, 128 to 207, 256 to 335, 384 to 463 - Power calibration information

This International Standard does not specify the format and the content of these bytes. They shall be ignored in interchange.

Bytes 80 to 83, 208 to 211, 336 to 339, 464 to 467 - Power calibration address

These fields shall specify the start ECC block address of the PCA where the last power calibration was performed.

Bytes 84 to 107, 212 to 235, 340 to 363, 468 to 491 - Running OPC information

This International Standard does not specify the format and the content of these bytes. They shall be ignored in interchange.

Bytes 108 to 127, 236 to 255, 364 to 383, 492 to 511, 512 to 2 047 - Reserved

These bytes shall be set to (00).

28.3.2.3 RMD Field2

RMD Field2 may specify user specific data.

This International Standard does not specify the format and the content of these bytes. They shall be ignored in interchange.

28.3.2.4 RMD Field3

If multiple-Border Recordings are performed, Border Zone information shall be recorded in RMD Field3 as shown in table 22.

If the RMD is recorded before the first Border closing or no Borders are recorded, all fields of RMD Field3 shall be set to (00).

Table 22 — RMD Field3

BP	Contents	Number of bytes
0 to 3	Start sector number of the Border-out Area #1	4
4 to 7	Start sector number of the Border-out Area #2	4
:	:	:
2 044 to 2 047	Start sector number of the Border-out Area #n	4

28.3.2.5 RMD Field4

RMD Field4 shall specify the information of RZone and the contents of this field shall be as specified in table 23.

The portion of the Data Zone that is reserved for recording user data is called the RZone. The RZone shall be divided into 2 types depending on the recording conditions. In an Open Rzone, additional data can be appended. In a Complete Rzone, no further user data can be appended. There shall not be more than two Open RZones in a Data Zone.

The portion of the Data Zone that is not yet reserved for recording data is called the Invisible RZone. Zones for subsequent RZones can be reserved in the Invisible RZone.

If no further data can be appended, no Invisible RZone exists.

Table 23 — RMD Field4

BP	Contents	Number of bytes
0 and 1	Invisible Rzone number	2
2 and 3	First Open Rzone number	2
4 and 5	Second Open RZone number	2
6 to15	Set to (00)	10
16 to 19	Start sector number of RZone #1	4
20 to 23	Last recorded address of RZone #1	4
24 to 27	Start sector number of RZone #2	4
28 to 31	Last recorded address of RZone #2	4
:	:	:
2 040 to 2 043	Start sector number of RZone #254	4
2 044 to 2 047	Last recorded address of RZone #254	4

Bytes 0 and 1 - Invisible RZone number

This field shall specify the Invisible RZone number.

The Invisible RZone number shall be the total number of Invisible RZones, Open RZones and Complete RZones.

Bytes 2 and 3 - First Open RZone number

This field shall specify the first Open RZone number.

If there is no first Open RZone, all bytes of this field shall be set to (00).

Bytes 4 and 5 - Second Open RZone number

This field shall specify the second Open RZone number. If there is no second Open RZone, all bytes of this field shall be set to (00).

Bytes 6 to 15 - Reserved

These bytes shall be set to (00).

Bytes 16 to 19, 24 to 27,..., 2 040 to 2 043 - Start sector number of RZone #n (n = 1, 2,..., 254)

These fields shall specify the start sector number of the RZone. If these fields are set to (00), there is no RZone for this RZone number.

Bytes 20 to 23, 28 to 31,... , 2 044 to 2 047 - Last recorded address of RZone #n (n = 1, 2,... , 254)

These fields shall specify the last recorded sector number of the RZone. If these fields are set to (00), there is no RZone reserved for this RZone number.

28.3.2.6 RMD Field5 to RMD Field12

RMD Field5 to RMD Field12 may specify the information of the RZone and the contents of this field shall be as specified in table 24.

If these fields are not used, they shall all be set to (00).

Table 24 — RMD Field 5 to RMD Field12

BP	Contents	Number of bytes
0 to 3	Start sector number of the Rzone #n	4
4 to 7	Start sector number of the Rzone #n	4
8 to 11	Start sector number of the Rzone #n+1	4
12 to 15	Last recorded address of the Rzone #n+1	4
:	:	:
2 044 to 2 047	Last recorded address of the Rzone #n+255	4

Each #n of RMD Field5 to RMD Field12 shall be as follows.

RMD Field5 : #n = 255
RMD Field6 : #n = 511
RMD Field7 : #n = 767
RMD Field8 : #n = 1 023
RMD Field9 : #n = 1 279
RMD Field10 : #n = 1 535
RMD Field11 : #n = 1 791
RMD Field12 : #n = 2 047

28.3.2.7 RMD Field13 and RMD Field 14

RMD Field13 and RMD Field14 shall be set to (00).

Annex A
(normative)

Measurement of the angular deviation α

The angular deviation is the angle α formed by an incident beam perpendicular to the Reference Plane P with the reflected beam (figure A.1.).

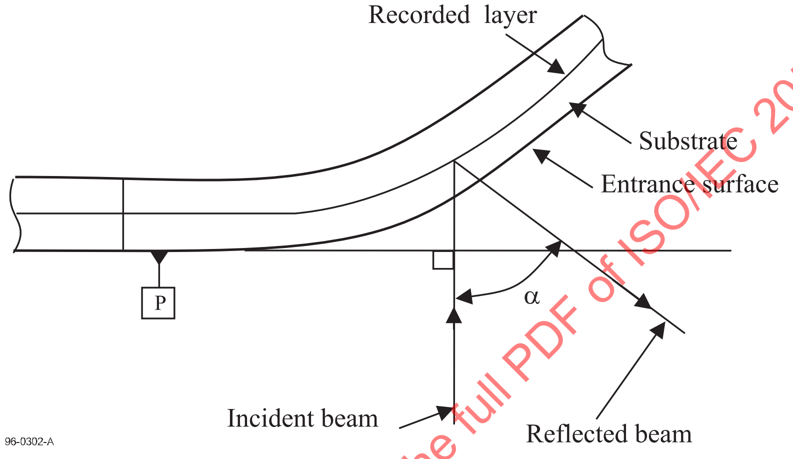


Figure A.1 — Angular deviation α

For measuring the angular deviation α, the disk shall be clamped between two concentric rings covering most of the Clamping Zone. The top clamping area shall have the same diameters as the bottom clamping area.

$$d_{in} = 22{,}3 \text{ mm} \begin{matrix} + 0{,}5 \text{ mm} \\ - 0{,}0 \text{ mm} \end{matrix}$$

$$d_{out} = 32{,}7 \text{ mm} \begin{matrix} + 0{,}0 \text{ mm} \\ - 0{,}5 \text{ mm} \end{matrix}$$

The total clamping force shall be F_1 = 2,0 N ± 0,5 N. In order to prevent warping of the disk under the moment of force generated by the clamping force and the chucking force F_2 exerted on the rim of the centre hole of the disk, F_2 shall not exceed 0,5 N (figure A.2). This measurement shall be made under the conditions of 8.1.1.a).

