
**Information technology — 120 mm
(8,54 Gbytes per side) and 80 mm
(2,66 Gbytes per side) DVD recordable
disk for dual layer (DVD-R for DL)**

*Technologies de l'information — Disques DVD enregistrables de
120 mm (8,54 Go par face) et 80 mm (2,66 Go par face) pour double
couche (DVD-R pour DL)*





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Contents

Page

Foreword	vii
Introduction.....	viii
1 Scope	1
2 Conformance	1
2.1 Optical Disk	1
2.2 Generating system	2
2.3 Receiving system	2
3 Normative references	2
4 Terms and definitions	2
5 Conventions and notations	6
5.1 Representation of numbers	6
5.2 Names	6
6 Abbreviated terms	6
7 General description of a disk	8
8 General requirement	9
8.1 Environments	9
8.1.1 Test environment.....	9
8.1.2 Operating environment.....	9
8.1.3 Storage environment.....	10
8.1.4 Transportation	10
8.2 Safety requirements	10
8.3 Flammability.....	10
9 Reference measurement devices	10
9.1 Pick-Up Head (PUH)	10
9.1.1 PUH for measuring recorded disks	10
9.1.2 PUH for measuring unrecorded disks.....	12
9.2 Measurement conditions	13
9.2.1 Recorded and unrecorded disk	13
9.2.2 Recorded disk.....	13
9.2.3 Unrecorded disk	13
9.3 Normalized servo transfer function.....	14
9.4 Reference servo for axial tracking.....	14
9.4.1 Recorded disk.....	14
9.4.2 Unrecorded disk	15
9.5 Reference servo for radial tracking	16
9.5.1 Recorded disk.....	16
9.5.2 Unrecorded disk	17
10 Dimensional characteristics.....	18
10.1 Overall dimensions	20
10.2 First transition area	20
10.3 Second transition area.....	21
10.4 Clamping Zone.....	21
10.5 Third transition area	21
10.6 R-Information Zone	22
10.6.1 Sub-divisions of the R-Information Zone.....	22
10.7 Information Zone	22
10.7.1 Sub-divisions of the Information zone	22

10.8	Track geometry	23
10.8.1	Track Path.....	23
10.9	Channel bit length.....	24
10.10	Rim area.....	24
10.11	Remark on tolerances	25
10.12	Label.....	25
11	Mechanical parameters	25
11.1	Mass.....	25
11.2	Moment of inertia.....	25
11.3	Dynamic imbalance	25
11.4	Sense of rotation.....	25
11.5	Runout	25
11.5.1	Axial runout.....	25
11.5.2	Radial runout.....	26
12	Optical parameters	26
12.1	Recorded and unrecorded disk parameters	26
12.1.1	Index of refraction.....	26
12.1.2	Thickness of the transparent substrate	26
12.1.3	Angular deviation.....	27
12.1.4	Birefringence of the transparent substrate.....	27
12.2	Recorded disk reflectivity	27
12.3	Unrecorded disk parameters	28
12.3.1	Polarity of reflectivity modulation.....	28
12.3.2	Recording power sensitivity variation.....	28
13	Operational signals for recorded disk	28
13.1	Measurement conditions	28
13.2	Read conditions	28
13.3	Recorded disk high frequency (HF) signals	28
13.3.1	Modulated amplitude.....	28
13.3.2	Signal asymmetry	29
13.3.3	Cross-track signal.....	29
13.4	Quality of signals	29
13.4.1	Jitter	29
13.4.2	Random errors	29
13.4.3	Defects	30
13.5	Servo signals.....	30
13.5.1	Differential phase tracking error signal.....	30
13.5.2	Tangential push-pull signal	30
13.6	Groove wobble signal	32
14	Operational signals for the unrecorded disk	33
14.1	Measurement conditions	33
14.2	Recording conditions.....	33
14.3	Write strategy for media testing.....	33
14.3.1	Definition of the write pulse.....	34
14.4	Servo signals.....	35
14.4.1	Radial push-pull tracking error signal	35
14.4.2	Defects	36
14.5	Addressing signals.....	36
14.5.1	Land Pre-Pit signal	36
14.5.2	Groove wobble signal	38
14.5.3	Relation in phase between wobble and Land Pre-Pit	38
15	Data Format	39
15.1	General.....	39
16	Data Frames	39
16.1	Identification Data (ID).....	40
16.2	ID Error Detection Code	41
16.3	RSV.....	41

16.4	Error Detection Code	41
17	Scrambled Frames	42
18	ECC Block configuration	43
19	Recording Frames	44
20	Modulation.....	45
21	Physical Sectors	46
22	Suppress control of the d.c. component	47
23	Linking scheme	48
23.1	Structure of linking.....	48
23.2	2K-Link and 32K-Link	49
23.3	Lossless-Link.....	49
24	General description of the Information Zone	51
24.1	Layout of the Information Zone	51
24.2	Physical Sector numbering	52
25	Lead-in Zone, Middle Zone and Lead-out Zone.....	53
25.1	Lead-in Zone	53
25.1.1	Initial Zone.....	54
25.1.2	Buffer Zone 0	54
25.1.3	R-Physical Format Information Zone	54
25.1.4	Reference Code Zone.....	58
25.1.5	Buffer Zone 1	58
25.1.6	Control Data Zone	59
25.1.7	Extra Border Zone	72
25.2	Middle Zone.....	72
25.3	Lead-out Zone.....	73
25.3.1	Structure of Lead-out Zone with Format4 RMD.....	73
25.3.2	Superficial Extra Border Zone.....	73
26	General description of the Unrecorded Zone	74
26.1	Layout of the Unrecorded Zone	74
26.2	ECC Block address	75
26.3	ECC Block numbering.....	75
27	Pre-pit Data format	76
27.1	General description.....	76
27.2	Pre-pit block structure	78
27.3	Pre-pit data block configuration	80
27.3.1	Relative address	82
27.3.2	ECC Block address data configuration.....	82
27.3.3	Parity A and Parity B	82
27.3.4	Field ID0.....	84
27.3.5	Field ID1.....	85
27.3.6	Field ID2.....	87
27.3.7	Field ID3 and Field ID4	88
27.3.8	Field ID5.....	90
28	Data structure of R-Information Zone and ODTA.....	90
28.1	Layout of Disk Testing Area and Recording Management Area	90
28.2	Structure of the Disk Testing Area	91
28.3	Data configuration of the Recording Management Area (RMA)	93
28.3.1	Sector format of the Recording Management Area	93
28.3.2	Recording Management Data (Format1 RMD and Format4 RMD).....	95
Annex A (normative)	Measurement of the angular deviation α	124
Annex B (normative)	Measurement of birefringence	126
Annex C (normative)	Measurement of the differential phase tracking error	129

Annex D (normative) Measurement of light reflectance.....	133
Annex E (normative) Tapered cone for disk clamping.....	135
Annex F (normative) Measurement of jitter.....	136
Annex G (normative) 8-to-16 Modulation with RLL (2,10) requirements.....	139
Annex H (normative) Optimum Power Control.....	149
Annex I (normative) Measurement of the groove wobble amplitude.....	151
Annex J (normative) Measurement methods for the operational signals for an unrecorded disk.....	153
Annex K (normative) NBCA Code.....	154
Annex L (normative) Border Zone.....	160
Annex M (normative) Measurement method of the Land Pre-Pit signal.....	173
Annex N (normative) Construction of Information Zone.....	174
Annex O (normative) Recording order.....	176
Annex P (normative) Clearance in the number of sectors.....	177
Annex Q (normative) Anchor Point Re-mapping.....	179
Annex R (informative) Measurement method of the Space layer thickness in a disk.....	181
Annex S (informative) Transportation.....	182

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 12862 was prepared by Ecma International (as ECMA-382) 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 second edition cancels and replaces the first edition (ISO/IEC 12862:2009), 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, TC31 has made major contributions to ISO/IEC JTC 1/SC 23 toward the development of International Standards for optical disks. 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. The following Ecma standards for DVD 120 mm and 80 mm have been published by Ecma and adopted by ISO/IEC JTC 1. These standards are based on original specifications from the DVD Forum.

ECMA-267 (2001) 120 mm DVD-Read-Only Disk, 3rd edition
ISO/IEC 16448

ECMA-268 (2001) 80 mm DVD-Read-Only Disk, 3rd edition
ISO/IEC 16449

ECMA-272 (1999) 120 mm DVD Rewritable Disk (DVD-RAM), 2nd edition
ISO/IEC 16824

ECMA-273 (1998) Case for 120 mm DVD-RAM Disks, 1st edition
ISO/IEC 16825

ECMA-279 (1998) 80 mm (1,23 Gbytes per side) and 120 mm (3,95 Gbytes per side) DVD-Recordable Disk (DVD-R), 1st edition
ISO/IEC 20563

ECMA-330 (2005) 120 mm (4,7 Gbytes per side) and 80 mm (1,46 Gbytes per side) DVD Rewritable Disk (DVD-RAM), 3rd edition
ISO/IEC 17592

ECMA-331 (2004) Cases for 120 mm and 80 mm DVD-RAM Disks, 2nd edition
ISO/IEC 17594

ECMA-338 (2002) 80 mm (1,46 Gbytes per side) and 120 mm (4,70 Gbytes per side) DVD Re-recordable Disk (DVD-RW), 1st edition
ISO/IEC 17342

ECMA-359 (2004) 80 mm (1,46 Gbytes per side) and 120 mm (4,70 Gbytes per side) DVD Recordable Disk (DVD-R), 1st edition
ISO/IEC 23912

ECMA-382 (2008) 120 mm (8,54 Gbytes per side) and 80 mm (2,66 Gbytes per side) DVD Recordable Disk for Dual Layer (DVD-R for DL), 1st edition
ISO/IEC 12862

ECMA-384 (2008) 120 mm (8,54 Gbytes per side) and 80 mm (2,66 Gbytes per side) DVD Re-recordable Disk for Dual Layer (DVD-RW for DL), 1st edition
ISO/IEC 13170

In April 2007, nine members proposed that TC31 develop a standard for 120 mm and 80 mm dual layer DVD recordable optical disks using organic dye recording technology. TC31 adopted this project, which resulted in ECMA-382 (2008).

In December 2009, a proposal was made that TC31 update this Ecma Standard for editorial corrections and clarifications. TC31 approved this proposal, which resulted in the second edition of ECMA-382.

This International Standard specifies two types of dual layer recordable optical disks, one (Type 1S) making use of recording on only a single side of the disk and yielding a nominal capacity of 8,54 Gbytes for a 120 mm disk and 2,66 Gbytes for an 80 mm disk, the other (Type 2S) making use of recording on both sides of the disk and yielding a nominal capacity of 17,08 Gbytes for a 120 mm disk and 5,32 Gbytes for an 80 mm disk.

Information technology — 120 mm (8,54 Gbytes per side) and 80 mm (2,66 Gbytes per side) DVD recordable disk for dual layer (DVD-R for DL)

1 Scope

This International Standard specifies the mechanical, physical and optical characteristics of a 120 mm and an 80 mm dual layer DVD recordable disk to enable the interchange of such disks. It specifies the quality of the pre-recorded, unrecorded and 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 disk for dual layer (DVD-R for DL).

This International Standard specifies the following:

- 120 mm and 80 mm nominal diameter disks that can 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 is in conformance with this International Standard if it meets the mandatory requirements specified for this 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 an optical disk in accordance with 2.1.

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.

ECMA-287, *Safety of electronic equipment*

4 Terms and definitions

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

**4.1
anchor point**
physical sector number corresponding to the specific logical sector number such as 16, 256, N-256 and N, where N is the maximum last-recorded address in logical volume space

NOTE The information in those sector numbers are used to fix Volume and File structure.

**4.2
basic recording speed**
recording speed at which a disk is under an obligation to be recorded

NOTE A basic recording speed is mandatory for each Class.

