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Information technology — Digitally recorded media for information interchange and storage — 120 mm Single Layer (25,0 Gbytes per disk) and Dual Layer (50,0 Gbytes per disk) BD Recordable disk

Technologies de l'information — Supports enregistrés numériquement pour échange et stockage d'information — Disques BD enregistrables de 120 mm simple couche (25,0 Go par disque) et double couche (50,0 Go par disque)

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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.

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

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

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

For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is ISO/IEC JTC 1, *Information technology*, SC 23, *Digitally recorded media for information interchange and storage*.

This second edition cancels and replaces the first edition (ISO/IEC 30190:2013), which has been technically revised. It also incorporates the Technical Corrigendum ISO/IEC 30190:2013/Cor 1:2015.

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Introduction

In March of 2002, nine companies known as the Blu-ray Disc Founders, or BDF, came together to create optical-disk formats with the large capacity and high-speed transfer rates that would be needed for recording and reproducing high-definition video content.

Then, in October of 2004, more than a hundred companies joined and the BDF became an open forum called the Blu-ray Disc Association (BDA). The BDA issued the first version of the Blu-ray Disc™ Recordable Format Part1 in October of 2005, and Version 1.3 of the Blu-ray Disc™ Recordable Format Part1 in April of 2008, which enabled the Recording Velocity up to 6x.

By the end of 2010, over a hundred million Blu-ray Disc™ had already been shipped, and Blu-ray™ devices such as players, recorders, game consoles and PC drives were in use all over the world.

The BDA also conducts verification activities for the disks and devices and has established more than 10 Testing Centers in Asia, Europe and the USA.

The BDA gave consumer applications the highest priority in the first few years. But it was known, of course, that International Standardization would be required before many government entities and their contractors would be allowed to use Blu-ray Disc™. In February and January of 2011, the chair of ISO/IEC JTC 1/SC 23 and JIIMA (Japan Image and Information Management Association) formally requested the BDA to consider International Standardization. The reason for this was to enable the inclusion of writable BDs, along with DVDs and CDs, in an International Standard specifying test methods for the estimation of lifetime of optical storage media for long-term data storage. In October 2011, the president of the BDA responded that his organization had decided to pursue International Standard of the basic physical formats for the Recordable and Rewritable Blu-ray™ Format.

In December of 2011, BDA sent project proposals for the International standardization of four formats to ISO/IEC JTC 1/SC 23 via the Japan national body. They are 120 mm Single Layer (25,0 Gbytes per disk) and Dual Layer (50,0 Gbytes per disk) BD Recordable disks, 120 mm Single Layer (25,0 Gbytes per disk) and Dual Layer (50,0 Gbytes per disk) BD Rewritable disks, 120 mm Triple Layer (100,0 Gbytes per disk) and Quadruple Layer (128,0 Gbytes per disk) BD Recordable disks and a 120 mm Triple Layer (100,0 Gbytes per disk) BD Rewritable disk.

This International Standard specifies the mechanical, physical and optical characteristics of a 120 mm recordable optical disk with a capacity of 25,0 Gbytes or 50,0 Gbytes.

Some technical errors were found during the editorial work for JIS X 6230, which is the Japanese Industrial Standard identical with ISO/IEC 30190:2013. In December of 2014, a Defect Report was submitted by the Japan national body of ISO/IEC JTC 1/SC 23. The project editor proposed a Draft Technical Corrigendum for ISO/IEC 30190:2013 and it was approved by ISO/IEC JTC 1/SC 23 in May of 2015.This International Standard is the updated First edition of ISO/IEC 30190:2013, including the Technical Corrigendum and additional corrections for some minor editorial errors.

A few additional specifications are required in order to write and read video-recording applications, such as the BDMV and BDAV formats, which have been specified by the BDA for use on BD Recordable disks. These specifications, which are related to the Application, the file systems or the Content-protection system, are required for the disk, the generating system and the receiving system. For more information of the Application, the Content-protection system and the additional requirements for the Blu-ray™ Format specifications, see http://www.blu-raydisc.info.

The International Organization for Standardization (ISO) and International Electrotechnical Commission (IEC) draw attention to the fact that it is claimed that compliance with this International Standard may involve the use of patents.

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ISO (http://www.iso.org/patents) and IEC (http://patents.iec.ch) maintain on-line databases of patents relevant to their standards. Users are encouraged to consult the databases for the most up to date information concerning patents.

NOTE Blu-ray™, Blu-ray Disc™ and the logos are trademarks of the Blu-ray Disc Association.

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Information technology — Digitally recorded media for information interchange and storage — 120 mm Single Layer (25,0 Gbytes per disk) and Dual Layer (50,0 Gbytes per disk) BD Recordable disk

1 Scope

This International Standard specifies mechanical, physical and optical characteristics of a 120 mm recordable optical disk with a capacity of 25,0 Gbytes or 50,0 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. User data can be written once and read many times using a non-reversible method. This disk is identified as BD Recordable disk.

This International Standard specifies the following:

— three related but different Types of this disk;

— 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 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 recorded on the disk, enabling data processing systems to read 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.

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2 Conformance

2.1 Optical disk

A claim of conformance with this International Standard shall specify the Type implemented. An optical disk shall be in conformance with this International Standard if it meets all mandatory requirements specified for its Type.

2.2 Generating system

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

2.3 Receiving system

A receiving system shall be in conformance with this International Standard if it is able to handle all three 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, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO/IEC 646, *Information technology — ISO 7-bit coded character set for information interchange*

ISO 9352, *Plastics — Determination of resistance to wear by abrasive wheels*

IEC 60068-2-2, *Environmental testing — Part 2-2: Tests — Test B: Dry heat*

IEC 60068-2-30, *Environmental testing — Part 2-30: Tests — Test Db: Damp heat, cyclic (12 h + 12 h cycle)*

IEC 60950-1, *Information technology equipment — Safety — Part 1: General requirements*

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4 Terms and definitions

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

4.1
Application
application specified for a *BD* (4.2), for instance, a video application, which requires area for a Content-protection system and for its own Defect-Management system on the disk

4.2
BD
disk having a *Cover Layer* (4.4) around 0,1 mm thick and a *Substrate* (4.35) around 1,1 mm thick on which data is read or recorded by an OPU using 405 nm laser diode and NA = 0,85 lens

Note 1 to entry: User Data recorded on the disk is formatted using 17PP modulation and an LDC+BIS Code.

4.3
Channel bit
element by which the binary value ZERO or ONE is represented by *Pits* (4.22) or *Marks* (4.17) and *Spaces* (4.34) on the disk

4.4
Cover Layer
transparent layer with precisely-controlled optical properties that covers the *Recording Layer* (4.27) closest to the *Entrance surface* (4.10) of the disk

4.5
Data Zone
n
area between the Inner Zone and the Outer Zone on *Layer* L*n* (4.16)

4.6
Defective Cluster
cluster in a *User-Data Area* (4.39) that has been registered in a Defect List as unreliable or uncorrectable one

4.7
Digital-Sum Value
DSV
arithmetic sum obtained from a bit stream by assigning the decimal value +1 to *Channel bits* (4.3) set to ONE and the decimal value –1 to Channel bits set to ZERO

4.8
Disk reference plane
plane defined by the perfect flat annular surface of an ideal spindle, onto which the Clamping Zone of the disk is clamped, that is normal to the axis of rotation

4.9
Embossed HFM Area
area on the disk where information has been stored by means of an *HFM Groove* (4.12) during the manufacture of the disk

4.10
Entrance surface
surface of the disk onto which the optical beam first impinges

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4.11
Groove
trench-like feature of the disk, connected to a *Recording Layer* (4.27)

Note 1 to entry: In case of a Single-Layer disk, the Groove can be carried by the *Substrate* (4.35). In case of a Dual-Layer disk, one Groove can be carried by the Substrate and the other Groove by the *Spacer Layer* (4.33) or the *Cover Layer* (4.4) (see Figure 1, 2 and 3). Grooves are used to define the Track locations. The Groove corresponds to the area that has been exposed to the mastering spot. In general, the Groove can be a depression in the carrier or an elevation on the carrier. If the Groove is nearer to the *Entrance surface* (4.10) than the *Land* (4.15) (see Figure 55), the recording method is called "On-Groove recording". If the Groove is farther from the Entrance surface than the Land, the recording method is called "In-Groove recording". In the BD Recordable system, the following are the three types of Groove:

— *Wobbled Groove* (4.41) in *Recordable Area* (4.26) containing address information;

— *HFM Groove* (4.12) in *Embossed HFM Area* (4.9) containing Permanent Information and Control data;

— Straight Groove without any modulation in the BCA Zone.

4.12
HFM Groove
High-Frequency Modulated Groove
groove (4.11) modulated in the radial direction with a rather high bandwidth signal

Note 1 to entry: HFM Groove creates a data channel with sufficient capacity and data rate for replicated information.

4.13
Information Area
area on the disk in which information can be recorded

4.14
Information Zone
recorded part of the *Information Area* (4.13)

4.15
Land
surface of the *Recording Layer* (4.27) between successive windings of a Groove

4.16
Layer L*n*
one *Recording Layer* (4.27) of the disk identified by *n*

Note 1 to entry: Layer L (*n*+1) is closer to the *Entrance surface* (4.10) of the disk than Layer, L*n*.

4.17
Marks
feature of the *Recording Layer* (4.27), which may take the form of lower/higher reflectivity domains in the Unrecorded Recording Layer, that can be sensed by the optical read-out system

Note 1 to entry: The pattern of Marks and *Spaces* (4.34) represents the data on the disk.

4.18
Measurement Velocity
linear velocity at which the disk is measured during reading

Note 1 to entry: *n*x Measurement Velocity means the Measurement Velocity of *n* times the *Reference Velocity* (4.29).

4.19
Modulation bit
alternative form representing the data that is more suited to be transmitted via a communication channel or to be stored on a storage system

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4.20
NRZ/NRZI conversion
method of converting a Modulation-bit stream into a physical signal

4.21
Padding
process in a drive to fill up the missing *Sectors* (4.32) in a 64K Cluster, which is consisting of 32 Sectors, with all 00h data when the host supplies less than 32 Sectors and need to fill up the Cluster

4.22
Pits
features of the *Recording Layer* (4.27) which may take the form of depressions in or elevations on the Land surface that can be sensed by the optical read-out system

Note 1 to entry: The pattern of Pits and *Spaces* (4.34) represents the data on the disk

4.23
Polarization
direction of the electric field vector of an optical beam

Note 1 to entry: The plane of Polarization is the plane containing the electric field vector and the direction of propagation of the beam.

4.24
Pre-recorded Area
area on the disk where information has been recorded by the manufacturer/supplier of the disk by applying standard recording techniques after finishing of the replication process

4.25
Protective Coating
optional additional layer on top of the *Cover Layer* (4.4) provided for extra protection against scratches and other types of damage

4.26
Recordable Area
area on the disk where information is recorded by means of *Marks* (4.17) and *Spaces* (4.34) according to the data format as defined in Clause 13; either by the manufacturer/supplier of the disk or by the end user of the disk

Note 1 to entry: The *Recording Layer* (4.27) material in the Area is composed is such that, once the *layer* (4.16) has been recorded, any attempt to change the information will result in Unreadable Data.

4.27
Recording Layer
part of the disk consisting of a stack of films of specific materials on or in which data is written during manufacture and/or use

4.28
Recording Velocity
linear velocity at which the disk is recorded

Note 1 to entry: *n*x Recording Velocity means the Recording Velocity of *n* times the *Reference Velocity* (4.29).

4.29
Reference Velocity
linear velocity that results in the nominal Channel-bit rate of 66,000 Mbit/s

4.30
Reserved
<value> value(s) not used in this International Standard

Note 1 to entry: In future standards, the value can be released.

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4.31
Reserved
<field> field(s) not specified in use, to be ignored in interchange and to be set to ZERO as value

Note 1 to entry: In future standards, the use of a field can be defined and value can be assigned.

4.32
Sector
minimum-size addressable data part of a *Track* (4.36) in the *Information Zone* (4.14)

4.33
Spacer Layer
transparent layer with precisely-controlled optical properties separating two *Recording Layers* (4.27)

4.34
Spaces
areas separating *Pits* (4.22) or *Marks* (4.17) in the tangential direction in the context of HF signal.

Note 1 to entry: The pattern of Pits/Marks and Spaces represents the data on the disk.

4.35
Substrate
layer which may be transparent or not, provided for the mechanical support of the *Recording Layer(s)* (4.27)

4.36
Track
360° turn of a continuous spiral, formed by the Grooves

4.37
Track Pitch
distance between centrelines of a *Groove* (4.11) in adjacent Tracks, measured in the radial direction

4.38
Transmission Stack
all layers together between the *Entrance surface* (4.10) of the disk and the *Recording Layer* (4.27) concerned

Note 1 to entry: In other words, the Transmission Stack of a specific Recording Layer consists of all layers that are passed through by the light beam when accessing that Recording Layer.

4.39
User-Data Area
collection of all *Data Zone(s)* (4.5) on the disk and consists only of the Clusters in which User Data can be recorded

4.40
Virgin Groove
blank Groove on the disk which have never been recorded

4.41
Wobbled Groove
groove (4.11) that has a periodic sinusoidal deviation from its average centreline

Note 1 to entry: By modulating the sinusoidal deviation, the wobble provides address information and general information about the disk.

4.42
Zone
annular area of the disk

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5 Conventions and notations

5.1 Terminology

5.1.1 Meaning of words

In this International Standard the following words have a special meaning:

May: indicates an action or feature that is optional.
Optional: describes a feature that may or may not be implemented.If implemented, the feature shall be implemented as described.
Shall: indicates an action or feature that is mandatory and to be implemented to claim compliance to this specification.
Should: indicates an action or feature that is optional, but its implementation is strongly recommended.

5.1.2 Levels of grouping

Many times data is collected into groups, where these groups of data can be collected into higher level groups. For the clarity of the grouping hierarchy, in this International Standard, the following levels of hierarchy will be used:

Frame: the lowest level of grouping. Generally, Frames contain bytes of information.
Block: the second level of grouping. Generally, Blocks consist of a number of Frames.
Cluster: the highest level of grouping. Clusters consist of several Blocks.
Fragment: a level of grouping that can be applied by the application. A certain amount of data will be allocated to a (fixed) number of consecutive Clusters.

5.2 Representation of numbers

A measured value, $x_{\mathbf{measured}}$, may be rounded off to the least-significant digit of the corresponding specified value, x, before being compared with this specified value.

EXAMPLES:

— The specification is: $x = 1{,}26\,^{+0{,}01}_{-0{,}02}$.
(nominal value = 1,26 with a positive tolerance of +0,01 and a negative tolerance of –0,02)
  — A measured value in the range $1{,}235 \leq x_{\mathbf{measured}} < 1{,}275$ fulfills this specification.

— The specification is: $x \leq 0{,}3$.
  — A measured value $x_{\mathbf{measured}} < 0{,}35$ fulfills this specification (rounding off is applied for $0{,}30 < x_{\mathbf{measured}} < 0{,}35$: $x_{\mathbf{rounded}} = 0{,}3$).

— The specification is: $x < 0{,}3$.
  — A measured value $x_{\mathbf{measured}} = 0{,}299$ fulfills this specification (no rounding off needs to be applied).
  — A measured value $x_{\mathbf{measured}} = 0{,}3$ exactly does not fulfill this specification.

In case the specified value is given as “max(imum) *x* units” or “minimum *x* units”, the measured value shall not be rounded off before comparing to the specified value. Parameters given in this way shall not violate the specified limits set by the exact value of *x*.

EXAMPLES:

— The specification is max(imum) 0,3 mm.
  — A measured value of 0,300 mm fulfills this specification.
  — A measured value of 0,301 mm does not fulfill this specification.
— The specification is minimum 3 dB.
  — A measured value of 3,00 dB fulfills this specification.

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— A measured value of 2,99 dB does not fulfill this specification.

Numbers in decimal notation are represented by the digits 0 to 9. The decimal symbol is “,” (comma). In large numbers, the “ ” (space) can be used as digit grouping symbol.

Numbers in hexadecimal notation are represented by the hexadecimal digits 0 to 9 and A to F in parentheses or followed by lowercase “h”. The character *x* in hexadecimal numbers represents any digit 0 to 9 or A to F.

Numbers in binary notation and bit patterns are represented by strings of digits 0 and 1, with the most-significant bit shown to the left. The character *x* in binary numbers represents a digit 0 or 1.

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

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.

An uninterrupted sequences of *m* 0s in a bit pattern can be represented by $[0^m]$.

The setting of bits is denoted by ZERO and ONE.

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

In data fields composed of nibbles, the data is recorded so that the most-significant nibble, identified as Nibble 0, shall be recorded first and the least-significant nibble last.

In a field of 4*n* bits, bit $b_{(4n-1)}$ shall be the most-significant bit (msb) and bit b_0 the least-significant bit (lsb). Bit $b_{(4n-1)}$ shall be recorded first.

A range of values is indicated as $x \sim y$, where *x* and *y* are included in the range.

A list of integers is indicated as *i* .. *j*. The list contains all numbers between *i* and *j*, including *i* and *j* (e.g. *k* = 0 .. 7). If the step size is different from one, this is indicated as: *i,* (*i* + step) .. *j* (e.g. *k* = 1, 4 .. 16, where step = 3).

A group of parameters is indicated as Param *m*..*n* or P_m .. P_n. The group contains all parameters with an index between *m* and *n*, including *m* and *n* (e.g. byte 16..31, bit 7..4, Add_0 .. Add_{255}).

If *x* is nearly equal to *y*, then it is expressed as $x \approx y$.

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5.3 Integer calculus

div(*n*,*d*) represents the integer part of the division of *n* by *d*
mod(*n*,*d*) represents the remainder of the division of *n* by d: mod(*n*,*d*) = $n - d \times$ div(n,d)

For example: div(+11, +3) = +3 div(–11, +3) = –3 div(+11, –3) = –3 div(–11, –3) = +3
mod(+11, +3) = +2 mod(–11, +3) = –2 mod(+11, –3) = +2 mod(–11, –3) = –2

floor(*x*) represents the largest integer number ≤*x*
For example: floor(+3,7) = +3 floor(–3,7) = –4

5.4 Names

The name of specific entities, e.g. particular Tracks, fields, etc., are given with an initial capital. Other terms having explicitly-defined meanings for the purpose of this International Standard are also capitalized.

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6 List of acronyms

ac	alternating current
ADIP	Address In Pre-Groove
APC	Automatic Power Control
AU	Address Unit
AUN	Address-Unit Number
BCA	Burst-Cutting Area
BIS	Burst-Indicating Subcode
BPF	Band-Pass Filter
CAV	Constant Angular Velocity
cbs	channel bits
CNR	Carrier-to-Noise Ratio
dc	direct current
DCZ	Drive-Calibration Zone
DDS	Disk-Definition Structure
DFL	Defect List
DI	Disk Information
DL	Dual Layer
DMA	Disk-Management Area
DMS	Disk-Management Structure
DSV	Digital-Sum Value
EB	Emergency Brake
ECC	Error-Correction Code
EDC	Error-Detection Code
FAA	First ADIP Address (of Data Zone)
FS	Frame Sync
FWHM	Full Width at Half Maximum
HF	High Frequency
HFM	High-Frequency Modulated
HMW	Harmonic-Modulated Wave
HPF	High-Pass Filter
HTL	High-To-Low
LAA	Last ADIP Address (of Data Zone)
LDC	Long-Distance Code
LPF	Low-Pass Filter
LRA	Last-Recorded Address
LSB	Least-Significant Byte
lsb	least-significant bit
LSN	Logical-Sector Number
LTH	Low-To-High
MM	MSK Mark
MSB	Most-Significant Byte
ms	millisecond
msb	most-significant bit
MSK	Minimum-Shift Keying
MW	Monotone Wobble
NA	Numerical Aperture
NHWS	Normalized HFM-Wobble Signal
NRZ	Non-Return-to-Zero
NRZI	Non-Return-to-Zero Inverting
ns	nanosecond
NWA	Next-Writable Address
NWL	Nominal Wobble Length
NWS	Normalized Wobble Signal
OPU	Optical Pick-up Unit
PAA	Physical ADIP Address
PIC	Permanent Information & Control data
PLL	Phase-Lock Loop
PoA	Post-amble

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PP	Push-Pull
pp	peak-to-peak
PrA	Pre-amble
ps	picosecond
PSN	Physical-Sector Number
RH	Relative Humidity
RHWG	Ratio HFM-Wobbled Groove
RIN	Relative-Intensity Noise
RMTR	Repeated Minimum-Transition Run-length
RS	Reed-Solomon (code)
RT	Relative Thickness
RUB	Recording-Unit Block
RxI_n	Reflectivity × I_n Resolution
RxM	Reflectivity × Modulation
SER	Symbol Error Rate
SHD	Second-Harmonic Distortion
SHL	Second-Harmonic Level
SL	Single Layer
SNR	Signal-to-Noise Ratio
SRM	Sequential-Recording Mode
SRR	Sequential-Recording Range
SRRI	Sequential-Recording Range Information
STW	Saw-Tooth Wobble
Sync	Synchronization
TDDS	Temporary Disk-Definition Structure
TDFL	Temporary Defect List
TDMA	Temporary Disk-Management Area
TDMS	Temporary Disk-Management Structure
TP	Track Pitch
TS	Transmission Stack
V_{ref}	Reference Velocity
wbs	wobbles

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7 General description of disk

The 120 mm optical disk that is the subject of this International Standard consists of a Substrate of about 1,1 mm nominal thickness. Clamping is performed in the Clamping Zone.

The Recording Layer of the disk may use High-To-Low (HTL) or Low-To-High (LTH) technology. Recorded HTL Marks have lower reflection than the Unrecorded Layer(s), recorded LTH Marks have higher reflection than the Unrecorded Layer(s).

This International Standard provides for three Types of such disks.

Type SL/HTL disk the Substrate is covered with a HTL Recording Layer, consisting of several films. On top of this Recording Layer, a transparent Cover Layer of 0,1 mm is applied with precisely-defined optical characteristics (see Figure 1). The capacity is 25,0 Gbytes.

Type DL/HTL disk the Substrate is covered with two HTL Recording Layers, each consisting of several films. The two Recording Layers are separated by a transparent Spacer Layer of about 0,025 mm. The first Recording Layer seen from the read-out side of the disk shall be semi-transparent. On top of this Recording Layer, a transparent Cover Layer of about 0,075 mm is applied. Both the Spacer Layer and the Cover Layer shall have precisely-defined optical characteristics (see Figure 2). The capacity is 50,0 Gbytes.

Type SL/LTH disk the Substrate is covered with a LTH Recording Layer, consisting of several films. On top of this Recording Layer, a transparent Cover Layer of 0,1 mm is applied with accurately defined optical characteristics (see Figure 3). The capacity is 25,0 Gbytes.

To improve the scratch resistance, the Cover Layer optionally can be protected with an additional hard coating.

Data can be written on the disk with a high-power focused optical beam. The data can be read with a low-power focused optical beam, using the difference in the reflectivity of the Marks and the Spaces.

The Recording Layer(s) contain Wobbled Groove(s) with addresses that enable a speed control and navigation system for the data to be written to the Recording Layer concerned.

Recording and read-out of the data is accomplished through the Cover Layer or through the total stack of Cover Layer, first Recording Layer and Spacer Layer, depending on which Recording Layer is involved.

For reference purposes all layers that the light beam passes through when accessing a certain Recording Layer is called the Transmission Stack of that specific Recording Layer (see Figure 1, 2 and 3).