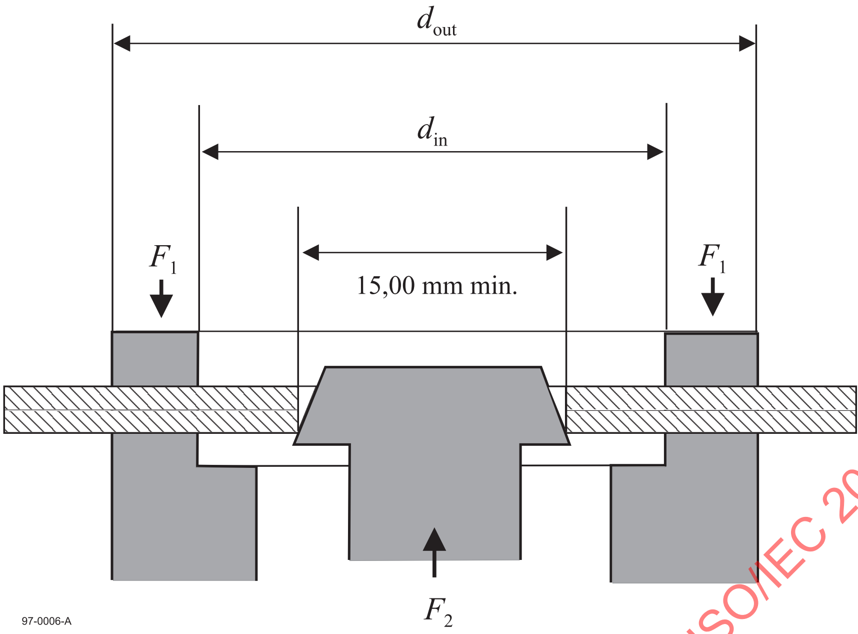


Figure A.2 — Clamping and chucking conditions

Annex B
(normative)

Measurement of birefringence

B.1 Principle of the measurement

In order to measure the birefringence, circularly polarized light in a parallel beam is used. The phase retardation is measured by observing the ellipticity of the reflected light.

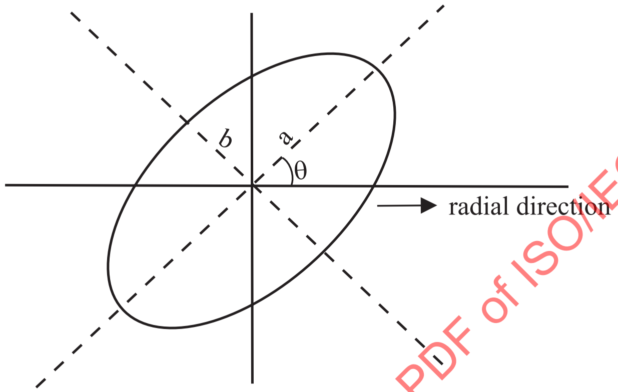


Figure B.1 — Ellipse with ellipticity *e* = *b*/*a* and orientation θ

The orientation θ of the ellipse is determined by the orientation of the optical axis

$$\theta = \gamma - \pi/4 \qquad \text{(I)}$$

where γ is the angle between the optical axis and the radial direction.

The ellipticity $e = b/a$ is a function of the phase retardation δ

$$e = \tan\left[\frac{1}{2}\left(\frac{\pi}{2} - \delta\right)\right] \qquad \text{(II)}$$

When the phase retardation δ is known the birefringence *BR* can be expressed as a fraction of the wavelength

$$BR = \frac{\lambda}{2\pi}\delta \quad \text{nm} \qquad \text{(III)}$$

Thus, by observing the elliptically polarized light reflected from the disk, the birefringence can be measured and the orientation of the optical axis can be assessed as well.

B.2 Measurements conditions

The measurement of the birefringence specified above shall be made under the following conditions.

Mode of measurement in reflection, double pass through the substrate

Wavelength λ of the laser light	640 nm ± 15 nm
Beam diameter (FWHM)	1,0 mm ± 0,2 mm
Angle β of incidence in radial direction relative to the radial plane perpendicular to Reference Plane P	7,0° ± 0,2°
Clamping and chucking conditions	as specified by annex A

Disk mounting	horizontally
Rotation	less than 1 Hz
Temperature and relative humidity	as specified in 8.1.1)

B.3 Example of a measuring set-up

Whilst this International Standard does not prescribe a specific device for measuring birefringence, the device shown schematically in figure B.2 as an example, is well suited for this measurement.

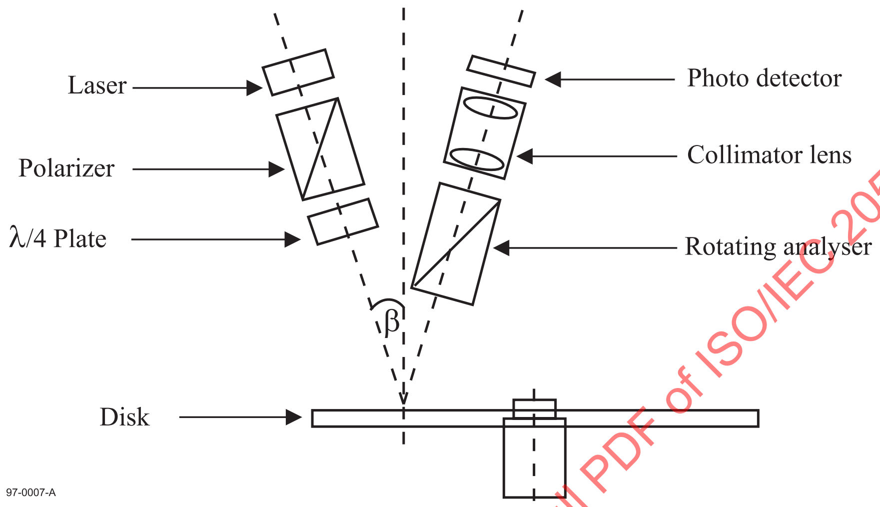


Figure B.2 — Example of a device for the measurement of birefringence

Light from a laser source, collimated into a polarizer (extinction ratio ≈ 10^{-5}), is made circular by a $\lambda/4$ plate. The ellipticity of the reflected light is analyzed by a rotating analyzer and a photo detector. For every location on the disk, the minimum and the maximum values of the intensity are measured. The ellipticity can then be calculated as

$$e^2 = I_{min} / I_{max} \qquad \text{(IV)}$$

Combining equations II, III and IV yields

$$BR = \lambda/4 - \lambda/\pi \times \arctan \sqrt{\frac{I_{min}}{I_{max}}}$$

This device can be easily calibrated as follows

- I_{min} is set to 0 by measuring a polarizer or a $\lambda/4$ plate,
- $I_{min} = I_{max}$ when measuring a mirror