**4.3
block SYNC guard area**
recorded area in the first ECC block of the contiguous area of which recording is started from the unrecorded area by using 32K-Link

**4.4
border zone**
linking region that prevents the pick-up head from overrunning on an unrecorded area when a disk is played back in a partially recorded state

**4.5
channel bit**
elements by which, after modulation, the binary values ZERO and ONE are represented on the disk by marks

**4.6
Clamping Zone**
annular part of the disk within which a clamping force is applied by a clamping device

4.7**class**

integer number, including 0, that indicates the basic recording speed supported by a disk

NOTE A group of recording speeds in a disk contains at least one basic recording speed which is mandatory for recording device and disk.

4.8**data zone**

zone between the Lead-in Zone and the Middle Zone on Layer 0 and zone between the Middle Zone and the Lead-out Zone on Layer 1, in which user data is recorded

NOTE In Border recording mode, Border Zone is included in Data Zone.

4.9**data recordable zone**

zone that is available to record user data

4.10**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

4.11**disk at once recording**

recording mode in which the Lead-in Zone, the user data and the Lead-out Zone are recorded sequentially

4.12**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

4.13**Disk Testing Area****DTA**

area used for Optimum Power Control

NOTE 1 There are two kinds of Disk Testing Area on a disk.

NOTE 2 The Inner Disk Testing Area (IDTA) is located in the R-Information Zone and situated adjacent to the inside of the Recording Management Area. The Outer Disk Testing Area (ODTA) is fixed and situated adjacent to the outside of the fixed Middle Zone.

NOTE 3 The optional IDTA can be located on Layer 1 facing the special allocation in the Initial zone on Layer 0 as an option for devices, when NBCA is not applied on a disk.

NOTE 4 The ODTA can be added when shifted Middle Zone exists as an option for devices. In this case, added ODTA is called flexible Outer Disk Testing Area (flexible ODTA) and is situated adjacent to the outside of the shifted Middle Zone on Layer 0 and Layer 1 respectively.

4.14**ECC block address**

absolute physical address used to define the recording position on the land of each area

NOTE 1 This address is pre-recorded as Land Pre-Pits and equal to the bit-inverted numbers from b23 to b4 of the Physical sector number recorded in the groove.

NOTE 2 Serially decremented numbers are assigned to blocks from the inner radius to the outer radius on Layer 0 and from the outer radius to the inner radius on Layer 1.

NOTE 3 The first ECC Block address in the Data Recordable Zone on Layer 0 is (FF CFFF).

NOTE 4 The bit-inverted number is calculated so that the bit value of ONE becomes that of ZERO and vice versa.

NOTE 5 The "ECC Block address" definition is specific to this International Standard.

4.15

Error Correction Code

ECC

mathematical computation yielding check bytes used for the detection and correction of errors in data

4.16

Error Detection Code

EDC

code designed to detect certain kinds of errors in data

NOTE Error Detection Code consists of data and the error detection parity.

4.17

finalization

action for changing into the state where the Lead-in, the Lead-out and the Middle Zones are recorded

NOTE 1 After Finalization, the information Zone from the Lead-in Zone to the Middle Zone on Layer 0 and from the Middle Zone to the Lead-out Zone on Layer 1 are recorded without any unrecorded areas.

NOTE 2 The disk will become write-protected once finalized.

4.18

groove

wobbled guidance track

4.19

incremental recording

recording mode in which the disk is recorded in several distinct recording operations (for example at different times and using different recording drives)

NOTE In this recording mode, the specified linking scheme shall be used.

4.20

information zone

zone comprising the Lead-in Zone, the Data Zone, the Middle Zone and the Lead-out Zone

4.21

initial information zone

zone comprising the Lead-in Zone, the Data Recordable Zone, the fixed Middle Zone and the Lead-out Zone

4.22

land

area between the grooves

4.23

Land Pre-Pit

LPP

pits embossed on the land during the manufacture of the disk substrate, which contain address information

4.24

Lead-in Zone

zone comprising Physical sectors adjacent to the inside of the Data Zone on Layer 0

4.25**Lead-out Zone**

zone comprising Physical sectors adjacent to the inside of the Data Zone on Layer 1

NOTE When the recording of user data is finished on Layer 0, the Lead-out Zone is located adjacent to the inside of the Middle Zone on Layer 1.

4.26**middle zone**

zone comprising physical sectors adjacent to the outside of the Data Zone on Layer 0 and Layer 1

NOTE 1 The fixed Middle Zone is located outside the Data Recordable Zone of a disk.

NOTE 2 The shifted Middle Zone can be added at the inner radius of the fixed Middle Zone as an option for devices, depending on the size of the Data Zone and located outside of the Data Zone.

4.27**Recording Management Area****RMA**

area containing the Recording Management Data (RMD), situated adjacent to the inside of the Lead-in Zone on Layer 0 and the Lead-out Zone on Layer 1

4.28**Recording Management Data****RMD**

information about the recording on the disk, including information on each recording mode

NOTE 1 Two kinds of RMD format are specified.

NOTE 2 Format1 RMD contains the information related to incremental recording mode and disk at once recording mode.

NOTE 3 Format4 RMD contains the information related to incremental recording mode, including Layer jump recording mode.

4.29**R-Information zone**

zone comprising the Inner Disk Testing Area (IDTA) and the Recording Management Area (RMA)

4.30**re-mapping**

replacement mechanism for physical layer to replace original anchor point with renewed anchor point

4.31**RZone**

ECC blocks that are continuous on a layer and assigned to user data on Layer 0 and/or Layer 1 during incremental recording mode

4.32**sector**

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

4.33**substrate**

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

4.34

track

360° turn of a continuous spiral of recorded marks or groove

4.35

track pitch

distance between adjacent average physical track centrelines of the wobbled grooves for the unrecorded disk, or between adjacent physical track centrelines of the successive recorded marks for the recorded disk, measured in the radial direction

4.36

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 1,275.

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

5.2 Names

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

6 Abbreviated terms

AP	Amplitude of the land Pre-Pit signal (without wobble amplitude)
AR	Aperture Ratio (of the Land Pre-Pit after recording)
BP	Byte Position
BPF	Band Pass Filter
CLV	Constant Linear Velocity
CNR	Carrier to Noise Ratio
DCC	DC Component suppress control

DSV	Digital Sum Value
ECC	Error Correction Code
EDC	Error Detection Code
HF	High Frequency
ID	Identification Data
LA	Lead-out Attribute
IDTA	Inner Disk Testing Area
IED	ID Error Detection (code)
LPF	Low-Pass Filter
LPP	Land Pre-Pit
LSB	Least Significant Byte
lsb	least significant bit
MSB	Most Significant Byte
msb	most significant bit
NBCA	Narrow Burst Cutting Area
NRZI	Non Return to Zero Inverted
ODTA	Outer Disk Testing Area
OPC	Optimum Power Control
OTP	Opposite Track Path
PBS	Polarizing Beam Splitter
PI	Parity (of the) Inner (code)
PLL	Phase Locked Loop
PO	Parity (of the) Outer (code)
PSN	Physical Sector Number
PTP	Parallel Track Path
PUH	Pick-Up Head
RBP	Relative Byte Position
RBW	Resolution Bandwidth
RESYNC	Re-Synchronization
RMA	Recording Management Area
RMD	Recording Management Data
RS	Reed-Solomon (code)
SYNC	Synchronization

7 General description of a disk

The 120 mm and 80 mm optical disks that are the subject of this Ecma Standard consist of two substrates bonded together by an adhesive layer, so that the recording layers 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 for Dual Layer (DVD-R for DL) may be either double-sided or single-sided with respect to the number of recording layers. A double-sided disk has the recording layers on the inside of each substrate. A single-sided disk has one substrate with the recording layers on the inside and a dummy substrate without a recording layer. A recorded disk provides for the data to be read many times by an optical beam of a drive. Figure 1 shows schematically a double-sided (Type 2S) and a single-sided (Type 1S) disk.

Type 1S consists of a substrate, two recording layers with a space layer between them, an adhesive layer, and a dummy substrate. Both recording layers can be accessed from one side only. The nominal capacity is 8,54 Gbytes for a 120 mm disk and 2,66 Gbytes for an 80 mm disk.

Type 2S consists of two substrates, each having two recording layers with a space layer between them, and an adhesive layer. From one side of the disk only one pair of recording layers can be accessed. The nominal total capacity is 17,08 Gbytes for a 120 mm disk and 5,32 Gbytes for an 80 mm disk.

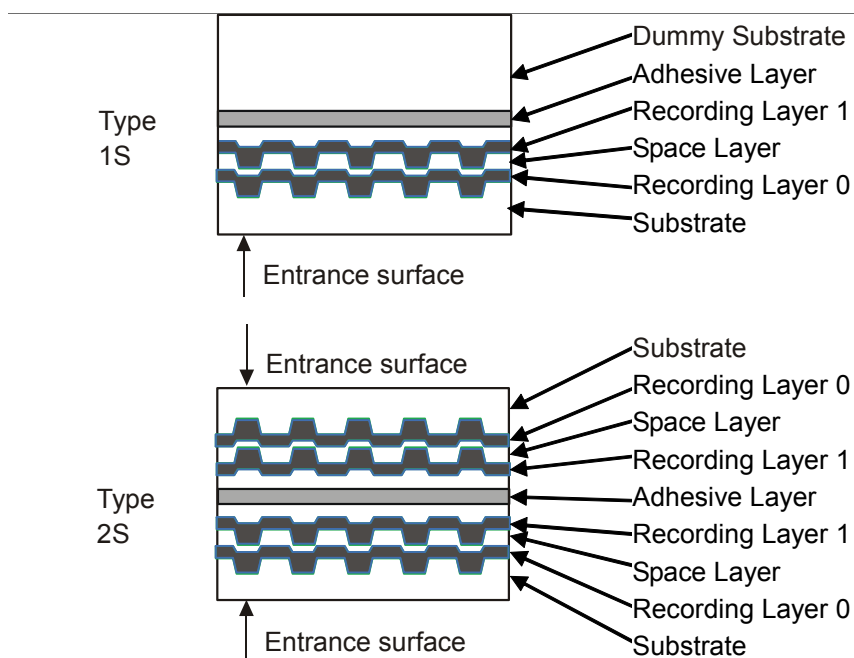


Figure 1 — Disk outline

8 General requirement

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: $23\text{ °C} \pm 2\text{ °C}$	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

This Ecma Standard requires that an optical disk which meets all mandatory requirements of this Ecma 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.

8.1.2.1 Environmental conditions during reading

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:	$0,5\text{ g/m}^3$ 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 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:	3 % to 95 %
absolute humidity:	$0,5\text{ g/m}^3$ 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/m³ to 30 g/m³

atmospheric pressure: 75 kPa to 106 kPa

temperature variation: 15 °C /h max.

relative humidity variation: 10 %/h max.

8.1.4 Transportation

This Ecma Standard does not specify requirements for transportation; guidance is given in Annex S.

8.2 Safety requirements

The disk shall satisfy the requirements of Standard ECMA-287, 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 ECMA-287.

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 Ecma 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. The optical system shall be used to measure the parameters specified for the recorded disk. Different components and locations of the components are permitted, provided that the performance remains the same as 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 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.

