
**Information technology — Data
interchange on 120 mm and 80 mm
optical disk using +R format — Capacity:
4,7 Gbytes and 1,46 Gbytes per side
(recording speed up to 16X)**

*Technologies de l'information — Échange de données sur disques
optiques de 120 mm et 80 mm en utilisant le format +R — Capacité: 4,7
Go et 1,46 Go par face (vitesse d'enregistrement inférieure ou égale à
16X)*



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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. In the field of information technology, ISO and IEC have established a joint technical committee, ISO/IEC JTC 1.

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

The main task of the joint technical committee is to prepare International Standards. Draft International Standards adopted by the joint technical committee are circulated to national bodies for voting. Publication as an International Standard requires approval by at least 75 % of the national bodies casting a vote.

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

ISO/IEC 17344 was prepared by Ecma International (as ECMA-349) and was adopted, under a special “fast-track procedure”, by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, in parallel with its approval by national bodies of ISO and IEC.

This fourth edition cancels and replaces the third edition (ISO/IEC 17344:2006), which has been technically revised.

Introduction

Ecma Technical Committee TC31 was established in 1984 for the standardization of Optical Disks and Optical Disk Cartridges (ODC). Since its establishment, the Committee has made major contributions to ISO/IEC toward the development of International Standards for 80 mm, 90 mm, 120 mm, 300 mm, and 356 mm media. Numerous standards have been developed by TC31 and published by Ecma, almost all of which have also been adopted by ISO/IEC under the fast-track procedure as International Standards.

In April 2003, a group of companies proposed that TC31 develop a standard for 120 mm recordable optical disks using the WORM recording technology and based on ISO/IEC 16448 and ISO/IEC 17341. TC31 adopted this project and started the work that resulted in the first edition of ISO/IEC 17344.

This International Standard specifies two Types of recordable optical disks: one (Type S) making use of recording on only a single side of the disk and yielding a nominal capacity of 4,7 Gbytes or 1,46 Gbytes per disk and the other (Type D) making use of recording on both sides of the disk and yielding a nominal capacity of 9,4 Gbytes or 2,92 Gbytes per disk.

In December 2003, a proposal was made to TC31 to update ISO/IEC 17344 for recording speeds up to eight times the reference velocity. TC31 adopted this project, which resulted in the second edition of ISO/IEC 17344.

In February 2005, a proposal was made to TC31 to update ISO/IEC 17344 for recording speeds up to 16 times the reference velocity and to facilitate the application of the Video Content Protection System.

This International Standard, taken together with a standard for volume and file structure, such as for instance developed in Ecma Technical Committee TC15, provides the requirements for information interchange between systems.

Information technology — Data interchange on 120 mm and 80 mm optical disk using +R format — Capacity: 4,7 Gbytes and 1,46 Gbytes per side (recording speed up to 16X)

1 Scope

This International Standard specifies the mechanical, physical and optical characteristics of 120 mm recordable optical disks with capacities of 4,7 Gbytes and 9,4 Gbytes. It specifies the quality of the recorded and unrecorded signals, the format of the data and the recording method, thereby allowing for information interchange by means of such disks. The data can be written once and read many times using a non-reversible method. These disks are identified as +R.

This International Standard also specifies 80 mm disks with capacities of 1,46 Gbytes and 2,92 Gbytes. These disks have the same characteristics as the 120 mm disks, except for some parameters related to the smaller dimensions. All parameters unique for the 80 mm disks are specified in Annex A.

This International Standard specifies the following:

- two related but different Types of this disk (see Clause 7);
- the conditions for conformance;
- the environments in which the disk is to be tested, operated and stored;
- the mechanical, physical and dimensional characteristics of the disk, so as to provide mechanical interchange between data processing systems;
- the format of the information on the disk, including the physical disposition of the tracks and sectors, the error correcting codes and the coding method;
- the characteristics of the signals recorded on the disk, thus enabling data processing systems to read the data from the disk.

This International Standard provides for the interchange of disks between optical 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 with this International Standard specifies the Type implemented. An optical disk is in conformance with this International Standard if it meets all mandatory requirements specified for its Type.

2.2 Generating system

A generating system is 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 is in conformance with this International Standard if it is able to handle both Types of optical disk according to 2.1.

2.4 Compatibility statement

A claim of conformance by a generating or receiving system with this International Standard shall include a statement listing any other standards supported. This statement shall specify the numbers of the standards, the optical disk types supported (where appropriate) and whether support includes reading only or both reading and writing.

3 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO/IEC 4873:1991, *Information technology — ISO 8-bit code for information interchange — Structure and rules for implementation*

ISO/IEC 16448:2002, *Information technology — 120 mm DVD — Read-only disk*

ECMA-287, *Safety of electronic equipment* (2002)

4 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

4.1

channel bit

elements by which the binary values ZERO and ONE are represented by marks and spaces on the disk

4.2

clamping zone

annular part of the disk within which the clamping force is applied by the clamping device

4.3

digital sum value

DSV

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

4.4

disk reference plane

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

4.5

dummy substrate

layer, which can be transparent or not, provided for the mechanical support of the disk and, in some cases, of the recording layer as well

4.6

entrance surface

surface of the disk onto which the optical beam first impinges

4.7**field**

subdivision of a sector

4.8**groove**

trench-like feature of the disk, applied before the recording of any information, and used to define the track location

NOTE The groove is located nearer to the entrance surface than the “land” in between the grooves. The recording is made on the groove.

4.9**interleaving**

process of reallocating the physical sequence of units of data so as to render the data more immune to burst errors

4.10**mark**

non-reversible feature of the recording layer that can take the form of a less reflective area, a pit, or any other type or form that can be sensed by the optical system

NOTE The pattern of marks and spaces represents the data on the disk.

4.11**multi-session disk**

disk containing more than one set of Lead-in/Intro, Data, and Lead-out/Closure Zones

4.12**physical sector**

smallest addressable part of a track in the Information Zone of a disk that can be accessed independently of other addressable parts of the zone

4.13**recording layer**

layer of the disk on which data is written during manufacture and/or use

4.14**Reed–Solomon code****RS**

error detection and/or correction code

4.15**reference velocity**

linear velocity that results in the nominal channel bit rate of 26,156 25 Mbit/s

4.16**single-session disk**

disk containing a Lead-in Zone, one Data Zone, and a Lead-out Zone

4.17**session**

continuous part of the Information Zone of the disk consisting of a Lead-in or Intro Zone, a Data Zone and a Lead-out or Closure Zone

4.18**space**

feature of the recording layer represented by any area between two marks which can be sensed by the optical system

NOTE The pattern of marks and spaces represents the data on the disk.

4.19

substrate

transparent layer of the disk, provided for mechanical support of the recording layer, through which the optical beam accesses the recording layer

4.20

track

360° turn of a continuous spiral

4.21

track pitch

distance between adjacent track centrelines, measured in a radial direction

4.22

Video Content Protection System

VCPS

method to prevent unauthorized copying and/or redistribution of video data that is recorded in the DVD+R/+RW video format

4.23

wobble

continuous sinusoidal deviation of the track from the average centreline

NOTE Location information is included as phase modulated data in the wobble.

4.24

zone

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 1,274.

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. In a pattern of n bits, bit $b_{(n-1)}$ shall be the most significant bit (msb) and bit b_0 shall be the least significant bit (lsb). Bit $b_{(n-1)}$ shall be recorded first.

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

In each data field, the data is recorded so that the most significant byte (MSB), identified as Byte 0, shall be recorded first and the least significant byte (LSB) last.

In a field of $8n$ bits, bit $b_{(8n-1)}$ shall be the most significant bit (msb) and bit b_0 the least significant bit (lsb). Bit $b_{(8n-1)}$ shall be recorded first.

5.2 Names

The names of entities, e.g. specific tracks, fields, etc., are given with an initial capital.

6 Abbreviated terms

a.c.	alternating current
ADIP	address in pre-groove
ASM	asymmetry
BP	Byte Position
BPF	Band Pass Filter
CAV	Constant Angular Velocity
CLD	Constant Linear Density
CLV	Constant Linear Velocity
cm	current mark
d.c.	direct current
DCB	Disk Control Block
DCC	d.c. Component suppression Control
DSV	Digital Sum Value
ECC	Error Correction Code
EDC	Error Detection Code
EI	Extended Information
HF	High Frequency
ID	Identification Data
IED	ID Error Detection code
LPF	Low Pass Filter
LSB	Least Significant Byte
lsb	least significant bit
LSN	Logical Sector Number
MSB	Most Significant Byte
msb	most significant bit
NA	Numerical Aperture
NRZ	Non Return to Zero
NRZI	Non Return to Zero Inverted
NSL	Normalized Slicing Level
NWPW	Normalized Write Power Window
OPC	Optimum Power Control
OTP	Opposite Track Path
PAA	Physical Address in ADIP
PBS	Polarizing Beam Splitter
PI	Parity of Inner-code
PLL	Phase Locked Loop
PO	Parity of Outer-code
PP	Push-Pull
pp	peak-to-peak
ps	previous space
PSN	Physical Sector Number
PTP	Parallel Track Path
RIN	Relative Intensity Noise
RPM	Revolutions Per Minute
RS	Reed–Solomon code

RSV	reserved (in use by specific applications)
RUN	Recording UNit
SDCB	Session DCB
SNR	Signal to Noise Ratio
SYNC	synchronization code
TOC	Table Of Contents

7 General description of the optical disk

The optical disk that is the subject of this International Standard consists of two substrates bonded together by an adhesive layer, so that the recording layer(s) is (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 accessed. Clamping is performed in the Clamping Zone. This International Standard provides for two Types of such disks.

Type S5 consists of a substrate, a single recording layer and a dummy substrate. The recording layer can be accessed from one side only. The capacity is 4,7 Gbytes for the 120 mm sized disk and 1,46 Gbytes for the 80 mm sized disk.

Type D10 consists of two substrates and two recording layers. From each side of the disk only one of the recording layers can be accessed. The capacity is 9,4 Gbytes for the 120 mm sized disk and 2,92 Gbytes for the 80 mm sized disk.

Data can be written onto the disk as marks in the form of low-reflective spots in the recording layer with a focused optical beam. The data can be read with a focused optical beam, using the difference in the reflectivity between recorded marks and unrecorded spaces. The beam accesses the recording layer through a transparent substrate of the disk.

Figure 1 shows schematically the two Types.

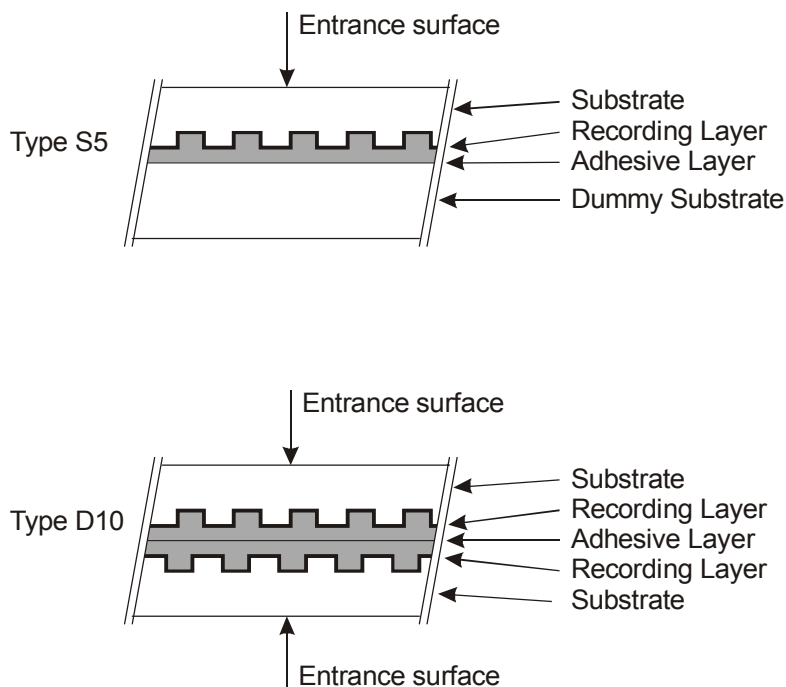


Figure 1 — Types of +R disk

Unauthorized copying and/or redistribution of video data that is recorded in the DVD+R/+RW Video Format can be prevented by applying the Video Content Protection System as referred to in Annex P.

8 General Requirements

8.1 Environments

8.1.1 Test environment

In the test environment, the air immediately surrounding the disk shall have the following properties:

temperature	: 23 °C ± 2 °C
relative humidity	: 45 % to 55 %
atmospheric pressure	: 60 kPa to 106 kPa

No condensation on the disk shall occur. Before testing, the disk shall be conditioned in this environment for 48 h minimum. It is recommended that, before testing, the entrance surface of the disk shall be cleaned according to the instructions of the manufacturer of the disk.