Apart of the d.c. contribution of the front surface reflection, a.c. components may occur, due to the interference of the reflection(s) of the front surface with the reflection(s) from the recorded layer. These a.c. reflectance effects are significant only if the disk substrate has an extremely accurate flatness and if the light source has a high coherence.

Annex C
(normative)

Measurement of the differential phase tracking error

C.1 Measuring method for the differential phase tracking error

The reference circuit for the measurement of the tracking error shall be that shown in figure C.1. Each output of the diagonal pairs of elements of the quadrant photo detector shall be digitized independently after equalization of the wave form defined by

$H(s) = (1 + 1{,}6 \times 10^{-7}\ i\omega) / (1 + 4{,}7 \times 10^{-8}\ i\omega)$

The gain of the comparators shall be sufficient to reach full saturation on the outputs, even with minimum signal amplitudes. Phases of the digitized pulse signal edges (signals B1 and B2) shall be compared to each other to produce a time-lead signal C1 and a time-lag signal C2. The phase comparator shall react to each individual edge with signal C1 or C2, depending on the sign of Δt_i. A tracking error signal shall be produced by smoothing the C1, C2 signals with low-pass filters and by subtracting by means of a unity gain differential amplifier. The low-pass filters shall be 1st order filters with a cut-off frequency of (-3 dB) 30 kHz.

Special attention shall be given to the implementation of the circuit because very small time differences have to be measured, indeed 1 % of T equals only 0,38 ns. Careful averaging is needed.

The average time difference between two signals from the diagonal pairs of elements of the quadrant detector shall be

$$\overline{\Delta t} = 1/N \sum \Delta t_i$$

where N is the number of edges both rising and falling.

C.2 Measurement of $\overline{\Delta t}/T$ without time interval analyzer

The relative time difference $\overline{\Delta t}/T$ is represented by the amplitude of the tracking error signal provided that the amplitudes of the C1 and C2 signals and the frequency component of the read-out signals are normalized. The relation between the tracking error amplitude $\overline{\Delta TVE}$ and the time difference is given by

$$\overline{\Delta TVE} = \frac{\sum \Delta t_i}{\sum T_i}\,\mathrm{Vpc} = \frac{\sum \Delta t_i}{N\,n\,T}\,\mathrm{Vpc} = \frac{\overline{\Delta t}}{T} \times \frac{\mathrm{Vpc}}{n}$$

where

Vpc is the amplitude of the C1 and C2 signals

T_i is the actual length of the read-out signal in the range 3T to 14T

*n*T is the weighted average value of the actual lengths

N n T is the total averaging time

Assuming that Vpc equals ≈ 5 V and that the measured value of *n* equals ≈ 5, then the above relation between the tracking error amplitude $\overline{\Delta TVE}$ and the time difference $\overline{\Delta t}$ can be simplified to

$\overline{\Delta TVE} = \overline{\Delta t}\ / \mathrm{T}$

The specification for the tracking gain can now be rewritten by using the tracking error amplitude as follows

$0{,}5\ (\mathrm{Vpc}/n) \le \overline{\Delta TVE} \le 1{,}1\ (\mathrm{Vpc}/n)$

at 0,1 µm radial offset.

C.3 Calibration of $\overline{\Delta t}$ /T

As the gain of the phase comparator tends to vary, special attention shall be given to the calibration of the gain of the phase comparator. The following check and calibration method shall be applied for the measurement of the DPD tracking error signal.

a) Checking the measurement circuit

a.1) Measure the relation between the amplitude of the first comparator input (3T) and the amplitude of the tracking error signal.

a.2) Check the current gain of the amplifier, using the saturation area (see figure C.2).

b) Determination of the calibration factor K

b.1) Generate two sinusoidal signals A1 and A2 of frequency 2,616 MHz (corresponding to 5T) with phase difference, and feed them into two equalizer circuits.

b.2) Measure the relation between $\overline{\Delta t}$ /T and $\overline{\Delta TVE}$ / Vpc.

($\overline{\Delta TVE}$ / Vpc) K = ($\overline{\Delta t}$ / T) / n

K = (0,2 $\overline{\Delta t}$ /T) / ($\overline{\Delta TVE}$ / Vpc)

for $n = 5$

The relation between $\overline{\Delta t}$ /T and $\overline{\Delta TVE}$ / Vpc is linear (see figure C.3)

c) Compare the measured $\overline{\Delta t}$ /T with the calculated one

c.1) Measure $\overline{\Delta t}$ /T using the method of C.1.

c.2) Calculate $\overline{\Delta t}$ /T(real) as follows

$$\overline{\Delta t} /T \text{ (real)} = K \times \overline{\Delta t} /T \text{ (measured)}$$