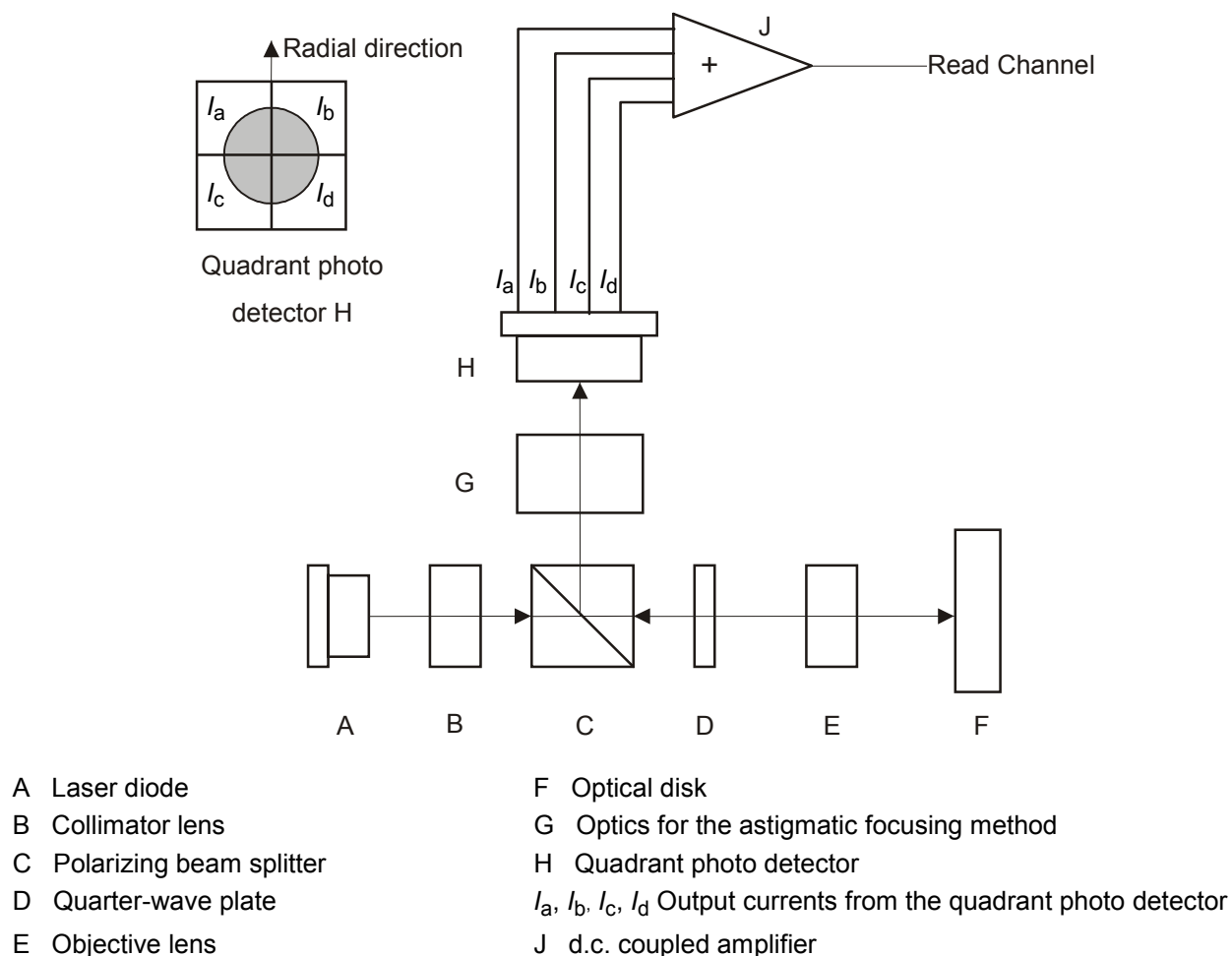


Figure 2 — Optical system of PUH for measuring recorded disk

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

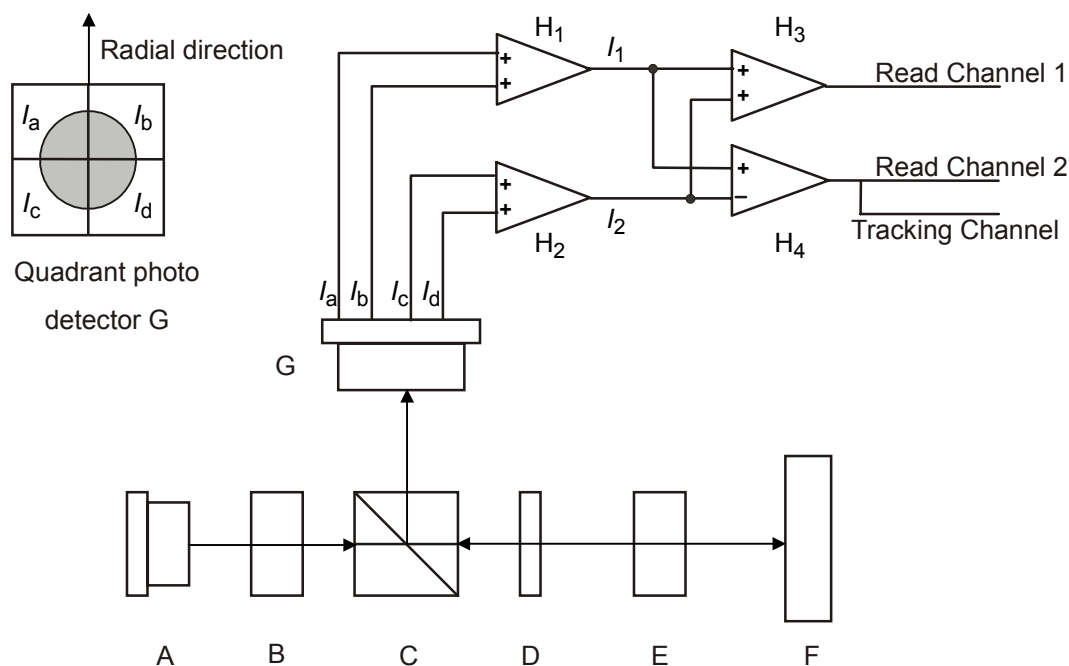
Wavelength (λ)	650 nm $\pm$ 5 nm
Polarization of the light	circular
Polarizing beam splitter	shall be used unless otherwise stated
Numerical aperture	0,60 $\pm$ 0,01
Light intensity at the rim of the pupil of the objective lens	60 % to 70 % of the maximum intensity the objective lens level in radial direction, and over 90 % of the maximum intensity level in the tangential direction
Wave front aberration after passing through an ideal substrate (Thickness: 0,6 mm and index of refraction: 1,56)	0,033 λ rms max.
Normalized detector size on a disk	100 < $A/(M^2)$ < 144 μm^2 , in which
A = the total surface area of the quadrant photo detector of the PUH and	
M = the transversal magnification factor from the disk to its conjugate plane near the quadrant photo detector	

Relative intensity noise (RIN) of the laser diode
 $10 \log [(a.c. \text{ light power density} / \text{Hz}) / d.c. \text{ light power}]$

-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 parameters specified for the unrecorded disk and for making 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.



- | | |
|----------------------------|--|
| 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)	+ 10 nm 650 nm - 5 nm
Polarization of the light	circular
Numerical aperture	0,60 $\pm$ 0,01
Light intensity at the rim of the pupil of the objective lens	over 40 % of the maximum intensity level in the radial direction and over 50 % of the maximum intensity level in the tangential direction
Wave front aberration after passing through an ideal substrate (Thickness: 0,6 mm and index of refraction: 1,56)	0,033 λ rms max.
Normalized detector size on a disk	100 < A/(M ²) < 144 μm^2 , in which A = the total surface area of the quadrant photo detector of the PUH and M = the transversal magnification factor from the disk to its conjugate plane near the quadrant photo detector
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

Clamping force	2,0 N $\pm$ 0,5 N
Clamping Zone	See 10.4 and Annex A.
Tapered cone angle	40,0° $\pm$ 0,5° see Annex E

9.2.2 Recorded disk

Scanning velocity at a Channel bit rate of 26,15625 Mbit/s	3,84 m/s $\pm$ 0,03 m/s
--	-------------------------

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

9.2.3 Unrecorded disk

For recordings:

Scanning velocity at a Channel bit rate of 52,3125 Mbit/s	7,68 m/s $\pm$ 0,03 m/s
---	-------------------------

For measurements of Servo signals and Addressing signals (see 14.4 and 14.5):

Scanning velocity at a Channel bit rate of 26,15625 Mbit/s	3,84 m/s $\pm$ 0,03 m/s
--	-------------------------

The measuring conditions for the unrecorded disk operational signals shall be as specified in Annex J.

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.

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

where

$$\omega = 2\pi f$$

$$\omega_0 = 2\pi f_0$$

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

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 given by

$$\text{lead break frequency:} \quad f_1 = f_0 \times 1/3$$

$$\text{lag break frequency:} \quad f_2 = f_0 \times 3$$

9.4 Reference servo for axial tracking

9.4.1 Recorded disk

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.

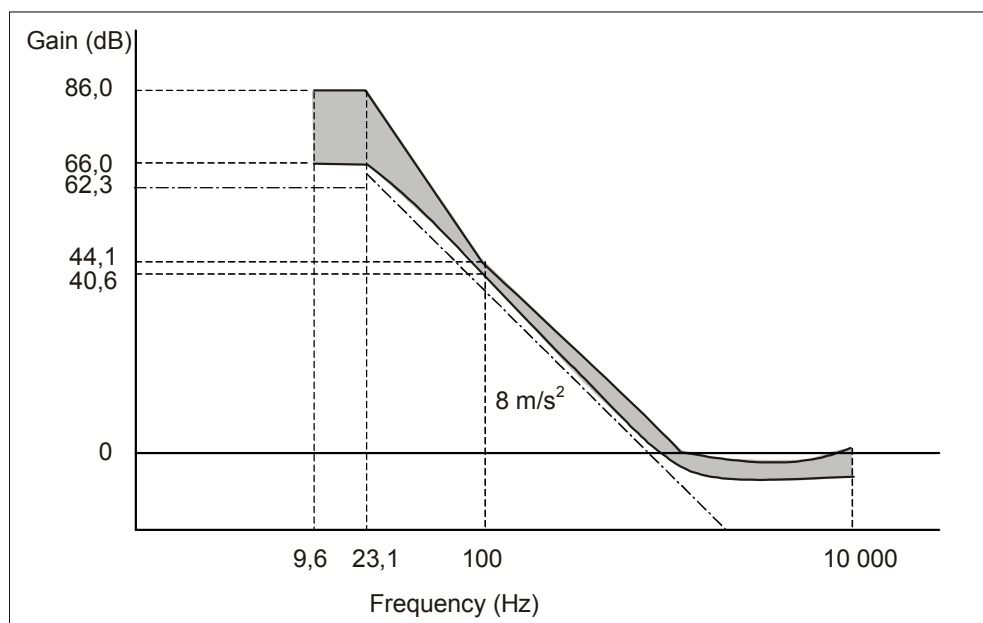


Figure 4 — Reference servo for axial tracking of recorded disk

Bandwidth 100 Hz to 10 kHz

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

The crossover frequency $f_0 = \omega_0 / 2\pi$ shall be specified by equation (II), where $\alpha_{\max}$ 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 $0,23 \text{ }\mu\text{m}$. Thus, the crossover frequency f_0 shall be

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

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 ($|1 + H_s| - 20\%$ at 100 Hz)

66,0 dB at 23,1 Hz ($|1 + H_s| - 20\%$ at 23,1 Hz)

86,0 dB at 23,1 Hz ($|1 + H_s| - 20\%$ at 23,1 Hz add 20 dB)

44,1 dB at 100 Hz ($|1 + H_s| + 20\%$ at 100 Hz)

Bandwidth 9,6 Hz to 23,1 Hz

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

9.4.2 Unrecorded disk

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 5.