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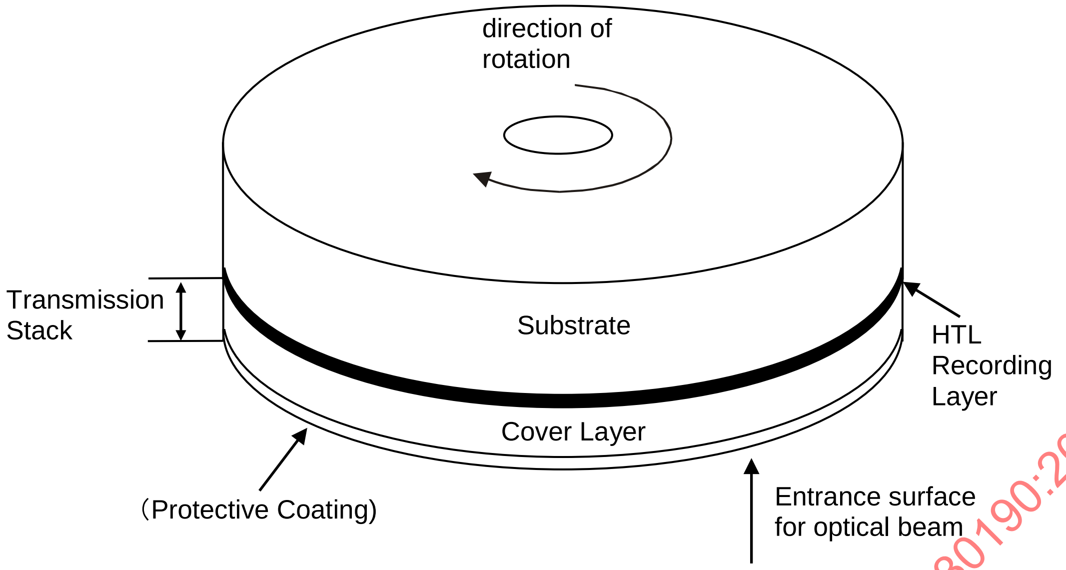

Figure 1 — Outline of Type SL/HTL disk

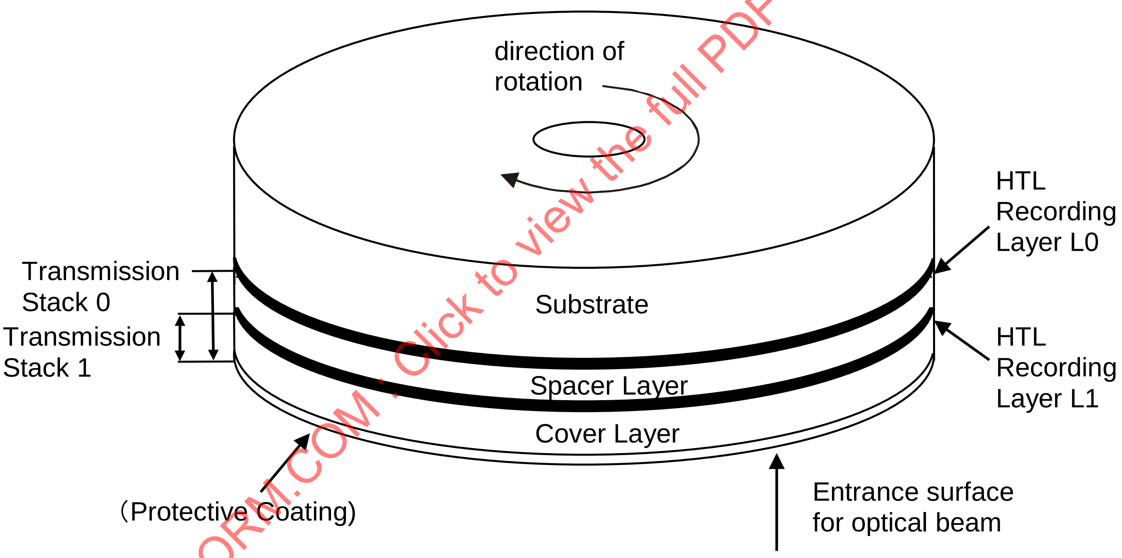

Figure 2 — Outline of Type DL/HTL disk

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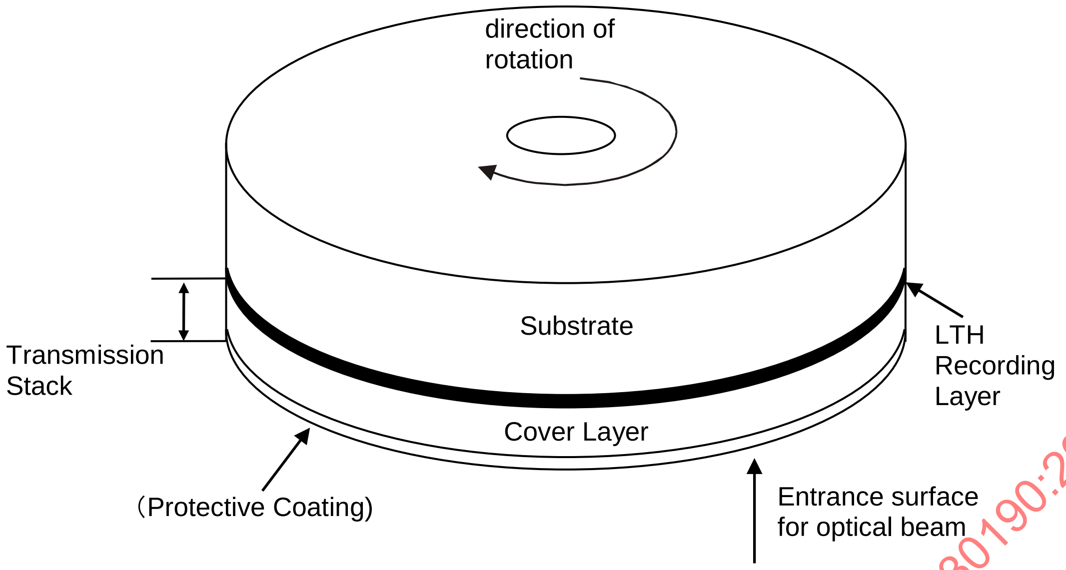

Figure 3 — Outline of Type SL/LTH disk

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This International Standard specifies four kinds of Recording Velocity: 1x, 2x, 4x, 6x.

Figure 4 shows the Recording Velocity requirements for each Disk Type.

Disk Type	Mark polarity	Push-Pull polarity	Layer Type	Recording Velocity			
				1x	2x	4x	6x
Type SL/HTL	HTL	On-Groove	SL	m	m	o	o
Type DL/HTL	HTL	On-Groove[a]	DL	m	m	o	o
Type SL/LTH	LTH	In-Groove	SL	m	m	o	o

m Mandatory
o Optional
[a] Groove polarity shall be On-Groove for both Layer L0 and Layer L1

Figure 4 — Recording Velocity requirements for Disk Type

Figure 5 shows the Recording Velocity requirements for the disk (see 15.8.3.7).

	Type SL/HTL				Type DL/HTL				Type SL/LTH			
	1x	2x	4x	6x	1x	2x	4x	6x	1x	2x	4x	6x
2x disk	m	m	-	-	m	m	-	-	m	m	-	-
4x disk	m	m	m	-	m	m	m	-	m	m	m	-
6x disk	m	m	m	m	m	m	m	m	m	m	m	m

m Mandatory
\- Not allowed in this International Standard.

Figure 5 — Recording Velocity requirements for disk

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8 General requirements

8.1 Environments

8.1.1 Test environment

8.1.1.1 General

During measurements for testing conformance of a disk with this International Standard, the disk shall be in the test environment. The test environment is the environment where the air immediately surrounding the disk shall have the following properties:

- temperature: (23 ± 2) °C;
- relative humidity: 45 % to 55 %;
- atmospheric pressure: 86 kPa to 106 kPa.

No condensation on the disk shall occur. Before testing, the disk shall be conditioned in this environment for a sufficient time.

8.1.1.2 Test conditions for sudden change in operating environment

Some parameters can be rather sensitive to changes in the operating environment. Where specified, the following two tests shall be performed. In both cases, the required specifications shall be fulfilled during the time it takes for the disk to acclimatize to the new environment.

a) Apply a sudden change in relative humidity, while keeping the temperature at a constant level: relative humidity = 90 %, temperature = 25 °C → relative humidity = 45 %, temperature = 25 °C (see Figure 6).

b) Apply a sudden change in temperature, while keeping the absolute humidity at a constant level (about 10,4 g/m³): temperature = 25 °C, relative humidity = 45 % → temperature = 55 °C, relative humidity = 10 % (see Figure 6).

8.1.2 Operating environment

A disk in conformance with this International Standard 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 90 %;
- absolute humidity: 0,5 g/m³ to 30 g/m³;
- atmospheric pressure: 60 kPa to 106 kPa.

There shall be no condensation of moisture on the disk. If a disk has been exposed to conditions outside those specified above, it shall be acclimatized in an operating environment for at least two hours before use.

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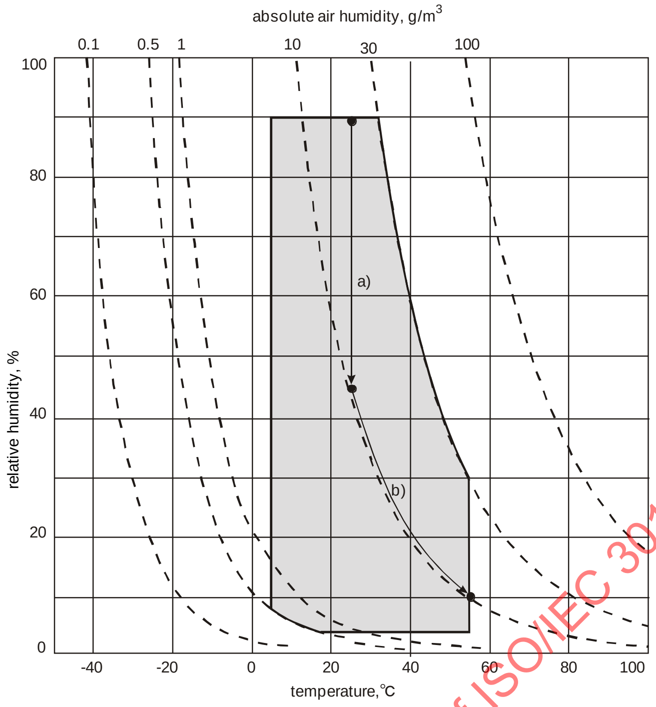

Figure 6 — Operating environment

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8.1.3 Storage environment

8.1.3.1 General

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

- temperature: –10 °C to 55 °C;
- relative humidity: 5 % to 90 %;
- absolute humidity: 1 g/m³ to 30 g/m³;
- atmospheric pressure: 60 kPa to 106 kPa;
- temperature variation max: 15 °C/h;
- relative humidity variation max: 10 %/h.

8.1.3.2 Climate storage tests

To check environmental stability of the disk, it shall be exposed to the following environments:

- Dry heat test according to IEC 60068-2-2 Ba:
  T = 55 °C, RH = 50 %, 96 hours;
- Damp heat cycle test according to IEC 60068-2-30 Db:
  T_{high} = 40 °C, T_{low} = 25 °C, RH = 95 %, cycle time = (12 + 12) hours, 6 cycles.

After exposure to these environmental conditions, one should allow for some recovery time before measuring [(24 or 48) hours].

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8.1.4 Transportation

8.1.4.1 General

As transportation occurs under a wide range of temperature and humidity variations, for differing periods, by many methods of transport and in all parts of the world, it is not possible to specify mandatory conditions for transportation or for packaging.

8.1.4.2 Packaging

8.1.4.2.1 General

The form of packaging should be agreed upon between sender and recipient or, in absence of such an agreement, is the responsibility of the sender. It should take into account the following hazards.

8.1.4.2.2 Temperature and humidity

Insulation and wrapping should be designed to maintain the conditions for storage over the estimated period of transportation.

8.1.4.2.3 Impact loads and vibrations

a) Avoid mechanical loads that would distort the shape of the disk.

b) Avoid dropping the disk.

c) Disks should be packed in a rigid box containing adequate shock-absorbent material.

d) The final box should have a clean interior and a construction that provides sealing to prevent the ingress of dirt and moisture.

8.2 Safety requirements

The disk shall satisfy the requirement of IEC 60950-1, when used in the intended manner or in any foreseeable uses 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 IEC 60950-1.

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9 Reference drive

9.1 General

A Reference drive shall be used for the measurement of optical and electrical signal parameters for conformance with the requirements of this International Standard. The critical components of this device have the characteristics specified in Clause 9.

9.2 Measurement conditions

During tests, the disk shall be in a test environment as defined in 8.1.1, unless stated otherwise.

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9.3 Optical system

The basic set-up of the optical system of the Reference drive used for measuring specified write and read parameters is shown in Figure 7. Different components and locations of components are permitted, provided that the performance remains the same as that of the set-up in Figure 7.

The optical system shall be aligned such that the focused optical beam is perpendicular to the Recording Layer on which the beam is focused at the radius where the measurement is to be performed.

The optical system shall be such that the detected light reflected from the Entrance surface of the disk is minimized so as not to affect the accuracy of the measurements.

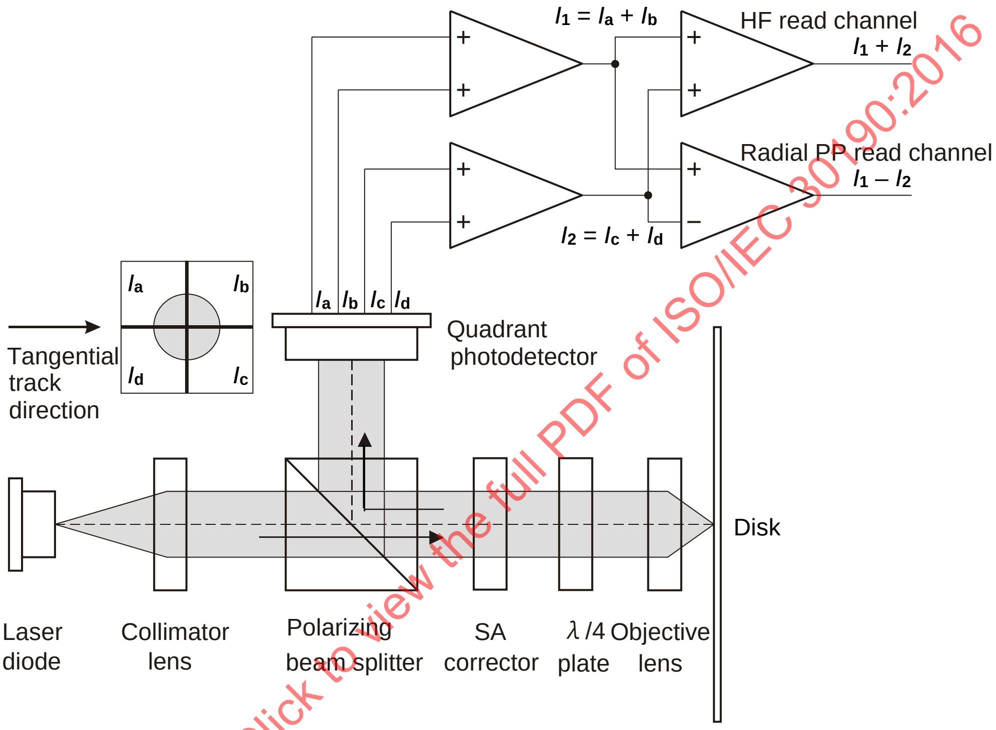

Figure 7 — Optical system of Reference drive

A polarizing beam splitter and a quarter-wavelength plate shall be used to separate the entrance light beam, coming from the laser diode and light beam reflected by the optical disk going toward the photodetector. The light beam transmitted through the splitter shall have a p:s intensity ratio of at least 100:1.

The optical beam shall be compensated for Spherical Aberrations (SA) such that these aberrations are minimized for the thickness of the Transmission Stack of the Recording Layer on which the beam is focused at the radius where the measurement is to be performed.

During measurements on one layer of a Dual-Layer disk, light reflected from the other layer can influence the measurements on the layer under investigation. To cope with these effects, the photodetector shall have limited dimensions. Its length and width shall be smaller than $M \times 5$ µm, where M is the transversal optical magnification from the disk to its conjugate plane near the quadrant photodetector.

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9.4 Optical beam

The focused optical beam used for writing and reading data shall have the properties listed below.

- Wavelength(λ) of the laser beam : (405 ± 5) nm.
- Polarization : circular.
- NA : 0,85 ± 0,01.
- Light intensity at the rim of the pupil of the objective lens relative to the maximum intensity:
  - In the tangential direction: (60 ± 5) %.
  - In the radial direction: (65 ± 5) %.
- Maximum wave-front aberration at the Recording Layer(s) : 0,033 × λ rms.
  (after correction of tilt and spherical aberrations)
- Maximum Relative-Intensity Noise of the laser diode : –125 dB/Hz.

$$\left[10 \times \log\left(\frac{\textit{ac light power density}/\mathrm{Hz}}{\textit{dc light power}}\right)\right]$$

- Normalized detector size : $S / M^2 \leq 25$ µm².
  (where S is the total surface of the quadrant photodetector.)
- Read power for disk testing (average) :
  - SL disk: (0,35 ± 0,1) mW.
  - DL disk: (0,70 ± 0,1) mW.
- Write power and pulse shape: see 29.4.2 and Annex F.

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9.5 HF read channel

The HF read channel is provided to supply a signal from which the User Data can be retrieved. This signal is generated by summing the currents from all four elements of the photodetector ($I_a + I_b + I_c + I_d$). These currents are modulated by the user-written information due to the difference in reflectivity of the Marks and Spaces.

In the frequency range from dc to 22 MHz, the HF read channel including the photodetectors shall have a flat amplitude response within ± 1,0 dB relative to its dc gain. The group delay variation shall be maximum 2 ns pp in the frequency range from 3 MHz to 22 MHz.

For measurement of jitter, the characteristics of the signal processing, the data slicer and the PLL, etc. are specified in Annex H.

9.6 Radial PP read channel

The radial PP read channel provides the tracking-error signal to control the servo for radial tracking of the optical beam. It also provides a wobble signal from which the information modulated on the Grooves can be retrieved.

The radial tracking error is generated as a signal $[(I_a + I_b) - (I_c + I_d)]$ related to the difference in the amount of light in the two halves of the exit pupil of the objective lens.

The read amplifiers, including the photodetectors, in the radial PP read channel shall have a flat amplitude response within ±1,0 dB relative to the dc gain from dc to 8 MHz.

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9.7 Disk Clamping

While its parameters are being measured, the disk shall be clamped between two concentric rings covering most of the Clamping Zone (see 10.6). The top Clamping Area shall have the same inner and outer diameters as the bottom Clamping Area (Figure 8).

Clamping shall occur between $d_{in} = (23{,}5 \pm 0{,}5)$ mm and $d_{out} = (32{,}5 \pm 0{,}5)$ mm .

The total clamping force shall be F_1 = 2,0 N ± 0,5 N.

In order to prevent warping of the disk under the moment of force generated by the clamping force and the chucking force F_2, which is exerted by the tapered cone on the rim of the centre hole of the disk, F_2 shall not exceed 0,5 N (see Figure 8).

The top angle α of the tapered cone for centering of the disk shall be 40,0° ± 0,5°.

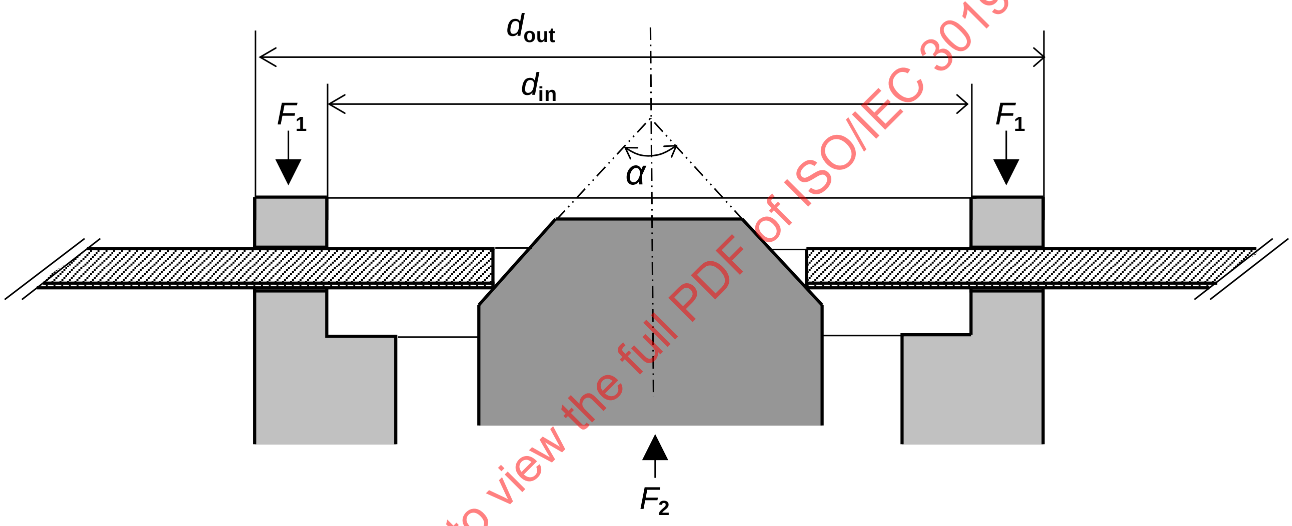

Figure 8 — Clamping conditions for measurement

9.8 Rotation of disk and Measurement Velocity

The direction of rotation shall be counter-clockwise as viewed from the objective lens.

All specifications are based on a tangential speed during reading that is equal to the Reference Velocity, unless otherwise specified. This corresponds to a Constant Linear Velocity of 4,917 m/s.

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9.9 Normalized servo transfer function

In order to specify the servo systems for axial and radial tracking, a function H_N ($i\omega$) is used. It specifies the nominal values of the open-loop transfer function H of the Reference servo(s).

$$H_N(i\omega) = \frac{1}{3} \times \left(\frac{\omega_0}{i\omega}\right)^2 \times \frac{1 + \frac{3 \times i\omega}{\omega_0}}{1 + \frac{i\omega}{3 \times \omega_0}} \times \left(1 + \frac{\omega_{int}}{i\omega}\right)^K$$

where

ω = 2π × f;

ω_0 = 2π × f_0;

ω_{int} = 2π × f_{int};

i^2 = – 1;

K = order of integrator.

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 the following:

— lead break frequency: $f_1 = f_0 / 3$;
— lag break frequency: $f_2 = f_0 \times 3$.

The term $\left(1+\frac{\omega_{int}}{i\omega}\right)$ in the formula above represents an integrator function. Such an integrator or equivalent function is used to further reduce low-frequency components, especially those due to deviations with frequencies equal to the rotational frequency of the disk or its harmonics.

Also, f_{int} is the crossover frequency of the integrator function.

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, α_{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), which guarantees the specified bandwidth.

9.10 Measurement Velocities and Reference servos for axial tracking

9.10.1 General

The applicable Reference servo and conditions for measuring residual axial errors depend on the Measurement Velocity of the disk under testing the following:

— a Reference servo for 2x disks to be measured at 1x Measurement Velocity (see 9.10.2);
— a Reference servo for 4x disks and for 6x disks at radii up to 36 mm to be measured at 2x Measurement Velocity (see 9.10.3);
— a Reference servo for 6x disks at radii 36 mm and higher to be measured at 3x Measurement Velocity (see 9.10.3).

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The servo for all conditions has the same basic characteristics, however with a modified integrator.

9.10.2 Reference servo for axial tracking for 1x Measurement Velocity

Regarding the open-loop transfer function *H*(*f*) of the Reference servo for axial tracking, $|1+H(f)|$ is shown schematically by the shaded area in Figure 9:

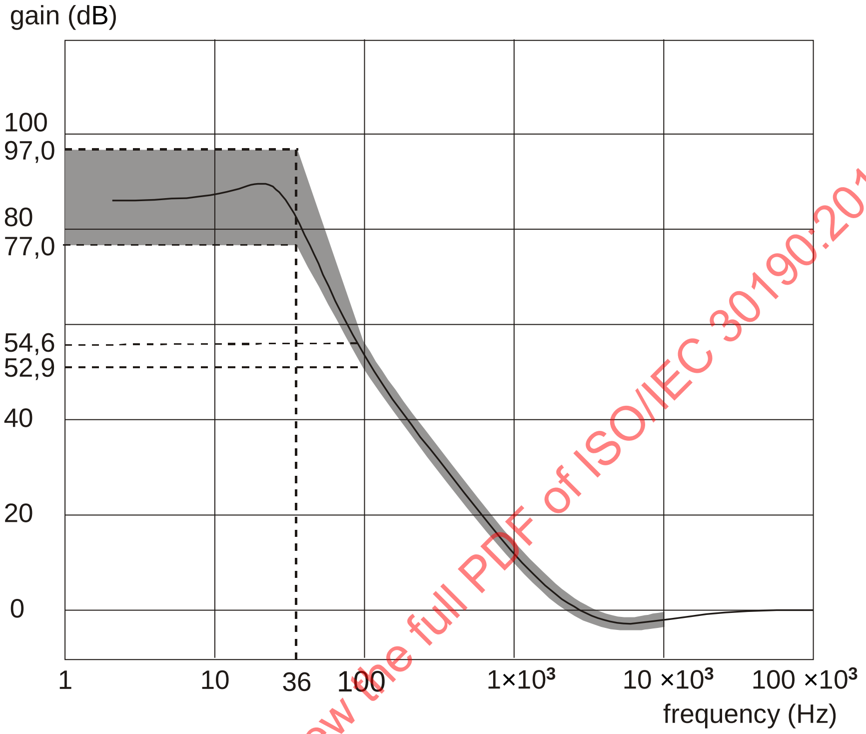

Figure 9 — Servo characteristic for axial tracking at 1x Measurement Velocity

The crossover frequency f_0 of H_N (*f*) (see 9.9) used to define the limits of $|1+H(f)|$, is specified by the following fomula. Here, α_{max} = 6,0 m/s² is the maximum expected axial acceleration due to local disturbances and α_{max} is multiplied by a factor *m* = 1,25 for servo margin. The tracking error e_{max}, caused by this $m \times \alpha_{max}$, shall be 55 nm. Thus, the 0 dB crossover frequency shall be:

$$f_0 = \frac{1}{2\pi}\sqrt{\frac{3 \times m \times \alpha_{max}}{e_{max}}} = \frac{1}{2\pi}\sqrt{\frac{3 \times 1{,}25 \times 6{,}0}{55 \times 10^{-9}}} = 3{,}2 \text{ kHz}$$

The integrator shall be first order (*K* = 1) with the crossover frequency of f_{int} = 100 Hz.

In the frequency range 100 Hz to 10 kHz:

$$0{,}9 \times |1+H_N(f)| \le |1+H(f)| \le 1{,}1 \times |1+H_N(f)|$$

In the frequency range 36 Hz to 100 Hz:

$$0{,}9 \times |1+H_N(f)| \le |1+H(f)| \le 1{,}1 \times |1+H_N(f_{int})| \times \left(\frac{f_{int}}{f}\right)^{4{,}78}$$

In the frequency range up to 36 Hz:

$$77{,}0\,dB \le |1+H(f)| \le 97{,}0\,dB$$

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The frequency, f_x, has the following value: $f_x = \frac{1}{2\pi}\sqrt{\frac{\alpha_{max}}{e_{max}}} = \frac{1}{2\pi}\sqrt{\frac{6,0}{55\times10^{-9}}} \approx 1,6$ kHz

9.10.3 Reference servo for axial tracking for 2x Measurement Velocity and 3x Measurement Velocity

For the open-loop transfer function $H(f)$ of the Reference servo for axial tracking, $|1+H(f)|$ is shown schematically by the shaded area in Figure 10:

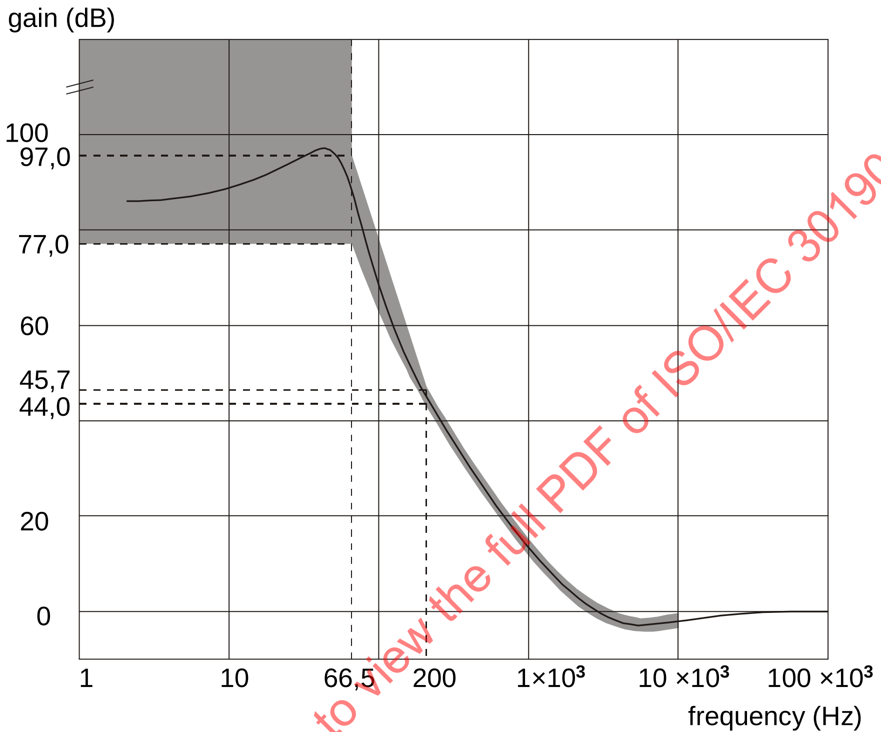

Figure 10 — Servo characteristics for axial tracking at 2x Measurement Velocity and 3x Measurement Velocity

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The 0 dB crossover frequency, f_0, shall be 3,2 kHz, the same as the measurement condition for the 1x Measurement Velocity.