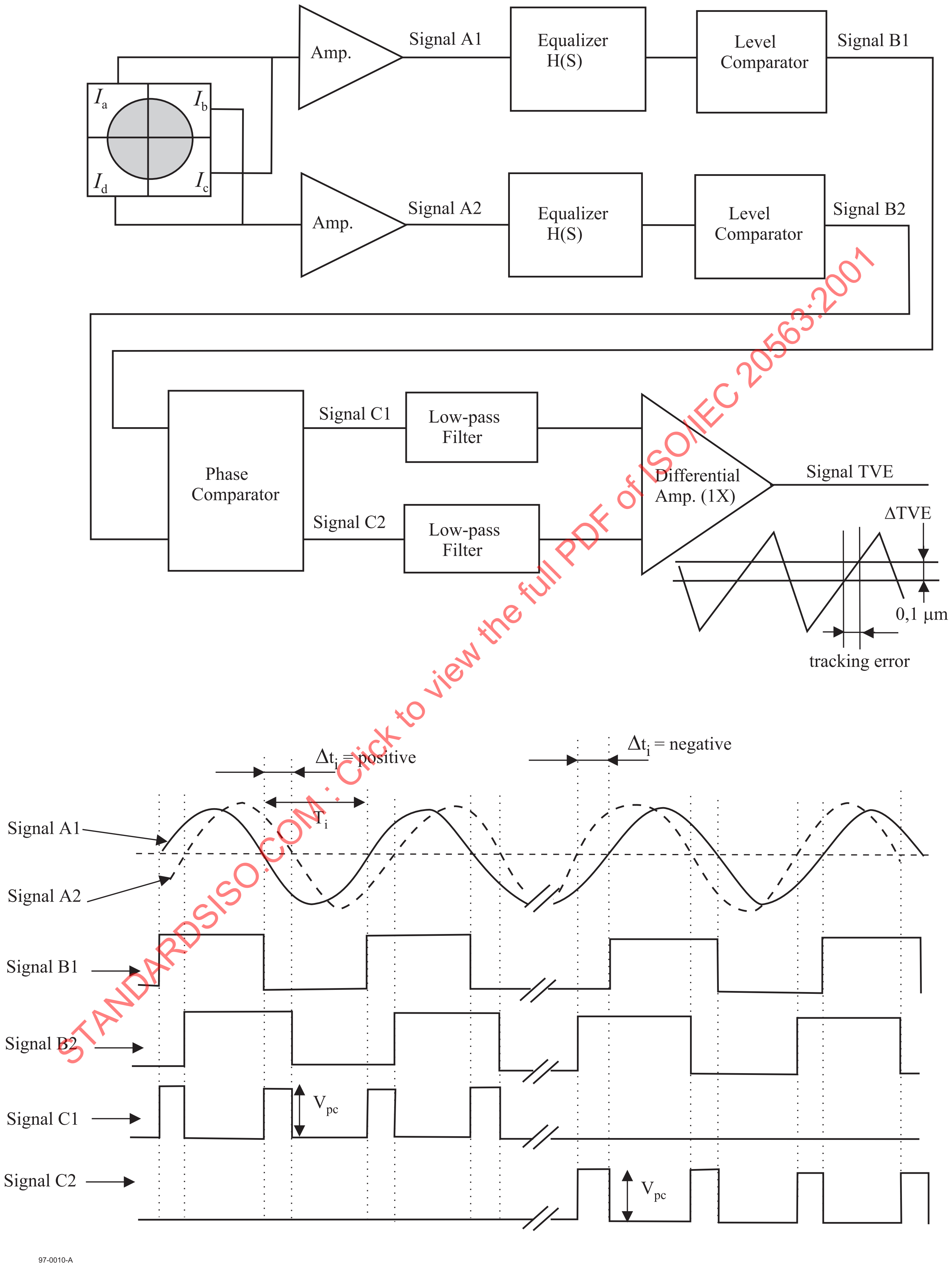


Figure C.1 — Circuit for tracking error measurements

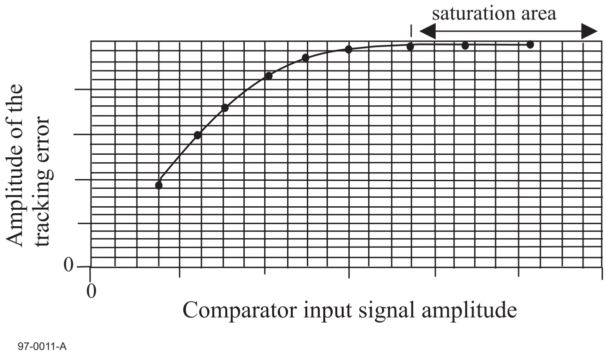


Figure C.2 — Comparator input signal amplitude vs tracking error signal amplitude

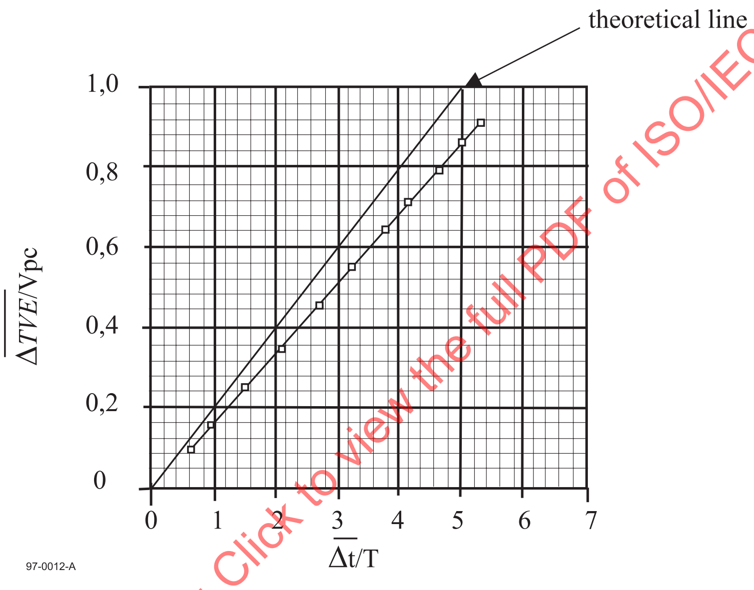


Figure C.3 — $\overline{\Delta t}$ /T vs $\overline{\Delta TVE}$ / Vpc

Annex D
(normative)

Measurement of light reflectance

D.1 Calibration method

A good reference disk shall be chosen, for instance 0,6 mm glass disk with a golden reflective mirror. This reference disk shall be measured by a parallel beam as shown in figure D.1

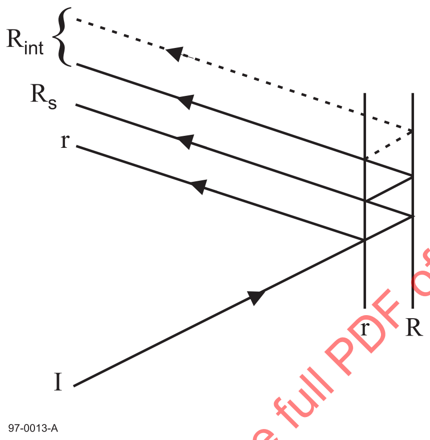


Figure D.1 — Reflectance calibration

In this figure the following applies.