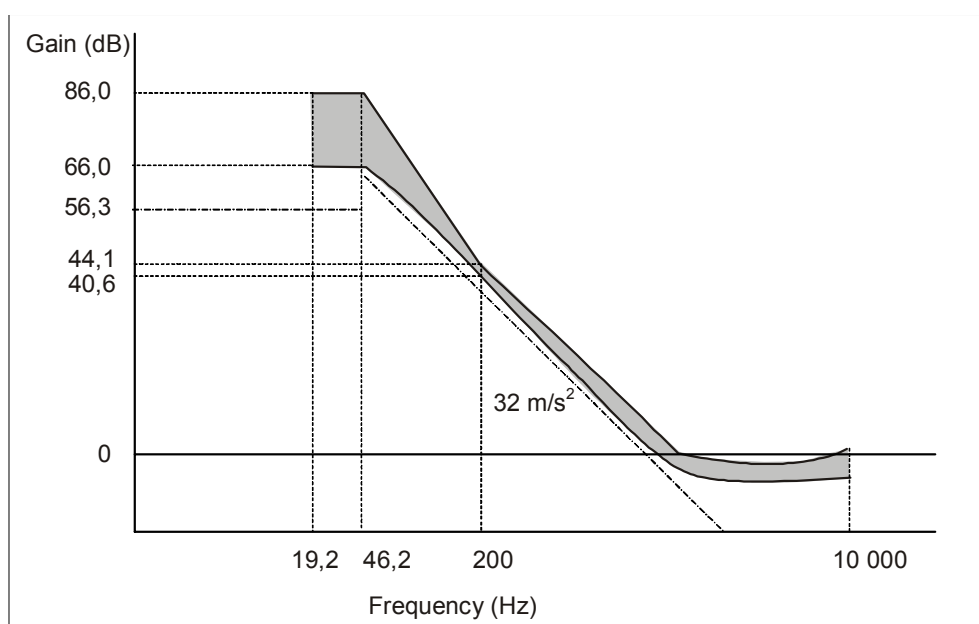


Figure 5 — Reference servo for axial tracking of unrecorded disk

Bandwidth 200 Hz to 10 kHz

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

The crossover frequency $f_0 = \omega_0 / 2\pi$ shall be specified by equation (III), where $\alpha_{\max}$ shall be 1,5 times larger than the expected maximum axial acceleration of 32 m/s^2 . The tracking error $e_{\max}$ shall not exceed $0,23 \text{ }\mu\text{m}$. Thus, the crossover frequency f_0 shall be

$$f_0 = \frac{1}{2\pi} \sqrt{\frac{3 \times \alpha_{\max}}{e_{\max}}} = \frac{1}{2\pi} \sqrt{\frac{3 \times 32 \times 1,5}{0,23 \times 10^{-6}}} = 4,0 \text{ kHz} \quad (\text{III})$$

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

Bandwidth 46,2 Hz to 200 Hz

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

40,6 dB at 200 Hz ($|1 + H_s| - 20\%$ at 200 Hz)

66,0 dB at 46,2 Hz ($|1 + H_s| - 20\%$ at 46,2 Hz)

86,0 dB at 46,2 Hz ($|1 + H_s| - 20\%$ at 46,2 Hz add 20 dB)

44,1 dB at 200 Hz ($|1 + H_s| + 20\%$ at 200 Hz)

Bandwidth 19,2 Hz to 46,2 Hz

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

9.5 Reference servo for radial tracking

9.5.1 Recorded disk

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 6.

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

Bandwidth from 100 Hz to 10k Hz

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

The crossover frequency $f_0 = \omega_0 / 2\pi$ shall be given by the equation (IV), where $\alpha_{\max}$ shall be 1,5 times as large as the expected radial acceleration of $1,1 \text{ m/s}^2$ and $e_{\max}$ shall not exceed $0,022 \text{ }\mu\text{m}$. Thus the crossover frequency f_0 shall be:

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

Bandwidth from 23,1 Hz to 100 Hz

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

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

Bandwidth from 9,6 Hz to 23,1 Hz

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

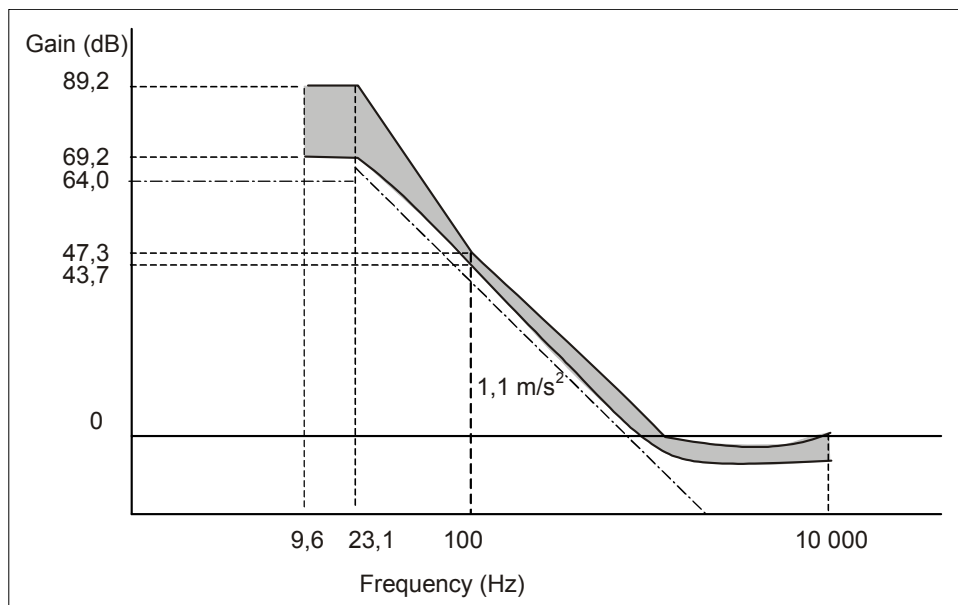


Figure 6 — Reference servo for radial tracking of recorded disk

9.5.2 Unrecorded disk

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 7.

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

Bandwidth from 200 Hz to 10 kHz

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

The crossover frequency $f_0 = \omega_0 / 2\pi$ shall be given by the equation (V), where $\alpha_{\max}$ shall be 1,5 times as large as the expected radial acceleration of 4,4 m/s² and $e_{\max}$ shall not exceed 0,022 μm . Thus the crossover frequency f_0 shall be:

$$f_0 = \frac{1}{2\pi} \sqrt{\frac{3 \times \alpha_{\max}}{e_{\max}}} = \frac{1}{2\pi} \sqrt{\frac{3 \times 4,4 \times 1,5}{0,022 \times 10^{-6}}} = 4,8 \text{ kHz} \quad (\text{V})$$

Bandwidth from 46,2 Hz to 200 Hz

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

43,7 dB at 200 Hz	$(1 + H_s - 20 \% \text{ at } 200 \text{ Hz})$
69,2 dB at 46,2 Hz	$(1 + H_s - 20 \% \text{ at } 46,2 \text{ Hz})$
89,2 dB at 46,2 Hz	$(1 + H_s - 20 \% \text{ at } 46,2 \text{ Hz add } 20 \text{ dB})$
47,3 dB at 200 Hz	$(1 + H_s + 20 \% \text{ at } 200 \text{ Hz})$

Bandwidth from 19,2 Hz to 46,2 Hz

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

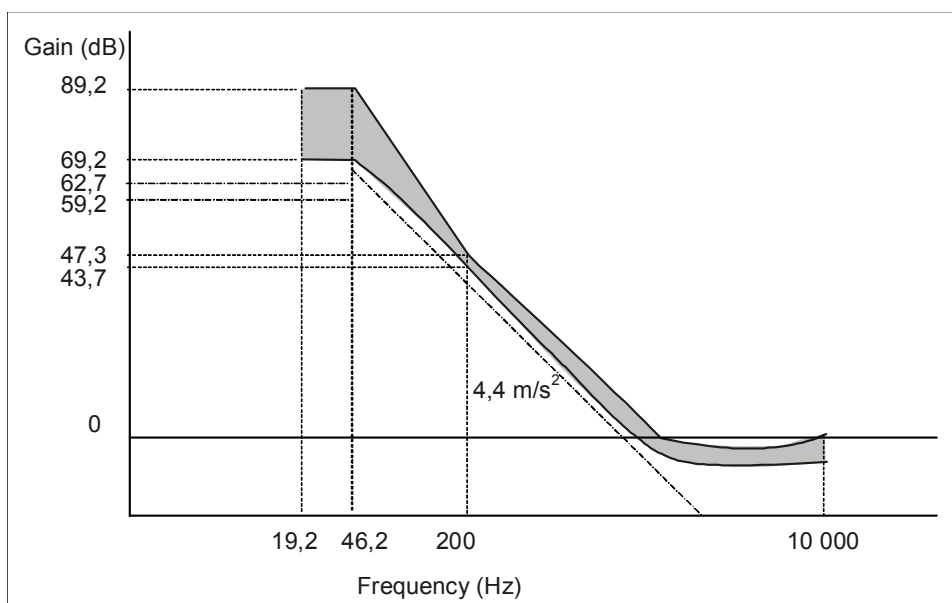


Figure 7 — Reference servo for radial tracking of recorded disk

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. Figures 8, 9 and 10 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.