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

8.1.2 Operating environment

This International Standard requires that a disk which meets all requirements of this International Standard in the specified test environment shall provide data interchange over the specified ranges of environmental parameters in the operating environment.

The operating environment is the environment where the air immediately surrounding the disk shall have the following properties:

temperature	: 5 °C to 55 °C
relative humidity	: 3 % to 85 %
absolute humidity	: 1 g/m ³ to 30 g/m ³
atmospheric pressure	: 60 kPa to 106 kPa
temperature gradient	: 10 °C/h max.
relative humidity gradient	: 10 %/h max.

No condensation on the disk shall occur. If the disk has been exposed to conditions outside those specified in this Clause, it shall be acclimatized in an allowed operating environment for at least 2 h before use.

8.1.3 Storage environment

The storage environment is defined as the environment where the air immediately surrounding the disk shall have the following properties:

temperature	: -10 °C to 55 °C
relative humidity	: 3 % to 90 %
absolute humidity	: 1 g/m ³ to 30 g/m ³
atmospheric pressure	: 60 kPa to 106 kPa
temperature gradient	: 15 °C/h max.
relative humidity gradient	: 10 %/h max.

No condensation on the disk shall occur.

8.1.4 Transportation

This International Standard does not specify requirements for transportation; guidance is given in Annex O.

8.2 Safety requirements

The disk shall satisfy the safety requirements of Standard ECMA-287, when used in the intended manner or in any foreseeable use in an information processing system.

8.3 Flammability

The disk and its components shall be made from materials that comply with the flammability class for HB materials, or better, as specified in Standard ECMA-287.

8.4 Light fastness

The disk and its components should be made from materials that are able to withstand a certain amount of light. A method of testing such light fastness is given in Annex N.

9 Reference Drive

The Reference Drive shall be used for the measurement of optical parameters for conformance with the requirements of this International Standard. The critical components of this device have the characteristics specified in this Clause.

9.1 Optical system

The basic set-up of the optical system of the Reference Drive used for measuring the write and read parameters is shown in Figure 2. Different components and locations of components are permitted, provided that the performance remains the same as that of the set-up in Figure 2. 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.

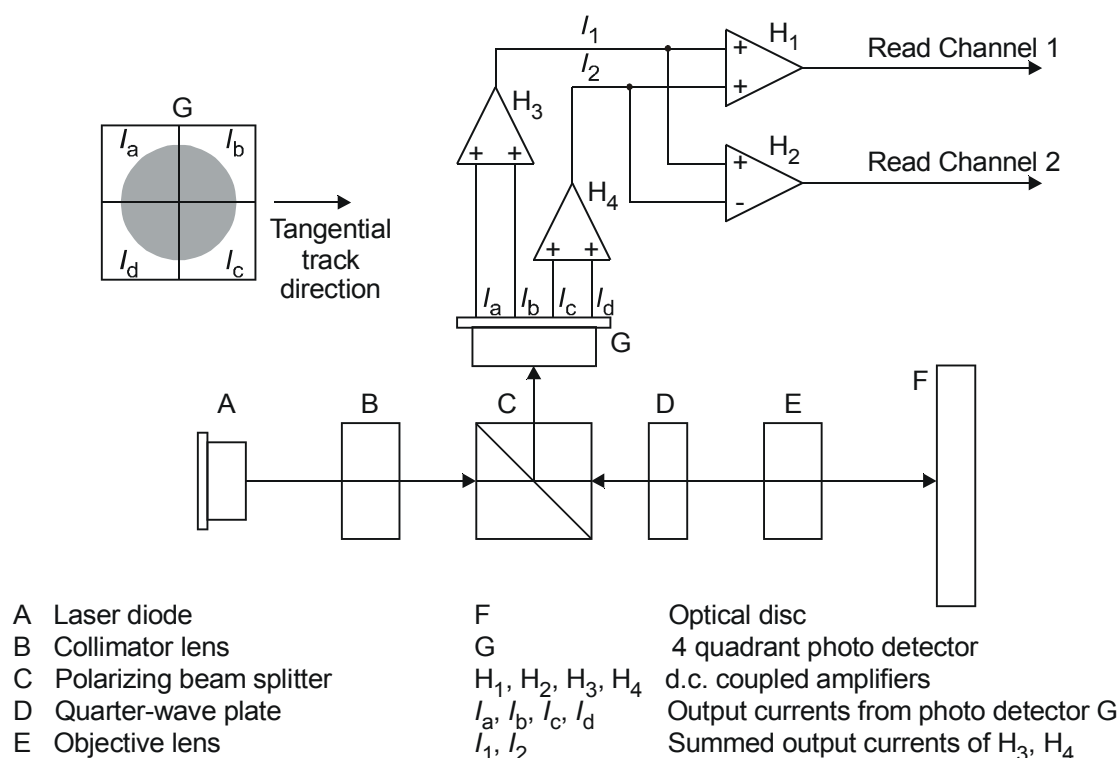


Figure 2 — Optical system of the Reference Drive

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

9.2 Optical beam

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

- | | |
|--|---|
| a) Wavelength (λ) | $655 \text{ nm} \begin{smallmatrix} +10 \text{ nm} \\ -5 \text{ nm} \end{smallmatrix}$ (see Annex K) |
| b) Numerical aperture of the objective lens (NA) | $0,65 \pm 0,01$ |
| c) The objective lens shall be compensated for spherical aberrations caused by a parallel substrate with nominal thickness (0,6 mm) and nominal refractive index (1,55). | |
| d) Wave front aberration | $0,033 \times \lambda$ rms max. |
| e) Light intensity at the rim of the pupil of the objective lens | 35 % to 50 % of the maximum intensity in the radial direction and 45 % to 60 % in the tangential direction. |
| f) Polarization of the light | Circular |
| g) Read power (average) | $0,7 \text{ mW} \pm 0,1 \text{ mW}$
(d.c. or HF modulated with a frequency >400 MHz) |
| h) Write power and pulse width | see Annex G |
| i) Relative Intensity Noise (RIN)* of the laser diode | -134 dB/Hz max. |
| *RIN (dB/Hz) = $10 \log [(a.c. \text{ light power density} / \text{Hz}) / d.c. \text{ light power}]$ | |

9.3 Read channel 1

Read channel 1 shall be provided to generate signals from the marks and spaces in the recording layer. This Read channel shall be used for reading the user-written information, using the change in reflectivity of the marks and spaces. The read amplifiers after the photo detectors in the Read channel shall have a flat response within 1 dB from d.c. to 20 MHz.

For measurement of jitter, the characteristics of the PLL and the slicer, etc. are specified in Annex E.

9.4 Disk clamping

For measuring, the disk shall be clamped between two concentric rings covering most of the Clamping Zone (see 10.5). The top clamping area shall have the same diameters as the bottom clamping area (Figure 3).

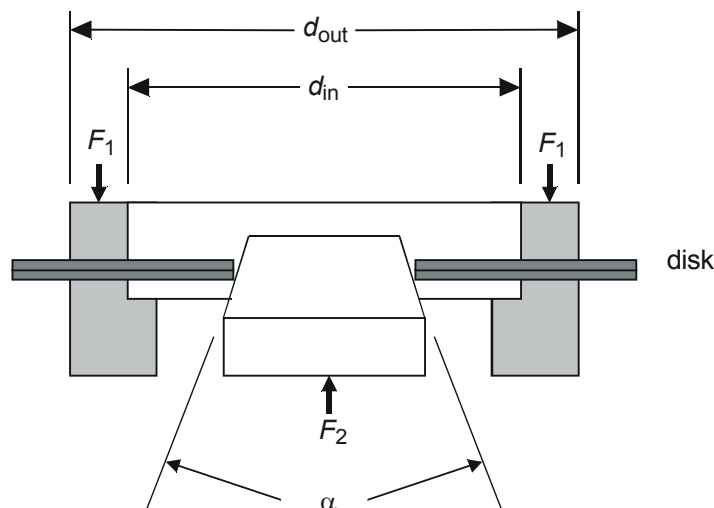


Figure 3 — Clamping and chucking conditions

Clamping shall occur between

$$d_{in} = 22,3 \text{ mm} \begin{matrix} +0,5\text{mm} \\ -0,0\text{mm} \end{matrix} \quad \text{and} \quad d_{out} = 32,7 \text{ mm} \begin{matrix} +0,0\text{mm} \\ -0,5\text{mm} \end{matrix}$$

The total clamping force shall be $F_1 = 2,0 \text{ N} \pm 0,5 \text{ N}$. 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 (see Figure 3).

The tapered cone angle, α , shall be $40,0^\circ \pm 0,5^\circ$.

9.5 Rotation of the disk

The actual rotation speed for reading the disk shall be such that it results in the Reference velocity of $3,49 \text{ m/s} \pm 0,03 \text{ m/s}$ at the nominal Channel bit rate of 26,156 25 Mbit/s. The direction of rotation shall be counter-clockwise when viewed from the objective lens.

The actual rotation speed (v_{actual}) for writing the disk shall be such that it includes all Primary and Upper velocities for which parameters are specified in the Physical format information in the ADIP Aux Frames in the Lead-in Zone of the disk (see 14.4.1.1 and 14.4.2).

NOTE The rotational speed of the disk is depending on the radial position: $\text{angular velocity} = 60 \times \frac{v_{\text{actual}}}{2\pi \times r} \text{ RPM}$

When testing the disk the actual speed is limited such that the angular velocity does not exceed 10 000 RPM.

9.6 Wobble channel (Read channel 2)

Read channel 2 of the drive provides the wobble signals to control the access to addressed locations on the disk during writing. The wobble signal is generated in Read Channel 2 as a signal ($I_1 - I_2$) related to the difference in the amount of light in the two halves of the exit pupil of the objective lens. The read amplifiers after the photo detectors in the Read channel shall have a flat response within 1 dB from d.c. to 20 MHz.

9.7 Tracking channel (Read channel 2)

Read channel 2 of the drive provides the tracking error signals to control the servos for radial tracking of the optical beam. The radial tracking error is generated in Read Channel 2 as a signal $(I_1 - I_2)$ related to the difference in the amount of light in the two halves of the exit pupil of the objective lens.

The method of generating the axial tracking error is not specified for the Reference Drive.

9.8 Reference servo systems

9.8.1 Normalized servo transfer function

The open-loop transfer function, $H_s(i\omega)$ for the axial and radial tracking servos is given by equation (1),

$$H_s(i\omega) = \frac{1}{3} \times \left(\frac{\omega_0}{i\omega} \right)^2 \times \frac{1 + \frac{3i\omega}{\omega_0}}{1 + \frac{i\omega}{3\omega_0}} \quad (1)$$

where: $i = \sqrt{-1}$, $\omega = 2\pi f$ and $\omega_0 = 2\pi f_0$

and f_0 is the 0 dB crossover frequency of the open-loop transfer function.

The crossover frequencies of the lead-lag network of the servo are

lead break frequency: $f_1 = f_0 / 3$

lag break frequency: $f_2 = f_0 \times 3$

Another frequency of importance is the frequency f_X at which a sinusoidal displacement with an amplitude equal to the maximum allowed residual tracking error $e_{\max}$, corresponds to the maximum expected acceleration $\alpha_{\max}$. This frequency can be calculated as follows:

$$f_X = \frac{1}{2\pi} \sqrt{\frac{\alpha_{\max}}{e_{\max}}}$$

Because the tracking error signals from the disk can have rather large variations, the tracking error signal fed into each reference servo loop shall be adjusted to a fixed level (effectively calibrating the total loop gain), such to guarantee the specified bandwidth.

9.8.2 Reference Servo for Axial Tracking

The crossover frequency of the normalized servo transfer function (H_s) for axial tracking, $f_0 = \omega_0 / (2\pi)$ shall be given by equation (2), where $\alpha_{\max}$ is the maximum expected axial acceleration of 8,0 m/s², which is multiplied by a factor $m = 1,5$ for servo margin. The tracking error $e_{\max}$, caused by this $m \times \alpha_{\max}$, shall be 0,20 μm .