I = incident beam

r = reflectance of the entrance surface

R_s = main reflectance of the recorded layer

R_{int} = other reflectances of the entrance surface and of the recorded layer

$R_{//}$ = measured value, using the arrangement of figure D.1

$R_{//} = r + R_s + R_{int}$

$r = ((n\text{-}1) / (n+1))^2$ where n is the refraction index of the substrate

$R_s = R_{//} - r - R_{int}$

$R_s = [(1\text{-}r)^2 \times (R_{//} - r)] / [1\text{-}r \times (2 - R_{//})]$

The reference disk shall be measured on a reference drive and I_{mirror} measured by the focused beam is equated to R_s as determined above.

Now the arrangement is calibrated and the focused reflectivity is a linear function of the reflectivity of the recorded layer, independently from the reflectivity of the entrance surface.

D.2 Measuring method

The measuring method comprises the following steps.

a) Measure the reflective light power D_S from the reference disk with calibrated reflectivity R_S

b) Measure I_{14H} in the Information Zone of the disk (see 13.2).

c) Calculate the reflectivity as follows

$$R_{14H} = R_s \times \frac{I_{14H}}{D_s}$$

Annex E
(normative)

Tapered cone for disk clamping

The device used for centring the disk for measurement shall be a cone with a taper angle β = 40,0°± 0,5° (see figure E.1).

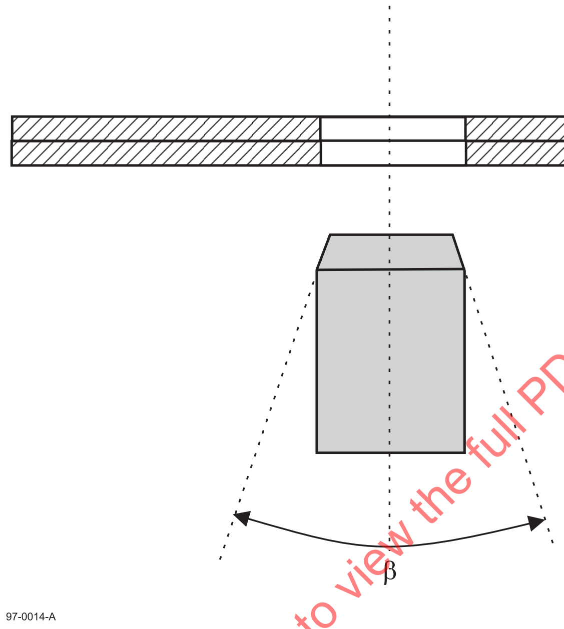


Figure E.1 — Tapered cone

Annex F
(normative)

Measurement of jitter

Jitter shall be measured under the conditions of 9.1 with the additional conditions specified in this annex.

F.1 System diagram for jitter measurement

The general system diagram for jitter measurement shall be as shown in figure F.1.

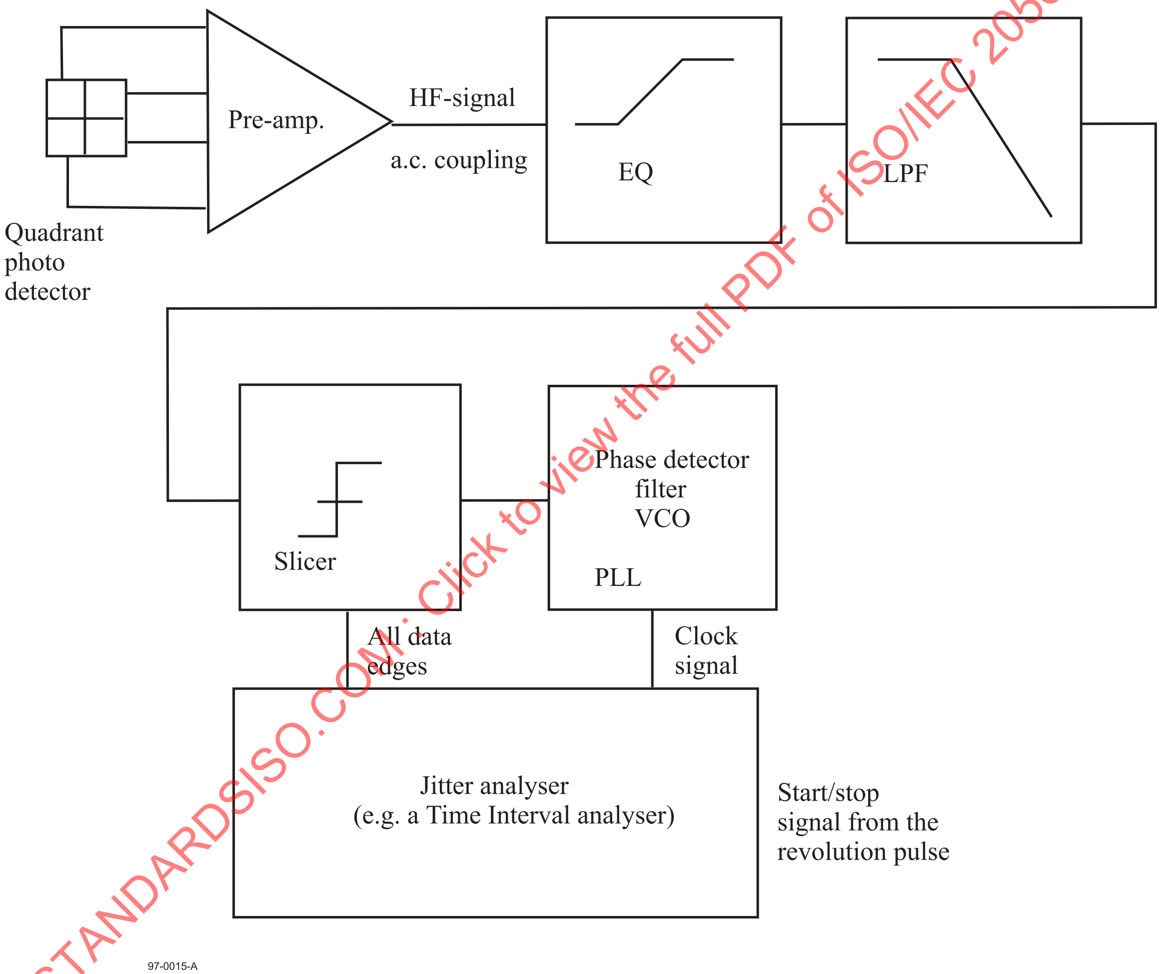


Figure F.1 — General diagram for jitter measurement

F.2 Open loop transfer function for PLL

The open-loop transfer function for the PLL shown in figure F.1 shall be as shown in figure F.2