For the maximum residual tracking error of 80 nm (see 11.4.3), this corresponds to an acceleration of

$$\alpha_{max} = \frac{(2\pi\times f_0)^2}{3}\times e_{max} = \frac{(2\pi\times 3,2\times10^3)^2}{3}\times 80\times10^{-9} = 10,8 \text{ m/s}^2$$

For the maximum residual tracking error of 110 nm (see 11.4.4), this corresponds to an acceleration of

$$\alpha_{max} = \frac{(2\pi\times f_0)^2}{3}\times e_{max} = \frac{(2\pi\times 3,2\times10^3)^2}{3}\times 110\times10^{-9} = 14,8 \text{ m/s}^2$$

The integrator shall be second order (K = 2) with the crossover frequency of f_{int} = 200 Hz.

In the frequency range 200 Hz to 10 kHz:

$$0,9\times|1+H_N(f)| \le |1+H(f)| \le 1,1\times|1+H_N(f)|$$

In the frequency range 66,5 Hz to 200 Hz:

$$0,9\times|1+H_N(f)| \le |1+H(f)| \le 1,1\times|1+H_N(f_{int})|\times\left(\frac{f_{int}}{f}\right)^{5,36}$$

In the frequency range up to 66,5 Hz:

$$|1+H(f)| \ge 77,0 \text{ dB}$$

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9.11 Measurement Velocities and Reference servos for radial tracking

9.11.1 General

The applicable Reference servo and conditions for measuring residual radial errors depend on the following Measurement Velocity of the disk under testing:

- a Reference servo for 2x disks to be measured at 1x Measurement Velocity (see 9.11.2);
- a Reference servo for 4x disks and for 6x disks at radii up to 36 mm to be measured at 2x Measurement Velocity (see 9.11.3);
- a Reference servo for 6x disks at radii 36 mm and higher to be measured at 3x Measurement Velocity (see 9.11.3).

The servo for all conditions has the same basic characteristics, however with a modified integrator.

9.11.2 Reference servo for radial tracking for 1x Measurement Velocity

For the open-loop transfer function *H*(*f*) of the Reference servo for radial tracking, $\left|1+H(f)\right|$ is shown schematically by the shaded area in Figure 11:

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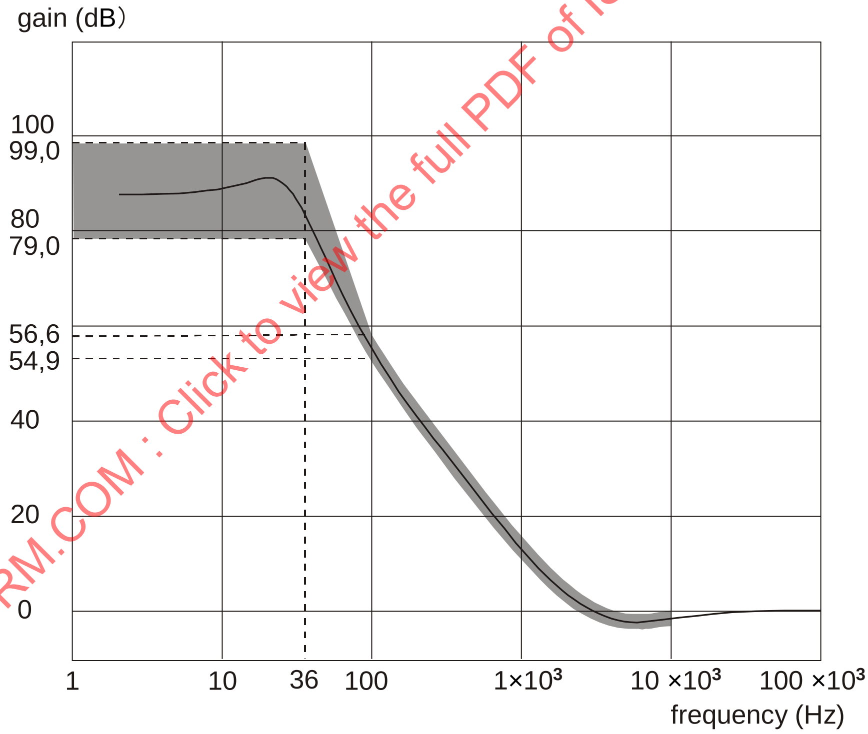

Figure 11 — Servo characteristics for radial tracking at 1x Measurement Velocity

The crossover frequency f_0 of H_N (*f*) (see 9.9), which is used to define the limits of $\left|1+H(f)\right|$, is specified by the following fomula. Here, α_{max} = 2,2 m/s² is the worst-case maximum expected radial acceleration due to local disturbances and α_{max} is multiplied by a factor *m* = 1,25 for servo margin. The tracking error, e_{max}, caused by this $m \times \alpha_{max}$ shall be 16 nm. Thus, the 0-dB crossover frequency shall be:

$$f_0 = \frac{1}{2\pi}\sqrt{\frac{3 \times m \times \alpha_{max}}{e_{max}}} = \frac{1}{2\pi}\sqrt{\frac{3 \times 1{,}25 \times 2{,}2}{16 \times 10^{-9}}} = 3{,}6\ \text{kHz}$$

The integrator shall be first order with crossover frequency of f_{int} = 100 Hz.

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In the frequency range 100 Hz to 10 kHz:

$$0{,}9 \times \left|1+H_N(f)\right| \le \left|1+H(f)\right| \le 1{,}1 \times \left|1+H_N(f)\right|$$

In the frequency range 36 Hz to 100 Hz:

$$0{,}9 \times \left|1+H_N(f)\right| \le \left|1+H(f)\right| \le 1{,}1 \times \left|1+H_N(f_{int})\right| \times \left(\frac{f_{int}}{f}\right)^{4{,}78}$$

In the frequency range up to 36 Hz:

$$79{,}0 \text{ dB} \le \left|1+H(f)\right| \le 99{,}0 \text{ dB}$$

The frequency f_x has the following value: $f_x = \frac{1}{2\pi}\sqrt{\frac{a_{max}}{e_{max}}} = \frac{1}{2\pi}\sqrt{\frac{2{,}2}{16\times10^{-9}}} \approx 1{,}8$ kHz.

9.11.3 Reference servo for radial tracking for 2x Measurement Velocity and 3x Measurement Velocity

For the open-loop transfer function $H(f)$ of the Reference servo for radial tracking, $\left|1+H(f)\right|$ is shown schematically by the shaded area in Figure 12:

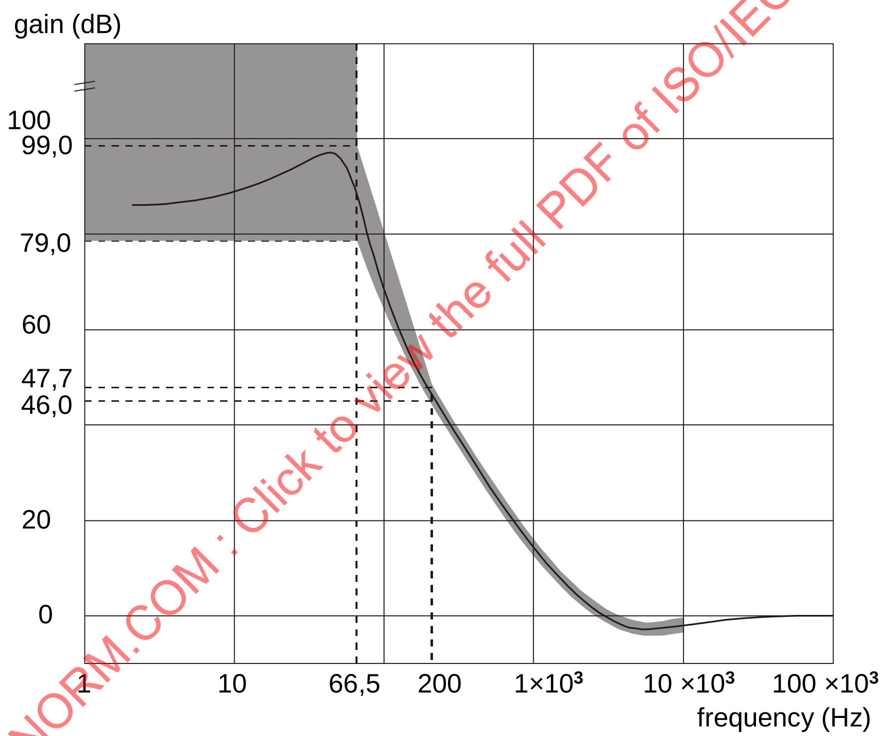

Figure 12 — Servo characteristics for radial tracking at 2x Measurement Velocity and 3x Measurement Velocity

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The 0 dB crossover frequency, f_0, shall be 3,6 kHz, the same as the measurement condition for the 1x Measurement Velocity. For the maximum residual tracking error of 20 nm (see 11.5.4), this corresponds to an acceleration of $a_{max} = \frac{(2\pi\times f_0)^2}{3} \times e_{max} = \frac{(2\pi\times 3{,}6\times10^3)^2}{3} \times 20\times10^{-9} = 3{,}4$ m/s²

The integrator shall be second order (K = 2) with the crossover frequency of f_{int} = 200 Hz.

In the frequency range 200 Hz to 10 kHz:

$$0{,}9 \times \left|1+H_N(f)\right| \le \left|1+H(f)\right| \le 1{,}1 \times \left|1+H_N(f)\right|$$

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In the frequency range 66,5 Hz to 200 Hz:

$$0{,}9 \times \left|1+H_N(f)\right| \le \left|1+H(f)\right| \le 1{,}1 \times \left|1+H_N(f_{int})\right| \times \left(\frac{f_{int}}{f}\right)^{5{,}36}$$

In the frequency range up to 66,5 Hz:

$$\left|1+H(f)\right| \ge 79{,}0 \text{ dB}$$

10 Dimensional characteristics

10.1 General

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. Figure 13 shows the dimensional requirements in summarized form. The different parts of the disk are described from the centre hole to the outside Rim.

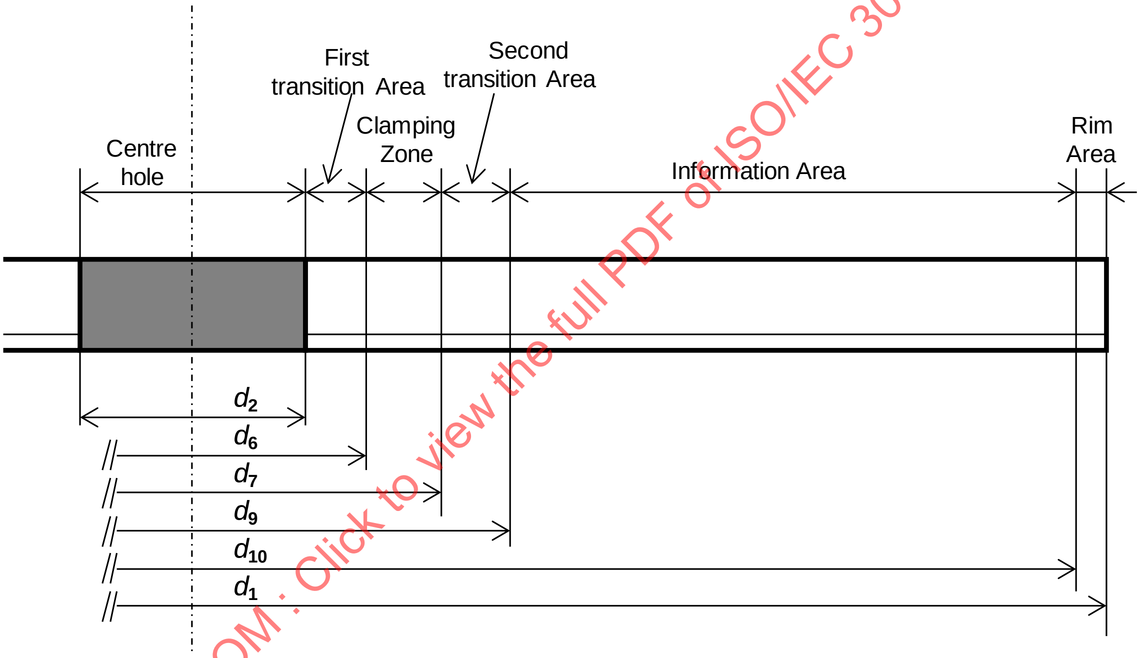

Figure 13 — Overview of disk dimensions

10.2 Disk reference planes and reference axis

For Disk reference planes, see also Figure 14 and Figure 15.

The Disk reference plane P is the plane determined by the surface of the Clamping Zone (see 10.6) at the read-out side of the disk.

The Disk reference plane Q is the plane determined by the surface of the Clamping Zone at the Substrate side of the disk.

The reference axis A is the axis through the middle of the centre hole, perpendicular to the Disk reference plane P.

The Disk reference plane R is a plane parallel to the Disk reference plane P. The distance between Disk reference plane R and Disk reference plane P shall be e_4 = (100 ± 25) µm towards the inside of the disk (see Figure 14 and 15).

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The Disk reference plane R shall intersect with Recording Layer L0 at Layer L0's average position between radius r_a = 23 mm and radius r_b = 24 mm (Layer L0 is the only Recording Layer on an SL disk or the deepest Recording Layer on a DL disk).

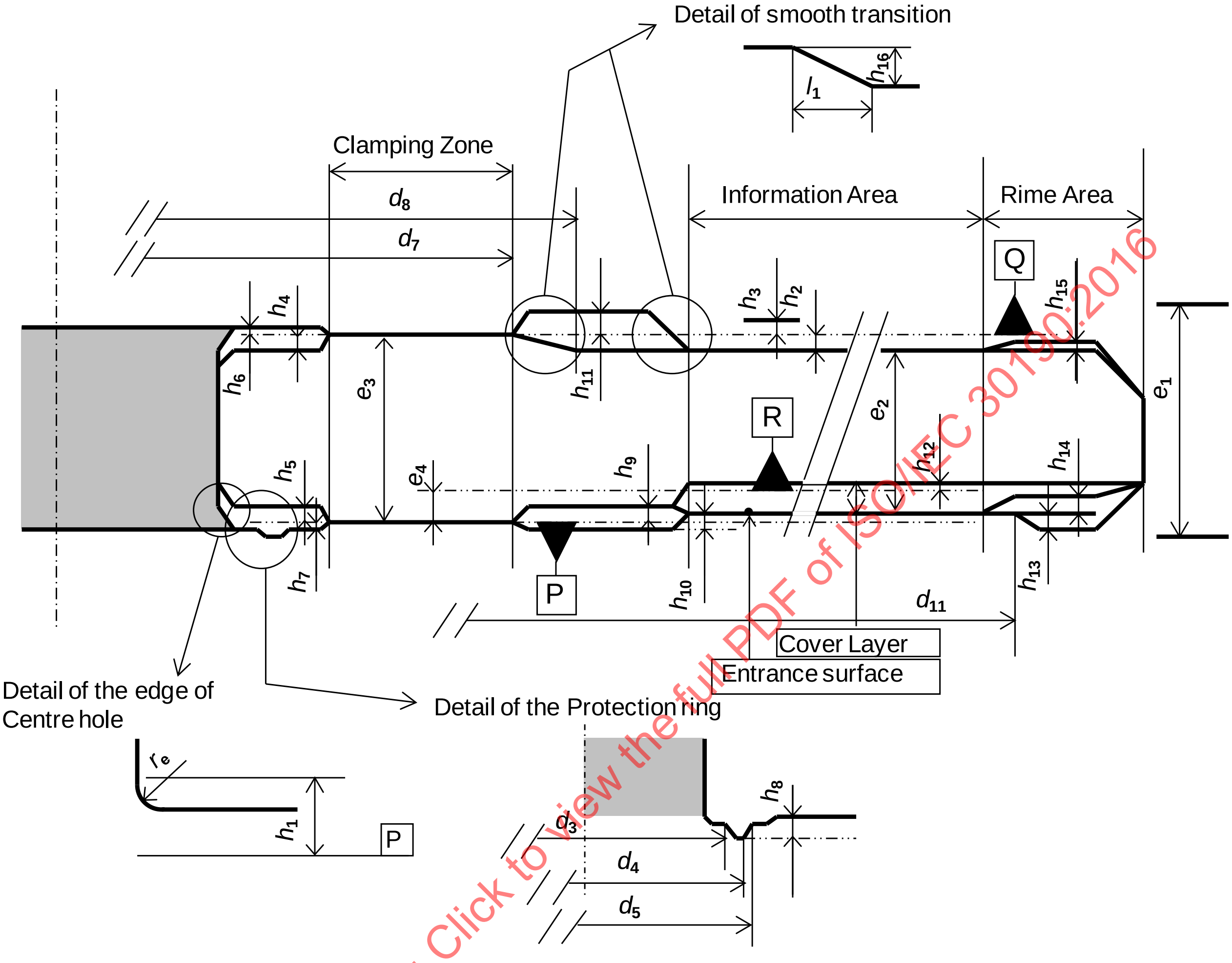

Figure 14 — Details of disk dimensions

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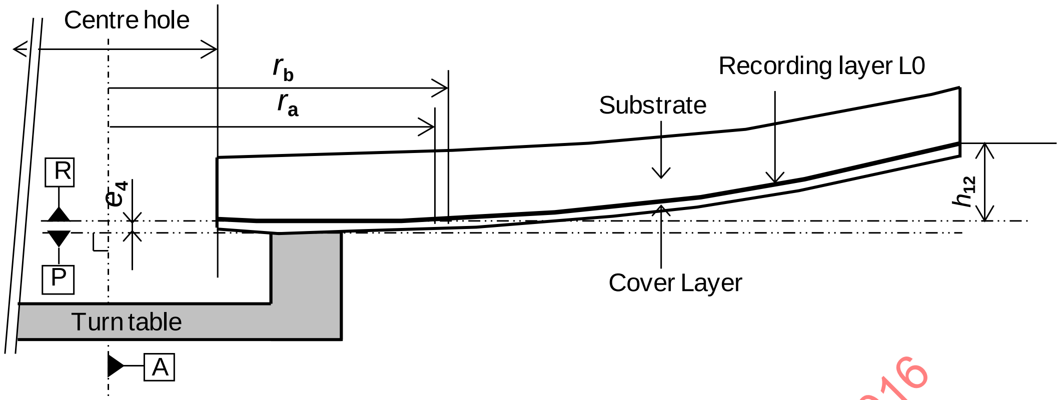

Figure 15 — Details of Disk reference planes P and R and Recording Layer L0

10.3 Overall dimensions

The overall outer diameter of the disk shall be d_1 = (120,0 ± 0,3) mm (see Figure 13).

The diameter of the centre hole shall be d_2 = $15{,}00\,^{+0{,}10}_{0{,}00}$ mm (see Figure 13).

There shall be no burr on the edge of the centre hole at the read-out side.

The edge of the centre hole at the read-out side is the reference for centering the disk and shall be rounded off or chamfered. The rounding radius shall be maximum r_e = 0,1 mm. The height of the chamfer shall be maximum 0,1 mm above the bottom surface of the First transition Area. The rounding or chamfer shall be maximum h_1 = 0,25 mm from Disk reference plane P (see detail in Figure 14).

The maximum thickness of the disk is defined as the distance in the direction of the reference axis A between the highest structure protruding from the Entrance surface of the disk and the highest structure protruding from the top surface of the disk.

The maximum thickness of the disk, including the Cover Layer, Protective Coating and Label printing at any radius shall be e_1 = 1,40 mm (see Figure 14).

The minimum thickness of the disk in the Information Area shall be e_2 = 0,90 mm.

Outside the Clamping Zone, the top surface may be inside the Disk reference plane Q by maximum h_2 = 0,4 mm.

Outside the Clamping Zone, the top surface may be outside the Disk reference plane Q by maximum h_3 = 0,1 mm (see Figure 14).

10.4 First transition Area

In the Inner Area inside the Clamping Zone (d < d_6) the surfaces may be inside the Disk reference planes P and Q by maximum h_5 = 0,20 mm and maximum h_4 = 0,12 mm, respectively. These surfaces may be uneven or have burrs up to maximum h_7 = 0,05 mm and maximum h_6 = 0,05 mm outside the Disk reference planes P and Q, respectively (see Figure 13 and 14).

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10.5 Protection ring

An optional ring-shaped protrusion in the Inner Area of the disk that can prevent full contact between the surface of the disk and a surface on which such a disk is laid down. By applying such a ring, the chance for damage to the read-out side of the disk can be minimized.

When applied, the Protection ring shall be located between diameter $d_3 = 17{,}5$ mm and diameter $d_5 = 21{,}0$ mm. Between d_3 and diameter $d_4 = 20{,}5$ mm, the height of the Protection ring shall be maximum $h_8 = 0{,}12$ mm above the clamping surface .

Between d_4 and d_5, the height of the Protection ring shall sink gradually to the surrounding surface (see Figure 14).

10.6 Clamping Zone

The inner diameter of the disk Clamping Zone shall be $d_6 \leq 23{,}0$ mm.
The outer diameter of the disk Clamping Zone shall be $d_7 \geq 33{,}0$ mm (see Figure 13).

The thickness of the disk within the Clamping Zone shall be $e_3 = 1{,}20^{+0{,}10}_{-0{,}05}$ mm (see Figure 14).

Within the Clamping Zone ($d_6 < d < d_7$), both sides of the disk shall be flat within maximum 0,1 mm.
Within the Clamping Zone ($d_6 < d < d_7$), both sides of the disk shall be parallel within maximum 0,1 mm.

10.7 Second transition Area

The Second transition Area is an area between the Clamping Zone and the Information Area: $d_7 < d < d_9$. (see Figure 13).

In the area, the surface at the read-out side of the disk may be inside the Disk reference plane P by maximum $h_9 = 0{,}12$ mm. This surface may be outside the Entrance surface in the Information Area by maximum $h_{10} = 0{,}01$ mm (see Figure 14).

In the area, the top surface of the disk may be outside the Disk reference plane Q by maximum $h_{11} = 0{,}2$ mm.

The step from the top surface in the area to the top surface in the Information Area is h_{16}. The distance between the start and the end diameters of the step is l_1. If $h_{16} > 0{,}2$ mm, then the slope down to the top surface of the Information Area shall be smooth and $l_1 > 1{,}8$ mm as indicated in Figure 14. If the top surface in the Information Area is stepped down from the top surface in the Second transition Area, then the step shall end within diameter $d_8 = 40{,}0$ mm.

10.8 Information Area

10.8.1 General

The Information Area shall extend from diameter $d_9 = 42$ mm to diameter $d_{10} = 117$ mm (see Figure 13 and 16).

On each Recording Layer, the Data Zone shall be located between inner diameter d_{DZI} and outer diameter d_{DZO}. The Data Zones on all Recording Layers shall have the same storage capacity.

The inner diameter d_{DZI} on Recording Layer Ln shall be $d_{DZIn} = 48{,}0^{0{,}0}_{-0{,}2}$ mm, and the outer diameter d_{DZO} on Recording Layer Ln shall be $d_{DZOn} \leq 116{,}2$ mm.

The area between d_9 and d_{DZI} is called the Inner Zone, and the area between d_{DZO} and d_{10} is called the Outer Zone (see Figure 16).

The total thickness of the disk in the Information Area is as specified in 10.3.

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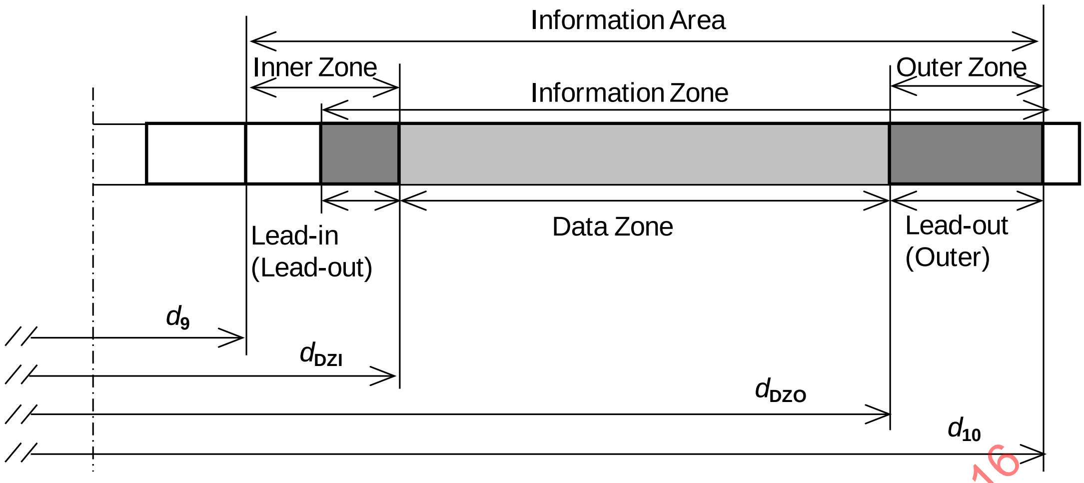

Figure 16 — Division of Information Area

10.8.2 Subdivision of Information Zone on SL disks

The Information Area is used to record the Information Zone.