Thus the crossover frequency f_0 shall be given by

$$f_0 = \frac{1}{2\pi} \sqrt{\frac{3 \times m \times \alpha_{\max}}{e_{\max}}} = \frac{1}{2\pi} \sqrt{\frac{3 \times 1,5 \times 8}{0,20 \times 10^{-6}}} = 2,1 \text{ kHz} \quad (2)$$

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

Bandwidth from 100 Hz to 10 kHz

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

Bandwidth from 26 Hz to 100 Hz

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

- 1) 41,7 dB at 100 Hz ($|1+H_s|$ at 100 Hz – 20 %)
- 2) 45,2 dB at 100 Hz ($|1+H_s|$ at 100 Hz + 20 %)
- 3) 65,1 dB at 26 Hz ($|1+H_s|$ at 26 Hz – 20 %)
- 4) 85,1 dB at 26 Hz ($|1+H_s|$ at 26 Hz – 20 % + 20 dB)

Bandwidth from 9,5 Hz to 26 Hz

$|1+H|$ shall be between 65,1 dB and 85,1 dB.

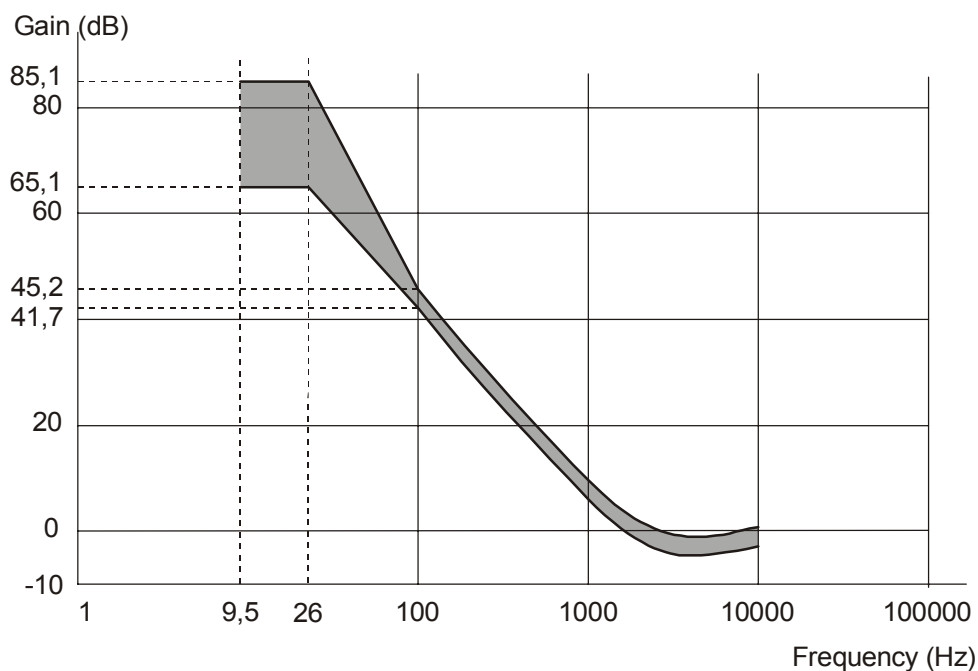


Figure 4 — Reference servo for axial tracking

9.8.3 Reference Servo for Radial Tracking

The crossover frequency of the normalized servo transfer function (H_s) for radial tracking, $f_0 = \omega_0 / (2\pi)$ shall be given by equation (3), where $\alpha_{\max}$ is the maximum expected radial acceleration of $1,1 \text{ m/s}^2$, which is multiplied by a factor $m = 1,5$ for servo margin. The tracking error $e_{\max}$, caused by this $m \times \alpha_{\max}$, shall be $0,022 \text{ }\mu\text{m}$.

Thus the crossover frequency f_0 shall be given by

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

For an open loop transfer function H of the Reference Servo for radial tracking, $|1+H|$ is limited as schematically shown by the shaded region of Figure 5.

Bandwidth from 100 Hz to 10 kHz

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

Bandwidth from 28,2 Hz to 100 Hz

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

- 1) 43,7 dB at 100 Hz ($|1+H_s|$ at 100 Hz – 20 %)
- 2) 47,2 dB at 100 Hz ($|1+H_s|$ at 100 Hz + 20 %)
- 3) 65,6 dB at 28,2 Hz ($|1+H_s|$ at 28,2 Hz – 20 %)
- 4) 85,6 dB at 28,2 Hz ($|1+H_s|$ at 28,2 Hz – 20 % + 20 dB)

Bandwidth from 9,5 Hz to 28,2 Hz

$|1+H|$ shall be between 65,6 dB and 85,6 dB.

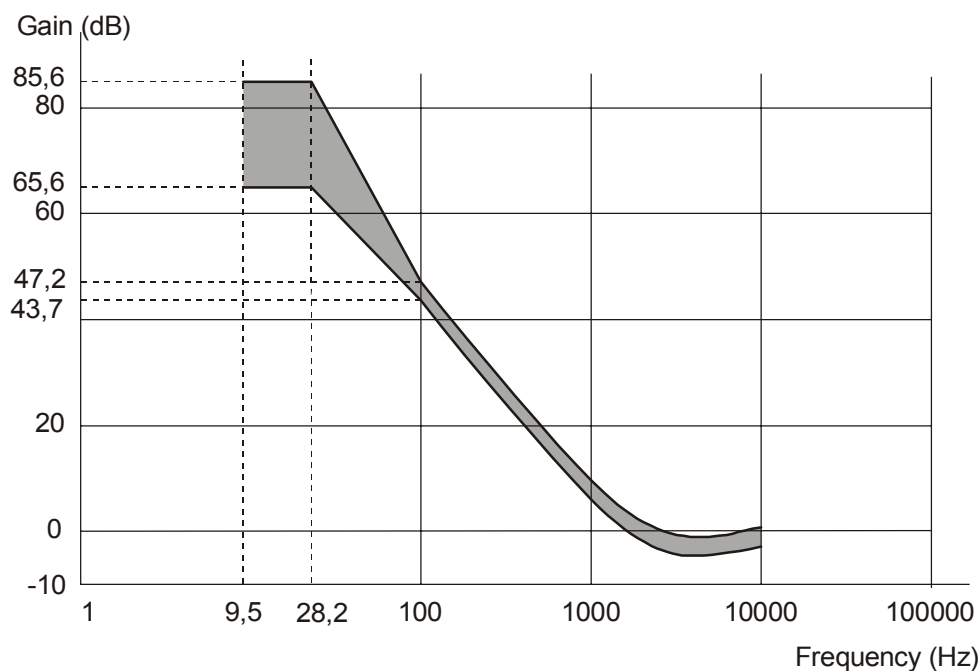


Figure 5 — Reference servo for radial tracking

10 Dimensional characteristics

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. The enclosed drawing, Figure 6 shows the dimensional requirements in summarized form. The different parts of the disk are described from the centre hole to the outside rim.

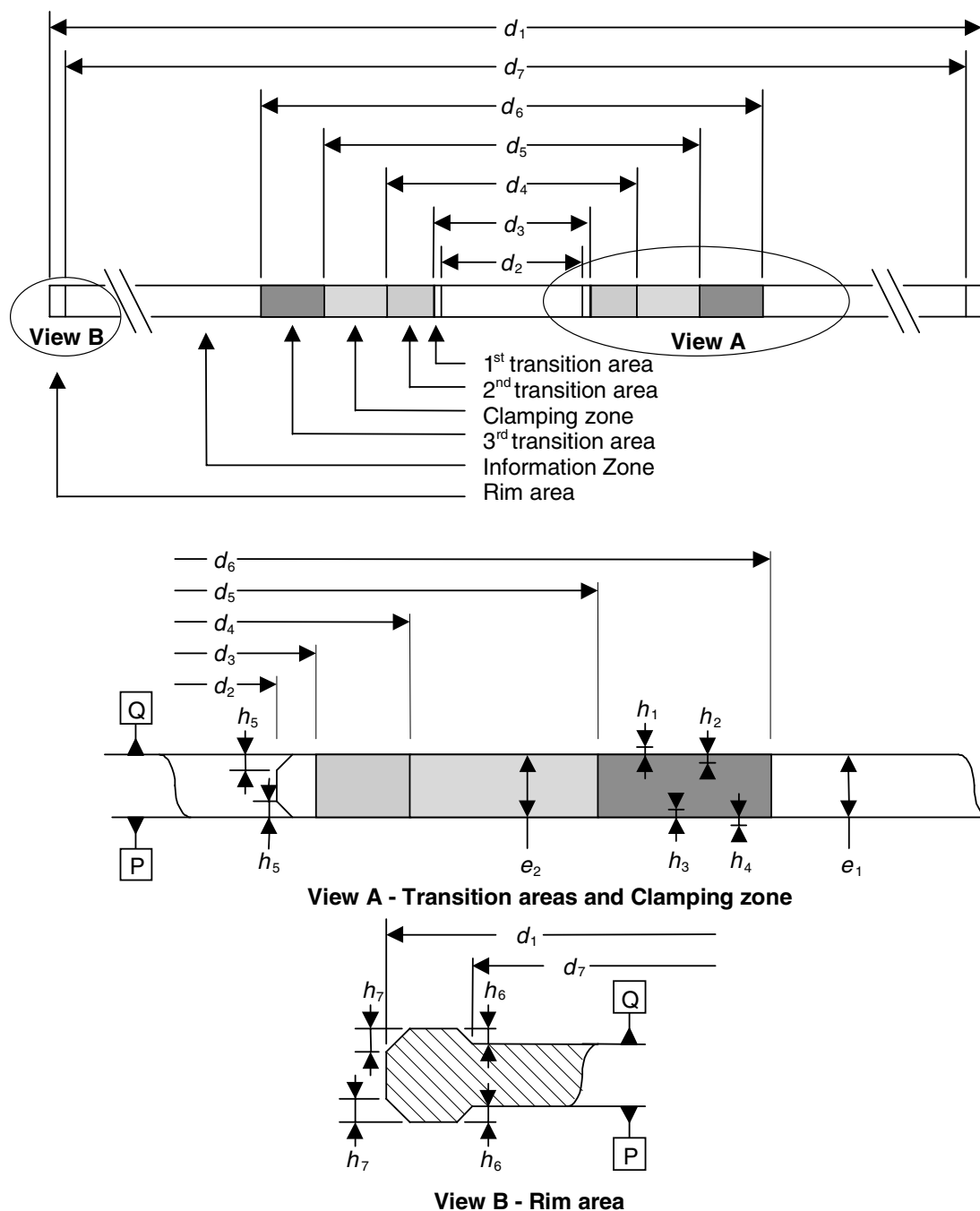


Figure 6 — Physical disk dimensions

10.1 Reference Planes

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 rests (see 10.5).

Reference Plane Q is the plane parallel to Reference Plane P at the height of the top surface of the Clamping Zone (see Figure 6).

10.2 Overall dimensions

The disk shall have an overall diameter (for 80 mm disk see Annex A)

$$d_1 = 120,00 \text{ mm} \pm 0,30 \text{ mm}$$

The centre hole of a substrate or a dummy substrate shall have a diameter (see Figure 7).

$$d_{\text{substrate}} = 15,00 \text{ mm} \begin{matrix} +0,15 \text{ mm} \\ -0,00 \text{ mm} \end{matrix}$$

The hole of an assembled disk, i.e. with both parts bonded together, shall have a diameter

$$d_2 = 15,00 \text{ mm min.}$$

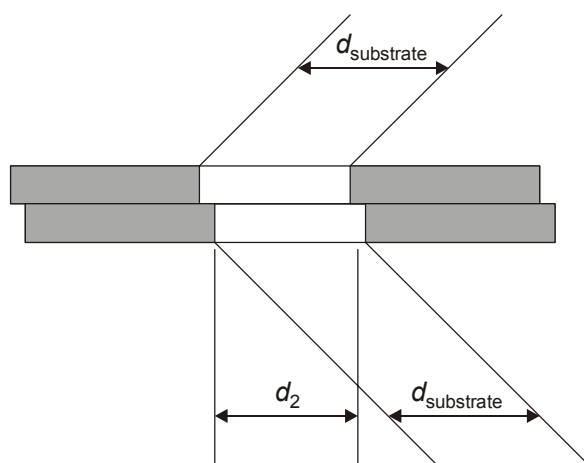


Figure 7 — Hole diameters for an assembled disk

The corners of the centre hole shall be free of any burrs or sharp features and shall be rounded off or chamfered by

$$h_5 = 0,1 \text{ mm max.}$$

The thickness of the disk shall be

$$e_1 = 1,20 \text{ mm} \begin{matrix} +0,30 \text{ mm} \\ -0,06 \text{ mm} \end{matrix}$$

10.3 First transition area

In the area defined by d_2 and

$$d_3 = 16,0 \text{ mm min.}$$

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

10.4 Second transition area

This area shall extend between diameter d_3 and diameter

$$d_4 = 22,0 \text{ mm max.}$$

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

10.5 Clamping Zone

This Zone shall extend between diameter d_4 and diameter

$$d_5 = 33,0 \text{ mm min.}$$

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. that of Reference Plane P within 0,1 mm.