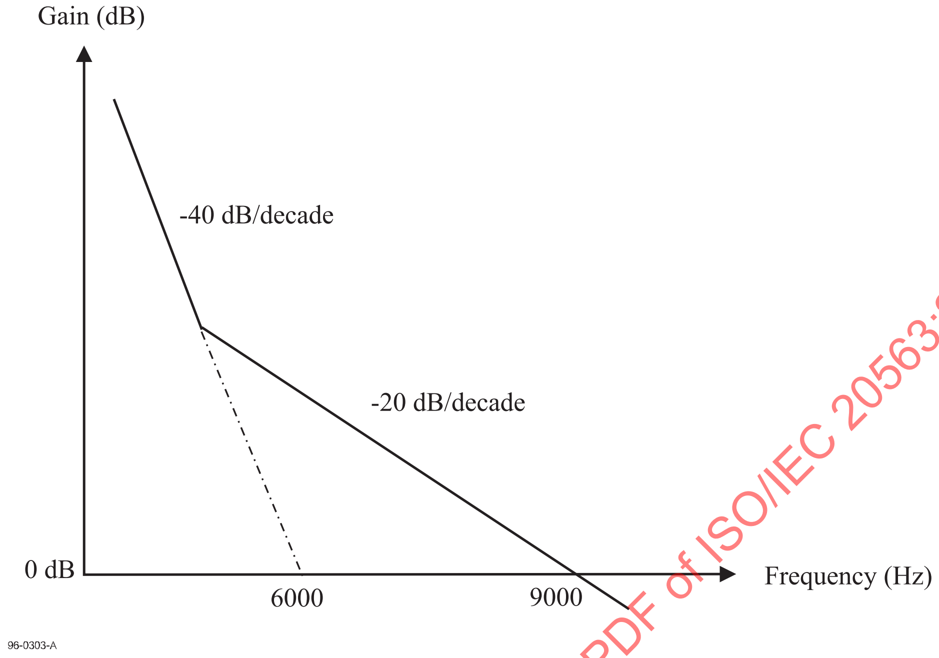


Figure F.2 — Schematic representation of the open-loop transfer function for PLL

F.3 Slicer

The slicer shall be a feed-back auto-slicer with a -3 dB closed-loop bandwidth of 5 kHz, 1st order integrating

F.4 Conditions for measurement

The bandwidth of the pre-amplifier of the photo detector shall be greater than 20 MHz in order to prevent group-delay distortion.

Low-pass filter : 6th order Bessel filter, f_c (-3 dB) = 8,2 MHz

Example of an analogue equalizer : 3-tap transversal filter with transfer function

$H(z) = 1{,}35\, z^{-2{,}093} - 0{,}175\, (1 + z^{-4{,}186})$

Filtering and equalization :

- Gain variation : 1 dB max. (below 7 MHz)
- Group delay variation : 3 ns max. (below 6,5 MHz)
- (Gain at 5,0 MHz - Gain at 0 Hz) = 3,2 dB ± 0,3 dB

a.c. coupling (high-pass filter) = 1st order, f_c (-3 dB) = 1 kHz

Correction of the angular deviation : only d.c. deviation.

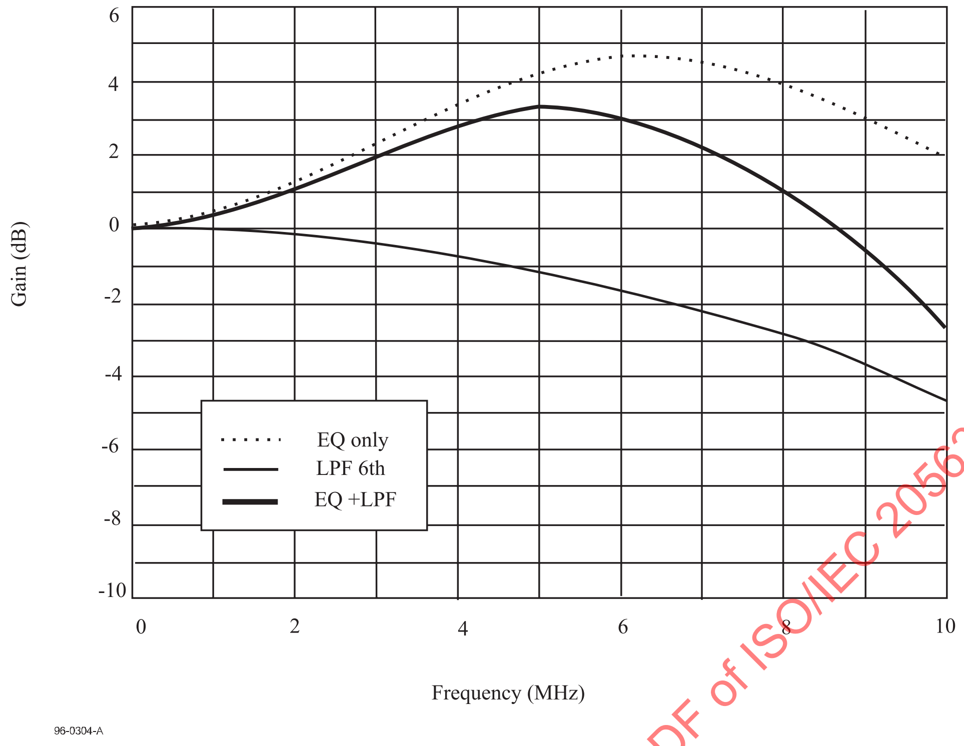


Figure F.3 — Frequency characteristics for the equalizer and the low-pass filter

F.5 Measurement

The jitter of all leading and trailing edges over one rotation shall be measured.

Under this measurement, the jitter shall be less than 9,0 % of the Channel bit clock period.

Annex G
(normative)

8-to-16 Modulation with RLL (2,10) requirements

Tables G.1 and G.2 list the 16-bit Code Words into which the 8-bit coded Data bytes have to be transformed. Figure G.1 shows schematically how the Code Words and the associated State specification are generated.