The Information Zone is subdivided into the following main parts (see Figure 17):
- a Lead-in Zone (part of the Inner Zone);
- a Data Zone;
- a Lead-out Zone (Outer Zone).

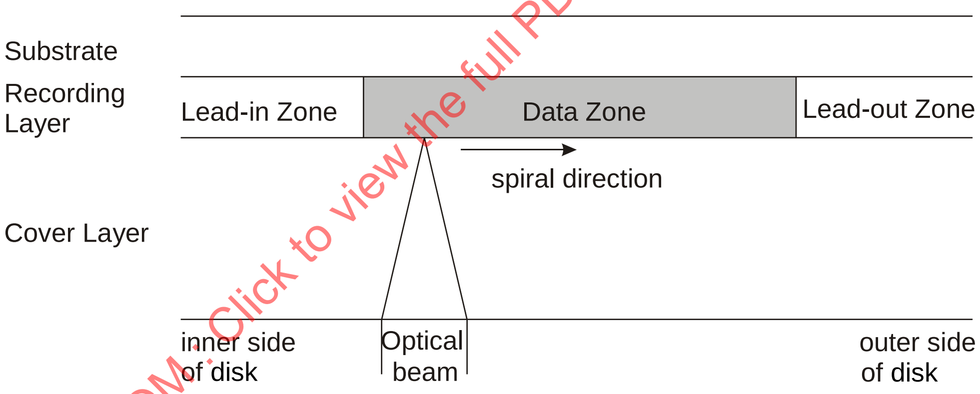

Figure 17 — Subdivision of Information Zone on SL disk

The Lead-in Zone starts in the area extending from diameter 44,0 mm to diameter 44,4 mm and shall end at the beginning of the Data Zone at diameter d_{DZI}.

The Lead-out Zone shall start at the end of the Data Zone at diameter d_{DZO} and shall end at diameter minimum 117 mm.

10.8.3 Subdivision of Information Zone on DL disks

The Information Area is used to record the Information Zone, divided over the two Recording Layers.

The Information Zone is subdivided into the following main parts (see Figure 18):

- on Recording Layer L0:
  - a Lead-in Zone (part of the Inner Zone 0);
  - a Data Zone 0;
  - a Outer Zone 0;

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- on Recording Layer L1:
  - a Outer Zone 1;
  - a Data Zone 1;
  - a Lead-out Zone (part of the Inner Zone 1).

On Layer L0, the Spiral Groove shall run from the inner side of the disk towards the outer side of the disk.

On Layer L1, the Spiral Groove shall run from the outer side of the disk towards the inner side of the disk.

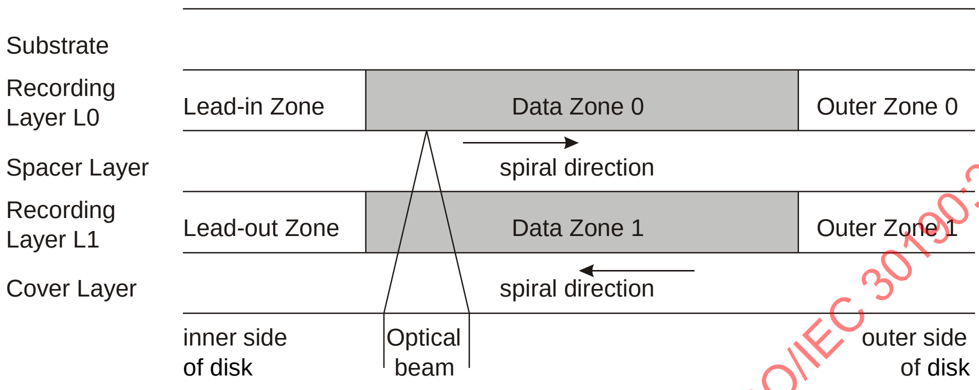

Figure 18 — Subdivision of Information Zone on DL disk

The Lead-in Zone starts in the area extending from diameter 44,0 mm to diameter 44,4 mm and shall end at the beginning of the Data Zone 0 at diameter d_{DZI0}.

The Outer Zone 0 shall start at the end of the Data Zone 0 at diameter d_{DZO0} and shall end at diameter minimum 117 mm.

The Outer Zone 1 shall start at diameter minimum 117 mm and shall end at the beginning of Data Zone 1 at diameter d_{DZO1}.

The Lead-out Zone shall start at the end of the Data Zone 1 at diameter d_{DZI1} and shall end in the area extending from diameter 44,0 mm to diameter 44,4 mm.

10.9 Rim Area

The Rim Area is the area outside the Information Area, starting at d_{10} and extending to the outer diameter of the disk (see Figure 13).

In the first 0,5 mm of the Rim Area, the surface at the read-out side of the disk shall not be outside the Entrance surface in the Information Area.

In the remainder of the Rim Area, the surface at the read-out side of the disk shall not be outside the Entrance surface in the Information Area by maximum h_{13} = 0,05 mm.

In the Rim Area, the surface at the read-out side of the disk may be inside the Entrance surface in the Information Area by maximum h_{14} = 0,12 mm (see Figure 14).

In the Rim Area, the top surface of the disk shall not be outside the top surface in the Information Area by maximum h_{15} = 0,05 mm (see Figure 14).

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11 Mechanical characteristics

11.1 Mass

The mass m of the disk shall be 12 g ≤ m ≤ 17 g.

11.2 Moment of inertia

The moment of inertia of the disk shall be ≤0,032 g·m².

11.3 Dynamic imbalance

The dynamic imbalance of the disk shall be ≤2,5 g·mm.

11.4 Axial runout

11.4.1 General

When measured by an optical system using the Reference servo for axial tracking and with the disk rotating at a scanning velocity of 4,917 m/s (for all capacities), the distance between each Recording Layer and the Disk reference plane R (see Figure 14 and 15) in the direction of the reference axis A shall be maximum h_{12} = 0,3 mm over the entire disk.

Within one Track (one revolution), the deviation of each Recording Layer from its average position in the direction of the reference axis A shall be maximum 0,1 mm.

At the inner side of the disk, rotating at a velocity of 4,917 m/s, this corresponds to a maximum acceleration of about 4,6 m/s², based upon a sinusoidal deviation at the rotational frequency of the disk.

Due to the integrator function in the Reference servo (see 9.10), this component will be suppressed sufficiently such that the residual tracking errors, as defined in 11.4.2 ,11.4.3 and 11.4.4, are mainly due to local disturbances.

11.4.2 Residual axial tracking error for 1x Measurement Velocity

The residual axial tracking error of each Recording Layer for frequencies below 1,6 kHz (= f_X, see 9.10.2), measured using the Reference servo for axial tracking as specified in 9.10.2, shall be maximum 45 nm (displacement of the objective lens needed to move the focal point of the optical beam onto the Recording Layer) with the disk rotating at 1×V_{ref}.

Spikes in the residual axial tracking-error signal due to local defects, such as dust and scratches, shall be excluded.

The measuring filter shall be a Butterworth LPF with f_{-3dB} = 1,6 kHz and slope = –60 dB/decade.

This means that for frequencies <1,6 kHz the maximum local acceleration of the Recording Layer in the direction of the reference axis A will not exceed 6,0 m/s².

The rms-noise value of the residual error signal in the frequency band from 1,6 kHz to 10 kHz, measured with an integration time of 20 ms and using the Reference servo for axial tracking, shall be maximum 32 nm. The measuring filter shall be a Butterworth BPF from f_{-3dB} = 1,6 kHz with slope = +60 dB/decade to f_{-3dB} = 10 kHz with slope = –60 dB/decade.

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11.4.3 Residual axial tracking error for 2x Measurement Velocity

The residual axial tracking error of each Recording Layer for frequencies below 3,2 kHz, measured using the Reference servo for axial tracking as specified in 9.10.2, shall be maximum 80 nm. (displacement of the objective lens needed to move the focal point of the optical beam onto the Recording Layer) with the disk rotating at $2 \times V_{ref}$.

Spikes in the residual axial tracking-error signal due to local defects, such as dust and scratches, shall be excluded. For 2x Measurement Velocity, local defects that cause large axial tracking errors shall be taken into account as described in Annex I.

The measuring filter shall be a Butterworth LPF with f_{-3dB} = 3,2 kHz and slope = –60 dB/decade.

This means that for frequencies <3,2 kHz the maximum local acceleration of the Recording Layer in the direction of the reference axis A will not exceed 10,8 m/s^2 (see 9.10.3). However, due to the additional reduction of low-frequency components by the second order integrator function, the maximum acceleration at frequencies below about 400 Hz can reach values up to 45 m/s^2.

The rms-noise value of the residual error signal in the frequency band from 3,2 kHz to 20 kHz, measured with an integration time of 10 ms and using the Reference servo for axial tracking, shall be maximum 32 nm. The measuring filter shall be a Butterworth BPF from f_{-3dB} = 3,2 kHz with slope = +60 dB/decade to f_{-3dB} = 20 kHz with slope = –60 dB/decade.

11.4.4 Residual axial tracking error for 3x Measurement Velocity

The residual axial tracking error of each Recording Layer for frequencies below 4,8 kHz, measured using the Reference servo for axial tracking as specified in 9.10.3, shall be

a) maximum 80 nm (displacement of the objective lens needed to move the focal point of the optical beam onto the Recording Layer) with the disk rotating at $3 \times V_{ref}$, or

b) maximum 110 nm (displacement of the objective lens needed to move the focal point of the optical beam onto the Recording Layer) with the disk rotating at $3 \times V_{ref}$ if the jitter performance at +/– 10 % power window meets the requirements.

Spikes in the residual axial tracking-error signal due to local defects, such as dust and scratches, shall be excluded. For 3x Measurement Velocity, local defects that cause large axial tracking errors shall be taken into account as described in Annex I.

The measuring filter shall be a Butterworth LPF with f_{-3dB} = 4,8 kHz and slope = –60 dB/decade.

This means that for frequencies <4,8 kHz the maximum local acceleration of the Recording Layer in the direction of the reference axis A will not exceed 14,8 m/s^2 (see 9.10.3). However, due to the additional reduction of low-frequency components by the second order integrator function, the maximum acceleration at frequencies below about 400 Hz can reach values up to 45 m/s^2.

The rms-noise value of the residual error signal in the frequency band from 4,8 kHz to 30 kHz, measured with an integration time of 10 ms and using the Reference servo for axial tracking, shall be maximum 32 nm. The measuring filter shall be a Butterworth BPF, from f_{-3dB} = 4,8 kHz with slope = +60 dB/decade, to f_{-3dB} = 30 kHz with slope = –60 dB/decade.

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11.5 Radial runout

11.5.1 General

The runout of the outer edge of the disk shall be maximum 0,3 mm pp.

The radial runout of the Tracks in each Recording Layer (including eccentricity and unroundness) shall be measured by an optical system using the Reference servo for radial tracking, while the disk is rotating at a scanning velocity of 4,917 m/s (for all capacities).

The radial runout shall be maximum 75 µm pp (SL and DL disks).

At the inner side of the disk, rotating at a velocity of 4,917 m/s, this corresponds to a maximum acceleration of about 1,7 m/s², based upon a sinusoidal deviation at the rotational frequency of the disk.

Due to the integrator function in the Reference servo (see 9.11), this component will be suppressed sufficiently such that the residual tracking errors as defined in 11.5.2, 11.5.3,11.5.4 and 11.5.5 are mainly due to local disturbances.

The residual tracking error shall be determined by applying the radial PP read channel ($I_1 - I_2$) signal for both measurement and radial servo control purposes as indicated in Figure 7.

11.5.2 Residual radial tracking error for 1x Measurement Velocity on SL disks

The residual radial tracking error for frequencies below 1,8 kHz (= f_X, see 9.11.2), measured using the Reference servo for radial tracking as specified in 9.11.2, shall be maximum 9 nm with the disk rotating at 1×V_{ref}.

Spikes in the residual radial tracking-error signal due to local defects, such as dust and scratches, shall be excluded.

The measuring filter shall be a Butterworth LPF with f_{-3dB} = 1,8 kHz and slope = –60 dB/decade.

This means that for frequencies <1,8 kHz the maximum local acceleration of the tracks in the radial direction will not exceed 1,5 m/s².

The rms-noise value of the residual error signal in the frequency band from 1,8 kHz to 10 kHz, measured with an integration time of 20 ms and using the Reference servo for radial tracking, shall be maximum 6,4 nm. The measuring filter shall be a Butterworth BPF from f_{-3dB} = 1,8 kHz with slope = +60 dB/decade to f_{-3dB} = 10 kHz with slope = –60 dB/decade.

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11.5.3 Residual radial tracking error for 1x Measurement Velocity on DL disks

The residual radial tracking error in each Recording Layer for frequencies below 1,8 kHz (= f_X, see 9.11.2), measured using the Reference servo for radial tracking as specified in 9.11.2, shall be maximum 13 nm with the disk rotating at 1 × V_{ref}.

Spikes in the residual radial tracking-error signal due to local defects, such as dust and scratches, shall be excluded.

The measuring filter shall be a Butterworth LPF, with f_{-3dB} = 1,8 kHz and slope = –60 dB/decade. This means that for frequencies <1,8 kHz the maximum acceleration of the tracks in the radial direction will not exceed 2,2 m/s².

The rms-noise value of the residual error signal in the frequency band from 1,8 kHz to 10 kHz, measured with an integration time of 20 ms and using the Reference servo for radial tracking, shall be maximum 9,2 nm. The measuring filter shall be a Butterworth BPF from f_{-3dB} = 1,8 kHz with slope = +60 dB/decade to f_{-3dB} = 10 kHz with slope = –60 dB/decade.

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11.5.4 Residual radial tracking error for 2x Measurement Velocity on SL and DL disks

The residual radial tracking error in each Recording Layer for frequencies below 3,6 kHz, measured using the Reference servo for radial tracking as specified in 9.11.3, shall be maximum 20 nm with the disk rotating at $2 \times V_{ref}$.

Spikes in the residual radial tracking-error signal due to local defects, such as dust and scratches, shall be excluded.

The measuring filter shall be a Butterworth LPF with f_{-3dB} = 3,6 kHz and slope = –60 dB/decade.

This means that for frequencies <3,6 kHz the maximum local acceleration in the radial direction will not exceed 3,4 m/s² (see 9.11.3). However, due to the additional reduction of low-frequency components by the second order integrator function the maximum acceleration at frequencies below about 400 Hz can reach values up to 15 m/s².

The rms-noise value of the residual error signal in the frequency band from 3,6 kHz to 20 kHz, measured with an integration time of 10 ms and using the Reference servo for radial tracking, shall be maximum 9,2 nm. The measuring filter shall be a Butterworth BPF from f_{-3dB} = 3,6 kHz with slope = +60 dB/decade to f_{-3dB} = 20 kHz with slope = –60 dB/decade.

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11.5.5 Residual radial tracking error for 3x Measurement Velocity on SL and DL disks

The residual radial tracking error in each Recording Layer at frequencies below 3,6 kHz, measured using the Reference servo for radial tracking as specified in 9.11.3, shall be maximum 20 nm with the disk rotating at $3 \times V_{ref}$.

Spikes in the residual radial tracking-error signal due to local defects, such as dust and scratches, shall be excluded.

The measuring filter shall be a Butterworth LPF with f_{-3dB} = 3,6 kHz and slope = –60 dB/decade.

This means that for frequencies <3,6 kHz the maximum local acceleration in the radial direction will not exceed 3,4 m/s² (see 9.11.3). However, due to the additional reduction of low-frequency components by the second order integrator function, the maximum acceleration at frequencies below about 400 Hz can reach values up to 15 m/s².

The rms-noise value of the residual error signal in the frequency band from 3,6 kHz to 30 kHz, measured with an integration time of 10 ms and using the Reference servo for radial tracking, shall be maximum 9,2 nm. The measuring filter shall be a Butterworth BPF from f_{-3dB} = 3,6 kHz with slope = +60 dB/decade to f_{-3dB} = 30 kHz with slope = –60 dB/decade.

11.6 Durability of Cover Layer

11.6.1 Impact resistance of Cover Layer

To prevent excessive disk damage in case an object lens hits the Entrance surface at the read-out side of the disk, the surface of the disk should have a minimum impact resistance. This impact resistance can be tested by the procedures described in Annex L.

11.6.2 Scratch resistance of Cover Layer

To prevent excessive scratching, the surface of the disk shall have a minimum hardness. The scratch resistance shall be tested by the procedure described in Annex C.

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11.6.3 Repulsion of fingerprints by Cover Layer

To prevent excessive contamination, the surface of the disk should repel grime as much as possible. The repulsion of grime shall be tested by the procedure described in Annex D.

12 Optical characteristics in Information Area

12.1 General

The following requirements shall be fulfilled within the Information Area of the disk.

These specifications of the Transmission Stacks (TS) include all possible layers on top of the Recording Layer concerned (such as e.g. gluing layers in case of foils, the Spacer Layer and the semi-transparent Recording Layer of Layer L1 in case of TS0, the Cover Layer and possibly a Protective Coating).

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12.2 Refractive index of Transmission Stacks (TS)

If the layers making up the total TS have different refractive indices, then the procedure described in Annex A shall be followed.

The refractive index n of the Cover Layer and Spacer Layer of the disk shall be $1,45 \le n \le 1,70$.

12.3 Thickness of Transmission Stacks (TS)

12.3.1 Thickness of Transmission Stack of SL disks

The average thickness between radius r_a and radius r_b is called the Reference Thickness of the Transmission Stack (TS) on the disk. (see 10.2 and Figure 15).

The thickness of the TS, measured over the whole disk, shall fulfill the following two requirements:

a) the thickness of TS as determined by its refractive index shall be within the upper shaded area in Figure 19 (in case of a refractive index of 1,6 the thickness shall be between 95 µm and 105 µm, and the dashed line indicates the nominal thickness as a function of the refractive index);

b) the maximum deviation ΔD of the thickness of the TS from the Reference Thickness shall meet the requirement $|\Delta D| \le 2,0$ µm.

12.3.2 Thickness of Transmission Stacks of DL disks

The average thickness between radius r_a and radius r_b is called the Reference Thickness of the related Transmission Stack (TS0 or TS1) on the disk.

The thickness of TS0 and TS1, measured over the whole disk, shall fulfill the following four requirements:

a) the thickness of TS0 (all layers on top of Layer L0) as determined by its refractive index shall be within the upper shaded area in Figure 19 (In case of a refractive index of 1,6 the thickness shall be between 95 µm and 105 µm, and the dashed line indicates the nominal thickness as a function of the refractive index);

b) the thickness of TS1 (all layers on top of Layer L1) as determined by its refractive index shall be within the lower shaded area in Figure 19 (In case of a refractive index of 1,6 the thickness shall be between 70 µm and 80 µm, and the dashed line indicates the nominal thickness as a function of the refractive index);

c) the thickness of Spacer Layer shall be between 20 µm and 30 µm;

d) the maximum deviation ΔD of the thicknesses of TS0 and TS1 from their respective Reference Thicknesses shall meet the requirement $|\Delta D| \le 2,0$ µm.

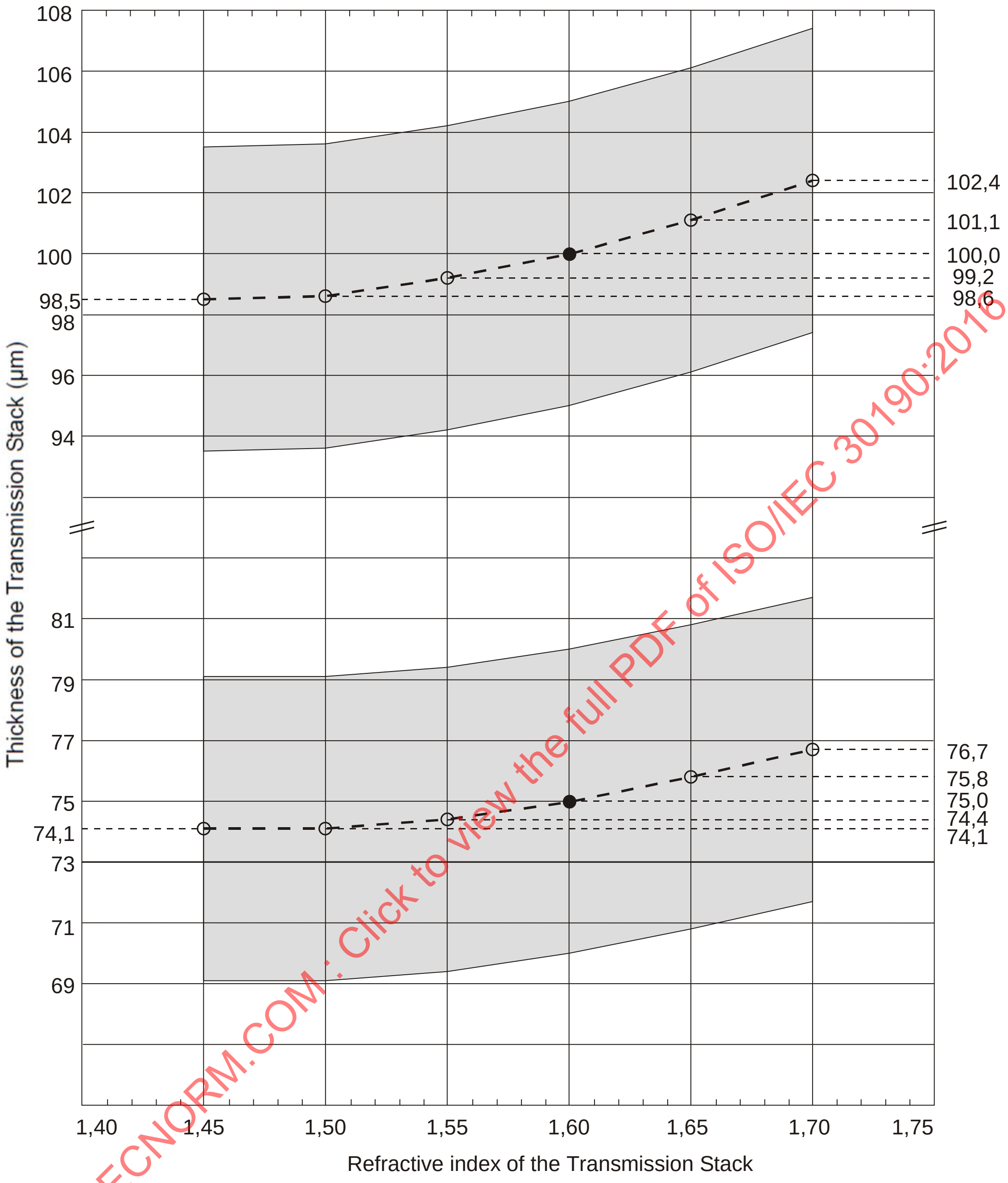

Figure 19 — Thickness of Transmission Stacks as function of reflective index

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12.4 Reflectivity

12.4.1 Reflectivity of Recording Layer of SL disks

The reflectivity of the Recording Layer in the Information Zone, including transmission through the Cover Layer, shall fulfill the following requirements under the measurement conditions of Annex B:

— in Unrecorded Virgin Groove: $R_{g\text{-}v}$ = 12 % to 24 %;

— in Recorded Groove:
  — for HTL disks: R_{8H} = 11 % to 24 %;
  — for LTH disks: R_{8H} = 16 % to 35 %;

— at each location on the disk:
  — for HTL disks: $0{,}75 \times R_{g\text{-}v} < R_{8H} < 1{,}25 \times R_{g\text{-}v}$;
  — for LTH disks: $0{,}75 \times R_{g\text{-}v} < R_{8L} < 1{,}25 \times R_{g\text{-}v}$.

Written Marks shall have a lower reflectivity than the Unrecorded Layer for HTL disks. Written Marks shall have a higher reflectivity than the Unrecorded Layer for LTH disks.

12.4.2 Reflectivity of Recording Layers of DL disks

The reflectivity of the Recording Layer in the Information Zone, including transmission through the Cover Layer, shall fulfill the following requirements under the measurement conditions of Annex B:

— in Unrecorded Virgin Grooves: $R_{g\text{-}v}$ = 4 % to 8 %;

— in Recorded Grooves: R_{8H} = 3,5 % to 8 %;

— at each location on the disk: $0{,}75 \times R_{g\text{-}v} < R_{8H} < 1{,}25 \times R_{g\text{-}v}$.

Written Marks shall have a lower reflectivity than the Unrecorded Layer.

12.5 Birefringence

The in-plane birefringence of the Transmission Stacks shall be (see Annex J) $\Delta n_{//} \leq 1{,}5 \times 10^{-4}$.

The perpendicular birefringence of the Transmission Stacks shall be (see Annex J) $\Delta n_{\perp} \leq 1{,}2 \times 10^{-3}$.

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12.6 Angular deviation

The angular deviation is the angle, *α*, between a parallel incident beam, perpendicular to the Disk reference plane P, and the reflected beam. The incident beam shall have a diameter in the range 0,3 mm to 1,0 mm. The angle, *α*, includes deflections of the Entrance surface and lack of parallelism of the Cover Layer and/or Spacer Layer (see Figure 20).