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

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

10.6 Third transition area

This area shall extend between diameter d_5 and diameter

$$d_6 = 44,0 \text{ mm max.}$$

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

$$h_1 = 0,25 \text{ mm max.}$$

or below Reference Plane Q by

$$h_2 = 0,10 \text{ mm max.}$$

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

$$h_3 = 0,10 \text{ mm max.}$$

or below Reference Plane P by

$$h_4 = 0,25 \text{ mm max.}$$

10.7 Information Zone

The Information Zone shall extend from diameter d_6 to diameter (for 80 mm disk see Annex A)

$$d_7 = 117,5 \text{ mm min.}$$

This Zone consists of the Lead-in Zone, the Data Zone, the Lead-out Zone and the Inner and Outer Drive Areas (see also Clause 15).

10.8 Rim Area

The rim area is that area extending from diameter d_7 to diameter d_1 . In this area the surfaces are permitted to both extend beyond Reference Plane Q or Reference Plane P

$$h_6 = 0,1 \text{ mm max.}$$

The outer corners of the disk shall be free of any burrs or sharp features and shall be rounded off or chamfered by

$$h_7 = 0,2 \text{ mm max.}$$

10.9 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.

11 Mechanical characteristics

11.1 Mass

The mass of the disk shall be in the range of 13,0 g to 20,0 g (for 80 mm disk see Annex A).

11.2 Moment of inertia

The moment of inertia of the disk, relative to its rotation axis, shall not exceed 0,040 g·m² (for 80 mm disk see Annex A).

11.3 Dynamic imbalance

The dynamic imbalance of the disk, relative to its rotation axis, shall not exceed 2,5 g·mm (for 80 mm disk see Annex A).

11.4 Axial runout

When measured by the optical system with the Reference Servo for axial tracking, the disk rotating at the Reference velocity of 3,49 m/s (see 9.5), the deviation of the recording layer from its nominal position in the direction normal to the Reference Planes shall not exceed 0,30 mm.

Some explanation about the use of the Reference Servo as a measurement tool and the way to translate the measurement results to a practical implementation for a high-speed servo is given in Annex L.

11.4.1 Tracking requirements at the Reference velocity (CLV)

The residual tracking error below 10 kHz, measured on the blank disk using the Reference Servo for axial tracking and the disk rotating at the Reference velocity, shall not exceed 0,13 µm (displacement of the objective lens needed to move the focal point of the optical beam onto the recording layer).

The measuring filter shall be a Butterworth LPF,

f_c (-3 dB): 10 kHz, with slope : -80 dB/decade.

11.4.2 Tracking requirements at 3 000 RPM (CAV)

Disks suited to be recorded at speeds $> 4 \times$ the Reference velocity, shall also fulfill the following requirement:

the residual tracking error below 10 kHz, measured on the blank disk using the Reference Servo for axial tracking and the disk rotating at a fixed rotational speed of 3 000 RPM, shall not exceed $E_{ax}(r)$ μm , where E_{ax} is a function of the radius r according to the following specifications:

for $r \leq 29$ mm: $E_{ax}(r) = 0,20$ μm ,

for $r \geq 29$ mm: $E_{ax}(r) = \left(\frac{r}{29}\right)^2 \times 0,20$ μm , with r expressed in mm.

Disks suited to be recorded at speeds $> 8 \times$ the Reference velocity, shall furthermore fulfil the following requirement, additional to the requirement above:

the residual tracking error shall not exceed 0,40 μm at any radius.

If present, the 50 Hz component shall be removed from the residual tracking error before applying these requirements (e.g. by software processing of the sampled measurement data).

11.5 Radial runout

The runout of the outer edge of the disk shall not exceed 0,30 mm peak-to-peak.

The radial runout of tracks shall not exceed 70 μm peak-to-peak.

Some explanation about the use of the Reference Servo as a measurement tool and the way to translate the measurement results to a practical implementation for a high-speed servo is given in Annex L.

11.5.1 Tracking requirements at the Reference velocity (CLV)

The residual tracking error below 1,1 kHz ($= f_X$ as defined in 9.8.1), measured on the blank disk using the Reference Servo for radial tracking and the disk rotating at the Reference velocity of 3,49 m/s (see 9.5), shall not exceed 0,015 μm .

The measuring filter shall be a Butterworth LPF,

f_c (-3 dB) : 1,1 kHz, with 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 not exceed 0,016 μm .

The measuring filter shall be a Butterworth BPF,

frequency range (-3 dB)	:	1,1 kHz, with slope : +80 dB/decade
to	:	10 kHz, with slope : -80 dB/decade.

11.5.2 Tracking requirements at 3 000 RPM (CAV)

Disks suited to be recorded at speeds $> 4 \times$ the Reference velocity, shall also fulfill the following requirement:

the residual tracking error below 10 kHz, measured on the blank disk using the Reference Servo for radial tracking and the disk rotating at a fixed rotational speed of 3 000 RPM, shall not exceed $E_{\text{rad}}(r)$ μm , where E_{rad} is a function of the radius r according to the following specifications:

for $r \leq 29$ mm: $E_{\text{rad}}(r) = 0,025$ μm ,

for $r \geq 29$ mm: $E_{\text{rad}}(r) = \left(\frac{r}{29}\right)^2 \times 0,025$ μm , with r expressed in mm.

Disks suited to be recorded at speeds $> 8 \times$ the Reference velocity, shall furthermore fulfil the following requirement, additional to the requirement above:

the residual tracking error shall not exceed 0,055 μm at any radius.

If present, the 50 Hz component shall be removed from the residual tracking error before applying these requirements (e.g. by software processing of the sampled measurement data). This process effectively removes the influence of the pure eccentricity of the disk.

12 Optical characteristics in the Information Zone

12.1 Index of refraction

The index of refraction of the substrate in the Information Zone shall be $1,55 \pm 0,10$.

12.2 Thickness of the substrate

The thickness of the substrate, from the entrance surface to the recording layer, varies with the index of refraction of the substrate and shall be defined as the enclosed region in Figure 8.

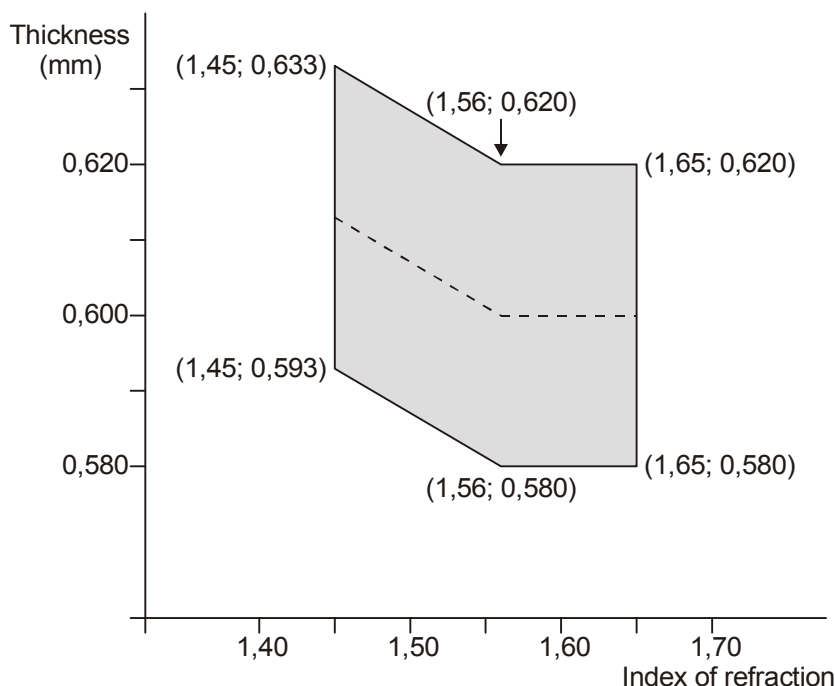


Figure 8 — Thickness of the substrate

12.3 Reflectivity

The double-pass optical transmission of the substrate and the reflectivity of the recording layer are measured together as the reflectance R of the disk. When measured according to Annex C the value of R shall be

in the Information Zone $0,45 \leq R_d \leq 0,85$ in the unrecorded groove

$0,45 \leq R_{14H} \leq 0,85$ in the recorded groove

The product of the reflectance of the unrecorded groove R_d and the optimized write power P_{peak} for the write strategy concerned (see 29.3.2) shall fulfil the following requirement:

$$R_d \times \text{actual } P_{\text{peak}} \leq \frac{P_{\text{peak_max}} \text{ for } \lambda \leq \lambda_{\text{IND}} \text{ for write strategy concerned}}{P_{\text{peak_max}} \text{ for } \lambda \leq \lambda_{\text{IND}} \text{ for basic write strategy}} \times 9 \text{ mW}$$

12.4 Birefringence

The birefringence of the substrate shall not exceed 60 nm when measured according to Annex D.

12.5 Angular deviation

The angular deviation is the angle α between a parallel incident beam perpendicular to the Reference Plane P and the reflected beam (see Figure 9). The incident beam shall have a diameter in the range 0,30 mm to 3,0 mm. This angle α includes deflection due to the entrance surface and to the unparallelism of the recording layer with the entrance surface.

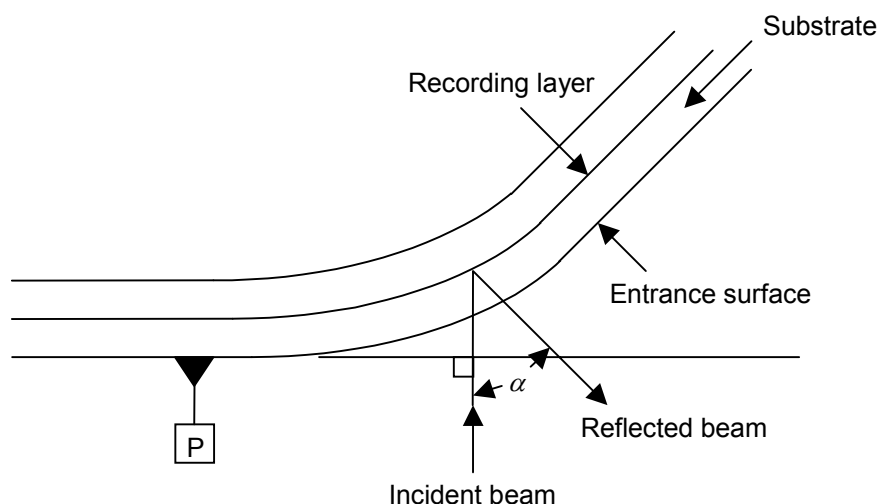


Figure 9 — Angular deviation α

The angular deviation shall be

In radial direction: $|\alpha| = 0,70^\circ \text{ max.}$

The variation of α in radial direction over one revolution shall be $0,80^\circ \text{ peak-to-peak max.}$

In tangential direction: $|\alpha| = 0,30^\circ \text{ max.}$

13 Data format

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,
- 16 Recording Frames,
- 16 Physical Sectors,
- a Recording Unit.

These steps are specified in the following clauses.

13.1 Data Frames

A Data Frame shall consist of 2 064 bytes arranged in an array of 12 rows each containing 172 bytes (Figure 10). The first row shall start with three fields, called Identification Data (ID), ID Error Detection Code (IED), and RSV bytes, 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 an Error Detection Code (EDC). The 2 048 Main Data bytes are identified as D_0 to $D_{2\,047}$.