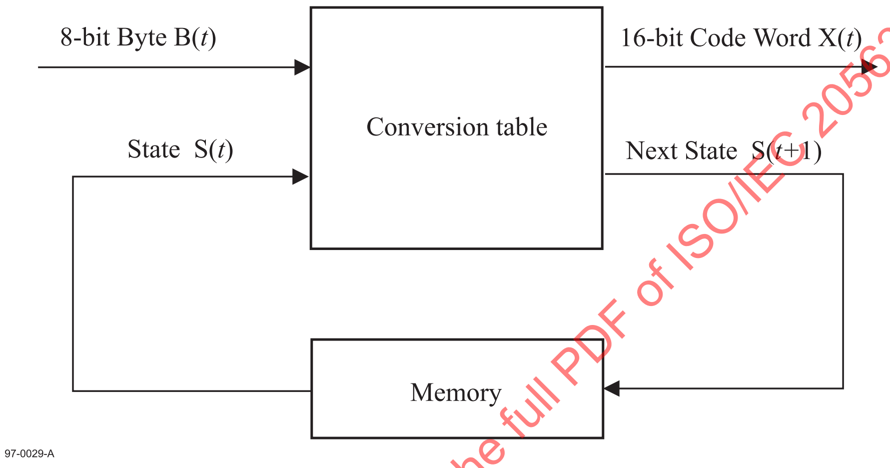


Figure G.1 — Code Words generation

In this figure :

$X(t) = H\{B(t), S(t)\}$ $X_{15}(t)$ = msb and $X_0(t)$ = lsb
$S(t+1) = G\{B(t), S(t)\}$
H is the output function
G is the next-state function

The Code Words leaving the States shall be chosen so that the concatenation of Code Words entering a State and those leaving that State satisfy the requirement that between two ONEs there shall be at least 2 and at most 10 ZEROs.

As additional requirements:

- Code Words leaving State 2 shall have both bit x15 and bit x3 set to ZERO, and
- in Code Words leaving State 3 bit x_{15} or bit x_3 or both shall be set to ONE.

This means that the Code Word sets of States 2 and 3 are disjoint.

Code Word X(t)	Next State S(t+1)	Code Word X(t+1)
Ends with 1 or no trailing ZERO	State 1	Starts with 2 or up to 9 leading ZEROs
Ends with 2 or up to 5 trailing ZEROs	State 2	Starts with 1 or up to 5 leading ZEROs, and $X_{15}(t+1), X_3(t+1) = 0,0$
Ends with 2 or up to 5 trailing ZEROs	State 3	Starts with none or up to 5 leading ZEROs, and $X_{15}(t+1), X_3(t+1) \neq 0,0$
Ends with 6 or up to 9 trailing ZEROs	State 4	Starts with 1 or no leading ZERO

Figure G.2 — Determination of States

Note that when decoding the recorded data, knowledge about the encoder is required to be able to reconstitute the original main Data.

$$B(t) = H^{-1} \{X(t), S(t)\}$$

Because of the involved error propagation, such state-dependent decoding is to be avoided. In the case of this 8-to-16 modulation, the conversion tables have been chosen in such a way that knowledge about the State is not required in most cases. As can be gathered from the tables, in some cases, two 8-bit bytes, for instance the 8-bit bytes 5 and 6 in States 1 and 2 in table G.1, generate the same 16-bit Code Words. The construction of the tables allows to solve this apparent ambiguity. Indeed, if two identical Code Words leave a State, one of them goes to State 2 and the other to State 3. Because the setting of bits X_{15} and X_3 is always different in these two States, any Code Word can be uniquely decoded by analysing the Code Word itself together with bits X_{15} and X_3 of the next Code Word :

$$B(t) = H^{-1} \{ X(t), X_{15}(t+1), X_3(t+1) \}$$

In the tables, the 8-bit bytes are identified by their decimal value.

Table G.1 — Main Conversion Table

8-bit byte	State 1 Code Word msb lsb	State 1 Next State	State 2 Code Word msb lsb	State 2 Next State	State 3 Code Word msb lsb	State 3 Next State	State 4 Code Word msb lsb	State 4 Next State
0	0010000000001001	1	0100000100100000	2	0010000000001001	1	0100000100100000	2
1	0010000000010010	1	0010000000010010	1	1000000100100000	3	1000000100100000	3
2	0010000100100000	2	0010000100100000	2	1000000000010010	1	1000000000010010	1
3	0010000001001000	2	0100010010000000	4	0010000001001000	2	0100010010000000	4
4	0010000010010000	2	0010000010010000	2	1000000100100000	2	1000000100100000	2
5	0010000000100100	2	0010000000100100	2	1001001000000000	4	1001001000000000	4
6	0010000000100100	3	0010000000100100	3	1000100100000000	4	1000100100000000	4
7	0010000001001000	3	0100000000010010	1	0010000001001000	3	0100000000010010	1
8	0010000010010000	3	0010000010010000	3	1000010010000000	4	1000010010000000	4
9	0010000100100000	3	0010000100100000	3	1001001000000001	1	1001001000000001	1
10	0010010010000000	4	0010010010000000	4	1000100100000001	1	1000100100000001	1
11	0010001001000000	4	0010001001000000	4	1000000010010000	3	1000000010010000	3
12	0010010010000001	1	0010010010000001	1	1000000010010000	2	1000000010010000	2
13	0010001001000001	1	0010001001000001	1	1000010010000001	1	1000010010000001	1
14	0010000001001001	1	0100000000100100	3	0010000001001001	1	0100000000100100	3
15	0010000100100001	1	0010000100100001	1	1000001001000001	1	1000001001000001	1
16	0010000010010001	1	0010000010010001	1	1000000100100001	1	1000000100100001	1
17	0010000000100010	1	0010000000100010	1	1000001001000000	4	1000001001000000	4
18	0001000000001001	1	0100000010010000	2	0001000000001001	1	0100000010010000	2
19	0010000000010001	1	0010000000010001	1	1001000100000000	4	1001000100000000	4
20	0001000000010010	1	0001000000010010	1	1000100010000000	4	1000100010000000	4
21	0000100000000010	1	0000100000000010	1	1000000010010001	1	1000000010010001	1
22	0000010000000001	1	0000010000000001	1	1000000001001001	1	1000000001001001	1
23	0010001000100000	2	0010001000100000	2	1000000001001000	2	1000000001001000	2
24	0010000100010000	2	0010000100010000	2	1000000001001000	3	1000000001001000	3
25	0010000010001000	2	0100000000100100	2	0010000010001000	2	0100000000100100	2
26	0010000001000100	2	0010000001000100	2	1000000000100010	1	1000000000100010	1
27	0001000100100000	2	0001000100100000	2	1000000000010001	1	1000000000010001	1
28	0010000000001000	2	0100000010010000	3	0010000000001000	2	0100000010010000	3
29	0001000010010000	2	0001000010010000	2	1001001000000010	1	1001001000000010	1
30	0001000001001000	2	0100000100100000	3	0001000001001000	2	0100000100100000	3
31	0001000000100100	2	0001000000100100	2	1001000100000001	1	1001000100000001	1
32	0001000000000100	2	0001000000000100	2	1000100100000010	1	1000100100000010	1
33	0001000000000100	3	0001000000000100	3	1000100010000001	1	1000100010000001	1
34	0001000000100100	3	0001000000100100	3	1000000000100100	2	1000000000100100	2
35	0001000001001000	3	0100001001000000	4	0001000001001000	3	0100001001000000	4
36	0001000010010000	3	0001000010010000	3	1000000000100100	3	1000000000100100	3
37	0001000100100000	3	0001000100100000	3	1000010001000000	4	1000010001000000	4
38	0010000000001000	3	0100100100000001	1	0010000000001000	3	0100100100000001	1
39	0010000001000100	3	0010000001000100	3	1001000010000000	4	1001000010000000	4
40	0010000010001000	3	0100010010000001	1	0010000010001000	3	0100010010000001	1
41	0010000100010000	3	0010000100010000	3	1000010010000010	1	1000010010000010	1
42	0010001000100000	3	0010001000100000	3	1000001000100000	2	1000001000100000	2
43	0010010001000000	4	0010010001000000	4	1000010001000001	1	1000010001000001	1
44	0001001001000000	4	0001001001000000	4	1000001000100000	3	1000001000100000	3
45	0000001000000001	1	0100010001000000	4	1000001001000010	1	0100010001000000	4