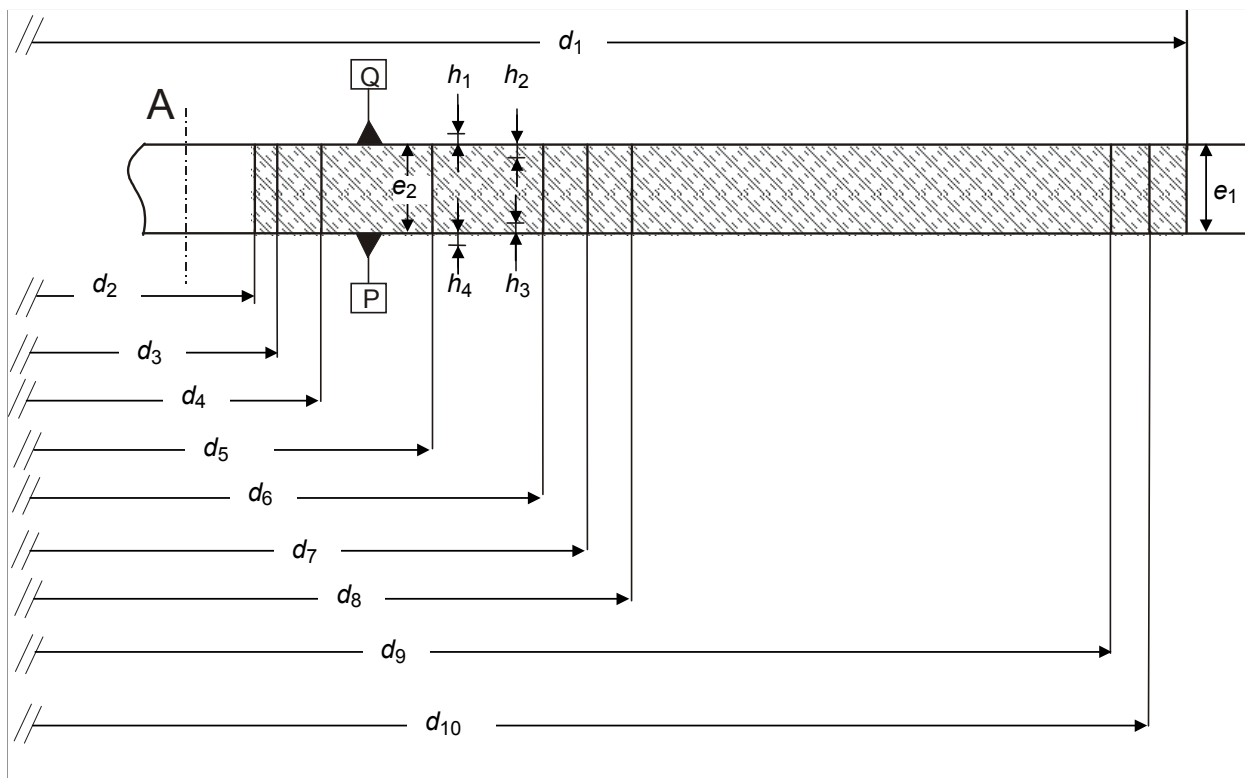


Figure 8 — Areas of the disk

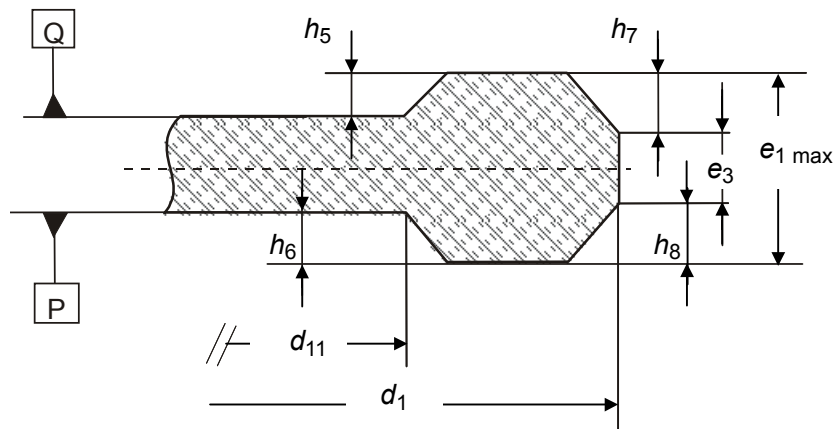


Figure 9 — Rim area

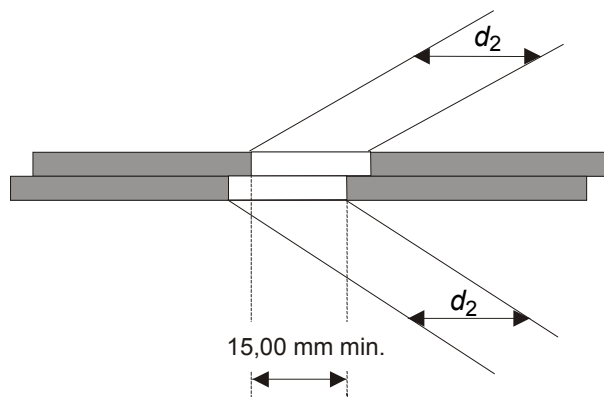


Figure 10 — Hole of the assembled disk

10.1 Overall dimensions

The 120 mm disk shall have an overall diameter

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

The 80 mm disk shall have an overall diameter

$$d_1 = 80,00 \text{ mm} \pm 0,30 \text{ mm}$$

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

$$d_2 = 15,00 \text{ mm} \begin{matrix} + 0,15 \text{ mm} \\ - 0,00 \text{ mm} \end{matrix}$$

The diameter of the hole of an assembled disk, i.e. with both parts bonded together, shall be 15,00 mm min. See Figure 10. 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

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

See Figure 8.

10.2 First transition area

In the area defined by diameter d_2 and

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

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. See Figure 8.

10.3 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 of burrs up to 0,05 mm max. beyond Reference Planes P and/or Q. See Figure 8.

10.4 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. Reference Plane P within 0,1 mm.

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

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

See Figure 8.

10.5 Third transition area

This area shall extend between diameter d_5 and diameter

$$d_6 = 40,0 \text{ mm max. for the 120 mm diameter disk or}$$

$$d_6 = 37,0 \text{ mm max. for the 80 mm diameter disk.}$$

In this area the top surface is permitted to be above the 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

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

See Figure 8.

10.6 R-Information Zone

The R-Information Zone on Layer 0 shall extend from $d_7 = 44,00$ mm min. which is the beginning of the Inner Disk Testing Area to the beginning of the Lead-in Zone as specified in Clause 28.

The R-Information Zone on Layer 1 shall extend from $d_7 = 44,00$ mm min. which is the beginning of the Inner Disk Testing Area to the end of the Lead-out 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.

See Figure 8.

10.6.1 Sub-divisions of the R-Information Zone

The main parts of the R-Information Zone are

- the Inner Disk Testing Areas (IDTA)
- the Recording Management Areas (RMA)

10.7 Information Zone

The Information Zone on Layer 0 shall extend from the beginning of the Lead-in Zone to diameter d_{10} the value of which is specified in Table 1.

The Information Zone on Layer 1 shall extend from the end of the Lead-out 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. See Figure 8.

10.7.1 Sub-divisions of the Information zone

The main parts of the Information Zone are

- the Lead-in Zone
- the Data Zones
- the Middle Zones
- the Lead-out Zone

10.7.1.1 Lead-in Zone

The Lead-in Zone shall extend on Layer 0 between the outer diameter of the R-Information Zone as specified in 26.3 and diameter d_8 . See Figure 8.

10.7.1.2 Data Zone

The Data Zone on Layer 0 shall start at

$$d_8 = \begin{matrix} + 0,0 \text{ mm} \\ 48,0 \text{ mm} \\ - 0,08 \text{ mm} \end{matrix}$$

and shall end at

$$d_9 = 116,2 \text{ mm max. for the 120 mm diameter disk or}$$

$$d_9 = 76,2 \text{ mm max. for the 80 mm diameter disk.}$$

See Figure 8.

The Data Zone on Layer 1 shall start at

$$d_{g'} = d_g + 0.13 \text{ mm min.}$$

and shall end at

$$d_{g'} = d_g$$

- 0,13 mm
- 0,29 mm .

10.7.1.3 Middle Zone

The Middle Zone on Layer 0 shall extend from diameter d_g to diameter d_{10} .

The Middle Zone on Layer 1 shall extend from diameter $d_{g'}$ to diameter d_{10} .

The value of d_{10} depends on the length of the Data Zone as shown in Table 1.

See Figure 8.

10.7.1.4 Lead-out Zone

The Lead-out Zone shall extend on Layer 1 between the outer diameter of the R-Information Zone as specified in 26.3 and diameter d_g .

Table 1 — End of the Information Zone

	Outer diameter d_g of the Data Zone	Value of diameter d_{10}
120 mm disk	Less than 69,2 mm	$70,0^{+1,0}_0$ mm min.
	69,2 mm to 116,2 mm	$d_g + 0,8$ mm min.
80 mm disk	Less than 69,2 mm	$70,0^{+1,0}_0$ mm min.
	69,2 mm to 76,2 mm	$d_g + 0,8$ 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 $0,74 \mu\text{m} \pm 0,01 \mu\text{m}$.

The maximum deviation of the track pitch from $0,74 \mu\text{m}$ shall be $\pm 0,03 \mu\text{m}$.

10.8.1 Track Path

In this standard, only the Opposite Track Path (OTP) is specified. Tracks are read starting on Layer 0 at the inner side towards outer side, continuing on Layer 1 from the outer side towards inner side of a disk as shown in Figure 11.

The spiral direction of Layer 1 is reversed from that of Layer 0.

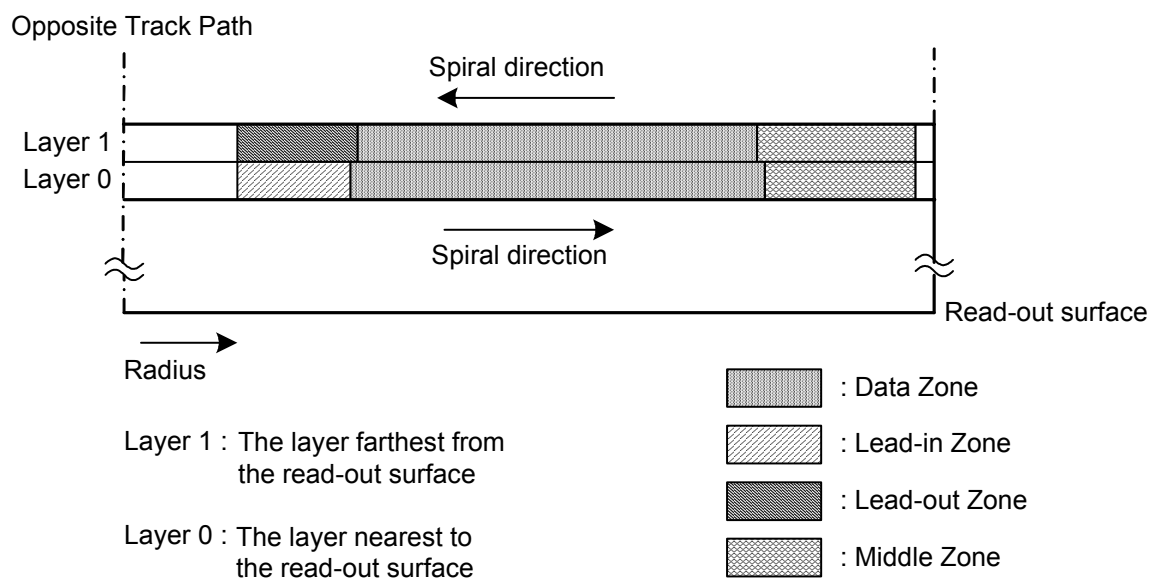


Figure 11 — Track Path

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 $146,7 \text{ nm} \pm 1,5 \text{ nm}$.

10.10 Rim area

The rim area shall be that area extending from diameter

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

$d_{11} = 78,0 \text{ mm}$ 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

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

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

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

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

$e_3 = 0,6 \text{ mm}$ min.

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

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

$h_8 = 0,2 \text{ mm}$ max.

See Figure 9.

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 $0,040 \text{ g}\cdot\text{m}^2$.

The moment of inertia of the 80 mm disk, relative to its rotation axis, shall not exceed $0,010 \text{ g}\cdot\text{m}^2$.

11.3 Dynamic imbalance

The dynamic imbalance of the 120 mm disk, relative to its rotation axis, shall not exceed $0,0025 \text{ g}\cdot\text{m}$.

The dynamic imbalance of the 80 mm disk, relative to its rotation axis, shall not exceed $0,0010 \text{ g}\cdot\text{m}$.

11.4 Sense of rotation

The sense of rotation of the disk shall be counter clockwise 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 $0,23 \text{ }\mu\text{m}$. The measuring filter shall be a Butterworth LPF, f_c (-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 0,30 mm, peak-to-peak.

The radial runout of tracks at the rotational frequency determined by the scanning velocity shall be less than 40 μm and 60 μm peak-to-peak, for Layer 0 and Layer 1 respectively.

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, f_c (-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 RI of the substrate shall be $1,55 \pm 0,10$.

The index of refraction of the space layer shall be 1,49 min. and $(RI \pm 0,10)$.

12.1.2 Thickness of the transparent substrate

The thickness of the substrate or the thickness of the substrate including the space layer shall be determined by its index of refraction as specified in Figure 12.

The thickness of the space layer shall be: $55 \mu\text{m}$
+ 15 μm
- 15 μm

The variation of the space layer thickness shall be $\pm 10 \mu\text{m}$ max. within a disk, and $\pm 4 \mu\text{m}$ max. within one revolution of a disk.