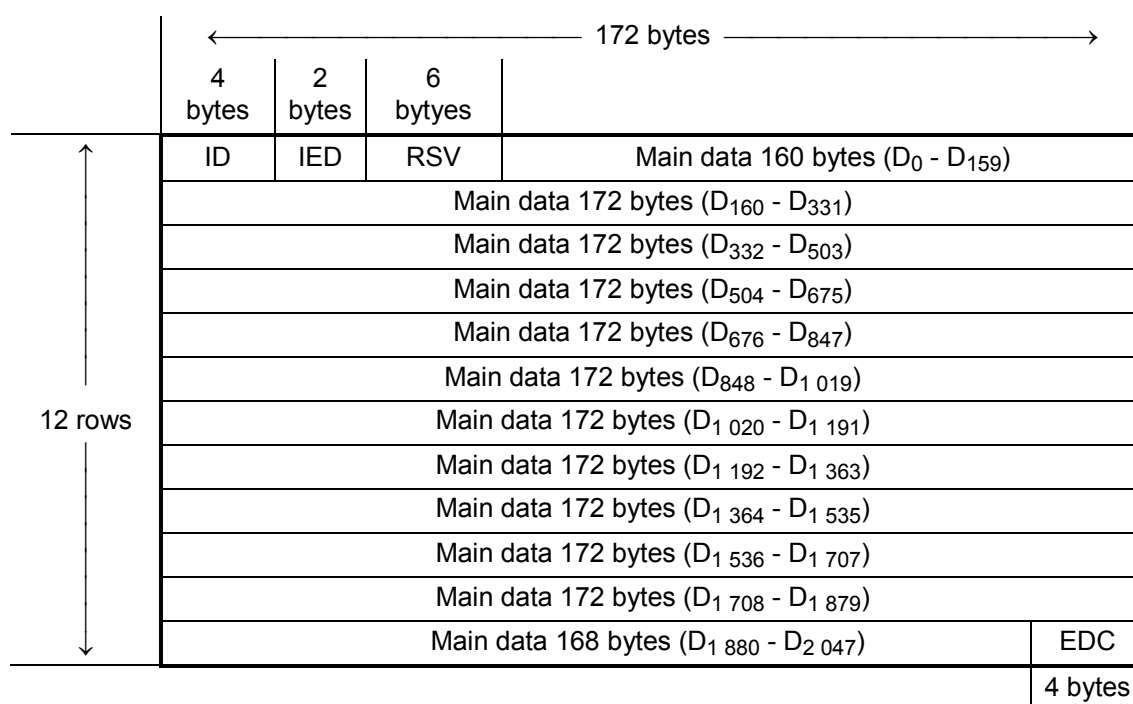


Figure 10 — Data Frame

13.1.1 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 11.

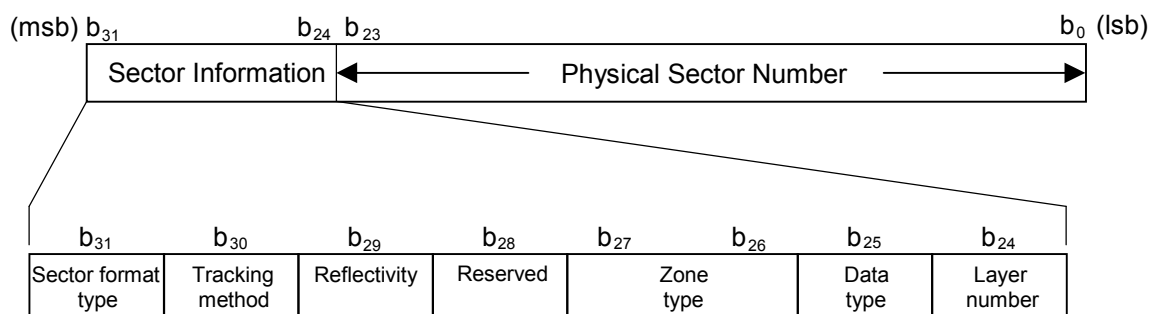


Figure 11 — Identification Data (ID)

The bits of the most significant byte, the Sector Information, shall be set as follows:

- Bit b_{31} shall be set to ZERO, indicating a CLD format
- Bit b_{30} shall be set to ZERO, indicating pit tracking capability (see 31.2.5)
- Bit b_{29} shall be set to ZERO indicating that the reflectance is greater than 40 %
- Bit b_{28} shall be set to ZERO
- Bits b_{27} to b_{26} shall be set to
 ZERO ZERO in the Data Zone
 ZERO ONE in the Lead-in Zone
 ONE ZERO in the Lead-out Zone
- Bit b_{25} shall be set to ZERO, indicating read only data.
- Bit b_{24} shall be set to ZERO, indicating that through an entrance surface only one recording layer can be accessed.

The least significant three bytes, bits b_{23} to b_0 , shall specify the Physical Sector Number in binary notation. The Physical Sector Number of the first Physical Sector of an ECC Block shall be an integer multiple of 16.

13.1.2 ID Error Detection Code (IED)

When identifying all bytes of the array shown in Figure 10 as $C_{i,j}$ for $i = 0$ to 11 and $j = 0$ to 171, the bytes of IED are represented by $C_{0,j}$ for $j = 4$ to 5. Their setting is obtained as follows.

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

where

$$I(x) = \sum_{j=0}^3 C_{0,j} x^{3-j} \quad \text{and} \quad G_E(x) = (x+1)(x+\alpha)$$

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

13.1.3 RSV

This field shall consist of 6 bytes. The first byte may be set by the application. If not specified by the application, it is reserved and shall be set to (00). The remaining 5 bytes are reserved and shall all be set to (00).

Under no circumstance may other data received from the host be recorded in this field.

Circumvention: Recorders and recording drives shall be considered as circumvention devices when these are produced to record, or can easily be modified to record, in any manner, a user-defined number in this field.

13.1.4 Error Detection Code (EDC)

This 4-byte field shall contain the parities 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 is shown as follows for $i = 0$ to 31:

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

where

$$I(x) = \sum_{i=32}^{16\,511} b_i x^i \quad \text{and} \quad G(x) = x^{32} + x^{31} + x^4 + 1$$

13.2 Scrambled Frames

The 2 048 Main Data bytes shall be scrambled by means of the circuit shown in Figure 12 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.

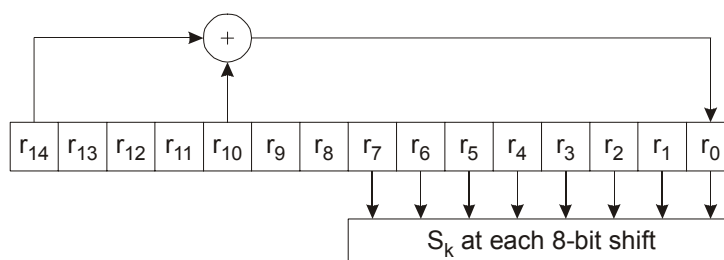


Figure 12 — Feedback shift register

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 1 (the msb of the pre-set value shall be discarded). 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 b_4 (lsb) of the ID field of the Data Frame. Table 1 specifies the initial pre-set value of the shift register corresponding to the 16 initial pre-set numbers.

Table 1 — Initial values of the shift register

Initial pre-set number	Initial pre-set value	Initial pre-set number	Initial pre-set 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)

The part of the initial value of r_7 to r_0 is taken out as scrambling byte S_0 . After that, an 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

$$D'_k = D_k \oplus S_k \quad \text{for } k = 0 \text{ to } 2\,047 \quad (\oplus \text{ stands for Exclusive OR})$$

13.3 ECC Blocks

An ECC Block is formed by arranging 16 consecutive Scrambled Frames in an array of 192 rows of 172 bytes each (Figure 13). To each of the 172 columns 16 bytes of Parity of Outer Code are added, then, to each of the resulting 208 rows, 10 bytes 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 is 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

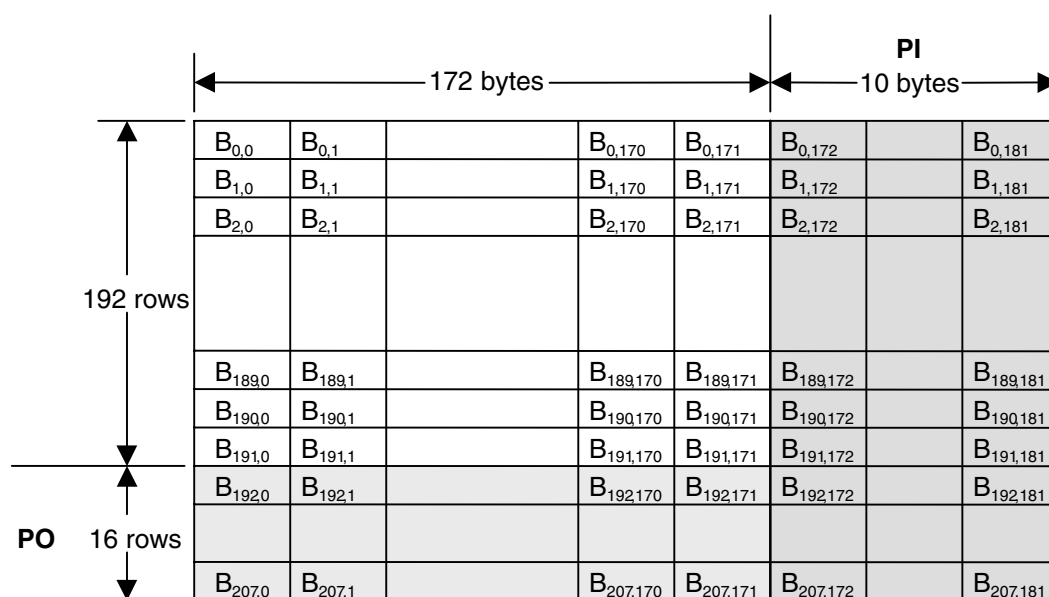


Figure 13 — ECC Block

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).

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

where

$$l_j(x) = \sum_{i=0}^{191} B_{i,j} x^{191-i} \quad \text{and} \quad G_{PO}(x) = \prod_{k=0}^{15} (x + \alpha^k)$$

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).

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

where

$$l_i(x) = \sum_{j=0}^{171} B_{i,j} x^{171-j} \quad \text{and} \quad G_{PI}(x) = \prod_{k=0}^9 (x + \alpha^k)$$

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

13.4 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 14). This is achieved by re-locating the bytes $B_{i,j}$ of the ECC Block as $B_{m,n}$ for

$$m = i + \text{int}[i / 12] \quad \text{and} \quad n = j \text{ for } i \leq 191$$

$$m = 13 \times (i - 191) - 1 \text{ and } n = j \text{ for } i \geq 192$$

where $\text{int}[x]$ 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.

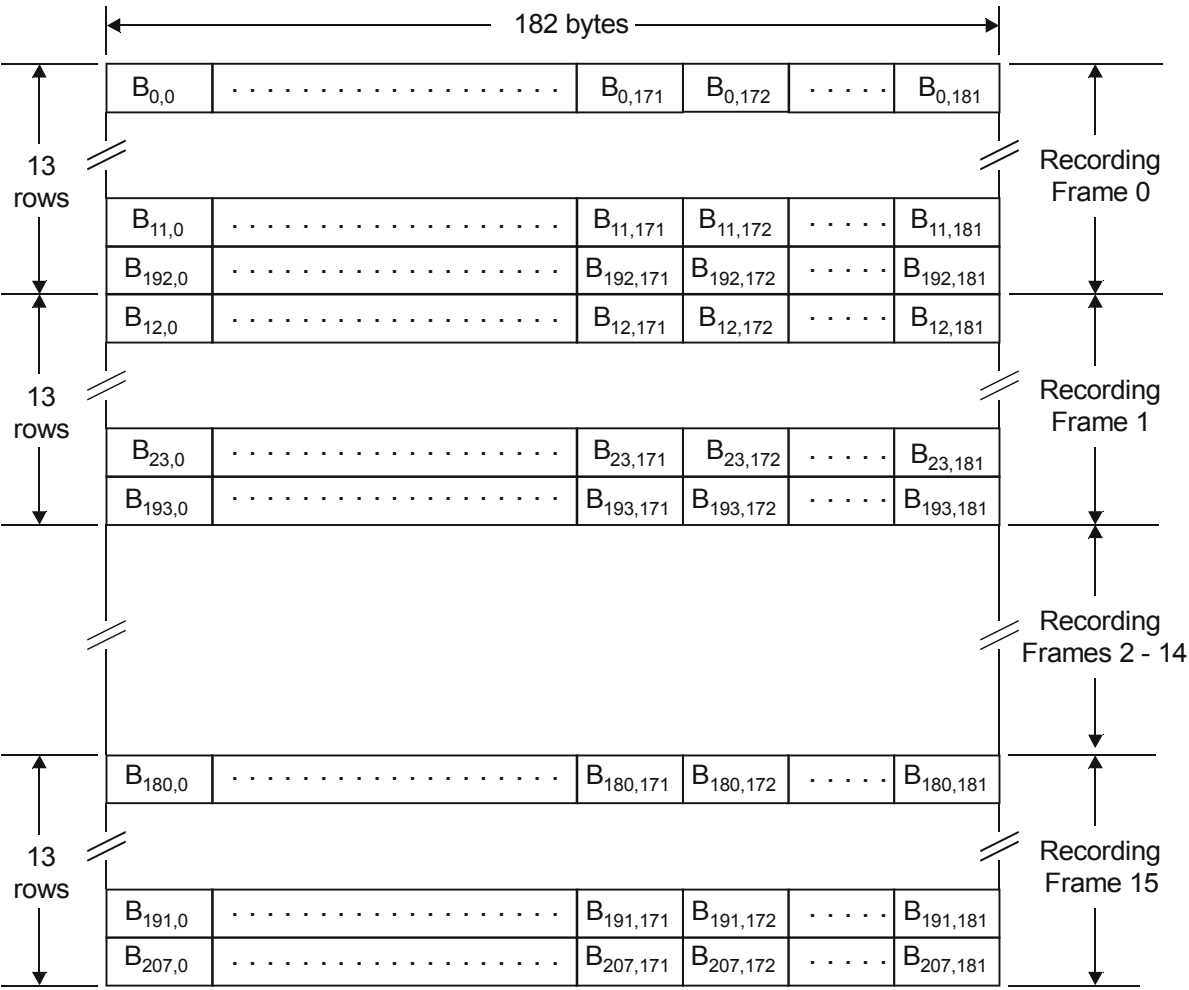


Figure 14 — Recording Frames obtained from an ECC Block

13.5 Modulation and NRZI conversion

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 H specifies the conversion tables to be applied. The Main Conversion table and the Substitution table specify a 16-bit Code Word for each 256 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 (see Figure 15). The Channel clock period is the time between 2 consecutive Channel bits.