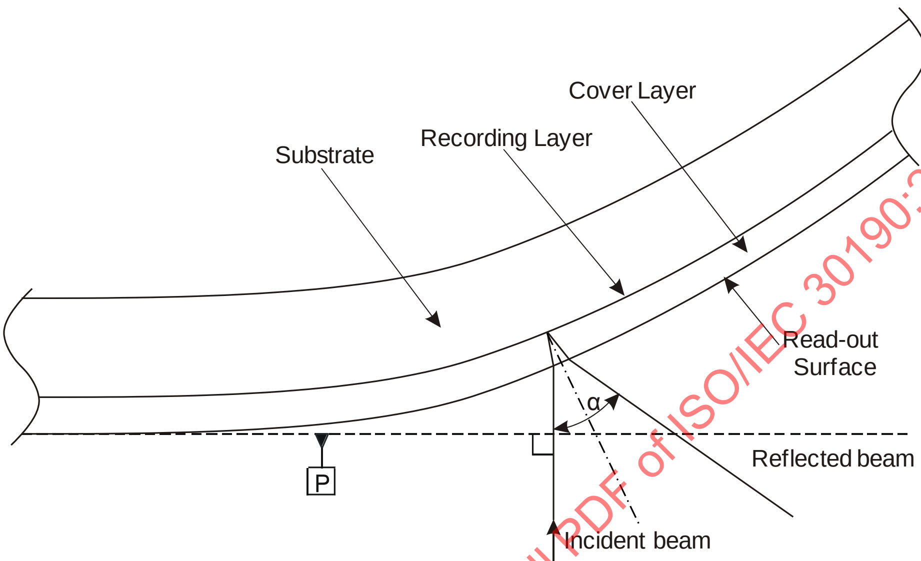

Figure 20 — Definition of angular deviation

The requirements for the angle, *α*, shall be the following:

— in the radial direction:

 — under the normal test conditions specified in 8.1.1: |*α*|max. = 0,60°;

 — under the “sudden change” test conditions specified in 8.1.1: |*α*|max. = 0,70°;

— in the tangential direction:

 — under the normal test conditions specified in 8.1.1: |*α*|max. = 0,30°.

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13 Data Format

13.1 General

The data received from the source (application or host), called User Data Frames, are formatted in a number of steps before being recorded on the disk (see Figure 21).

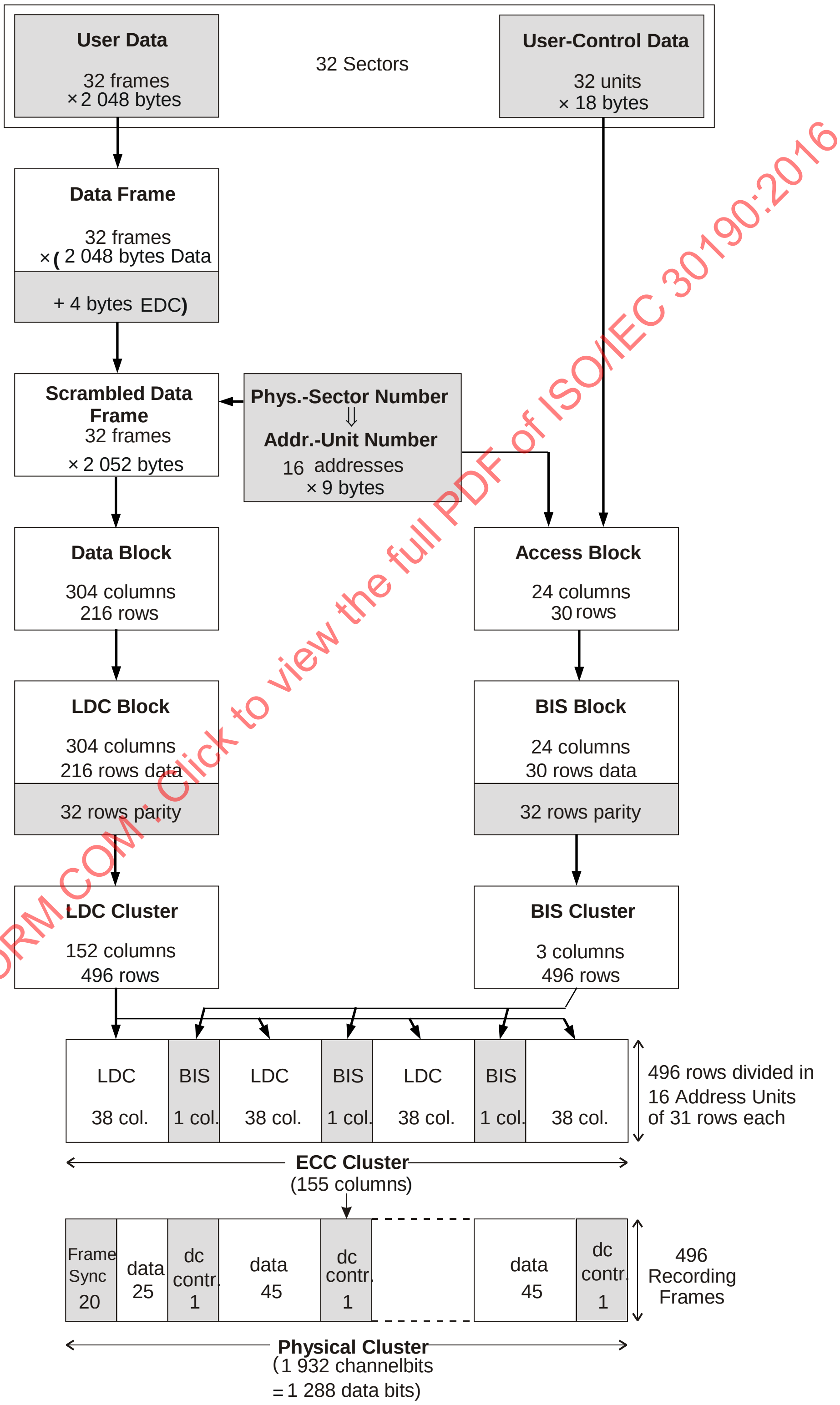

Figure 21 — Schematic representation of encoding process

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They are transferred successively into

— Data Frames, Scrambled Data Frames, a Data Block, an LDC Block and an LDC Cluster.

The address and Control Data, added by the BD Recordable system, are transferred successively into

— an Access Block, a BIS Block, and a BIS Cluster.

The LDC Cluster and the BIS Cluster are multiplexed and modulated into

— an ECC Cluster, subdivided into 16 Address Units, and

— a Physical Cluster, consisting of 496 Recording Frames.

The data on BD Recordable disks is recorded in 64K partitions, called Clusters, containing 32 Data Frames with 2 048 bytes of User Data. These Clusters are protected by two error correction mechanisms.

— First the data is protected by a Long Distance (LDC) Error-Correction Code, consisting of (248,216,33) Reed-Solomon (RS) code-words. This code has ample parities and interleaving length with a good overall efficiency, and can correct both random errors and burst errors.

— Secondly, the data is multiplexed with a powerful Burst-Indicating Subcode (BIS), which consists of (62,30,33) Reed-Solomon (RS) code-words. These BIS code-words carry addresses for allocation purposes and Control Information belonging to the User Data. They can also be used to indicate long burst errors, by means of which the LDC can efficiently perform erasure corrections.

The combination of these two codes is called an “LDC + BIS Code” (see Figure 22).

All the data is arranged in an array as indicated in Figure 22. This array is read in the horizontal direction, row after row, and recorded on the disk after insertion of additional dc-control bits, modulation, and insertion of Synchronization patterns.

The Error-Correction Codes are applied in the vertical direction, which gives a good basic break-up of burst errors on the disk. Additionally, the LDC code-words have been interleaved in a diagonal direction.

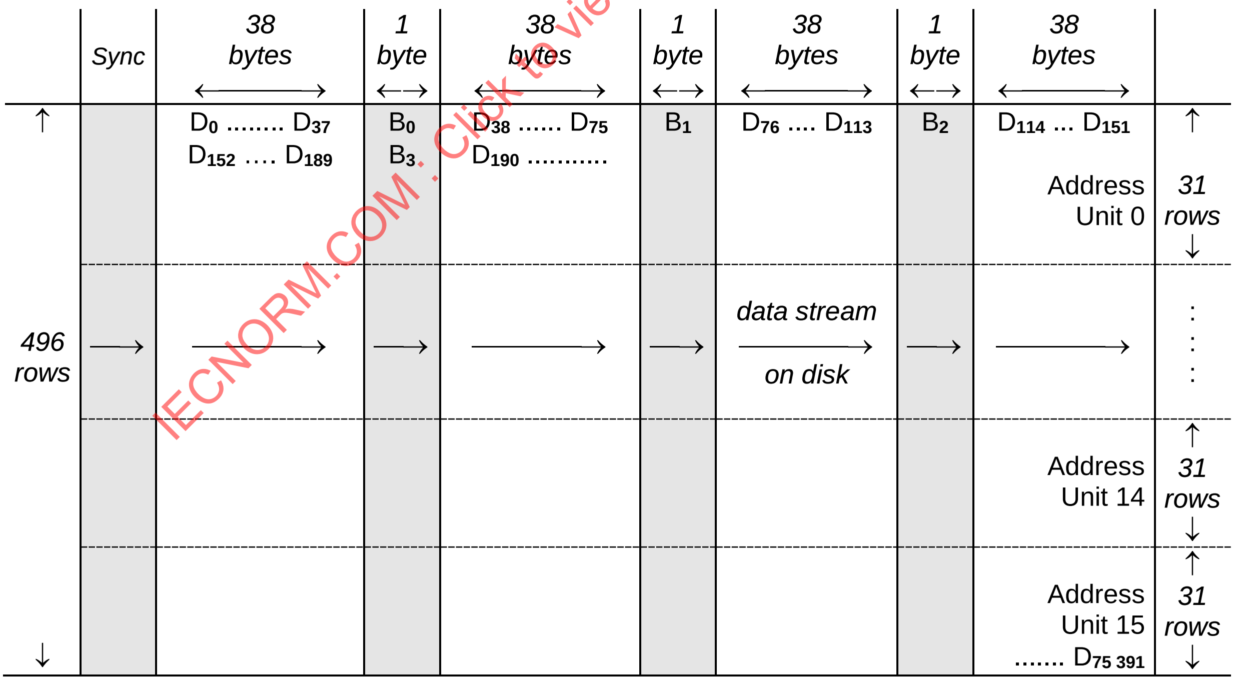

Figure 22 — Schematic representation of Physical Cluster on disk

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Address Units, Physical Sectors and Logical Sectors

Address Units
For the purpose of allocating the optical pick-up to a certain position on the disk, the Physical Cluster is subdivided into 16 Address Units, each consisting of 31 consecutive rows. The Address-Unit Numbers (AUN) provide a fast addressing mechanism embedded in the written data.

Physical Sectors
A Data Frame accompanied by it’s Control Data is called a Sector. All Sectors in all Physical Clusters all over the disk (including the Inner and Outer Zones) are called Physical Sectors. All Physical Sectors have a virtual number assigned, called the Physical-Sector Number (PSN). These PSNs are not recorded onto the disk, however they are synchronized with the AUNs.

Logical Sectors
Not all Physical Sectors are available for storage of User Data delivered by the application or host. The Inner and Outer Zones are excluded. The remaining Sectors are available for storing User Data and are called Logical Sectors.

13.2 Data Frame

A Data Frame consists of 2 052 bytes: 2 048 bytes of User Data and 4 bytes of Error-Detection Code (EDC). The 2 048 User Data bytes are identified as ud_0 to $ud_{2\,047}$ and the 4 EDC bytes as $ed_{2\,048}$ to $ed_{2\,051}$ (see Figure 23).

↑	ud_0	↑
2 048	:	
User Data	:	
bytes	:	*2 052*
↓	$ud_{2\,047}$	*bytes*
↑	$ed_{2\,048}$	
4	$ed_{2\,049}$	
EDC bytes	$ed_{2\,050}$	
↓	$ed_{2\,051}$	↓

Figure 23 — Data Frame

13.3 Error-Detection Code (EDC)

The 4-byte field $ed_{2\,048}$ to $ed_{2\,051}$ shall contain an Error-Detection Code computed over the 2 048 bytes of User Data. Considering the Data Frame as a single-bit field, starting with the most-significant bit of the first User Data byte (ud_0) and ending with the least-significant bit of the last EDC byte ($ed_{2\,051}$), then the msb will be $b_{16\,415}$ and the lsb will be b_0.

Each bit b_i of the EDC is shown as follows for i = 0 to 31:

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

where $I(x) = \sum_{i=16\,415}^{32} b_i x^i$ and $G(x) = x^{32} + x^{31} + x^4 + 1$

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13.4 Scrambled Data Frame

Each Data Frame, consisting of 2 052 bytes of User Data + EDC, shall be scrambled with the output of the circuit defined in Figure 24, in which bits s_7 (msb) to s_0 (lsb) represent a scrambling byte at each 8-bit shift.

The heart of the circuit is a Linear-Feedback Shift Register (LFSR) based on the polynomial

$$\Phi(x) = x^{16} + x^{15} + x^{13} + x^4 + 1$$

Here, s_0 to s_{15} form a 16-bit shift register. At each shift clock the content of s_n shifts to s_{n+1} (n = 0..14), while s_0 is set to $s_{15} \oplus s_{14} \oplus s_{12} \oplus s_3$ ($\oplus$ stands for Exclusive-Or).

At the beginning of the scrambling procedure of each Data Frame, the shift register s_0 to s_{15} shall be preset with a value derived from the (virtual) PSN associated with the Data Frame (see Clause 17). The 16-bit preset value shall be composed in the following way:

— s_{15} shall be set to ONE;

— s_{14} ..s_0 shall be set to PS_{19} .. PS_5 of the PSN (see Figure 24);

The same preset value shall be used for all 32 Data Frames within the same Cluster.

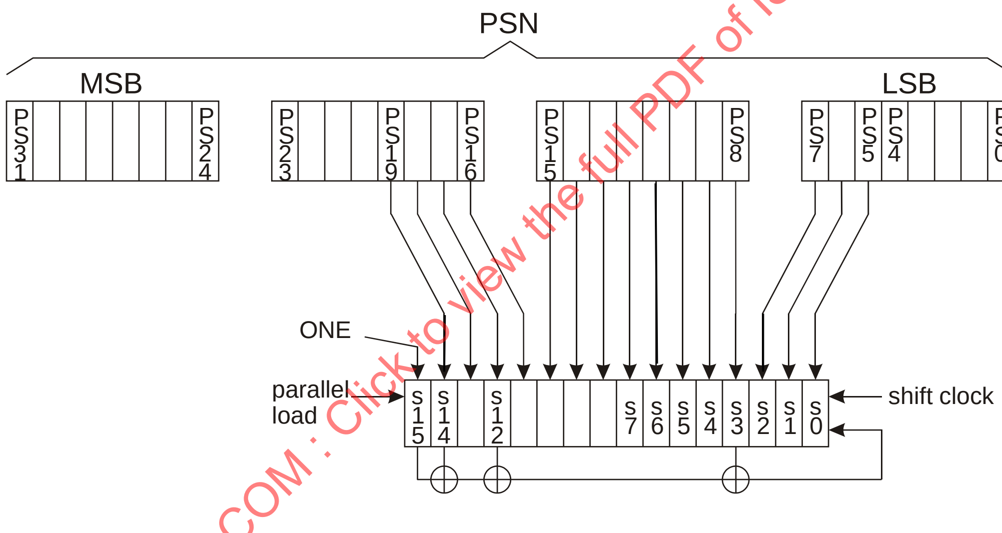

Figure 24 — Scrambler circuit

After loading the preset value, s_7 .. s_0 are taken out as scrambling byte S_0. Then, an 8-bit shift is repeated 2 051 times and the following 2 051 bytes are taken from s_7 .. s_0 as the scrambling bytes S_1 to $S_{2\,051}$.
The 2 052 bytes ud/ed_k of the Data Frame become scrambled bytes d_k where

$d_k = ud/ed_k \oplus S_k$ for k = 0 to 2 051; ($\oplus$ stands for Exclusive-Or)

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13.5 Data Block

In the next step, 32 Scrambled Data Frames (F = 0..31) are combined into one block of data (see Figure 25).

	←		*32 Frames*			→
	0	1	:	*F*	:	31
↑	$d_{0,0}$	$d_{0,1}$	:	$d_{0,F}$	:	$d_{0,31}$
	$d_{1,0}$	$d_{1,1}$	:	$d_{1,F}$	:	$d_{1,31}$
2 052	:		:	:	:	:
bytes	:		:	:	:	:
	$d_{2\,050,0}$	$d_{2\,050,1}$	:	$d_{2\,050,F}$	:	$d_{2\,050,31}$
↓	$d_{2\,051,0}$	$d_{2\,051,1}$	:	$d_{2\,051,F}$	:	$d_{2\,051,31}$

Figure 25 — 32 Scrambled Data Frames

These data are rearranged into an array of 216 rows × 304 columns by dividing each Scrambled Data Frame into 9,5 columns as shown in Figure 26. This new array is called a Data Block. It should be noted that every even Scrambled Data Frame ends halfway down a column, and every odd Scrambled Data Frame starts halfway down a column.

	←				*304 columns*					→
	0	1	:	9	10	:	18	19		303
↑	$d_{0,0}$	$d_{216,0}$	:	$d_{1\,944,0}$	$d_{108,1}$	:	$d_{1\,836,1}$	$d_{0,2}$	:	$d_{1\,836,31}$
	$d_{1,0}$	$d_{217,0}$	:	$d_{1\,945,0}$	$d_{109,1}$	:	$d_{1\,837,1}$	$d_{1,2}$	:	$d_{1\,837,31}$
	:	:	:	:	:	:	:	:	:	:
	:	:	:	$d_{2\,050,0}$	:	:	:	:	:	:
216	:	:	:	$d_{2\,051,0}$	:	:	:	:	:	:
rows	:	:	:	$d_{0,1}$	:	:	:	:	:	:
	:	:	:	$d_{1,1}$	:	:	:	:	:	:
	:	:	:	:	:	:	:	:	:	:
	:	:	:	$d_{106,1}$	:	:	:	:	:	:
↓	$d_{215,0}$	$d_{431,0}$	:	$d_{107,1}$	$d_{323,1}$	:	$d_{2\,051,1}$	$d_{215,2}$	:	$d_{2\,051,31}$

Figure 26 — Composition of Data Block from 32 Scrambled Data Frames

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13.6 LDC Block

The bytes in each column of the Data Block are renumbered as shown in Figure 27 starting from the top of each column as follows: $e_{0,L}$ $e_{1,L}$ .. $e_{i,L}$ .. to $e_{215,L}$, in which L represents the code-word number (= the column number: 0 to 303).

The LDC Block is completed by extending each of the columns with 32 Parity bytes according to a (248,216,33) Long-Distance RS Code. The Parity bytes are numbered: $p_{216,L}$ $p_{217,L}$ .. $p_{j,L}$ .. to $p_{247,L}$.

		←			*304 columns*			→
		Code word 0	Code word 1	:	Code word *L*	:	Code word 302	Code word 303
↑	↑	$e_{0,0}$	$e_{0,1}$	:	$e_{0,L}$	:	$e_{0,302}$	$e_{0,303}$
	216	$e_{1,0}$	$e_{1,1}$	:	$e_{1,L}$	:	$e_{1,302}$	$e_{1,303}$
	rows	$e_{2,0}$	:	:	:	:	:	:
	with	:	:	:	:	:	:	:
1 LDC	*data*	:	:	:	:	:	:	:
code-word	↓	$e_{215,0}$	$e_{215,1}$	:	$e_{215,L}$	:	$e_{215,302}$	$e_{215,303}$
= 248	↑	$p_{216,0}$	$p_{216,1}$	:	$p_{216,L}$	:	$p_{216,302}$	$p_{216,303}$
bytes	*32*	:	:	:	:	:	:	:
	rows	:	:	:	:	:	:	:
	with	:	:	:	:	:	:	:
	parity	:	:	:	:	:	:	:
↓	↓	$p_{247,0}$	$p_{247,1}$	:	$p_{247,L}$	:	$p_{247,302}$	$p_{247,303}$

Figure 27 — Renumbering data bytes and forming LDC Block by adding parities

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13.7 LDC code-words

The Long-Distance RS Code is defined over the finite field GF(2^8). The non-zero elements of the finite field GF(2^8) are generated by a primitive element α, where α is a root of the primitive polynomial $p(x)$.

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

The symbols of GF(2^8) are represented by bytes (groups of 8 bits), using the polynomial-base representation, with (α^7, α^6, α^5, .. , α^2, α, 1) as a basis. The root α is thus represented as

$$\alpha = 00000010$$

Each LDC code-word, represented by the vector l_{dc} = ($e_{0,L}$ .. $e_{i,L}$ .. $e_{215,L}$ $p_{216,L}$ .. $p_{j,L}$ .. $p_{247,L}$), is a Reed-Solomon code over GF(2^8) having 32 parity bytes and 216 information bytes. Such a code word can be represented by a polynomial $l_{dc}(x)$ of degree 247 (possibly having some coefficients equal to zero), where the highest degrees correspond to the information part of the vector ($e_{0,L}$ .. etc.) and the lowest degrees correspond to the parity part of the vector ($p_{216,L}$ .. etc.).

$l_{dc}(x)$ is a multiple of the generator polynomial $g(x)$ of the LDC code-word. The generator polynomial equals

$$g(x) = \prod_{i=0}^{31} \left(x - \alpha^i\right)$$

The LDC is systematic. The 216 information bytes appear unaltered in the highest-degree positions of each code word. The parity-check matrix H_{LDC} of code l_{dc} is such that

$$H_{LDC} \times l_{dc}^T = 0 \text{ for all LDC code-words } l_{dc}$$

The second row, $h_{LDC\ 2}$, of the parity-check matrix, H_{LDC}, corresponding to the zero α of the generator polynomial $g(x)$, defines the code-word positions to be used for error locations. This second row, h_{LDC2}, of the parity-check matrix, H_{LDC}, is given by the formula below.

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$h_{\text{LDC 2}} = (\alpha^{247}, \alpha^{246} \,..\, \alpha^{2}, \alpha, 1)$

13.8 LDC Cluster

13.8.1 General

After generating the LDC code-words, the LDC Block is interleaved in a two-step process resulting in the LDC Cluster.

13.8.2 First interleaving step

In the first interleaving step, the 304 columns of height 248 are rearranged into a new array with 152 columns and 496 rows.

Each new column is formed by multiplexing each even column from the LDC Block with the next odd column. The new column is filled by taking the first byte from the even LDC Block column, then the first byte from the odd LDC Block column, next the second byte from the even LDC Block column, followed by the second byte from the odd LDC Block column, etc. as shown in Figure 28.

	←		*152 columns*		→	
	0	1			151	
↑	$e_{0,0}$	$e_{0,2}$	:	:	$e_{0,302}$	↑
	$e_{0,1}$	$e_{0,3}$	:	:	$e_{0,303}$	
432	$e_{1,0}$	$e_{1,2}$	:	:	$e_{1,302}$	
rows	$e_{1,1}$	$e_{1,3}$	:	:	$e_{1,303}$	
with	:	:	:	:	:	
data	:	:	:	:	:	
	$e_{215,0}$	$e_{215,2}$	:	:	$e_{215,302}$	
↓	$e_{215,1}$	$e_{215,3}$	:	:	$e_{215,303}$	*496*
↑	$p_{216,0}$	$p_{216,2}$	:	:	$p_{216,302}$	*rows*
	$p_{216,1}$	$p_{216,3}$	:	:	$p_{216,303}$	
64	$p_{217,0}$	$p_{217,2}$	:	:	$p_{217,302}$	
rows	$p_{217,1}$	$p_{217,3}$	:	:	$p_{217,303}$	
with	:	:	:	:	:	
parity	:	:	:	:	:	
	$p_{247,0}$	$p_{247,2}$	:	:	$p_{247,302}$	
↓	$p_{247,1}$	$p_{247,3}$	:	:	$p_{247,303}$	↓

Figure 28 — First step of interleaving

13.8.3 Second interleaving step

To reduce the influence of error propagation and further improve the burst-error correcting capabilities, an additional interleaving is introduced.

All rows of an LDC Block, resulting from the first interleaving step, shall be shifted over mod(k × 3, 152) bytes to the left where k = div(row_number,2), 0 ≤ row_number ≤495. The bytes that shift out at the left side are re-entered in the array from the right side (see Figure 29).

After this process, the bytes are renumbered in the horizontal direction through all the rows resulting in the numbering D_0 to $D_{75\,391}$ as indicated in Figure 22.

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	← 152 bytes →																
← *shift 0*	$e_{0,0}$	$e_{0,2}$		…						…						$e_{0,300}$	$e_{0,302}$
	$e_{0,1}$	$e_{0,3}$		…						…						$e_{0,301}$	$e_{0,303}$
← *shift 3*	$e_{1,6}$	$e_{1,8}$		…						…			$e_{1,300}$	$e_{1,302}$	$e_{1,0}$	$e_{1,2}$	$e_{1,4}$
	$e_{1,7}$	$e_{1,9}$		…						…			$e_{1,301}$	$e_{1,303}$	$e_{1,1}$	$e_{1,3}$	$e_{1,5}$
← *shift 6*	$e_{2,12}$	$e_{2,14}$		…						…	$e_{2,302}$	$e_{2,0}$	$e_{2,2}$	$e_{2,4}$	$e_{2,6}$	$e_{2,8}$	$e_{2,10}$
	$e_{2,13}$	$e_{2,15}$		…						…	$e_{2,303}$	$e_{2,1}$	$e_{2,3}$	$e_{2,5}$	$e_{2,7}$	$e_{2,9}$	$e_{2,11}$
	…	…		…						…							
	…	…		…						…							
← *shift 150*	$e_{50,300}$	$e_{50,302}$	$e_{50,0}$	…						…							$e_{50,298}$
	$e_{50,301}$	$e_{50,303}$	$e_{50,1}$	…						…							$e_{50,299}$
← *shift 1*	$e_{51,2}$	$e_{51,4}$		…						…					$e_{51,300}$	$e_{51,302}$	$e_{51,0}$
	$e_{51,3}$	$e_{51,5}$		…						…					$e_{51,301}$	$e_{51,303}$	$e_{51,1}$
	…	…		…						…							
	…	…		…						…							
← *shift mod(k×3, 152)*	…	…		…						…							
	…	…		…						…							
	…	…		…						…							
	…	…		…						…							
← *shift 130*	$p_{246,260}$	$p_{246,262}$		…				$p_{246,302}$	$p_{246,0}$	…							$p_{246,258}$
	$p_{246,261}$	$p_{246,263}$		…				$p_{246,303}$	$p_{246,1}$	…							$p_{246,259}$
← *shift 133*	$p_{247,266}$	$p_{247,268}$		…	$p_{247,302}$	$p_{247,0}$	$p_{247,2}$	$p_{247,4}$	$p_{247,6}$	…							$p_{247,264}$
	$p_{247,267}$	$p_{247,269}$		…	$p_{247,303}$	$p_{247,1}$	$p_{247,3}$	$p_{247,5}$	$p_{247,7}$	…							$p_{247,265}$

Figure 29 — LDC Cluster

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13.9 Addressing and Control Data

13.9.1 General

For the purpose of accessing the data on the disk, addressing and Control Data is included.