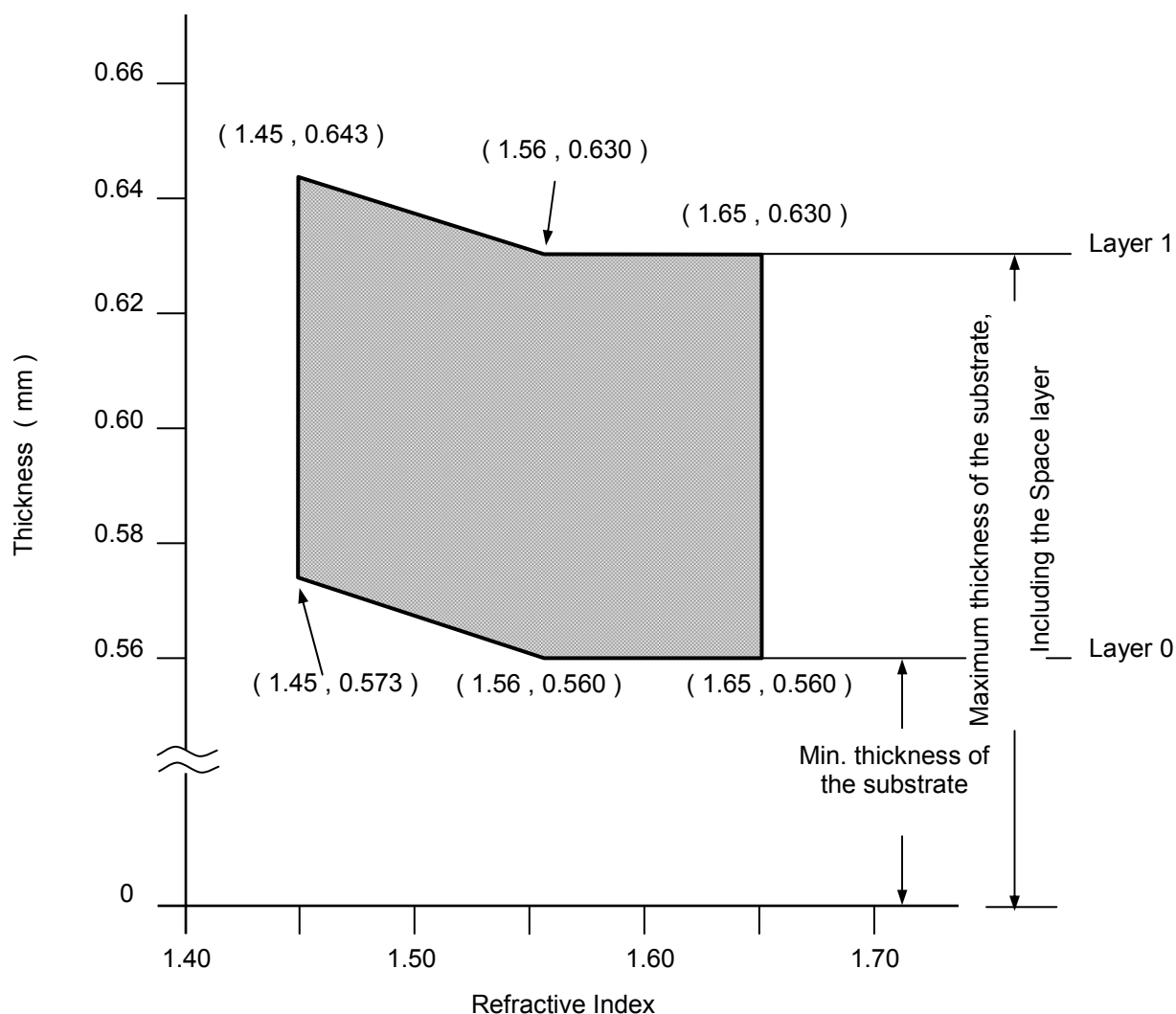


Figure 12 — Substrate thickness as a function of the index of refraction

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: $\alpha = 0,80^\circ$ max.

In tangential direction: $\alpha = 0,30^\circ$ 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, the reflectivity of the recorded layer(s) shall be 16 % to 27 % (PUH with PBS).

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 over the surface of the disk shall be less than $\pm 0,05 P_0$. See Annex H.

13 Operational signals for recorded disk

13.1 Measurement conditions

The operational signals shall be measured after recording 8/16 modulated data in more than 5 tracks.

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 normalized servo transfer function shall be as specified in 9.3.

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

The reference servo for radial tracking shall be as specified in 9.5.

13.2 Read conditions

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

13.3 Recorded disk high frequency (HF) signals

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

13.3.1 Modulated amplitude

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 the following requirements:

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

$$I_3 / I_{14} = 0,20 \text{ min.}$$

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

See Figure 13.

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

	Over each layer	Over 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 disk is recorded at the optimum recording power P_0 . See Figure 13:

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

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 14. The low pass filter is a 1st-order filter.

The cross-track signal shall meet the following requirements:

$$I_T = I_H - I_L$$

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

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 8,0 % 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 19) 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 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 15 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 16. 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, see Figure 16:

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

The asymmetry shall meet the following requirement, see Figure 16:

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

where

- T1 is the positive peak value of $\overline{\Delta t}/T$,
- T2 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 17:

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

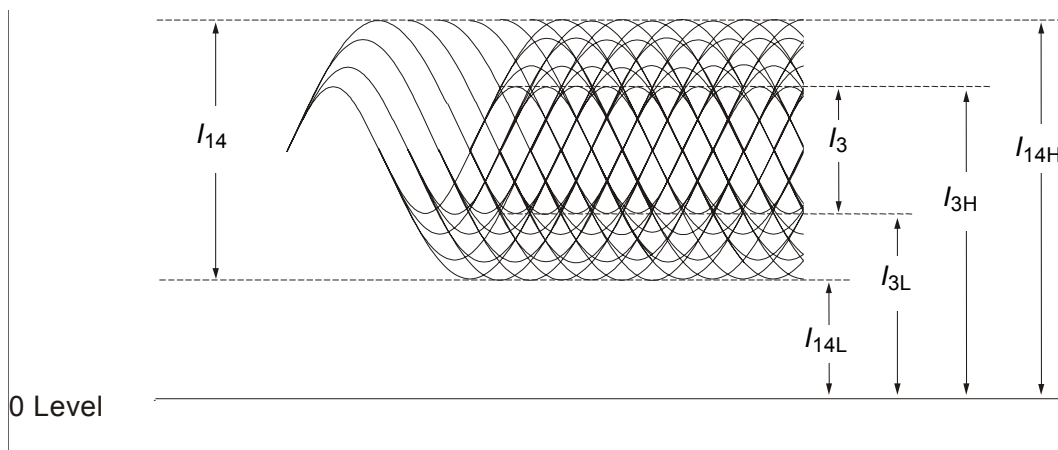


Figure 13 — Modulated amplitude

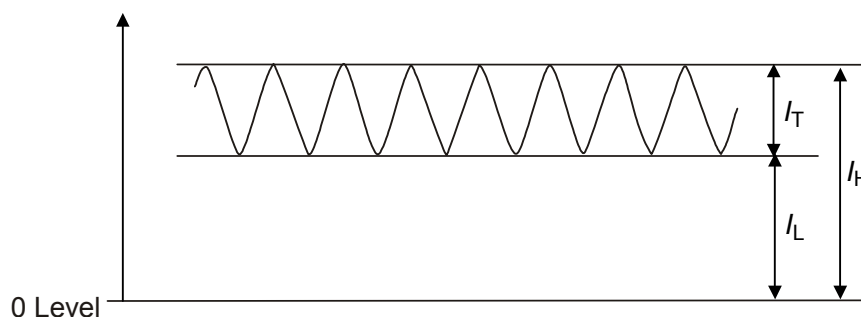


Figure 14 — Cross-track signal

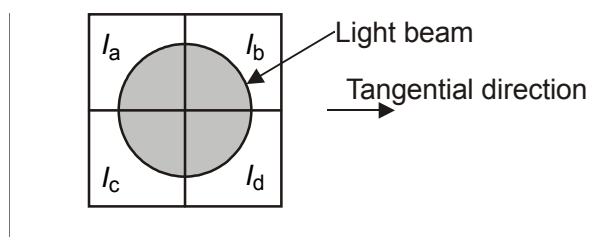


Figure 15 — Quadrant photo detector

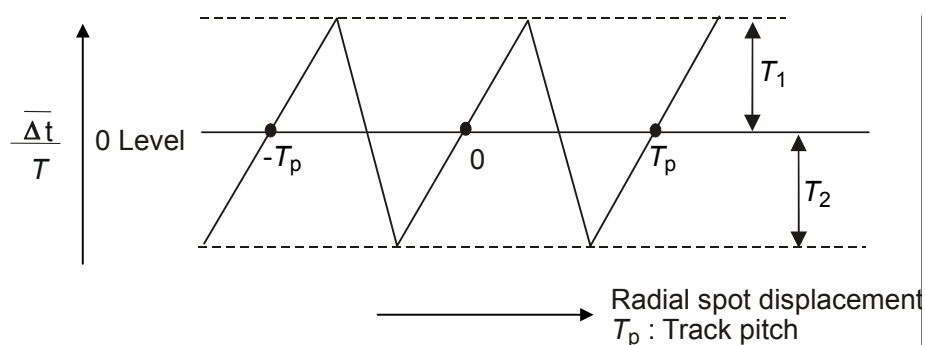


Figure 16 — Differential phase tracking error signal

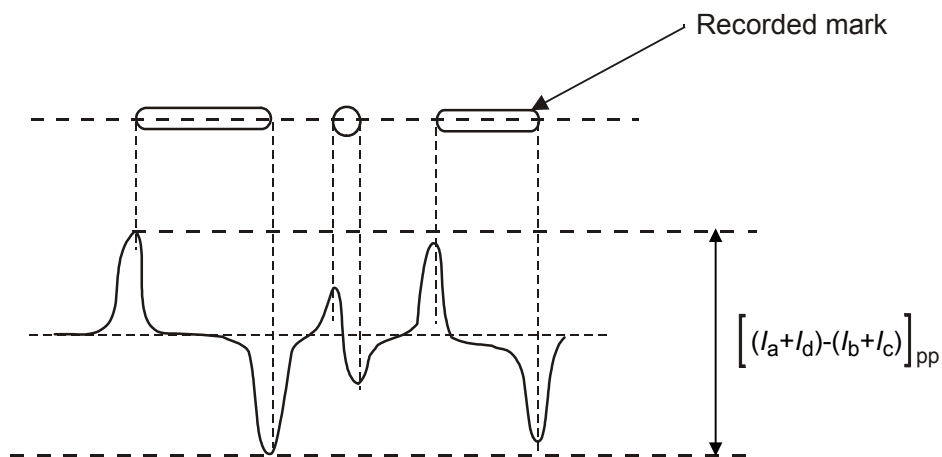


Figure 17 — Tangential push-pull signal

13.6 Groove wobble signal

The output current of each quadrant photo detector element of the PUH are I_a , I_b , I_c and I_d , see Figure 15.

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 meet the following requirements.

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

CNR of the groove wobble signal shall be greater than 31 dB (RBW = 1 kHz).

The CNR of the groove wobble signal shall be measured for the average value using a spectrum analyser where the Resolution Bandwidth (RBW) setting is 1 kHz, see Figure 18.

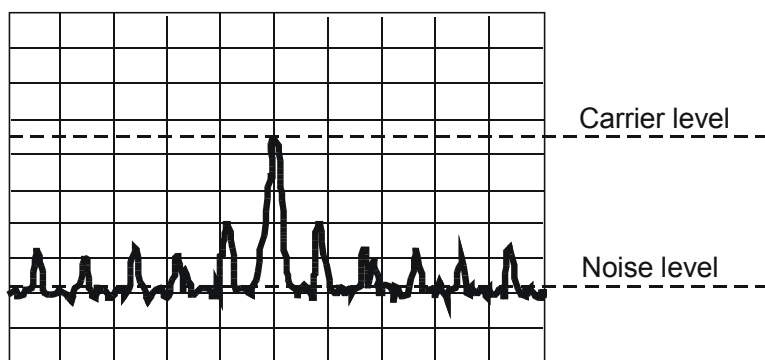


Figure 18 — Measurement of the wobble CNR

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 normalized servo transfer function shall be as specified in 9.3.
- The reference servo for axial tracking shall be as specified in 9.4.
- The reference servo for radial tracking shall be as specified in 9.5.

14.2 Recording conditions

- General recording strategy : In groove
- Optimum recording power : Determined by OPC specified in Annex H
- Optimum recording power range of all disks : $10,0 \text{ mW} \leq P_o \leq 32,0 \text{ mW}$
- Bias power : $P_b \leq 0,7 \text{ mW}$
- Recording power window : $P_o \pm 0,25 \text{ mW}$

14.3 Write strategy for media testing

During the recordings necessary for disk measurements using the PUH specified in 9.1.2, the laser power shall be modulated according to the basic write strategy, see Figure 19.

Each write pulse of length 5T to 11T and 14T consists of two parts; a top pulse and last pulse with T representing the length of one clock period. The top pulse and the last pulse are linked together by the middle power (P_m). The 3T and 4T marks are recorded using the top pulse only.

This write pulse modulation method is referred as write strategy with Non-multi-pulse.

The top pulse for a 3T and 4T mark is generated by starting its leading edge a short time after the leading edge of the recording data, the trailing edge of the top pulse is ended at the trailing edge of the recording data. The trailing edge of the top pulse can be shifted and each shift ($3T_{dtop}$, $4T_{dtop}$) and the top pulse width ($3T_{top}$, $4T_{top}$) shall be given in the Write Strategy code, see 25.1.6.1. Each top pulse width shall be kept regardless of the trailing edge shift.