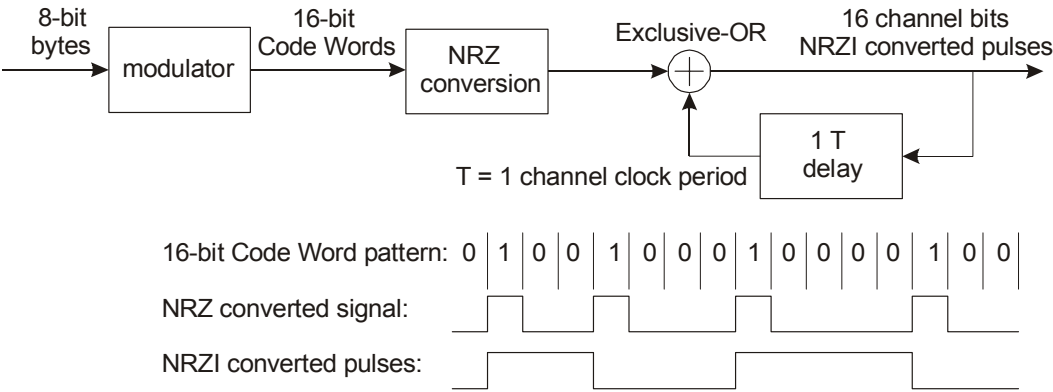


Figure 15 — NRZI conversion

13.6 Physical Sectors

The structure of a Physical Sector is shown in Figure 16. It shall consist of 13 rows, each comprising two Sync Frames. A Sync Frame shall consist of a SYNC Code from Table 2 and 1 456 Channel bits representing 91 8-bit bytes. Each row of the Physical Sector shall consist of two Sync Frames with the first 1 456 Channel bits representing the first 91 bytes of each row of a Recording Frame and the second 1 456 Channel bits representing the second 91 bytes of each row of a Recording Frame.

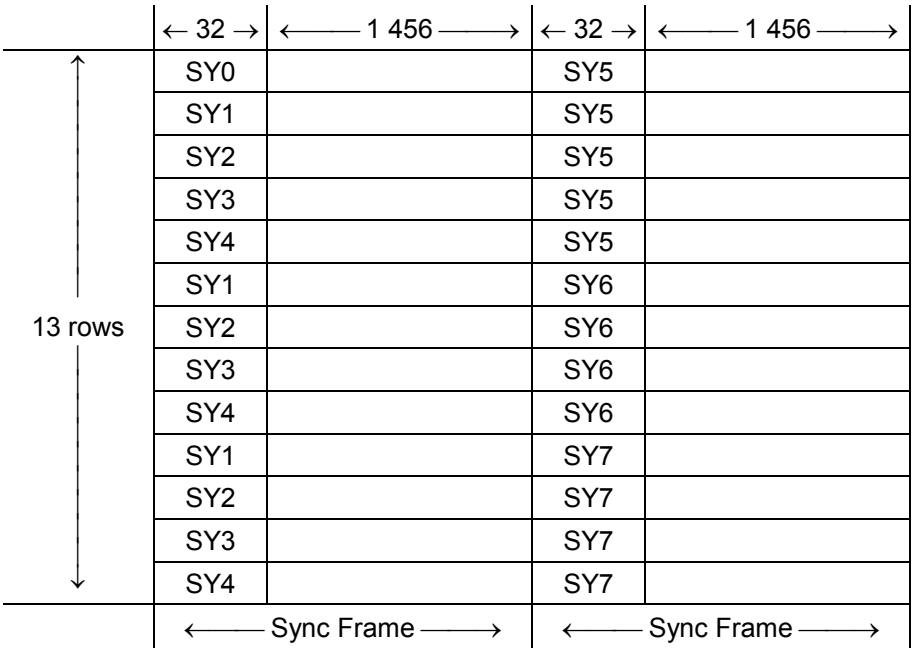


Figure 16 — Physical Sector

Recording of the Physical Sector 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. The state of each SYNC Code and each subsequent set of 16 Channel bits shall follow the rules defined in 13.8.

Table 2 — SYNC Codes

State 1 and State 2 (next state is state 1)			
Primary SYNC codes		Secondary SYNC codes	
(msb)	(lsb)	(msb)	(lsb)
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 (next state is state 1)			
Primary SYNC codes		Secondary SYNC codes	
(msb)	(lsb)	(msb)	(lsb)
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	/ 1000000010000100	0000000000010001
SY7 = 1000100010000100	0000000000010001	/ 1000000010000100	0000000000010001

13.7 Layout of a Recording Unit (RUN)

A RUN shall consist of an integer number ($M \geq 1$) of sets of 16 Physical Sectors, each from a single ECC Block. The M ECC Blocks shall be preceded by 8 Channel bits, which are meant to reduce possible influences of inaccuracies of the linking point, while the last 8 Channel bits of the last Physical Sector shall be discarded at recording. The 8 linking Channel bits and the next SYNC Code SY0 (chosen from State 1/2 or State 3/4) shall be chosen randomly, such that the runlength constraints specified in 13.5 are fulfilled.

Each RUN of M ECC Blocks ($M \geq 1$) starting with ECC Block N shall be recorded in the following way:

8 Channel bits for linking in ECC Block $N-1$,

full ECC Blocks N to $N + M - 2$ (if $M \geq 2$),

ECC Block $N + M - 1$, except for the last 8 Channel bits, which bits shall not be recorded.

The positioning of a Recording Unit is shown in Figure 17.

When the RUN starting with ECC Block N is to be recorded, and ECC Block $N-1$ has not yet been recorded, then the RUN shall be extended with a dummy ECC Block $N-1$ of which all Main Data bytes shall be set to (00) (see also Clause 23: Sequential recording).

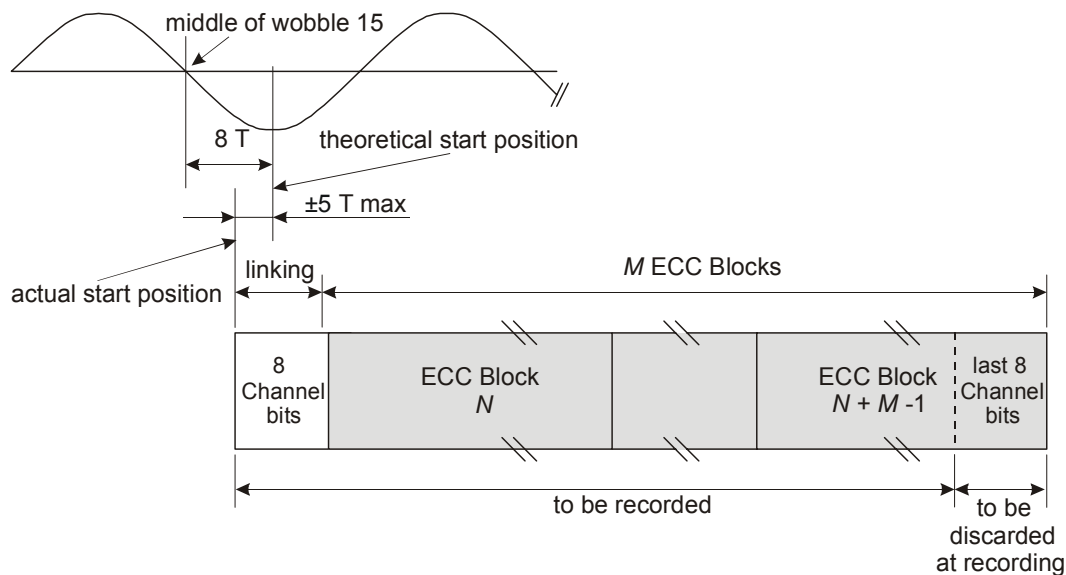


Figure 17 — Recording Unit

13.7.1 Recording Unit position

Each ECC Block, consisting of 16 Physical Sectors, shall correspond to 4 ADIP words (see 14.4.1.1). RUNs shall be mapped onto the structure of tracks (see 14.4), such that the Physical Sector Numbers (PSN), of which the 2 least significant bits have been discarded, correspond to the local Physical Address in ADIP (PAA). In mathematical form: $PSN = 4 \times PAA + i$, where $i = 0, 1, 2$, or 3 (for example: Physical Sector Numbers (030000) to (030003) correspond to Physical ADIP Address (00C000)).

The reference for the theoretical start positions is wobble 15 following the ADIP word sync unit of the ADIP words of which the 2 least significant address bits are 00 (see 14.4.1.1 and Figure 21). The theoretical start position is 8 Channel bits after the nominal position of the zero crossing in the middle of the above mentioned wobble 15 of the wobble signal from Read channel 2.

The start of each recording shall be within ± 5 Channel bits of the theoretical start position. During writing the Channel bit clock shall be phase locked to the wobble frequency.

13.8 d.c. component suppression control

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 4.3) shall be kept as close to zero 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:

- Choice of SYNC Codes between Primary or Secondary SYNC Codes.
- For the 8-bit bytes in the range 0 to 87, the Substitution table offers an alternative 16-bit Code Word for all States.
- 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. 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:

- 1) At the end of each Sync Frame, whether or not case b) and or case c) have occurred, the accumulated DSVs of both streams are compared. The stream with the lower $|DSV|$ is selected and duplicated to the other stream. Then the next Primary SYNC Code and the Secondary SYNC Code of the proper category are inserted each in one of the streams.

Optionally the procedure for case a) can be extended in the following way:

- 2) If the DSV at the end of the resulting Sync Frame is greater than + 63 or smaller than -64, then the SYNC Code at the beginning of the Sync Frame is 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 -1 000 and +1 000, thus it is recommended that the count range for the DSV be at least from -1 024 to +1 023.

14 Track format

14.1 Track shape

The area in the Information Zone (see 10.7) shall contain tracks formed from a single spiral groove. Each track shall form a 360° turn of a continuous spiral. The shape of each track is determined by the requirements in Clause 26 and following. Recordings shall be made on the groove.

The tracks in the Information Zone contain a phase modulated sinusoidal deviation from the nominal centrelines, called wobble, which contains addressing information.

The tracks shall be continuous in the Information Zone.

The groove tracks shall start at a radius of 22,00 mm max,
and end at a radius of 58,75 mm min (for 80 mm disk see Annex A).

14.2 Track path

The track path shall be a continuous spiral from the inside (beginning of the Lead-in Zone) to the outside (end of the Lead-out Zone) when the disk rotates counter-clockwise as viewed from the optical head.

14.3 Track pitch

The track pitch is the distance measured between the average track centrelines of adjacent tracks, measured in the radial direction. The track pitch shall be $0,74\ \mu\text{m} \pm 0,03\ \mu\text{m}$. The track pitch averaged over the Information Zone shall be $0,74\ \mu\text{m} \pm 0,01\ \mu\text{m}$.

14.4 Track layout

The wobble of the tracks is a sinusoidal deviation from the nominal centrelines, with a wavelength of $4,265\ 6\ \mu\text{m} \pm 0,045\ 0\ \mu\text{m}$ (equivalent to 32 Channel bits). The Total Harmonic Distortion (THD) of the oscillator for generating the wobble sine wave shall be $\leq -40\ \text{dB}$.

The wobble is phase modulated by inverting wobble cycles. The information contained in the wobble modulation is called Address-in-Pregroove or ADIP (see 14.4.1.1).

14.4.1 ADIP information

The data to be recorded onto the disk must be aligned with the ADIP information modulated in the wobble. Therefore 93 wobbles shall correspond to 2 Sync Frames. Of each 93 wobbles, 8 wobbles are phase modulated with ADIP information (see Figure 18).