13.9.2 Address Units

13.9.2.1 General

For positioning the optical head onto the desired Track, a fast addressing mechanism is implemented by subdividing the 64K Physical Clusters into 16 Address Units. Each Address Unit contains an address, which is placed in such a way into the BIS code-words (see 13.11) that it can be accessed quickly (see Figure 30).

Each Address Field consists of 9 bytes:
- 4 bytes for the Address-Unit Number (see Clause 17);
- 1 byte for flag bits;
- 4 bytes for error correction.

		←		*16 addresses*			→
		0	1	:	*s*	:	15
↑	Address-Unit Numbers	$AF_{0,0}$	$AF_{0,1}$	:	$AF_{0,s}$	:	$AF_{0,15}$
		$AF_{1,0}$	$AF_{1,1}$	:	:	:	$AF_{1,15}$
		:	:	:	:	:	:
9		$AF_{3,0}$	$AF_{3,1}$	:	$AF_{3,s}$	:	$AF_{3,15}$
bytes	Flag bits	$AF_{4,0}$	$AF_{4,1}$	:	$AF_{4,s}$	:	$AF_{4,15}$
	Parities	$AF_{5,0}$	$AF_{5,1}$	:	$AF_{5,s}$	:	$AF_{5,15}$
		:	:	:	:	:	:
↓		$AF_{8,0}$	$AF_{8,1}$	:	$AF_{8,s}$	:	$AF_{8,15}$

Figure 30 — 16 Address Fields

13.9.2.2 Byte assignment for Address Fields

$AF_{0,s}$ = MSB of the Address-Unit Number.
$AF_{1,s}$ = 2nd SB of the Address-Unit Number.
$AF_{2,s}$ = 3rd SB of the Address-Unit Number.
$AF_{3,s}$ = LSB of the Address-Unit Number.
$AF_{4,s}$ = flag bits: These bits can be used to indicate a status of individual Data Frames in a Cluster or can be used to hold other information, such as an address. The basic format for assigning some of these flag bits is specified in 13.9.2.4. Flag bits not used shall be set to ZERO.
$AF_{5,s}$ .. $AF_{8,s}$ = parity bytes for forming an (9,5,5) RS code over the Address Field.

This RS code is defined over the finite field GF(2^8). The non-zero elements of the finite field GF(2^8) are generated by a primitive element α, where α is a root of the primitive polynomial $p(x)$.

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

The symbols of GF(2^8) are represented by bytes (groups of 8 bits), using the polynomial-base representation with ($\alpha^7, \alpha^6, \alpha^5, .., \alpha^2, \alpha, 1$) as a basis. The root α is thus represented as

$$\alpha = 00000010$$

Each Address-Field code-word, represented by the vector afc = ($AF_{0,s}$ .. $AF_{i,s}$ .. $AF_{8,s}$), is a Reed-Solomon code over GF(2^8) having 4 parity bytes and 5 information bytes. Such a code word can be represented by a polynomial $afc(x)$ of degree 8 (possibly having some coefficients equal to zero), where the highest degrees correspond to the information part of the vector ($AF_{0,s}$ .. etc.) and the lowest degrees correspond to the parity part of the vector ($AF_{5,s}$ .. etc.).

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afc(*x*) is a multiple of the generator polynomial *g*(*x*) of the Address-Field code-word. The generator polynomial equals

$$g(x)=\prod_{i=0}^{3}\left(x-\alpha^{i}\right)$$

The Address-Field code is systematic. The 5 information bytes appear unaltered in the highest-degree positions of each code word. The parity-check matrix H_{AFC} of code *afc* is such that

$$H_{AFC} \times afc^{T} = 0 \text{ for all Address-Field code-words } afc$$

The second row, $h_{AFC\ 2}$, of the parity-check matrix, H_{AFC}, corresponding to the zero α of the generator polynomial $g(x)$, defines the code-word positions to be used for error locations. This second row, $h_{AFC\ 2}$, of the parity-check matrix H_{AFC} is given by

$$h_{AFC\ 2} = (\alpha^{8}, \alpha^{7} .. \alpha^{2}, \alpha, 1)$$

13.9.2.3 Address-Unit Numbers

The 16 Address Fields to be recorded in the BIS columns of the Physical Cluster each contain a 4-byte Address-Unit Number (AUN).

The Address-Unit Numbers shall be derived from the Physical-Sector Numbers (PSN) as defined in Figure 31.

The Address-Unit Numbers increase by two for each successive Address Unit, for reasons of synchronization with the PSNs (see Clause 17).

The Address-Unit Number of the first Address Unit of each Physical Cluster is a multiple of 32.

The first Address-Unit Number in Data Zone 0 will be 00 10 00 00h (1 048 576 decimal).

The last Address-Unit Number in Data Zone 1 will be 01 EF FF FEh (32 505 854 decimal).

The bits of the Address-Unit Numbers shall be set as follows.

- AU_{31} .. AU_{5} shall be a copy of PS_{31} .. PS_{5} from the PSNs.
- AU_{4} .. AU_{1} shall count from 0 to 15 inside the Physical Cluster.
- AU_{0} shall be Reserved.

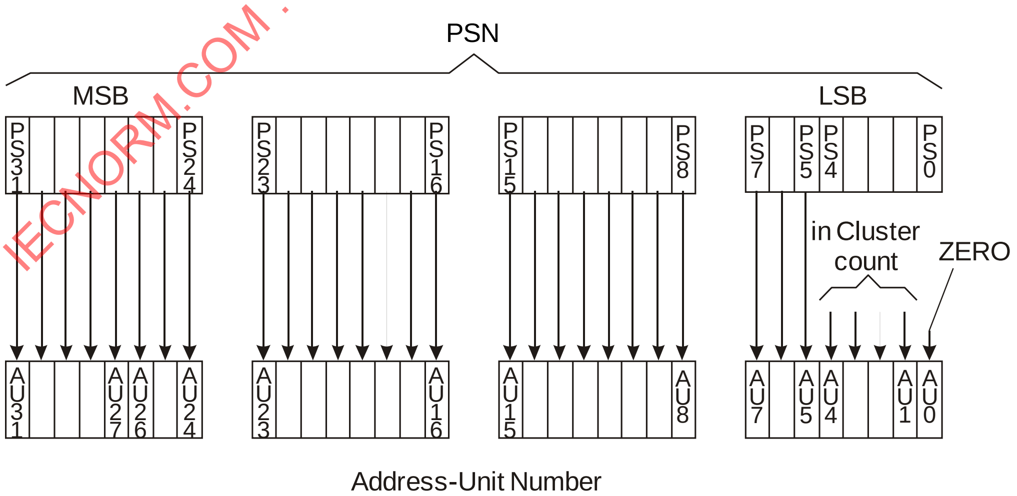

Figure 31 — Composition of AUNs from PSNs

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13.9.2.4 Assignments for flag bits

Bit / Byte $AF_{4,s}$	b_7	b_6	b_5	b_4	b_3	b_2	b_1	b_0
$AF_{4,0}$	$Sa_{0,1}$	$Sa_{1,1}$	$Sa_{0,0}$	$Sa_{1,0}$	Rsv	Rsv	Rsv	Rsv
$AF_{4,1}$	$Sa_{2,1}$	$Sa_{3,1}$	$Sa_{2,0}$	$Sa_{3,0}$	Rsv	Rsv	Rsv	Rsv
$AF_{4,2}$	$Sa_{4,1}$	$Sa_{5,1}$	$Sa_{4,0}$	$Sa_{5,0}$	Rsv	Rsv	Rsv	Rsv
$AF_{4,3}$	$Sa_{6,1}$	$Sa_{7,1}$	$Sa_{6,0}$	$Sa_{7,0}$	Rsv	Rsv	Rsv	Rsv
$AF_{4,4}$	$Sa_{8,1}$	$Sa_{9,1}$	$Sa_{8,0}$	$Sa_{9,0}$	Rsv	Rsv	Rsv	Rsv
$AF_{4,5}$	$Sa_{10,1}$	$Sa_{11,1}$	$Sa_{10,0}$	$Sa_{11,0}$	Rsv	Rsv	Rsv	Rsv
$AF_{4,6}$	$Sa_{12,1}$	$Sa_{13,1}$	$Sa_{12,0}$	$Sa_{13,0}$	Rsv	Rsv	Rsv	Rsv
$AF_{4,7}$	$Sa_{14,1}$	$Sa_{15,1}$	$Sa_{14,0}$	$Sa_{15,0}$	Rsv	Rsv	Rsv	Rsv
$AF_{4,8}$	$Sa_{16,1}$	$Sa_{17,1}$	$Sa_{16,0}$	$Sa_{17,0}$	Rsv	Rsv	Rsv	Rsv
$AF_{4,9}$	$Sa_{18,1}$	$Sa_{19,1}$	$Sa_{18,0}$	$Sa_{19,0}$	Rsv	Rsv	Rsv	Rsv
$AF_{4,10}$	$Sa_{20,1}$	$Sa_{21,1}$	$Sa_{20,0}$	$Sa_{21,0}$	Rsv	Rsv	Rsv	Rsv
$AF_{4,11}$	$Sa_{22,1}$	$Sa_{23,1}$	$Sa_{22,0}$	$Sa_{23,0}$	Rsv	Rsv	Rsv	Rsv
$AF_{4,12}$	$Sa_{24,1}$	$Sa_{25,1}$	$Sa_{24,0}$	$Sa_{25,0}$	Rsv	Rsv	Rsv	Rsv
$AF_{4,13}$	$Sa_{26,1}$	$Sa_{27,1}$	$Sa_{26,0}$	$Sa_{27,0}$	Rsv	Rsv	Rsv	Rsv
$AF_{4,14}$	$Sa_{28,1}$	$Sa_{29,1}$	$Sa_{28,0}$	$Sa_{29,0}$	Rsv	Rsv	Rsv	Rsv
$AF_{4,15}$	$Sa_{30,1}$	$Sa_{31,1}$	$Sa_{30,0}$	$Sa_{31,0}$	Rsv	Rsv	Rsv	Rsv

Rsv : Reserved unless otherwise specified by the Application

Figure 32 — Flag bits from 16 Address Fields

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Status bits $Sa_{i,j}$ ($0 \le i \le 31$, $0 \le j \le 1$): Because each Cluster contains 32 Data Frames and there are only 16 Address Units, each such Address Unit has to hold the flag bits for 2 Data Frames (see Figure 32).

Bit b_7 and bit b_5 of successive flag bytes $AF_{4,S}$ are defined as status bits $Sa_{2S,1}$ and $Sa_{2S,0}$, respectively, for Data Frame 2*S*.

Bit b_6 and bit b_4 of successive flag bytes $AF_{4,S}$ are defined as status bits $Sa_{2S+1,1}$ and $Sa_{2S+1,0}$, respectively, for Data Frame 2*S*+1.

Bits b_3 to b_0 of all flag bytes $AF_{4,S}$ shall be Reserved unless otherwise specified by the Application.

13.9.2.5 Usage of status bits $Sa_{i,j}$

Each pair of status bits $Sa_{i,1}/Sa_{i,0}$ is used to indicate the status of an individual Data Frame in a Cluster. The following settings are defined:

$Sa_{i,1}/Sa_{i,0}$ = 00: the Data Frame contains general User Data;

11: the Data Frame contains Padding data inserted by the drive to complete Clusters before recording them onto the disk;

other settings: Reserved unless otherwise specified by the Application.

In the User-Data Area, the status bits $Sa_{i,1}/Sa_{i,0}$ shall be set to 11 in Data Frames that have been inserted by the drive to complete Clusters before recording them onto the disk (Padding).

In other cases, where the data for Data Frame *i* is supplied by the host, the status bits $Sa_{i,1}/Sa_{i,0}$ shall be set to 00.

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13.9.3 User-Control Data

For accessing the User Data, special Control Data can be added to each User Data Frame. These additional bytes can carry Application-dependent information. A User Data Frame accompanied by its User-Control Data Unit is called a Sector. Each User-Control Data Unit consists of 18 bytes (see Figure 33).

	←		*32 Units*			→
	0	1	:	*S*	:	31
↑	$UC_{0,0}$	$UC_{0,1}$	:	$UC_{0,s}$	:	$UC_{0,31}$
	$UC_{1,0}$	$UC_{1,1}$	:	:	:	$UC_{1,31}$
18 bytes	:	:	:	:	:	:
	:	:	:	:	:	:
↓	$UC_{17,0}$	$UC_{17,1}$	:	$UC_{17,s}$	:	$UC_{17,31}$

Figure 33 — 32 User-Control Data Units

13.9.4 Byte/Bit assignment for User-Control Data

The User-Control Data bytes are Application dependent. If this setting is not specified by the Application, these bytes shall be set to 00h.

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	← *24 columns* →															
↑	$AF_{0,0}$	$AF_{1,0}$	$AF_{2,0}$	$AF_{0,7}$	$AF_{1,7}$	$AF_{2,7}$	$AF_{0,6}$	$AF_{1,6}$	$AF_{2,6}$	$AF_{0,5}$	:	:	$AF_{0,1}$	$AF_{1,1}$	$AF_{2,1}$	↑
6 rows	$AF_{0,8}$	$AF_{1,8}$	$AF_{2,8}$	$AF_{0,15}$	:	:	$AF_{0,14}$	:	:	$AF_{0,13}$	:	:	$AF_{0,9}$	$AF_{1,9}$	$AF_{2,9}$	
with	$AF_{4,1}$	$AF_{5,1}$	$AF_{3,1}$	$AF_{4,0}$	$AF_{5,0}$	$AF_{3,0}$	$AF_{4,7}$	$AF_{5,7}$	$AF_{3,7}$	$AF_{4,6}$	:	:	$AF_{4,2}$	$AF_{5,2}$	$AF_{3,2}$	
Physical	$AF_{4,9}$	:	:	$AF_{4,8}$	$AF_{5,8}$	$AF_{3,8}$	$AF_{4,15}$	:	:	$AF_{4,14}$	:	:	$AF_{4,10}$	$AF_{5,10}$	$AF_{3,10}$	
Addresses	$AF_{8,2}$	$AF_{6,2}$	$AF_{7,2}$	$AF_{8,1}$	$AF_{6,1}$	$AF_{7,1}$	$AF_{8,0}$	$AF_{6,0}$	$AF_{7,0}$	$AF_{8,7}$	:	:	$AF_{8,3}$	$AF_{6,3}$	$AF_{7,3}$	
↓	$AF_{8,10}$	:	:	$AF_{8,9}$	:	:	$AF_{8,8}$	$AF_{6,8}$	$AF_{7,8}$	$AF_{8,15}$	:	:	$AF_{8,11}$	$AF_{6,11}$	$AF_{7,11}$	
↑	$UC_{0,0}$	$UC_{6,1}$	$UC_{12,2}$	$UC_{0,4}$	:	:	:	:	:	:	:	:	:	:	$UC_{12,30}$	
	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	
	:	:	$UC_{17,2}$	:	:	:	:	:	:	:	:	:	:	:	$UC_{17,30}$	*30*
24 rows	:	:	$UC_{0,3}$	:	:	:	:	:	:	:	:	:	:	:	$UC_{0,31}$	*rows*
with	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	
User	:	$UC_{17,1}$	:	:	:	:	:	:	:	:	:	:	:	:	:	
Control	:	$UC_{0,2}$	:	:	:	:	:	:	:	:	:	:	:	$UC_{0,30}$	:	
Data	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	
	$UC_{17,0}$	:	:	$UC_{17,4}$	:	:	:	:	:	:	:	:	:	:	:	
	$UC_{0,1}$	:	:	$UC_{0,5}$	:	:	:	:	:	:	:	:	:	:	:	
	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	
↓	$UC_{5,1}$	$UC_{11,2}$	$UC_{17,3}$	:	:	:	:	:	:	:	:	:	:	$UC_{11,30}$	$UC_{17,31}$	↓

Figure 34 — Composition of Access Block

(from 16 Address Fields and 32 User-Control Data Units)

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13.10 Access Block

The data for the Address Fields and User-Control Data Units is mapped into an array of 30 rows × 24 columns, that is called an Access Block.

Because of the need for a fast access of the Address Fields, the data for these Address Fields is mapped in a special pre-interleaved way.

The 9 bytes of each of the 16 addresses (see Figure 34) are grouped into three groups of 3 bytes.

The three groups of bytes of each of the addresses 0 to 7 are placed in the Access Block in a diagonal direction in the first, third and fifth row, starting with address 0 and each successive address shifted cyclically three positions to the left (see Figure 34).

The three groups of bytes of each of the addresses 8 to 15 are placed in a diagonal direction in the second, fourth and sixth row, starting with address 8 and each successive address shifted cyclically three positions to the left.

Within each group of bytes in the third and fourth rows, the bytes are shifted cyclically to the left over 1 byte position.

Within each group of bytes in the fifth and sixth rows, the bytes are shifted cyclically to the left over 2 byte positions.

Mathematically, this mapping of the address bytes into the Access Block can be represented by the following formulae:

byte $AF_{x,y}$ shall be allocated in: row $r = 2 \times \text{div}(x,3) + \text{div}(y,8)$
and column $c = 3 \times \text{mod}\{[\text{div}(x,3) + 16 - y],8\} + \text{mod}\{[x - \text{div}(x,3)],3\}$

The User-Control Data Unit is placed in the column direction, whereby each User-Control Data Unit only fills ¾ of a column (4 User-Control Data Units in 3 full columns; see Figure 34).

13.11 BIS Block

The bytes in each column of an Access Block are renumbered as shown in Figure 35 starting from the top of each column as follows: $b_{0,C}$ $b_{1,C}$ .. $b_{i,C}$ .. to $b_{29,C}$, where C represents the code-word number (= the column number: 0 to 23).

The BIS Block is completed by extending each of the columns with 32 Parity bytes according to a (62,30,33) RS code. The Parity bytes are numbered: $pb_{30,C}$ $pb_{31,C}$ .. $pb_{j,C}$ .. to $pb_{61,C}$.

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		← 24 columns →						
		Code word 0	Code word 1	:	Code word *C*	:	Code word 22	Code word 23
↑ *One BIS code-word* *= 62 bytes*	↑ *30 Information bytes* ↓	$b_{0,0}$ $b_{1,0}$: : : $b_{29,0}$	$b_{0,1}$ $b_{1,1}$: : : $b_{29,1}$	: : : : : :	$b_{0,C}$ $b_{1,C}$: $b_{N,C}$: $b_{29,C}$	: : : : : :	: : : : : :	$b_{0,23}$ $b_{1,23}$: : : $b_{29,23}$
↓	↑ *32 Parity bytes* ↓	$pb_{30,0}$: : : $pb_{61,0}$	$pb_{30,1}$: : : $pb_{61,1}$	: : : : :	$pb_{30,C}$: : : $pb_{61,C}$	: : : : :	: : : : :	$pb_{30,23}$: : : $pb_{61,23}$

Figure 35 — Renumbering data bytes and forming BIS Block by adding parities

13.12 BIS code-words

The BIS RS code is defined over the finite field GF(2^8). The non-zero elements of the finite field GF(2^8) are generated by a primitive element α, where α is a root of the primitive polynomial $p(x)$.

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

The symbols of GF(2^8) are represented by bytes (groups of 8 bits), using the polynomial-base representation, with (α^7, α^6, α^5, .. , α^2, α, 1) as a basis. The root α is thus represented as

$$\alpha = 00000010$$

Each BIS code-word, represented by the vector *bis* = ($b_{0,C}$ .. $b_{i,C}$ .. $b_{29,C}$ $pb_{30,C}$ .. $pb_{j,C}$ .. $pb_{61,C}$), is a Reed-Solomon code over GF(2^8) having 32 parity bytes and 30 information bytes. Such a code word can be represented by a polynomial *bis*(x) of degree 61 (possibly having some coefficients equal to zero), where the highest degrees correspond to the information part of the vector ($b_{0,C}$ .. etc.) and the lowest degrees correspond to the parity part of the vector ($pb_{30,C}$ .. etc.).

bis(x) is a multiple of the generator polynomial $g(x)$ of the BIS code-word. The generator polynomial equals

$$g(x) = \prod_{i=0}^{31} \left(x - \alpha^i\right)$$

The BIS code is systematic: the 30 information bytes appear unaltered in the highest-degree positions of each code word. The parity-check matrix H_{BIS} of code *bis* is such that

$$H_{BIS} \times bis^T = 0 \text{ for all BIS code-words } bis$$

The second row $h_{BIS\,2}$ of the parity-check matrix H_{BIS} corresponding to the zero α of the generator polynomial $g(x)$, defines the code-word positions to be used for error locations. This second row $h_{BIS\,2}$ of the parity-check matrix H_{BIS} is given by the formula below.

$$h_{BIS\,2} = (\alpha^{61}, \alpha^{60} .. \alpha^2, \alpha, 1)$$

13.13 BIS Cluster

After generating the BIS code-words, the BIS Block is mapped in an interleaved way into an array of 496 rows × 3 columns. This newly formed array is called a BIS Cluster.

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The BIS Cluster is subdivided according to the Address Units as shown in Figure 22. The Units are numbered *u* = 0 to 15 the rows in such a Unit are numbered *r* = 0 to 30 and the columns are numbered *e* = 0 to 2 (see Figure 36).

The essentials of the BIS interleaving scheme are the following (see Figure 35, Figure 36 and the examples in Figure 37 and 38):

— each row of a BIS Block is split into eight groups of 3 bytes. These 3-byte groups are each placed in one row of the BIS Cluster;

— the even rows of the BIS Block are mapped into Units 0 to 7, the odd rows of the BIS Block are mapped into Units 8 to 15;

— the 3-byte groups from an even row of the BIS Block are placed each in the same row of Units 0 to 7, whereby the Units are used in reverse order (according to their numbering);

— the first 3-byte group of each successive row of the BIS Block shall be placed in a Unit with a number which is one higher than the start Unit used for the previous row:

  — row *N* = 0 of the BIS Block is placed on rows *r* = 0 of Units: 0, 7, 6, 5, .. , 2, 1;

  — row *N* = 2 of the BIS Block is placed on rows *r* = 1 of Units: 1, 0, 7, 6, .. , 3, 2;

  — row *N* = 4 of the BIS Block is placed on rows *r* = 2 of Units: 2, 1, 0, 7, .. , 4, 3 etc.;

  — this process is repeated cyclically until row *N* = 60, which is placed on rows *r* = 30 of Units: 6, 5, 4, 3, .. , 0, 7;

— now, within each Unit, each row *r* is shifted cyclically to the right by mod(*r*,3) positions: so row *r* = 0 is not shifted, row *r* = 1 is shifted 1, row *r* = 2 is shifted 2, row *r* = 3 is not shifted, row *r* = 4 is shifted 1, etc.;

— for the odd rows of the BIS Block, the same kind of procedure is followed, but then using the Units 8 to 15.

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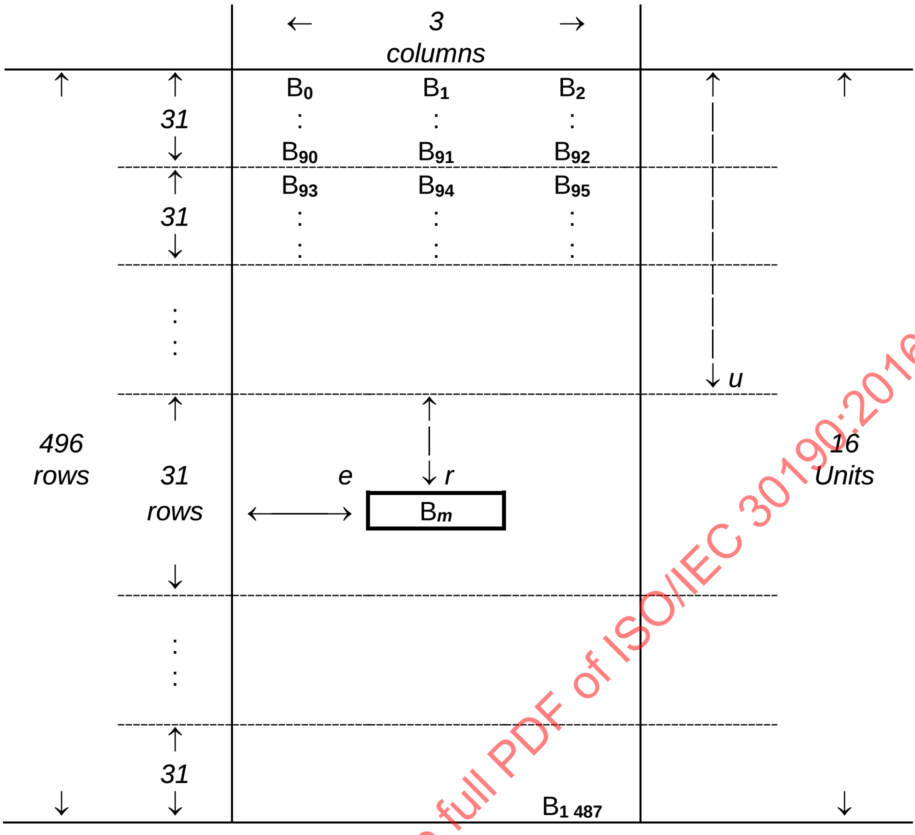

Figure 36 — BIS Cluster

Mathematically, the mapping of the bytes from a BIS Block into a BIS Cluster can be represented by the following formulae:

Byte $b_{N,C}$ or $pb_{N,C}$ (see Figure 35) is placed

- in Unit : $u = \text{mod}\{[\text{div}(N,2) + 8 - \text{div}(C,3)],8\} + 8 \times \text{mod}(N,2)$,
- on row : $r = \text{div}(N,2)$,
- in column : $e = \text{mod}\{[C + \text{div}(N,2)],3\}$.