Table G.1 — Main Conversion Table (continued)

8-bit byte	State 1 Code Word msb lsb	State 1 Next State	State 2 Code Word msb lsb	State 2 Next State	State 3 Code Word msb lsb	State 3 Next State	State 4 Code Word msb lsb	State 4 Next State
46	0010010010000010	1	0010010010000010	1	1000001000100001	1	1000001000100001	1
47	0010000010001001	1	0100001001000001	1	0010000010001001	1	0100001001000001	1
48	0010010001000001	1	0010010001000001	1	1000000100010000	2	1000000100010000	2
49	0010001001000010	1	0010001001000010	1	1000000010001000	2	1000000010001000	2
50	0010001000100001	1	0010001000100001	1	1000000100010000	3	1000000100010000	3
51	0001000001001001	1	0100000100100001	1	0001000001001001	1	0100000100100001	1
52	0010000100100010	1	0010000100100010	1	1000000100100010	1	1000000100100010	1
53	0010000100010001	1	0010000100010001	1	1000000100010001	1	1000000100010001	1
54	0010000010010010	1	0010000010010010	1	1000000010010010	1	1000000010010010	1
55	0010000001000010	1	0010000001000010	1	1000000010001001	1	1000000010001001	1
56	0010000000100001	1	0010000000100001	1	1000000001000010	1	1000000001000010	1
57	0000100000001001	1	0100000010010001	1	0000100000001001	1	0100000010010001	1
58	0001001001000001	1	0001001001000001	1	1000000000100001	1	1000000000100001	1
59	0001000100100001	1	0001000100100001	1	0100000001001001	1	0100000001001001	1
60	0001000010010001	1	0001000010010001	1	1001001000010010	1	1001001000010010	1
61	0001000000100010	1	0001000000100010	1	1001001000001001	1	1001001000001001	1
62	0001000000010001	1	0001000000010001	1	1001000100000010	1	1001000100000010	1
63	0000100000010010	1	0000100000010010	1	1000000001000100	2	1000000001000100	2
64	0000010000000010	1	0000010000000010	1	0100000001001000	2	0100000001001000	2
65	0010010000100000	2	0010010000100000	2	1000010000100000	2	1000010000100000	2
66	0010001000010000	2	0010001000010000	2	1000001000010000	2	1000001000010000	2
67	0010000100001000	2	0100000000100010	1	0010000100001000	2	0100000000100010	1
68	0010000010000100	2	0010000010000100	2	1000000100001000	2	1000000100001000	2
69	0010000000010000	2	0010000000010000	2	1000000010000100	2	1000000010000100	2
70	0001000010001000	2	0100001001000000	2	0001000010001000	2	0100001001000000	2
71	0001001000100000	2	0001001000100000	2	0100000010001000	2	0100000010001000	2
72	0001000000001000	2	0100000100010000	2	0001000000001000	2	0100000100010000	2
73	0001000100010000	2	0001000100010000	2	1000000001000100	3	1000000001000100	3
74	0001000001000100	2	0001000001000100	2	0100000001001000	3	0100000001001000	3
75	0000100100100000	2	0000100100100000	2	1000010000100000	3	1000010000100000	3
76	0000100010010000	2	0000100010010000	2	1000001000010000	3	1000001000010000	3
77	0000100001001000	2	0100000001000100	2	0000100001001000	2	0100000001000100	2
78	0000100000100100	2	0000100000100100	2	1000000100001000	3	1000000100001000	3
79	0000100000000100	2	0000100000000100	2	1000000010000100	3	1000000010000100	3
80	0000100000000100	3	0000100000000100	3	0100000010001000	3	0100000010001000	3
81	0000100000100100	3	0000100000100100	3	1000100001000000	4	1000100001000000	4
82	0000100001001000	3	0100000001000100	3	0000100001001000	3	0100000001000100	3
83	0000100010010000	3	0000100010010000	3	1000000010001000	3	1000000010001000	3
84	0000100100100000	3	0000100100100000	3	1001001001001000	2	1001001001001000	2
85	0001000000001000	3	0100000100010000	3	0001000000001000	3	0100000100010000	3
86	0001000001000100	3	0001000001000100	3	1001001000100100	2	1001001000100100	2
87	0001000010001000	3	0100001001000000	3	0001000010001000	3	0100001001000000	3
88	0001000100010000	3	0001000100010000	3	1001001001001000	3	1001001001001000	3
89	0001001000100000	3	0001001000100000	3	1001000010000001	1	1001000010000001	1
90	0010000000010000	3	0010000000010000	3	1000100100010010	1	1000100100010010	1
91	0010000010000100	3	0010000010000100	3	1000100100001001	1	1000100100001001	1
92	0010000100001000	3	0100000000010001	1	0010000100001000	3	0100000000010001	1
93	0010001000010000	3	0010001000010000	3	1000100010000010	1	1000100010000010	1
94	0010010000100000	3	0010010000100000	3	1000100001000001	1	1000100001000001	1