1 wobble equals 32 Channel bits (= 32T)
one ADIP unit = 8 modulated wobbles per 2 Sync Frames

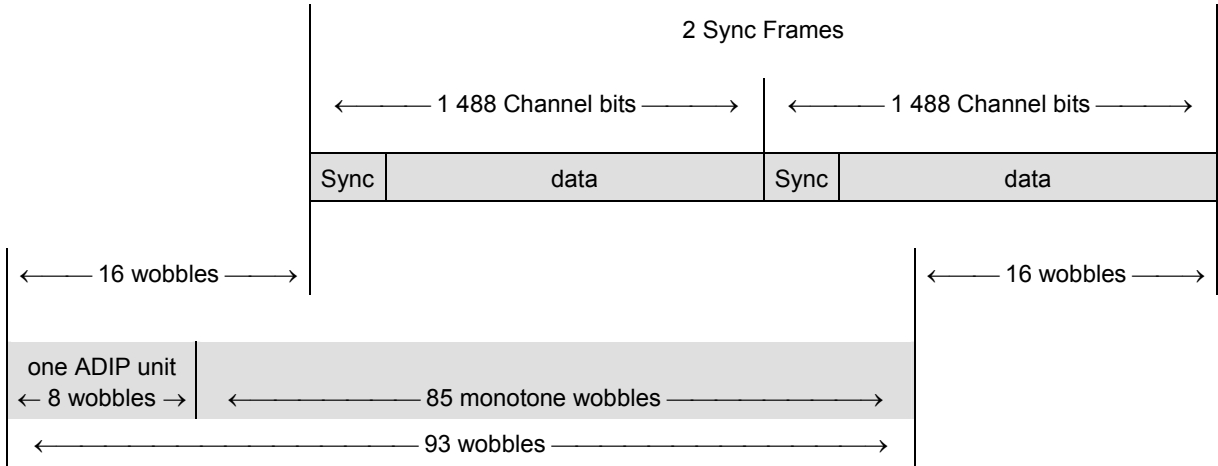


Figure 18 — General ADIP structure

14.4.1.1 ADIP word structure

52 ADIP units are grouped into one ADIP word each.
This means that one ADIP word corresponds to $4 \times 13 \times 2$ Sync Frames $\equiv$ 4 Physical Sectors.

Each ADIP word shall consist of: 1 ADIP sync unit + 51 ADIP data units.
ADIP sync unit = 4 inverted wobbles for word sync + 4 monotone wobbles.

ADIP data unit = 1 inverted wobble for bit sync + 3 monotone wobbles + 4 wobbles representing one data bit.
(see 14.4.1.3)

ADIP word structure:

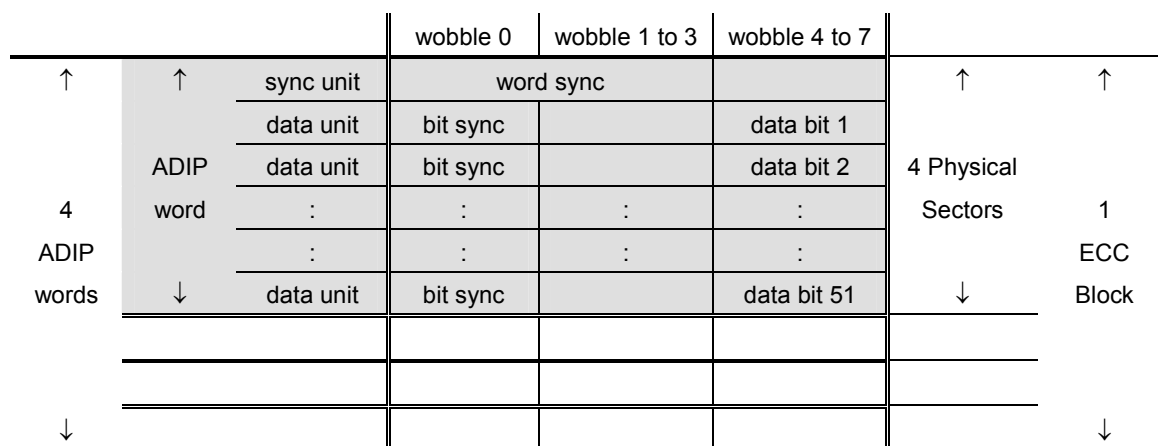


Figure 19 — ADIP word structure

The information contained in the data bits is as follows:

bit 1: this bit is **reserved** and shall be set to ZERO.

bits 2 to 23: these 22 bits contain a **Physical ADIP Address**.

Data bit 2 is the msb and data bit 23 is the lsb. The addresses increase by one for each next ADIP word.

The first address in the Information Zone shall be such that Physical ADIP Address (00C000) is located at radius $24,00^{+0,00}_{-0,20}$ mm.

Physical ADIP Address (098150), which is the first address corresponding to the Lead-out Zone, shall be located at a radius $\leq 58,00$ mm (for 80 mm disk see Annex A).

bits 24 to 31: these 8 bits contain **auxiliary information** about the disk.

Bit 24 to 31 from 256 consecutive ADIP words, shall form one ADIP Aux Frame with 256 bytes of information. The first byte of each ADIP Aux Frame shall be located in an ADIP word with a Physical ADIP Address that is a multiple of 256 (Physical ADIP Address = (xxxx00)).

In the Lead-in Zone and the Inner Drive Area of the disk the auxiliary bytes shall be used for storing Physical format information. The contents of the 256 bytes are defined in Table 3 and 14.4.2.

In the Data Zone of the disk the auxiliary bytes may be used for storing Extended format information as defined in Annex B. If not used for such purpose all bytes shall be set to (00).

In the Lead-out Zone / Outer Drive Area of the disk the auxiliary bytes shall be set to (00).

bits 32 to 51: these 20 bits contain **error correction parities** for the ADIP information (see 14.4.1.2).

14.4.1.2 ADIP error correction

For the ADIP error correction the ADIP data bits are grouped into 4-bit nibbles. The mapping of the data bits into the nibble array is defined in Figure 20. Bit 0 is a dummy bit, which shall be considered as set to ZERO for the error corrector.

nibble N ₀	bit 0	bit 1	bit 2	bit 3	↑ 6 nibbles ↓ ADIP address
nibble N ₁	bit 4	bit 5	:	:	
:	:	:	:	:	
:	bit 20	:	:	bit 23	
:	bit 24				↑ 2 ↓ nibbles AUX data
nibble N ₇	bit 28		:	bit 31	
nibble N ₈	bit 32	:	:	:	↑ 5 nibbles ↓ nibble based R-S ECC
:	:	:	:	:	
:	:	:	:	:	
:	:	:	:	:	
nibble N ₁₂	bit 48	bit 49	bit 50	bit 51	

Figure 20 — ADIP error correction structure

A nibble-based RS(13,8,6) code is constructed, of which the 5 parity nibbles N₈ to N₁₂, are defined by the remainder polynomial R(x):

$$R(x) = \sum_{i=8}^{12} N_i x^{12-i} = I(x) x^5 \bmod G_{PA}(x)$$

where

$$I(x) = \sum_{i=0}^7 N_i x^{7-i} \quad \text{and} \quad G_{PA}(x) = \prod_{k=0}^4 (x + \alpha^k)$$

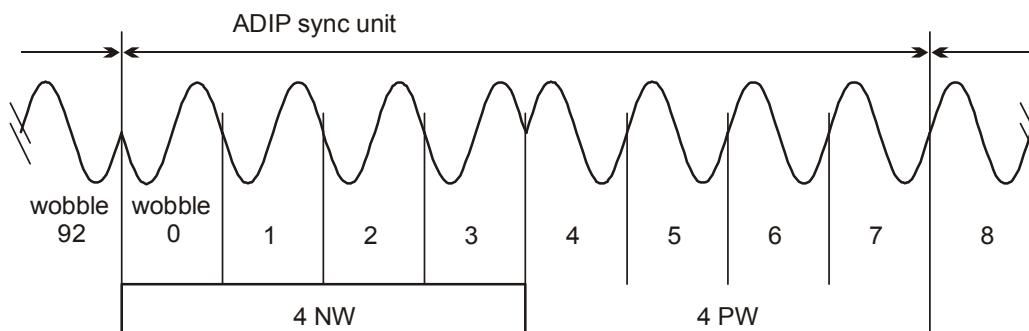
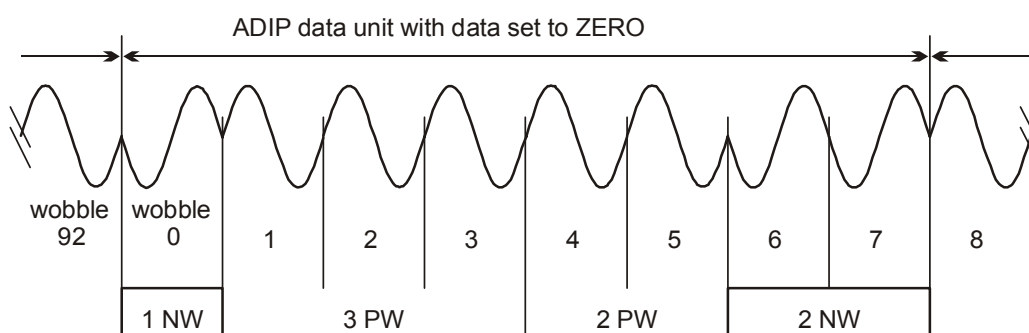
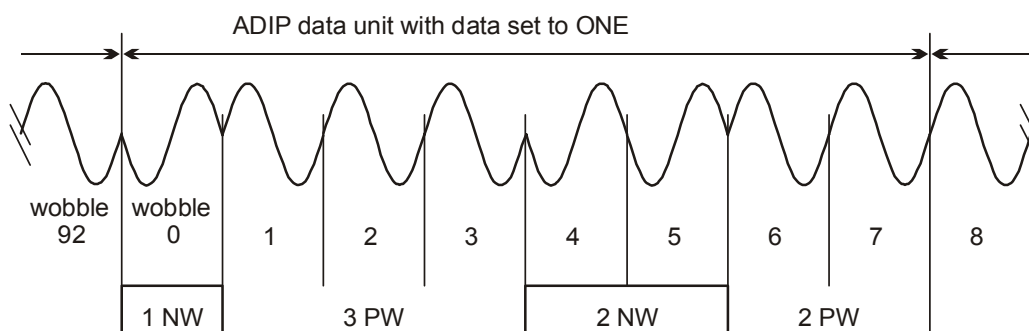
α is the primitive root 0010 of the primitive polynomial $P(x) = x^4 + x + 1$

All bits of the 5 parity nibbles N₈ to N₁₂ shall be inverted before recording.

14.4.1.3 ADIP modulation rules

The ADIP units are modulated by inverting some of the 8 wobble cycles:

- PW is a positive wobble, which shall start moving towards the inside of the disk.
- NW is a negative wobble, which shall start moving towards the outside of the disk.
- all monotone wobbles shall be PWs.

Modulation of the ADIP word sync:**Modulation of an ADIP ZERO bit:****Modulation of an ADIP ONE bit:****Figure 21 — ADIP modulation rules****14.4.2 Physical format information in ADIP**

This information shall comprise the 256 bytes shown in Table 3. It contains disk information and values for the write strategy parameters to be used with the Optimum Power Control (OPC) algorithm to determine optimum laser power levels for writing (see Annex G and Annex I). The information is copied to the Control Data Zone (see 18.8.1) during finalization of the Lead-in Zone of the disk.