The byte number m, giving the sequence number, B_m, as the Physical Cluster is written to the disk (see Figure 22):

$$m = (u \times 31 + r) \times 3 + e$$

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Unit *u*	row *r*	*Byte number N,C from BIS Block* column *e* 0	1	2	Shift right (= mod(*r*,3))	Filling in upward direction
0	0	0,0	0,1	0,2	0	start of Block row *N* = 0
	1	2,5	2,3	2,4	1	↑ continuation of Block row *N* = 2
	2	4,7	4,8	4,6	2	
	3	6,9	6,10	6,11	0	
	:					
	7	14,23	14,21	14,22	1	
	8	16,1	16,2	16,0	2	start of Block row *N* = 16
	:					
	30	60,18	60,19	60,20	0	
1	0	0,21	0,22	0,23	0	end of Block row *N* = 0
	1	2,2	2,0	2,1	1	start of Block row *N* = 2
	2	4,4	4,5	4,3	2	
	3	6,6	6,7	6,8	0	
	:					
2	0	0,18	0,19	0,20	0	
	1	2,23	2,21	2,22	1	end of Block row *N* = 2
	2	4,1	4,2	4,0	2	start of Block row *N* = 4
	3	6,3	6,4	6,5	0	
	:					
3	0	0,15	0,16	0,17	0	
	1	2,20	2,18	2,19	1	
	2	4,22	4,23	4,21	2	
	3	6,0	6,1	6,2	0	start of Block row *N* = 6
	:					
4	0	0,12	0,13	0,14	0	
	1	2,17	2,15	2,16	1	
	2					
	:					
5	0	0,9	0,10	0,11	0	
	1	2,14	2,12	2,13	1	
	2					
	:					
6	0	0,6	0,7	0,8	0	
	1	2,11	2,9	2,10	1	
	2	4,13	4,14	4,12	2	
	:					
7	0	0,3	0,4	0,5	0	↑ continuation of Block row *N* = 0
	1	2,8	2,6	2,7	1	↑ continuation of Block row *N* = 2
	2	4,10	4,11	4,9	2	
	:					
	7	14,2	14,0	14,1	1	start of Block row *N* = 14
	:					
	30	60,21	60,22	60,23	0	end of Block row *N* = 60

Figure 37 — Example of mapping (partial) of BIS bytes into first 8 Units

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		Byte number N,C from BIS Block			Shift right (= mod(*r*,3))	Filling in upward direction
			column *e*			
Unit *u*	row *r*	0	1	2		
8	0	1,0	1,1	1,2	0	start of Block row *N* = 1
	1	3,5	3,3	3,4	1	
	2	5,7	5,8	5,6	2	
	3	7,9	7,10	7,11	0	
	:					
	8	17,1	17,2	17,0	2	start of Block row *N* = 17
	:					
	30	61,18	61,19	61,20		
9	0	1,21	1,22	1,23		end of Block row *N* = 1
10	0	1,18	1,19	1,20		
11	0	1,15	1,16	1,17		
12	0	1,12	1,13	1,14		
13	0	1,9	1,10	1,11		
14	0	1,6	1,7	1,8		
15	0	1,3	1,4	1,5	0	↑ continuation of Block row *N* = 1
	1	3,8	3,6	3,7	1	
	2	5,10	5,11	5,9	2	
	:					
	7	15,2	15,0	15,1	1	start of Block row *N* = 15
	:					
	30	61,21	61,22	61,23	0	end of Block row *N* = 61

Figure 38 — Example of mapping (partial) of BIS bytes into last 8 Units

The following are some conclusions:

— all information bytes of a BIS Block are found in the first 15 rows of each Address Unit;
— all parity bytes of a BIS Block are found in the last 16 rows of each Address Unit;
— each Address Field is found in the first 3 rows of each Address Unit (see Figure 39).

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13.14 ECC Cluster

After constructing the LDC Cluster and the BIS Cluster, the LDC Cluster is split into four groups of 38 columns each. In between these four groups, the 3 columns from the BIS Cluster are inserted one by one. After multiplexing the BIS Cluster with the LDC Cluster, the ECC Cluster of Figure 39 is reached.

	LDC 38 columns ← →	*BIS 1 column* ← →	*LDC 38 columns* ← →	*BIS 1 column* ← →	*LDC 38 columns* ← →	*BIS 1 column* ← →	*LDC 38 columns* ← →	
↑		$AF_{0,0}$ $AF_{3,0}$ $AF_{6,0}$ $UC_{u,v}$:		$AF_{1,0}$ $AF_{4,0}$ $AF_{7,0}$: :		$AF_{2,0}$ $AF_{5,0}$ $AF_{8,0}$: :		Address Unit 0
496 rows		$AF_{0,1}$ $AF_{3,1}$ $AF_{6,1}$ $UC_{x,y}$:		$AF_{1,1}$ $AF_{4,1}$ $AF_{7,1}$: :		$AF_{2,1}$ $AF_{5,1}$ $AF_{8,1}$: :		Address Unit 1
↓		: : : :		: : : :		: : : :		: : : :

Figure 39 — ECC Cluster after multiplexing of BIS Cluster with LDC Cluster

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13.15 Recording Frames

Each row of the ECC Cluster is transformed into a Recording Frame by adding locations for Frame Sync bits and for dc-control bits.

For this purpose, a stream of 1 240 data bits which is formed by the 155 bytes of each row of the ECC Cluster is divided into one group of 25 data bits and 27 groups of 45 data bits (see Figure 40) with the most-significant bits of the bytes handled first.

The first group of 25 data bits is extended with 20 data-bit positions for the insertion of the Frame Sync, which is a special sequence of 30 modulation/Channel bits.

Next, each group of 45 data bits is completed with one additional bit position to form a dc-control Block.

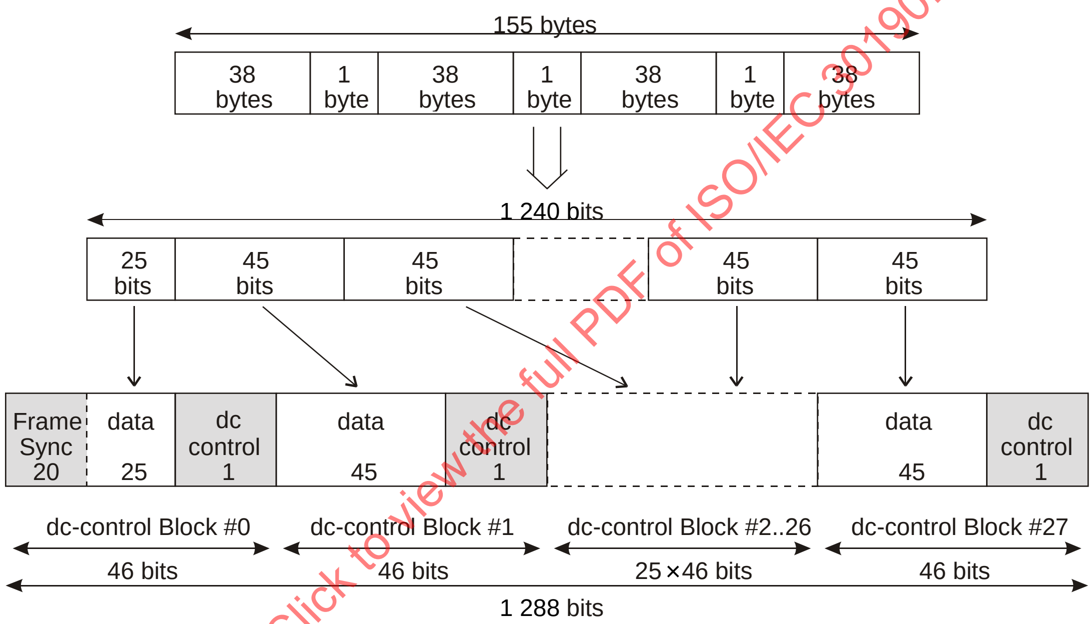

Figure 40 — Composition of Recording Frame

13.16 Physical Cluster

The 496 rows from an ECC Cluster, transformed into Recording Frames, are called a Physical Cluster.

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13.17 17PP modulation for Recordable data

13.17.1 General

All the bits of Recording Frames except the Frame Sync are converted to Modulation bits according to the 17PP modulation code. This is an RLL(1,7) code with run-lengths ≥2T and ≤8T and some special properties. PP means: Parity preserve/Prohibit RMTR.

— Parity preserve: if the number of ONEs in the data-bit stream is even, then also the number of ONEs in the Modulation-bit stream is even.
if the number of ONEs in the data-bit stream is odd, then also the number of ONEs in the Modulation-bit stream is odd.
This property makes it easy to control the low-frequency content of the recorded signal efficiently (see 13.17.3).

— Prohibit RMTR: the number of consecutive minimum run-lengths (2T) is limited to 6.
Because of the low signal levels on minimum run-lengths this improves the read-out performance.

13.17.2 Bit conversion rules

The table in Figure 41 defines the conversion rules from data bits to Modulation bits. The data bits shall be processed from the left to the right (msb first, see Figure 40). Remaining bits at the end of the Recording Frame shall be encoded according to the table for terminating bits.

A ONE in the tables represents a transition in the recorded signal. The Modulation-bit stream is converted to an NRZI Channel-bit stream (see 13.18), and subsequently recorded onto the disk.

Data bits	Modulation bits	
00 00 00 00	010 100 100 100	
00 00 10 00	000 100 100 100	
00 00 00	010 100 000	
00 00 01	010 100 100	
00 00 10	000 100 000	
00 00 11	000 100 100	
00 01	000 100	
00 10	010 000	
00 11	010 100	
01	010	
10	001	
11	000 101	if preceding Modulation bits = xx1 if preceding Modulation bits = xx0

Data bit pattern to be substituted	Substituting Modulation bits	Condition for substitution
11 01 11	001 000 000	if next Modulation bits = 010

Terminating data bits	Terminating Modulation bits	
00 00	010 100	
00	000	

Figure 41 — 17PP modulation code conversion table

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13.17.3 dc-control procedure

Because a ONE in the Modulation-bit stream means a transition in the recorded signal, the polarity of this signal can be inverted if an odd number of ONEs is added to the Modulation-bit stream in a controlled way. Because of the parity-preserve property of the 17PP modulation code, this is possible just by inserting additional bits into the data-bit stream and setting these to ONE if an inversion is needed.

In this way the accumulated DSV of the recorded signal shall be minimized after each dc-control Block by setting the dc-control bit at the end of the previous dc-control Block to ZERO or ONE (see Figure 40).

13.17.4 Frame Sync

The Physical Clusters consist of 16 Address Units, where each Address Unit contains 31 Recording Frames (see Figure 22 and Figure 40).

A modulated Recording Frame starts with a Frame Sync consisting of 30 Channel bits.

The main body of the Frame Sync is formed by a 24-bit pattern violating the 17PP modulation rules (two times run-length 9T).

The last 6 bits define a signature, that identifies one of seven different Frame Sync patterns. The 6-bit signatures for the Frame Sync IDs are selected such that their distance with relation to transition shifts is ≥2.

If the last data bits preceding the Frame Sync have been coded according to the termination table (see Figure 40), then the first Modulation bit of the Frame Sync # = ONE, else # = ZERO (see Figure 42).

The Frame Sync patterns are defined in terms of Modulation bits. A ONE in the table represents a transition in the recorded signal. Before recording onto the disk the Frame-Sync codes are converted to an NRZI Channel-bit stream (see 13.18).

Sync number	24-bit Sync body	6-bit Sync ID
FS0	#01 010 000 000 010 000 000 010	000 001
FS1	#01 010 000 000 010 000 000 010	010 010
FS2	#01 010 000 000 010 000 000 010	101 000
FS3	#01 010 000 000 010 000 000 010	100 001
FS4	#01 010 000 000 010 000 000 010	000 100
FS5	#01 010 000 000 010 000 000 010	001 001
FS6	#01 010 000 000 010 000 000 010	010 000

Figure 42 — 30-bit Frame-Sync codes

Because seven different Frame Syncs are insufficient to identify 31 Recording Frames, each frame is identified by the combination of its own Frame Sync and the Frame Sync of one of the preceding Recording Frames. The mapping of these combinations can be made such that, even with missing Frame Syncs in 1, 2 or 3 preceding frames, a Recording Frame can still be identified by its own Frame Sync and the last present Frame Sync (see Figure 43).

Rec. Frame *n*–4	Rec. Frame *n*–3	Rec. Frame *n*–2	Rec. Frame *n*–1	Rec. Frame *n*

Recording Frame n can be identified from the Frame Sync IDs of:
Recording Frame *n* + Recording Frame *n*–1
Recording Frame *n* + Recording Frame *n*–2
Recording Frame *n* + Recording Frame *n*–3
Recording Frame *n* + Recording Frame *n*–4

Figure 43 — Identification of Recording Frames

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The first Recording Frame of each Address Unit has a unique Frame Sync: FS0.

The other Frame Syncs are mapped as specified in Figure 44.

Frame number	Frame Sync	Frame number	Frame Sync
0	FS0		
1	FS1	16	FS5
2	FS2	17	FS3
3	FS3	18	FS2
4	FS3	19	FS2
5	FS1	20	FS5
6	FS4	21	FS6
7	FS1	22	FS5
8	FS5	23	FS1
9	FS5	24	FS1
10	FS4	25	FS6
11	FS3	26	FS2
12	FS4	27	FS6
13	FS6	28	FS4
14	FS6	29	FS4
15	FS3	30	FS2

Figure 44 — Mapping of Frame-Sync codes on Recording Frames

13.18 Modulation and NRZI conversion

Before being recorded onto the disk, data bits are converted to Modulation bits, which in turn are converted to NRZI Channel bits according to the following process (see Figure 45):

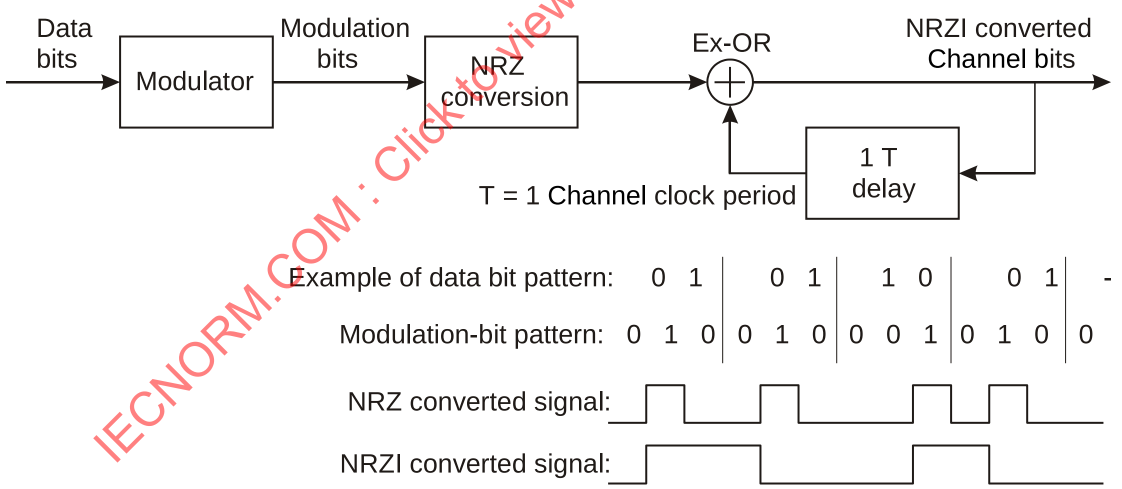

Figure 45 — Modulation and NRZI conversion

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14 Physical Data Allocating and Linking

14.1 General

The unit of recording is a Recording-Unit Block (RUB), consisting of a Physical Cluster preceded by a Data Run-in and followed by a Data Run-out.

Recording-Unit Blocks can be written one by one or in a continuous sequence of several RUBs (write_streaming).

In the Recordable Areas of the disk, a wobble cycle shall correspond to 69 Channel bits if the Channel-bit rate is locked to the wobble frequency. This means that a modulated Recording Frame, which is 1 932 Channel bits (= 1 288 data bits), covers exactly 28 wobble cycles. This locked case is considered to be the nominal situation.

14.2 Recording-Unit Block (RUB)

14.2.1 General

Each RUB consists of a Data Run-in of 2 760 cbs (nominally 40 wobble periods), a Physical Cluster of 496 × 1 932 cbs (nominally 496 × 28 wobble periods) and a Data Run-out of 1 104 cbs (nominally 16 wobble periods).

Run-in	Physical Cluster	Run-out	Guard_3
←40 wbs→	←496 × 28 wbs→	←16 wbs→	←8 wbs→

Figure 46 — Layout of single written Recording-Unit Block

Each single written RUB or each continuously written sequence of RUBs shall be terminated by a Guard_3 field, ensuring that no gaps (Unrecorded Areas) will ever occur between any 2 RUBs.

Such a Guard_3 field shall consist of 540 cbs (nominally ≈ 8 wobble periods).

Run-in	Physical Cluster	Run-out	Run-in	Physical Cluster	:	Physical Cluster	Run-out	Guard_3
←40 wbs→	←496 × 28 wbs→	←16 wbs→	←40 wbs→	←496 × 28 wbs→	:	←496 × 28 wbs→	←16 wbs→	←8 wbs→

Figure 47 — Layout of continuously written sequence of Recording-Unit Blocks

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14.2.2 Data Run-in

14.2.2.1 General

The Data Run-in consists of the following parts:

— Guard_1: 1 100 Channel bits;

— PrA (Pre-amble): 1 660 Channel bits.

The PrA field is meant as a run-in for signal processing (for locking and synchronization).

The Guard_1 field is meant to cope with the overlaps due to inaccuracies in determining the start location of recording sequences (see Figure 48).

Guard_1 1 100 cbs		PrA 1 660 cbs
optional APC ≈ 5 wobbles	repeated bit pattern ≈ 11 wobbles	nominally ≈ 24 wobbles

Figure 48 — Layout of Data Run-in

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14.2.2.2 Content of Guard_1 fields

The Guard_1 field has a length of 1 100 Channel bits.

The content represented in Modulation bits is 55 times repeated $01[0^2]1[0^2]10101[0^4]1[0^3]$.

These patterns result in a repeated 3T/3T/2T/2T/5T/5T sequence, which is well-suited to re-settle the electronic circuits.

14.2.2.3 Automatic Power Control (APC)

The first 5 wobbles of the Guard_1 field at the start of a recording sequence can be used for performing an Automatic Power-Control procedure. The Modulation-bit pattern to be used for such an APC procedure can be chosen freely by the recorder manufacturer and is allowed to be different from the repeated pattern as defined in 14.2.2.2.

14.2.2.4 Content of PrA fields

The PrA field has a length of 1 660 Channel bits.

The content of the PrA field shall be as shown in Figure 49:

77 times repeated $01[0^2]1[0^2]10101[0^4]1[0^3]$	Sync_1	2 times repeated $01[0^2]1[0^2]10101[0^4]1[0^3]$	Sync_2	$01[0^2]1[0^2]10101[0^4]1[0^3]$
⟵ 1 540 cbs ⟶	⟵30 cbs⟶	⟵ 40 cbs ⟶	⟵30 cbs⟶	⟵ 20 cbs ⟶

Figure 49 — Layout of PrA field

In general Sync_1 shall be FS{mod[(N+4),7]} and Sync_2 shall be FS{mod[(N+6),7]} if the first Frame Sync after the PrA is FS(N)(N = 0..6, see 13.17.4).

This means that Sync_1 shall be FS4 and Sync_2 shall be FS6 (the first Frame Sync after the PrA is

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FS0).The first bit of each of Sync_1, Sync_2 and the first Frame Sync after the PrA is allowed to be used for dc-control (# = ZERO or ONE, see Figure 42).

14.2.3 Data Run-out

14.2.3.1 General

The Data Run-out consists of the following parts:

— PoA (Post-amble): 564 Channel bits;

— Guard_2: 540 Channel bits.

The PoA field is meant as a runout for signal processing.

The Guard_2 field is meant to cope with inaccuracies in determining the start location of recording sequences (see Figure 50).

PoA 564 cbs	Guard_2 540 cbs
nominally ≈ 8 wobbles	nominally ≈ 8 wobbles

Figure 50 — Layout of Data Run-out

14.2.3.2 Content of PoA fields

The PoA field has a length of 564 Channel bits.

The content of the PoA field shall be as shown in Figure 51:

Sync_3	01[0^8]1[0^8]1[0^8]1[0^8]1[0^8]1[0^7]	24 times repeated 01[0^2]1[0^2]10101[0^4]1[0^3]
← 30 cbs→	← 54 cbs →	← 480 cbs →

Figure 51 — Layout of PoA field

In general, Sync_3 shall be chosen such that it corresponds to a Frame number *n*+1 if the User Data before the PoA ends with Frame number *n* (see 13.17.4).

This means that Sync_3 shall be FS0.

The first bit of the Sync_3 patterns shall be used as defined in 13.17.4.

The 9T/9T/9T/9T/9T/9T pattern after Sync_3 can be used as a “stop of User Data” indicator.

14.2.3.3 Content of Guard_2 fields

The Guard_2 field has a length of 540 Channel bits.

The content represented in Modulation bits is 27 times repeated 01[0^2]1[0^2]10101[0^4]1[0^3].

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14.2.4 Guard_3 field

14.2.4.1 General

Guard_3 540 cbs	
repeated bit pattern ≈ 3 wobbles	optional APC ≈ 5 wobbles

Figure 52 — Layout of Guard_3 field

The Guard_3 field has a length of 540 Channel bits.

The content represented in Modulation bits is 27 times repeated $01[0^2]1[0^2]10101[0^4]1[0^3]$ (see Figure 52).

14.2.4.2 Automatic Power Control (APC)

The last 5 wobbles of the Guard_3 field at the end of a recording sequence can be used for performing an Automatic Power-Control procedure. The Modulation-bit pattern to be used for such an APC procedure can be chosen freely by the recorder manufacturer and is allowed to be different from the repeated pattern as defined in 14.2.4.1.

14.2.4.3 Linking requirements

The Guard_1 and Guard_3 fields shall be used for linking separately written Recording-Unit Block sequences. The Guard_3 Area of the previous Recording-Unit Block sequence shall be overwritten by the Guard_1 field of the actual written Recording-Unit Block sequence. The SER requirement for linked sequences is specified in 34.1.

A linking example of 3 separately-written single Recording-Unit Blocks is given in Figure 53.

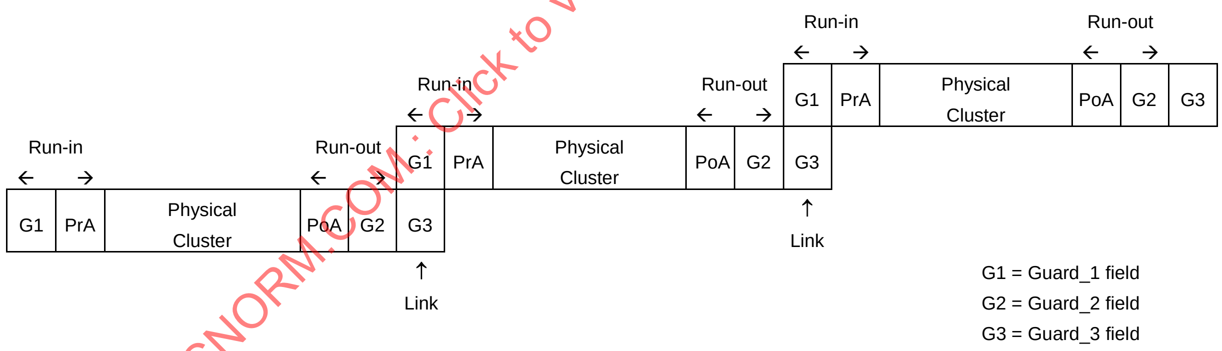

Figure 53 — Linking of 3 separately-written single Recording-Unit Blocks

14.3 Locating data relative to wobble addresses

The nominal start positions for recordings (and single RUB) as continuous sequences of several RUBs, are the locations of the middle of the wobble in NWL 25 in the Reference Unit between the Sync_3 Unit and the first Data_x Unit of the ADIP words with a PAA of which bits AA1,AA0 = 00 (see 15.7).

The accuracy for determining the start positions shall be better than ±34 cbs.

As a consequence, the length of the OverWritten Area shall be between 7 and 9 wobble lengths.

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15 Track format

15.1 General

A Track is formed by a 360° turn of a continuous spiral.

Each Recording Layer shall have the same basic Tracks at about the same locations (see Figure 54).

For consistency reasons, the sole Recording Layer on an SL disk is also called Layer L0.

15.2 Track shape

The Zone between radius r_1 = 21,0 mm and radius r_3 = 22,2 mm is reserved to be used for the BCA (see Clause 35). In this Zone, there shall be Tracks formed by a Single Spiral Groove starting from (on Layer L0) or ending at (on Layer L1) radius $21{,}0^{0{,}0}_{-0{,}1}$ mm.

A transition from Straight Groove to the HFM Groove between the BCA Zone and the Embossed HFM Area shall occur between radius r_2 = 22,0 mm and r_3 (see Figure 54). At this transition the Spiral Groove shall be uninterrupted.

The Groove Tracks in the BCA Zone shall be Straight Groove(s) (without any modulation) between a radius of 21 mm and the point where the encoding of the HFM Groove in the Embossed HFM Area starts on Layer L0 or the Wobbled Groove ends on Layer L1 (see Clause 18).

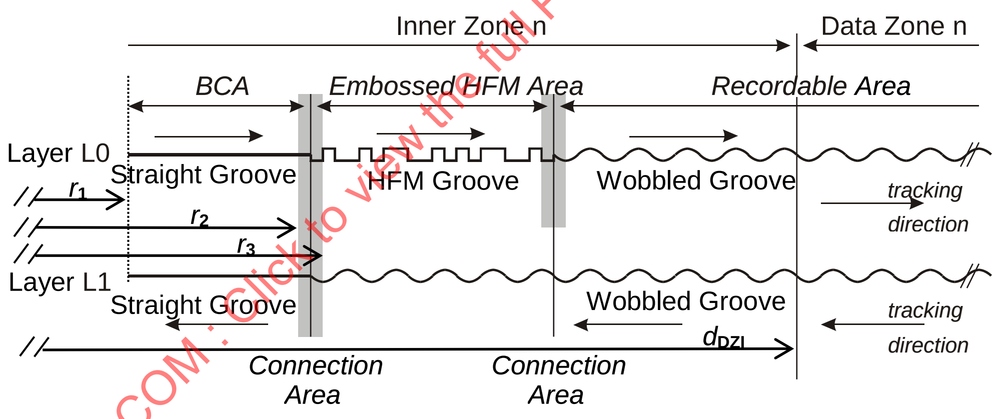

Figure 54 — Connection Areas between different Groove Types

In the Embossed HFM Area on Layer L0 (see Clause 16), the Tracks are formed by a Single Spiral Groove continuing uninterruptedly from the end of the Straight Groove in the BCA Zone.