The write pulse of length 5T to 11T and 14T is generated by starting the leading edge of the top pulse a short time after the leading edge of the recording data, the trailing edge of the last pulse is ended at the trailing edge of the recording data. The write pulse width (nT_{wt}), the top pulse width (nT_{top}) and the last pulse width (nT_{lp}) shall be given in the Write Strategy code, see 25.1.6.1.

The off pulse (T_{off}) is generated by starting at the trailing edge of the write pulses of all marks to be recorded.

The length of the off pulse shall be given in the Write Strategy code, see 25.1.6.1.

According to the adaptive write pulse modulation as shown in Figure 19, the leading and trailing edges of the top pulse and the last pulse can be shifted along the time axis independently. The shift of the leading edge (T_{ld} , T_{ld2}) and of the trailing edge (T_{tr} , T_{tr2}) shall be selected according to the preceding space length (T_{sp}) and the recording data length (T_{wd}). Each pulse width is changed when each edge is shifted.

The detailed parameters for the adaptive write pulse modulation shall be given in the Write Strategy code, see 25.1.6.1.

The recording power ratio of the optimum recording power and the optimum middle power (P_o/P_m) is given in the Write Strategy code, see 25.1.6.1.

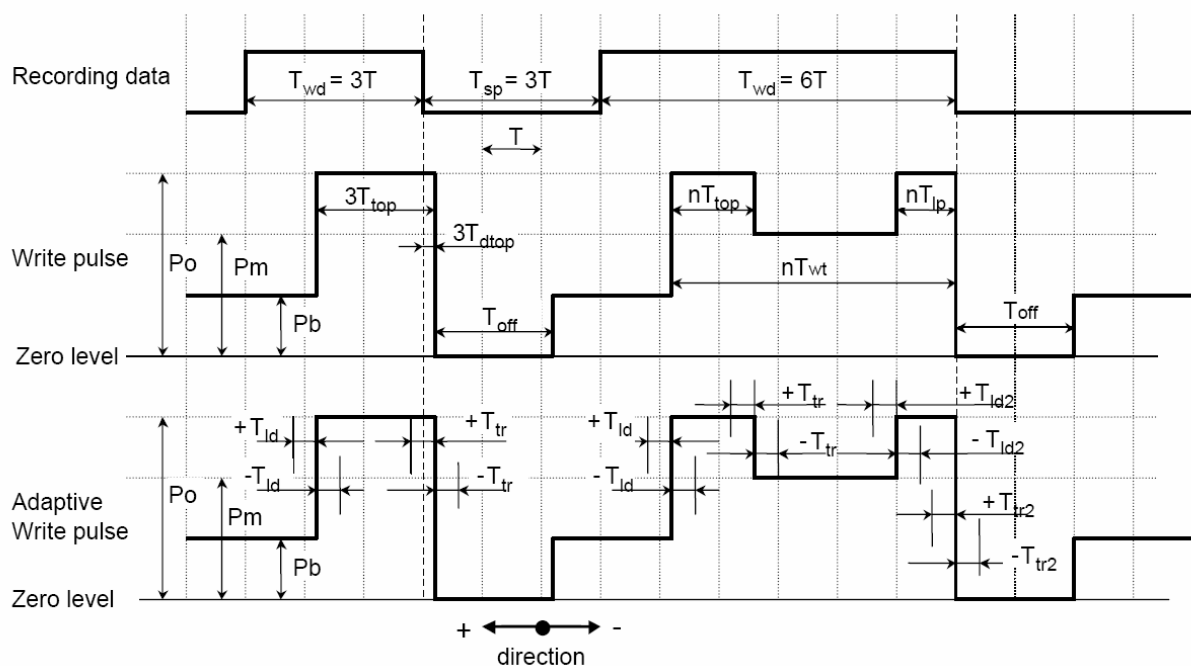


Figure 19 — Write pulse modulation

14.3.1 Definition of the write pulse

The write pulse from the objective lens shall be as shown in Figure 20.

The rise times (T_r) and fall times (T_f) shall not exceed 2 ns.

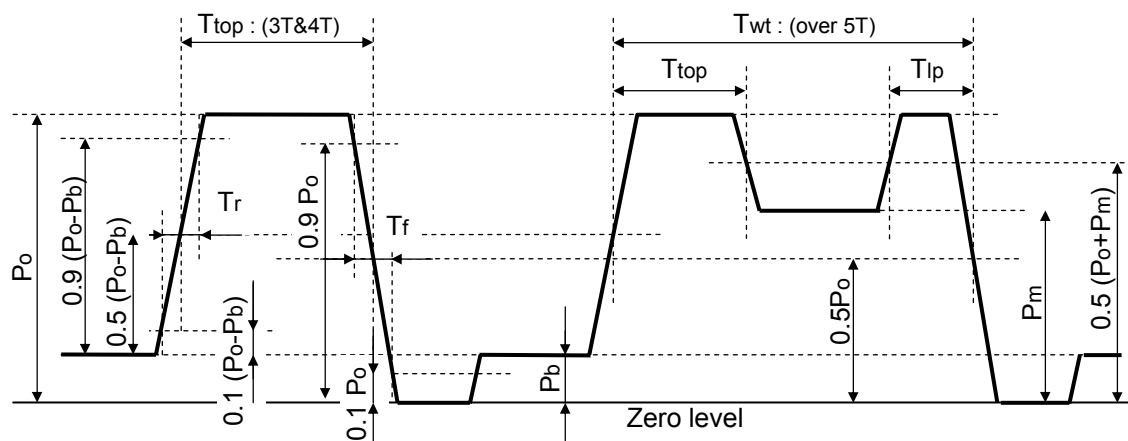


Figure 20 — Write pulse

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 , see Figure 21. The photo detector elements (I_a and I_b) are located at a greater radius than elements (I_c and I_d).

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 21 are defined as:

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

$|(I_a + I_b + I_c + I_d)|_{d.c.}$ shall be measured from zero level to the average level of $|(I_a + I_b + I_c + I_d)|_{a.c.}$ (see Figure 22).

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

$$PPr = PPb / PPa.$$

The above parameters shall meet the following requirements:

- PPb signal amplitude : $0,22 < PPb < 0,44$
- Push Pull ratio : $0,5 < PPr < 1,0$
- Variation in PPb signal : $\Delta PPb < 15 \%$

where $\Delta PPb = [(PPb) \text{ max.} - (PPb) \text{ min.}] / [(PPb) \text{ max.} + (PPb) \text{ min.}]$

- ΔPPb shall be measured over the entire disk surface (from 22,0 to 58,6 mm for 120 mm disk and to 38,6 mm for 80 mm disk).

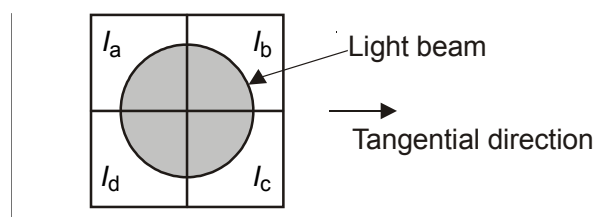


Figure 21 — Quadrant photo detector

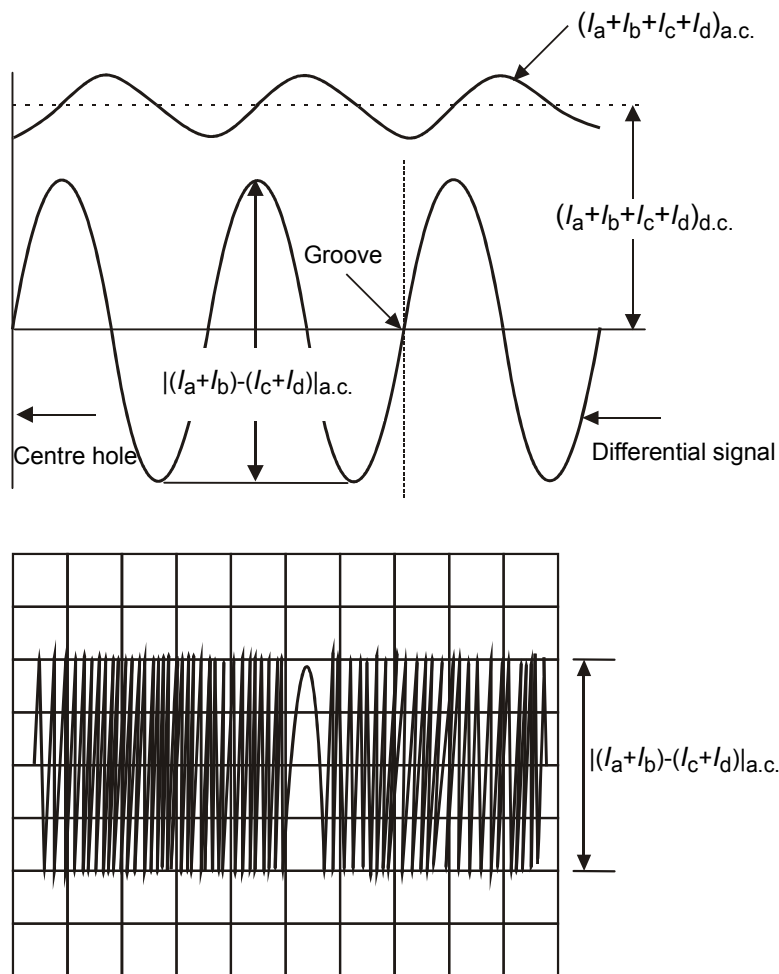


Figure 22 — Radial push-pull tracking error signal

14.4.2 Defects

The requirements shall be as specified in 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 21.

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) shall be defined as:

$$\text{LPPb} = |(I_a + I_b) - (I_c + I_d)|_{o-p} / |(I_a + I_b + I_c + I_d)|_{d.c.} \text{ See Figure 22 and 23.}$$

$|(I_a + I_b) - (I_c + I_d)|_{o-p}$ shall be measured at the average point of maximum and minimum signals and the bandwidth of the photo-detector amplifiers shall be higher than 20 MHz.

$| (I_a + I_b + I_c + I_d) |_{d.c.}$ shall be measured when the light beam is following a track and shall be low pass filtered with a cut-off frequency of 30 kHz.

The aperture ratio of the Land Pre-Pit after recording (AR) shall be defined as:

$$AR = AP_{min.} / AP_{max.}$$

$AP_{min.}$ and $AP_{max.}$ are the minimum and the maximum values of the Land Pre-Pit signal amplitude
 $AP = | (I_a + I_b) - (I_c + I_d) |$ without the wobble amplitude.

See Figure 23 and Annex M.

The above parameters shall meet the following requirements:

- Signal amplitude before recording: $0,18 < LPPb < 0,28$
- Aperture ratio after recording: $AR > 12 \%$
 $AR > 10 \%$, when $0,23 < LPPb < 0,28$
- Block error ratio before recording: $BLERb < 3 \%$
- Block error ratio after recording: $BLERa < 5 \%$

The Half Maximum Full Width of LPPb signal shall be larger than 1T.

The Land Pre-Pit on the outer side of the track shall be detected when the laser beam is following the track.

For the measurement of the Block error ratio of the Land Pre-Pit data, the parity A errors before error correction shall be measured over 1000 ECC Blocks.