Table 3 — Physical format information

Byte number	Content	Number of bytes
0	Disk Category and Version Number	1
1	Disk size	1
2	Disk structure	1
3	Recording density	1
4 to 15	Data Zone allocation	12
16	General Flag bits	1
17	Disk Application Code	1
18	Extended Information indicators	1
19 to 26	Disk Manufacturer ID	8
27 to 29	Media Type ID	3
30	Product revision number	1
31	number of Physical format information bytes in use in ADIP up to byte 63	1
32	Primary recording velocity for the basic write strategy	1
33	Upper recording velocity for the basic write strategy	1
34	Wavelength λ_{IND}	1
35	normalized Write power dependency on Wavelength $(dP/d\lambda)/(P_{IND}/\lambda_{IND})$	1
36	Maximum read power at Primary velocity	1
37	P_{IND} at Primary velocity	1
38	β_{target} at Primary velocity	1
39	Maximum read power at Upper velocity	1
40	P_{IND} at Upper velocity	1
41	β_{target} at Upper velocity	1
42	$T_{top} (\geq 4T)$ first pulse duration for $cm^* \geq 4T$ at Primary velocity	1
43	$T_{top} (=3T)$ first pulse duration for $cm^* = 3T$ at Primary velocity	1
44	T_{mp} multi pulse duration at Primary velocity	1
45	T_{lp} last pulse duration at Primary velocity	1
46	$dT_{top} (\geq 4T)$ first pulse lead time for $cm^* \geq 4T$ at Primary velocity	1
47	$dT_{top} (=3T)$ first pulse lead time for $cm^* = 3T$ at Primary velocity	1
48	dT_{le} first pulse leading edge shift for $ps^* = 3T$ at Primary velocity	1
49	$T_{top} (\geq 4T)$ first pulse duration for $cm^* \geq 4T$ at Upper velocity	1
50	$T_{top} (=3T)$ first pulse duration for $cm^* = 3T$ at Upper velocity	1
51	T_{mp} multi pulse duration at Upper velocity	1
52	T_{lp} last pulse duration at Upper velocity	1
53	$dT_{top} (\geq 4T)$ first pulse lead time for $cm^* \geq 4T$ at Upper velocity	1
54	$dT_{top} (=3T)$ first pulse lead time for $cm^* = 3T$ at Upper velocity	1
55	dT_{le} first pulse leading edge shift for $ps^* = 3T$ at Upper velocity	1
56 to 63	Reserved - All (00)	8
64 to 95	Extended Information block 0	32
96 to 127	Extended Information block 1	32
128 to 159	Extended Information block 2	32

* cm = current mark, ps = previous space (see also Annex G)

Table 3 — Physical format information (concluded)

Byte number	Content	Number of bytes
160 to 191	Extended Information block 3	32
192 to 223	Extended Information block 4	32
224 to 247	Extended Information block 5	24
248 to 255	Reserved for use in the Control Data Zone – All (00)	8

This version of this document specifies several types of disks, with different recording velocity ranges. The specific write parameters for each recording velocity range shall be specified in separate blocks (EI blocks, see 14.4.2.3). The following types of disks (characterized by the so-called X-speed) have now been defined and their ADIP shall contain the EI Blocks as indicated in Table 4.

Table 4 — Types of disks

type of disk	basic write strategy bytes 32 to 63 (1x & 2,4x speed)	4x+ write strategy EI block Format 1 (4x speed)	6x+ write strategy EI block Format 2 (6x ~ 8x speed)	6x+ write strategy EI block Format 3 (6x ~ 16x speed)	remarks
“2,4x”	+	—	—	—	this disk shall be suited for recording speeds of 3,49 & 8,44 m/s only
“4x”	+	+	—	—	this disk shall be suited for recording speeds of 3,49 & 8,44 m/s and 13,95 m/s
“8x”	+	+	+	—	this disk shall be suited for recording speeds of 3,49 & 8,44 m/s, 13,95 m/s and 20,9 ~ 27,9 m/s
“16x”	+	+	+	+	this disk shall be suited for recording speeds of 3,49 & 8,44 m/s, 13,95 m/s and 20,9 ~ 55,8 m/s

+ shall be present — shall not be used

14.4.2.1 General information - Bytes 0 to 31

Byte 0 – Disk Category and Version Number

Bits b_7 to b_4 shall specify the Disk Category,
bit b_7 shall be set to 1 indicating a disk according to the +R/+RW Format (see Clause 3),
bit b_6 shall be set to 0 indicating a single layer disk,
bits b_5 and b_4 shall be set to 10 indicating a +R disk.

Bits b_3 to b_0 shall specify the Version Number,
they shall be set to 0001 indicating this International Standard.
This Version Number identifies amongst others the definitions of the data in bytes 32 to 63.
Drives not acquainted with the specific Version Number of a disk should not try to record on that disk using the information in bytes 32 to 63, which bytes contain the basic write strategy parameters (see Annex Q).

NOTE Version number 0000 can be used for identification of test disks. Such test disks might not contain the correct Physical format information in their ADIP Aux Frames.

Byte 1 – Disk size and maximum transfer rate

Bits b₇ to b₄ shall specify the disk size,
they shall be set to 0000, indicating a 120 mm disk (for 80 mm disk see Annex A)

Bits b₃ to b₀ shall specify the maximum read transfer rate,
they shall be set to 1111 indicating no maximum read transfer rate is specified

Byte 2 – Disk structure

Bits b₇ to b₄ shall be set to 0000

Bits b₃ to b₀ shall specify the type of the recording layer(s):
they shall be set to 0010, indicating a write-once recording layer.

Byte 3 – Recording density

Bits b₇ to b₄ shall specify the average Channel bit length in the Information Zone,
they shall be set to 0000, indicating 0,133 µm.

Bits b₃ to b₀ shall specify the average track pitch,
they shall be set to 0000, indicating an average track pitch of 0,74 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 PSN 196 608 of the first Physical Sector of the Data Zone

Byte 8 shall be set to (00).

Bytes 9 to 11 shall be set to (26053F) to specify PSN 2 491 711 as the last possible Physical Sector of the Data Zone (for 80 mm disk see Annex A).

Bytes 12 to 15 shall be set to (00).

Byte 16 – General Flag bits

Bit b₇ shall be set to ZERO

Bit b₆ shall specify if the disk contains Extended format information in the ADIP Aux Frames in the Data Zone related to the VCPS copy protection system,

shall be set to 0, indicating no Extended format information for VCPS is present,

shall be set to 1, indicating the Data Zone contains Extended format information for VCPS as defined in Annex B and the VCPS System Description (see Annex P).

Bit b₅ is reserved for use in the Control Data Zone and shall be set to ZERO

Bits b₄ to b₀ are reserved and shall be set to 0 0000

Byte 17 – Disk Application Code

This byte can identify disks that are restricted to be used for special applications only. Drives not able to identify the particular application related to a specific Disk Application Code or not able to act according to the rules as defined for this particular application are not allowed to write on a disk with such a code.

- (00) identifies a disk for General Purpose use
(no restrictions, all drives are allowed to write on a disk carrying this code),

all other codes are reserved.

Byte 18 – Extended Information indicators

Bits b_7 to b_6 are reserved and shall be set to 00

Bits b_5 to b_0 each of these bits shall indicate the presence of an Extended Information block.
Bit b_i shall be set to 1 if Extended Information block i , consisting of bytes $(64 + i \times 32)$ to $(95 + i \times 32)$, is in use. Else bit b_i shall be set to 0.

Bytes 19 to 26 – Disk Manufacturer ID

These 8 bytes shall identify the manufacturer of the disk. This name shall be represented by characters from the G0 set + SPACE according to ISO/IEC 4873. Trailing bytes not used shall be set to (00).

If the Disk Manufacturer ID is not used, these 8 bytes shall be set to (00).

Bytes 27 to 29 – Media Type ID

Disk manufacturers can have different types of media, which shall be specified by these 3 bytes. The specific type of disk is denoted in this field by characters from the G0 set + SPACE according to ISO/IEC 4873. Trailing bytes not used shall be set to (00).

If the Media Type ID is not used these 3 bytes shall be set to (00)

NOTE If bytes 19 to 29 are used for disk identification, disks with different characteristics shall be identified by different and unique combinations of Disk Manufacturer ID / Media Type ID. Therefore the contents of bytes 19 to 29 shall be approved by the licensors of the +R system.

Byte 30 – Product revision number

This byte shall identify the product revision number in binary notation. All disks with the same Disk Manufacturer ID and the same Media Type ID, regardless of Product revision numbers, must have the same recording properties (only minor differences are allowed: Product revision numbers shall be irrelevant for recorders). The content of this byte can be chosen freely by the disk manufacturer.

If not used this byte shall be set to (00).

Byte 31 – number of Physical format information bytes in use in ADIP up to byte 63

This byte forms one 8-bit binary number indicating the number of bytes actually in use for the basic Physical format information (in bytes 0 to 63). It shall be set to (38) indicating that only the first 56 bytes of the Physical format information are used.

14.4.2.2 Basic write strategy parameters - Bytes 32 to 63

Byte 32 – Primary recording velocity for the basic write strategy

This byte indicates the lowest recording velocity of the disk for the parameters as defined in bytes 34 to 63 in this Physical format information. This recording velocity is equal to the Reference velocity and shall be specified as a number n such that

$$n = 10 \times v_{\text{Primary,basic}} \text{ (} n \text{ rounded off to an integral value)}$$

It shall be

set to (23) indicating a Primary writing speed of about 3,49 m/s (1x).

Byte 33 – Upper recording velocity for the basic write strategy

This byte indicates the highest recording velocity of the disk for the parameters as defined in bytes 34 to 63 in this Physical format information. This recording velocity shall be specified as a number n such that

$$n = 10 \times v_{\text{Upper,basic}} \text{ (} n \text{ rounded off to an integral value)}$$

It shall be

set to (54) indicating a Upper writing speed of about 8,44 m/s (2,4x).

Byte 34 – Wavelength λ_{IND}

This byte shall specify the laser wavelength in nanometers at which the optimum write parameters in the following bytes are specified, as a number n such that

$$n = \text{Wavelength} - 600$$

For this version of the +R system, n shall be equal to (37) indicating that λ_{IND} is 655 nanometers.

Byte 35 – Normalized Write power dependency on Wavelength

This byte shall specify the average write power dependency on the wavelength normalized by the ratio of P_{IND} and λ_{IND} (see 29.3.3 and Annex K), as a number n such that

$$n = (dP/d\lambda)/(P_{\text{IND}}/\lambda_{\text{IND}})$$

Byte 36 – Maximum read power, P_r at Primary velocity

This byte shall specify the maximum read power P_r in milliwatts at Primary velocity as a number n such that

$$n = 20 \times (P_r - 0,7)$$

Byte 37 – P_{IND} at Primary velocity

P_{IND} is the starting value for the determination of P_{wo} used in the OPC algorithm, see Annex I and Annex K.

This byte shall specify the indicative value P_{IND} of P_{wo} in milliwatts at Primary velocity and λ_{IND} as a number n such that

$$n = 20 \times (P_{\text{IND}} - 5)$$

Byte 38 – β_{target} at Primary velocity

This byte shall specify the target value for β , β_{target} at Primary velocity used in the OPC algorithm (see Annex I) as a number n such that

$$n = 100 \times (\beta_{\text{target}} + 1)$$

Byte 39 – Maximum read power, P_r at Upper velocity

This byte shall specify the maximum read power P_r in milliwatts at Upper velocity as a number n such that

$$n = 20 \times (P_r - 0,7)$$

Byte 40 – P_{IND} at Upper velocity

P_{IND} is the starting value for the determination of *P*_{wo} used in the OPC algorithm, see Annex I and Annex K.

This byte shall specify the indicative value P_{IND} of *P*_{wo} in milliwatts at Upper velocity and λ_{IND} as a number *n* such that

$$n = 20 \times (P_{IND} - 5)$$

Byte 41 – β_{target} at Upper velocity

This byte shall specify the target value for β, β_{target} at Upper velocity used in the OPC algorithm (see Annex I) as a number *n* such that

$$n = 100 \times (\beta_{target} + 1)$$

Byte 42 – T_{top} (≥4T) first pulse duration for current mark ≥4T at Primary velocity

This byte shall specify the duration of the first pulse of the multi pulse train when the current mark is a 4T or greater mark for recording at Primary velocity (see Annex G.1). The value is expressed in fractions of the Channel bit clock period as a number *n* such that

$$n = 16 \times \frac{T_{top}}{T_W} \quad \text{and } 4 \leq n \leq 40$$

Byte 43 – T_{top} (=3T) first pulse duration for current mark =3T at Primary velocity

This byte shall specify the duration of the first pulse of the multi pulse train when the current mark is a 3T mark for recording at Primary velocity (see Annex G.1). The value is expressed in fractions of the Channel bit clock period as a number *n* such that

$$n = 16 \times \frac{T_{top}}{T_W} \quad \text{and } 4 \leq n \leq 40$$

Byte 44 – T_{mp} multi pulse duration at Primary velocity

This byte shall specify the duration of the 2nd pulse through the 2nd to last pulse of the multi pulse train for recording at Primary velocity (see Annex G.1). The value is expressed in fractions of the Channel bit clock period as a number *n* such that

$$n = 16 \times \frac{T_{mp}}{T_W} \quad \text{and } 4 \leq n \leq 14$$

Byte 45 – T_{lp} last pulse duration at Primary velocity

This byte shall specify the duration of the last pulse of the multi pulse train when the current mark is a 4T or greater mark for recording at Primary velocity (see Annex G.1). The value is expressed in fractions of the Channel bit clock period as a number *n* such that

$$n = 16 \times \frac{T_{lp}}{T_W} \quad \text{and } 4 \leq n \leq 24$$

Byte 46 – dT_{top} (≥4T) first pulse lead time for current mark ≥4T at Primary velocity

When the current mark is a 4T or greater mark, this byte shall specify the lead time of the first pulse of the multi pulse train relative to the trailing edge of the second Channel bit of the data pulse, for recording at