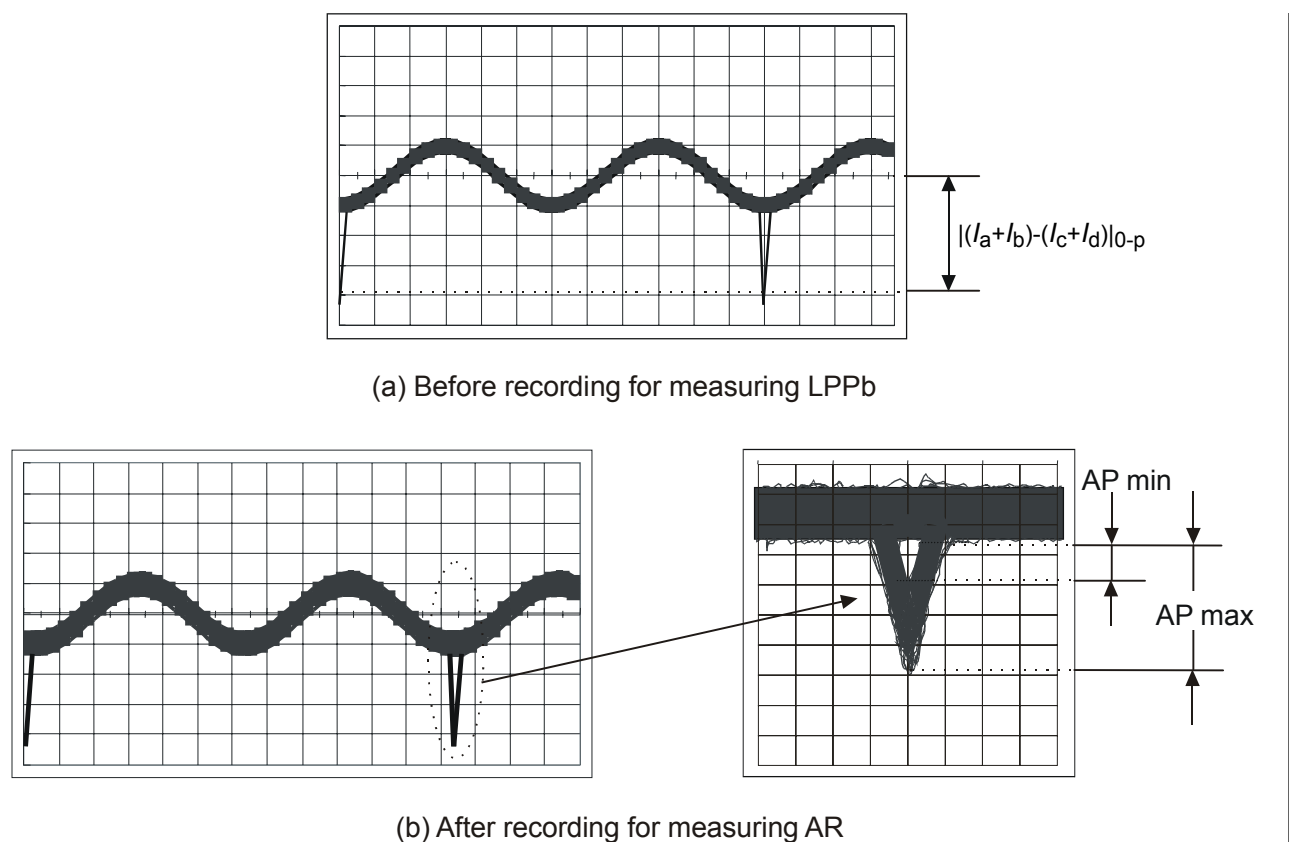


Figure 23 — Land Pre-Pit signal

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:

$$WOb, WOa = [(I_a + I_b) - (I_c + I_d)]_{p-p}$$

The above parameters shall meet the following requirements:

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

See Clause 21.

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 using a spectrum analyser where the Resolution Bandwidth (RBW) setting is 1 kHz, see Figure 24.

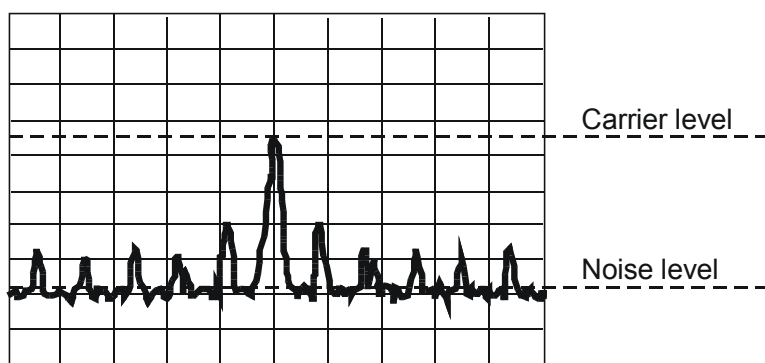


Figure 24 — Measurement of the wobble CNR

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

$NWO = WOb / RPS$ and its value shall be $0,06 < NWO < 0,12$ where RPS is the peak to peak value of the radial push-pull signal $[(I_a + I_b) - (I_c + I_d)]$ before recording, when the light spot crosses the tracks and is low pass filtered with a cut-off frequency 30 kHz.

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:

$$PWP = -90^\circ \pm 10^\circ.$$

The PWP value shall be measured as the phase difference between the largest amplitude point of the LPP signal and the averaged zero crossing point of the wobble, see Figure 25.

The PWP value shall be measured before recording.

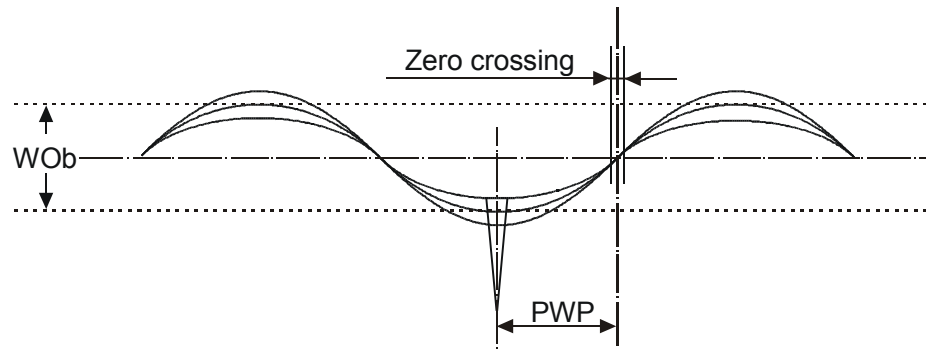


Figure 25 — Relation in phase between wobble and Land Pre-Pit

15 Data Format

15.1 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

A Data Frame shall consist of 2 064 bytes arranged in an array of 12 rows each containing 172 bytes, see Figure 26. The first row shall start with three fields, called Identification Data (ID), the check bytes of ID Error Detection Code (IED), and RSV, 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 check bytes of Error Detection Code (EDC). The 2 048 Main Data bytes are identified as D_0 to $D_{2\,047}$.

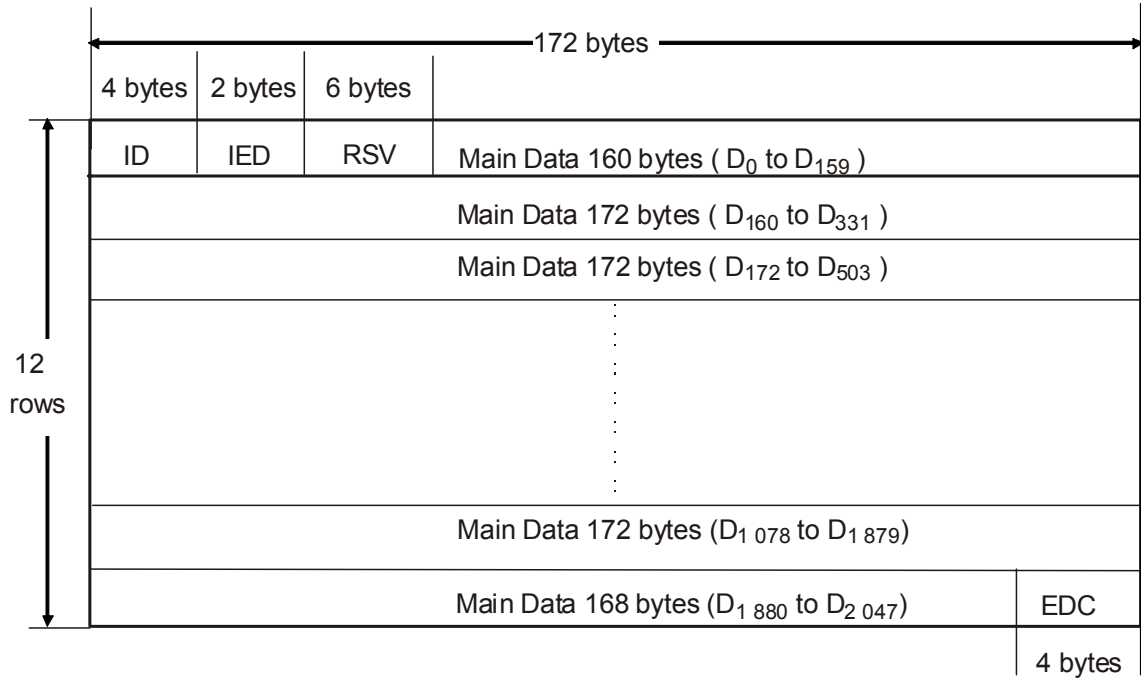


Figure 26 — Data Frame

16.1 Identification Data (ID)

This field shall consist of four bytes. Within these bytes the bits shall be numbered consecutively from b_0 (lsb) to b_{31} (msb), see Figure 27.

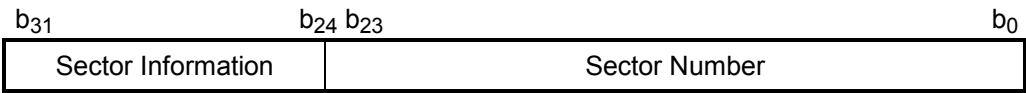


Figure 27 — Identification Data (ID)

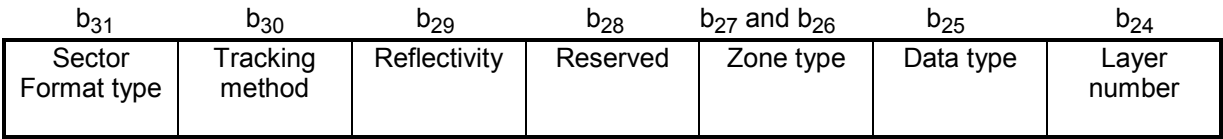


Figure 28 — Sector Information of the Identification Data (ID)

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 28, 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 Differential Phase tracking.

c) Reflectivity	bit b_{29}	shall be set to ONE, indicating the reflectivity is less than or equal to 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. shall be set to ONE ONE in the Middle Zone.
f) Data type	bit b_{25}	shall be set to ZERO, indicating Read-Only data. shall be set to ONE, indicating Linking data (see Clause 23).
g) Layer number	bit b_{24}	shall be set to ZERO, indicating Layer 0. shall be set to ONE, indicating Layer 1.

Other settings are prohibited by this Ecma Standard.

16.2 ID Error Detection Code

When identifying all bytes of the array shown in Figure 23 as $C_{i,j}$ for $i = 0$ to 11 and $j = 0$ to 171, the check bytes for ID Error Detection code (IED) are represented by $C_{0,j}$ for $j = 4$ to 5. Their setting shall be 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

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

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

α represents the primitive root of the primitive polynomial

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

16.3 RSV

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 all ZEROS.

16.4 Error Detection Code

This field shall contain four check bytes of Error Detection Code (EDC) 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:

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

where:

$$l(x) = \sum_{i=16\ 511}^{32} b_i x^i$$
$$G(x) = x^{32} + x^{31} + x^4 + 1.$$

17 Scrambled Frames

The 2 048 Main Data bytes shall be scrambled by means of the circuit shown in Figure 29 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)

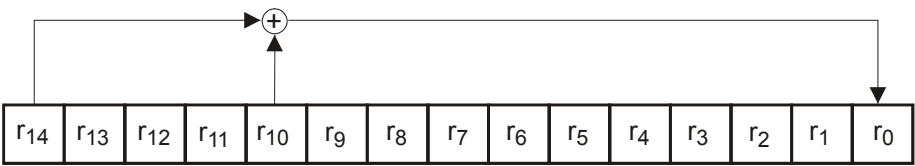


Figure 29 — Feedback shift register for generating scramble data

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_{2047} . The Main Data bytes D_k of the Data Frame become scrambled bytes D'_k where

$$D'_k = D_k \oplus S_k \text{ for } k = 0 \text{ to } 2\ 047$$

$\oplus$ stands for Exclusive OR.