These Groove Tracks in the Embossed HFM Area move with a rather high frequency deviation in the radial direction around their nominal centrelines, thereby providing a high bit rate/high capacity data channel for the storage of replicated information (HFM Groove).

The shape of each Track is determined by the requirements in Clause 26.

In the Recordable Areas (see Clause 16) the Tracks are formed by a Single Spiral Groove, starting from the end of the Embossed HFM Area on Layer L0 or ending at the beginning of the Straight-Groove Area on Layer L1. The Groove in the Recordable Areas move with a mainly monotone sinusoidal deviation in the radial direction around their nominal centrelines [Wobbled Groove(s)]. The sinusoidal deviation is modulated by replacing some cycles at certain locations by different patterns.

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The wobble can be used for speed control of the disk and synchronization of the write clock of the drive, and the modulated parts represent addressing information called Address In Pre-Groove or ADIP (see 15.7). The shape of each Track is determined by the requirements in Clause 27.

NOTE Although the term of "Pre-Groove" is not defined in this International Standard, "ADIP" is widely used as an acronym of "Address In Pre-groove" in optical disk standards. Meaning of "Pre-Groove" is the same as that of "Groove" in this International Standard.

At the connection between the Embossed HFM Area and the Recordable Area, the Spiral Groove shall be uninterrupted. Between the replicated information in the HFM Groove and the ADIP information in the Wobbled Groove it is allowed to have a Groove-Only part (without any modulation) for maximum 1 mm in the tangential direction along the Track.

Groove geometry
On each layer either On-Groove recording or In-Groove recording is allowed.

For On-Groove recording a geometry is used where the Grooves are nearer to the Entrance surface of the disk than the Land. For In-Groove recording a geometry is used where Grooves are farther from the Entrance surface of the disk than the Land. The outline of the Groove geometry is presented in Figure 55.

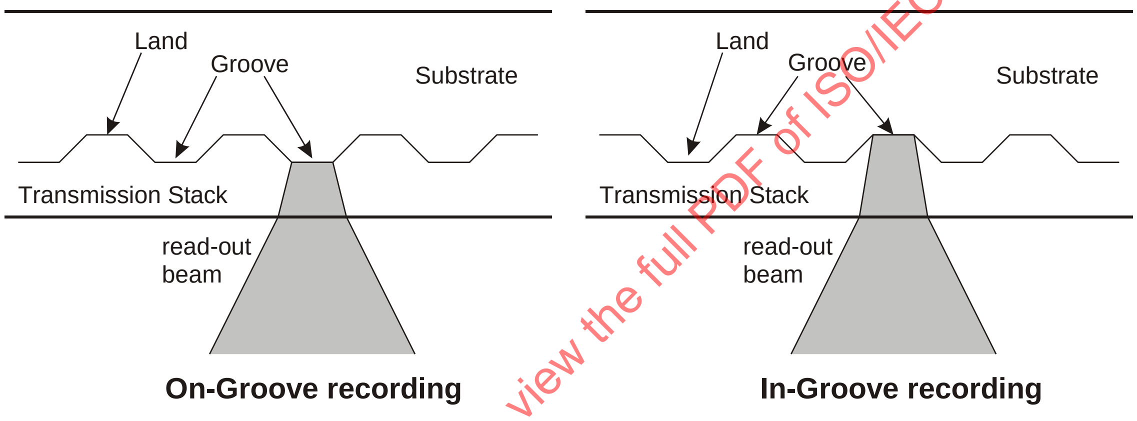

Figure 55 — Outline of Groove geometry

(Radial cross-section of disk)

15.3 Track path

On Layer L0 the spiral shall run from the inner side of the disk towards the outer side of the disk when the disk rotates according to the specification in 9.8.

On Layer L1 the spiral shall run from the outer side of the disk towards the inner side of the disk when the disk rotates according to the specification in 9.8.

On an SL disk, the Tracks shall start at the beginning of the Inner Zone, terminate at the end of the Outer Zone and be continuous in the Information Zone (see Figure 17).

On a DL disk, the Tracks on Layer L0 shall start at the beginning of the Inner Zone, terminate at the end of the Outer Zone 0 and be continuous in the Information Zone. On Layer L1, the Tracks shall start at the beginning of the Outer Zone 1, terminate at the end of Inner Zone 1 and be continuous in the Information Zone (see Figure 18).

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15.4 Track Pitch

15.4.1 Track Pitch in BCA Zone

The Track Pitch (TP) in BCA Zone is the distance between the average centerlines of a Groove in adjacent Tracks, measured in the radial direction.

The Track Pitch shall be (2,0 ± 0,1) µm.

In the area between r_2 and r_3, the Track Pitch has to change over from 2,0 µm to the Track Pitch of the Embossed HFM Area (on Layer L0) or to the Wobbled Groove Area (on Layer L1).

15.4.2 Track Pitch in Embossed HFM Area

The Track Pitch in Embossed HFM Area is the distance between the average centrelines of an HFM Groove in adjacent Tracks, measured in the radial direction.

The Track Pitch shall be (0,350 ± 0,010) µm.

The Track Pitch averaged over the Embossed HFM Area shall be (0,350 ± 0,003) µm.

15.4.3 Track Pitch in Recordable Area(s)

The Track Pitch in Recordable Area(s) is the distance between the average centrelines of a Wobbled Groove in adjacent Tracks, measured in the radial direction.

The Track Pitch shall be (0,320 ± 0,010) µm.

The Track Pitch averaged over the Recordable Area(s) shall be (0,320 ± 0,003) µm.

15.4.4 Track Pitch between Embossed HFM Area and Recordable Area

The change in Track Pitch from 0,35 µm to 0,32 µm (on Layer L0) shall be realized within maximum 100 Tracks (revolutions), which Tracks shall be located completely in Protection-Zone 2 (see Figure 84).

15.5 Track layout of HFM Groove

15.5.1 General

In 15.5, only the encoding format of the data will be described. The locations and the content will be defined in Clause 18 and 18.2.

The data in HFM Groove is recorded in 4K partitions, called PIC Clusters. Each such PIC Cluster contains 2 Data Frames, each with 2 048 bytes of data. The Error-Correction mechanisms used to protect this data and the procedures to build up fully formatted partition are very similar to those described in Clause 13.

A reduced combination of LDC+BIS Code is used as shown schematically in Figure 56.

For detailed descriptions of the related processing steps and applied codes, reference will be made to the descriptions in Clause 13.

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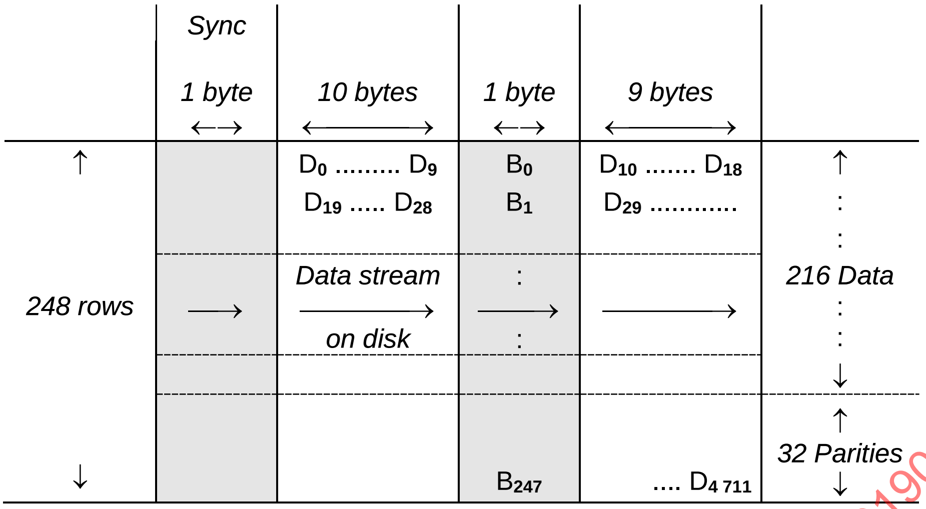

Figure 56 — Schematic representation of 4K PIC Cluster on disk

15.5.2 Data Format

15.5.2.1 Data Frame

Each Data Frame is extended with a 4-byte Error-Detection Code (EDC) as described in 13.2 and 13.3.

15.5.2.2 Scrambled Data Frame

Each Data Frame with its EDC is scrambled according the procedure described in 13.4. For the preset of the scrambler AUN_{15} .. AUN_1 (see 15.5.3.2 and 13.9.2.2) shall be used instead of PS_{19} .. PS_5.

15.5.2.3 Data Block

Each 2 Scrambled Data Frames are mapped into an array of 216 rows × 19 columns as described in 13.5 and indicated in Figure 26 (only columns 0..18).

15.5.2.4 LDC Block

Next 32 rows with Error-Correction Parities are added according to the procedure described in 13.5 and 13.6, with the difference being that there are only 19 columns (L = 0..18). The result of this processing is a matrix of 248 rows × 19 columns.

15.5.2.5 Interleaving

The interleaving procedure is different from the one described in 13.8. Only the second interleaving step described in 13.8.3 is applied., That is each successive row is shifted one more byte position to the left [shift = mod(k, 19), where k is the row number, $0 \le k \le 247$)]. The bytes that shift out at the left side are re-entered in the array from the right side (see Figure 57).

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	← 19 bytes →								
← *shift 0*	$e_{0,0}$	$e_{0,1}$	…		…			$e_{0,18}$	↑
← *shift 1*	$e_{1,1}$	$e_{1,2}$	…		…		$e_{1,18}$	$e_{1,0}$	
← *shift 2*	$e_{2,2}$	$e_{2,3}$	…		…	$e_{2,18}$	$e_{2,0}$	$e_{2,1}$	
	…	…	…		…				
← *shift 18*	$e_{18,18}$	$e_{18,0}$	…		…			$e_{18,17}$	*248*
← *shift 0*	$e_{19,0}$	$e_{19,1}$	…		…			$e_{19,18}$	*rows*
	…	…	…		…				
← *shift mod(k,19)*	…	…	…		…				
	…	…	…		…				
← *shift 18*	$p_{246,18}$	$p_{246,0}$	…		…			$p_{246,17}$	
← *shift 0*	$p_{247,0}$	$p_{247,1}$	…		…			$p_{247,18}$	↓

Figure 57 — Interleaving of PIC LDC Block

After this process the bytes are renumbered in the horizontal direction through all the rows resulting in the numbering D_0 to $D_{4\,711}$ as indicated in Figure 56.

15.5.3 Addressing and Control Data

15.5.3.1 General

Unlike the format in Recordable Areas of the disk, a BIS Block is composed of 4 BIS code-words and filled up with 8 addresses of 9 bytes each, in 18 rows and 2 User-Control Data Units of 24 bytes each, in 12 rows (see Figure 58).

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	Row	0	1	2	3	
		← 4 columns →				
	0	***$AF_{0,0}$***	$AF_{0,3}$	$AF_{0,2}$	$AF_{0,1}$	
	1	$AF_{0,4}$	$AF_{0,7}$	$AF_{0,6}$	$AF_{0,5}$	
	2	$AF_{1,1}$	***$AF_{1,0}$***	$AF_{1,3}$	$AF_{1,2}$	
	3	$AF_{1,5}$	$AF_{1,4}$	$AF_{1,7}$	$AF_{1,6}$	
	4	$AF_{2,2}$	$AF_{2,1}$	***$AF_{2,0}$***	$AF_{2,3}$	
	5	$AF_{2,6}$	$AF_{2,5}$	$AF_{2,4}$	$AF_{2,7}$	
	6	$AF_{3,3}$	$AF_{3,2}$	$AF_{3,1}$	***$AF_{3,0}$***	
	7	$AF_{3,7}$	$AF_{3,6}$	$AF_{3,5}$	$AF_{3,4}$	
	8	***$AF_{4,0}$***	:	:	$AF_{4,1}$	*18 rows Addresses*
	9	$AF_{4,4}$	:	:	:	
	10	$AF_{5,1}$	***$AF_{5,0}$***	:	:	
	11	$AF_{5,5}$	:	:	:	
1 BIS code-word = 62 bytes	12	$AF_{6,2}$	$AF_{6,1}$	***$AF_{6,0}$***	:	
	13	$AF_{6,6}$	:	:	:	
	14	$AF_{7,3}$	:	$AF_{7,1}$	***$AF_{7,0}$***	
	15	$AF_{7,7}$	:	:	:	
	16	***$AF_{8,0}$***	:	:	$AF_{8,1}$	
	17	$AF_{8,4}$	$AF_{8,7}$	$AF_{8,6}$	$AF_{8,5}$	
	18	$UC_{0,0}$	$UC_{12,0}$	$UC_{0,1}$	$UC_{12,1}$	
	19	$UC_{1,0}$	$UC_{13,0}$	$UC_{1,1}$	$UC_{13,1}$	*12 rows User Control Data*
	:	:	:	:	:	
	28	$UC_{10,0}$	$UC_{22,0}$	$UC_{10,1}$	$UC_{22,1}$	
	29	$UC_{11,0}$	$UC_{23,0}$	$UC_{11,1}$	$UC_{23,1}$	
	30	$pb_{30,0}$	$pb_{30,1}$	$pb_{30,2}$	$pb_{30,3}$	
	31	$pb_{31,0}$	$pb_{31,1}$	$pb_{31,2}$	$pb_{31,3}$	*32 rows Parities*
	:	:	:	:	:	
	61	$pb_{61,0}$	$pb_{61,1}$	$pb_{61,2}$	$pb_{61,3}$	
		Code word 0	Code word 1	Code word 2	Code word 3	

Figure 58 — PIC BIS Block

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15.5.3.2 Address Fields

Comparable to the Recordable Areas of the disk, where each 1/16 of a 64K Cluster (= 4K bytes) is identified by one Address-Unit Number (see 13.9.2), each 4K PIC Cluster shall be identified by one Address-Unit Number. These Address-Unit Numbers shall increase by two for each successive 4K PIC Cluster.

Each PIC BIS Block contains eight repetitions (S = 0 .. 7) of the same address, where the flag bits are used to identify the repetition number.

$AF_{0,S}$ = MSB of the Address-Unit Number (all the same for S = 0 .. 7)
$AF_{1,S}$ = 2^{nd} SB of the Address-Unit Number (all the same for S = 0 .. 7)
$AF_{2,S}$ = 3^{rd} SB of the Address-Unit Number (all the same for S = 0 .. 7)
$AF_{3,S}$ = LSB of the Address-Unit Number (all the same for S = 0 .. 7)
$AF_{4,S}$ = flag bits
Bits b_7 to b_3: Reserved
Bits b_2 to b_0: set to the binary value of S
$AF_{5,S}$ .. $AF_{8,S}$ = parity bytes for forming an (9,5,5) RS code over the Address Field.
The parity bytes shall be calculated according to the definitions given in 13.9.2.

The 8 addresses are mapped into the PIC BIS Block in a special pre-interleaved way.

The bytes of addresses 0 to 3 are placed in a diagonal direction in the even-numbered rows, starting with byte 0 of address 0 in row 0, column 0 and each successive address being shifted cyclically one position to the left (see Figure 58).

The bytes of addresses 4 to 7 are placed in a diagonal direction in the odd-numbered rows, starting with byte 0 of address 4 in row 1, column 0 and each successive address being shifted cyclically one more position to the left.

Mathematically, this mapping of the address bytes into the PIC BIS Cluster can be represented by the following formulae:

byte $AF_{x,y}$ shall be allocated in row $r = 2 \times x + \text{div}(y,4)$
and in column $c = \text{mod}[(x + 8 - y),4]$.

15.5.3.3 User-Control Data

There are two User-Control Data Units, each consisting of 24 bytes. Bytes 0 to 11 of the first User-Control Data Unit shall be placed in column 0, rows 18 to 29 of the PIC BIS Block and bytes 12 to 23 in column 1, rows 18 to 29. In the same way, bytes 0 to 11 of the second User-Control Data Unit shall be placed in column 2 and bytes 12 to 23 in column 3 (see Figure 58).

All bytes of both User-Control Data Units shall be Reserved.

15.5.3.4 BIS code-words

The PIC BIS Block is completed by adding 32 rows with parity bytes (see Figure 58) according to the procedure described in 13.11 and 13.12, with the difference that there are only 4 columns (c = 0..3). The result is now a matrix of 62 rows × 4 columns.

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15.5.3.5 BIS Cluster

Finally, the matrix of BIS code-words is reconstructed into one-column of 248 bytes that can be inserted in the PIC Cluster as indicated in Figure 56.

Bytes B_0 to B_{123} are filled by successively copying bytes from the even rows by going through the BIS Block cyclically in a diagonal direction starting from row 0, column 0 (see Figure 59).

Bytes B_{124} to B_{247} are filled by successively copying bytes from the odd rows by going through the BIS Block cyclically in a diagonal direction starting from row 1, column 0.

Mathematically, the mapping of the bytes from the PIC BIS Block into the PIC BIS Cluster can be represented by the following formulae:

Let byte $b_{r,c}$ be the byte in row r and column c of the BIS Block,
and byte B_i is the i^{th} byte in the column of the BIS Cluster,

then $r = \text{mod}(2 \times i, 62) + \text{div}(i,124)$,
$c = \text{mod}(i,4)$,

and vice versa $i = 124 \times \text{mod}(r,2) + \text{div}(r,2) + 31 \times \text{mod}\{[4 - c + \text{div}(r,2)],4\}$.

As a result of this interleaving, the one-column 248-byte BIS Cluster is divided into eight groups of 31 bytes, where each 31-byte group is composed of 9 address bytes, 6 UC data bytes, and 16 parity bytes in succession. The address bytes, due to the pre-interleaving, appear in the correct order for direct access.

BIS Block

i	*c* = 0	1	2	3
r = 0	***0***	***93***	***62***	***31***
1	124	217	186	155
2	***32***	***1***	***94***	***63***
3	156	125	218	187
4		***33***	***2***	***95***
5		157	126	219
6			***34***	***3***
7			158	127
8	***4***			***35***
9	128			159
10		***5***		
11		129		
12			***6***	
13			130	
:	:	:	:	:
53				243
54	***120***			***27***
55	244			
56	***28***	***121***		
57	152	245		
58	***60***	***29***	***122***	
59	184	153	246	
60	***92***	***61***	***30***	***123***
61	216	185	154	247

⇒

BIS Cluster

← 1 byte →	
B_0	↑
:	
:	
:	
:	
B_i	
:	
:	
:	
:	
:	
B_{123}	*248*
B_{124}	*rows*
:	
:	
:	
:	
:	
:	
:	
:	
:	
:	
B_{247}	↓

Figure 59 — Reading order for constructing PIC BIS Cluster

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15.5.4 Recording Frames

15.5.4.1 General

In the next processing step, the 19 columns of an interleaved LDC Block are multiplexed with the one-column BIS Cluster and extended with a column of Synchronization patterns as defined in Figure 56.

Each row of this 21-column by 248-row matrix is called a PIC Recording Frame.

15.5.4.2 Modulation

The 168 bits of each PIC Recording Frame, except some of the bits of the Synchronization pattern are converted into modulation bits by applying a Biphase modulation method. In this modulation method, a bit with value ZERO is represented by a transition at the start of the bit cell and a bit with value ONE is represented by a transition at the start and in the middle of the bit cell (see example in Figure 60). The modulation bits are recorded on the disk by a deviation of the Groove from its average centreline as indicated in Figure 60. The length of each bit cell shall be 36 T, where T corresponds to the length of a Channel bit in the Recordable Areas.

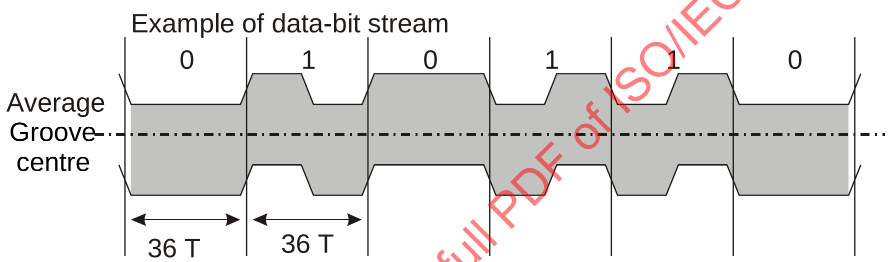

Figure 60 — Biphase modulated HFM Groove

15.5.4.3 Frame Sync

Each Recording Frame starts with a Synchronization pattern equivalent to 8 data bits. The first 4 bits are replaced by 4 bit cells with a special pattern that violates the normal Biphase encoding rules (see Figure 61: two possible patterns depending on the initial phase).

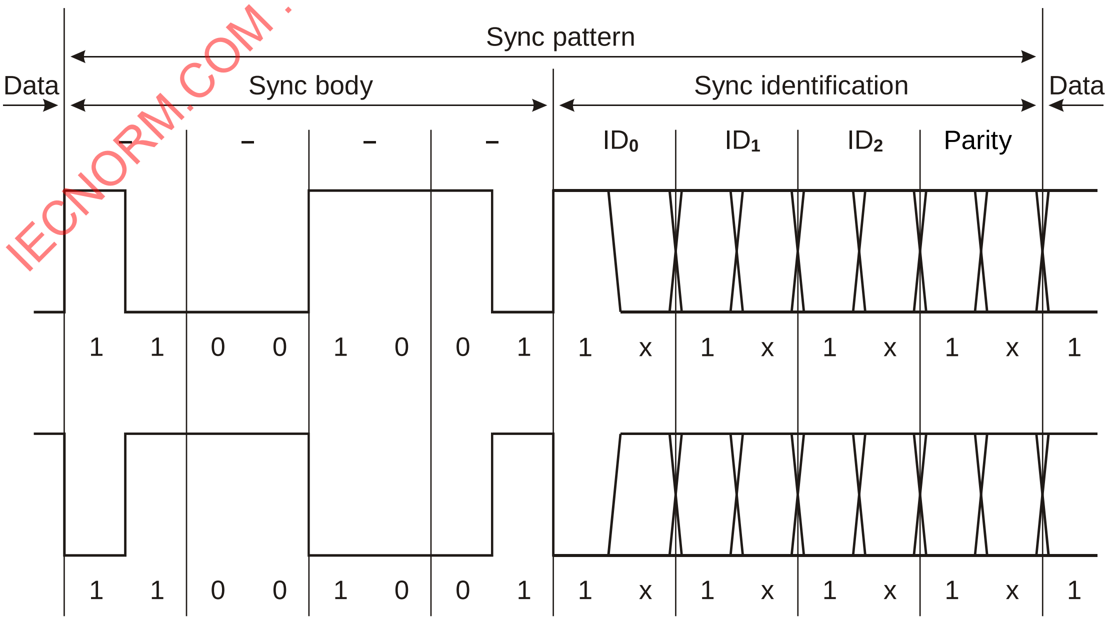

Figure 61 — Biphase Synchronization pattern

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Seven different Sync patterns are identified by the last 4 bits: ID_0 .. ID_2 and a Parity bit (see Figure 62).

Sync number	ID_0	ID_1	ID_2	Parity
FS0	0	0	0	0
FS1	0	0	1	1
FS2	0	1	0	1
FS3	0	1	1	0
FS4	1	0	0	1
FS5	1	0	1	0
FS6	1	1	0	0

Figure 62 — Sync identification

By means of the PIC BIS column, the 248 rows of a PIC Cluster can be divided into eight groups of 31 Recording Frames, where each group of Recording Frames carries an address in its first nine rows (see 15.5.3.5).

The 31 successive Recording Frames of each such group are identified by a special sequence of Sync patterns (see also 13.17.4). The first Recording Frame of each group has the unique Sync pattern FS0.

The other Sync patterns are mapped as specified in Figure 63.

Frame number	Sync number	Frame number	Sync number
0	FS0		
1	FS1	16	FS5
2	FS2	17	FS3
3	FS3	18	FS2
4	FS3	19	FS2
5	FS1	20	FS5
6	FS4	21	FS6
7	FS1	22	FS5
8	FS5	23	FS1
9	FS5	24	FS1
10	FS4	25	FS6
11	FS3	26	FS2
12	FS4	27	FS6
13	FS6	28	FS4
14	FS6	29	FS4
15	FS3	30	FS2

Figure 63 — Mapping of Sync patterns on PIC Recording Frames

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15.6 Track layout of Wobbled Groove(s)

15.6.1 General

The wobble of the Tracks is a more or less sinusoidal deviation from their average centrelines.

The Nominal Wobble Length NWL (equivalent to 69 Channel bits) shall be 5,140 5 µm ± 0,005 µm for a disk with a User Data capacity of 25,0 GB per layer, averaged over the Recordable Areas.

This corresponds to a fundamental frequency f_{wob} = 956,522 kHz at the Reference Velocity.

15.6.2 Modulation of wobbles

15.6.2.1 General

The basic shape of the wobble is a cosine wave: cos(2π × f_{wob} × t). Wobbles with this basic shape are called "Monotone Wobbles" (MW).

Some wobbles are modulated, where two modulation methods shall be used simultaneously:

- the first modulation method is called "MSK-cos" (Minimum-Shift Keying – cosine variant);
- the second modulation method is called "HMW" (Harmonic-Modulated Wave).

In the Protection-Zone 3 Area in the Outer Zone(s) (see Clause 16 and 20.2.10) the Groove shall be modulated by MSK-cos only and NOT by HMW.

Both modulation methods shall represent ADIP information as defined in 15.7.

15.6.2.2 MSK-cos modulation

MSK-cos modulation is applied by replacing three consecutive Monotone Wobbles by one MSK Mark (MM). An MSK Mark consists of three Nominal Wobble Lengths NWL with the following wobble patterns as indicated in Figure 64:

- the first NWL starts the MSK Mark with a cosine wobble with a frequency = 1,5 × f_{wob};
- the second NWL continues the MSK Mark with a cosine wobble with a frequency = f_{wob};
- the third NWL terminates the MSK Mark with a cosine wobble with a frequency = 1,5 × f_{wob}

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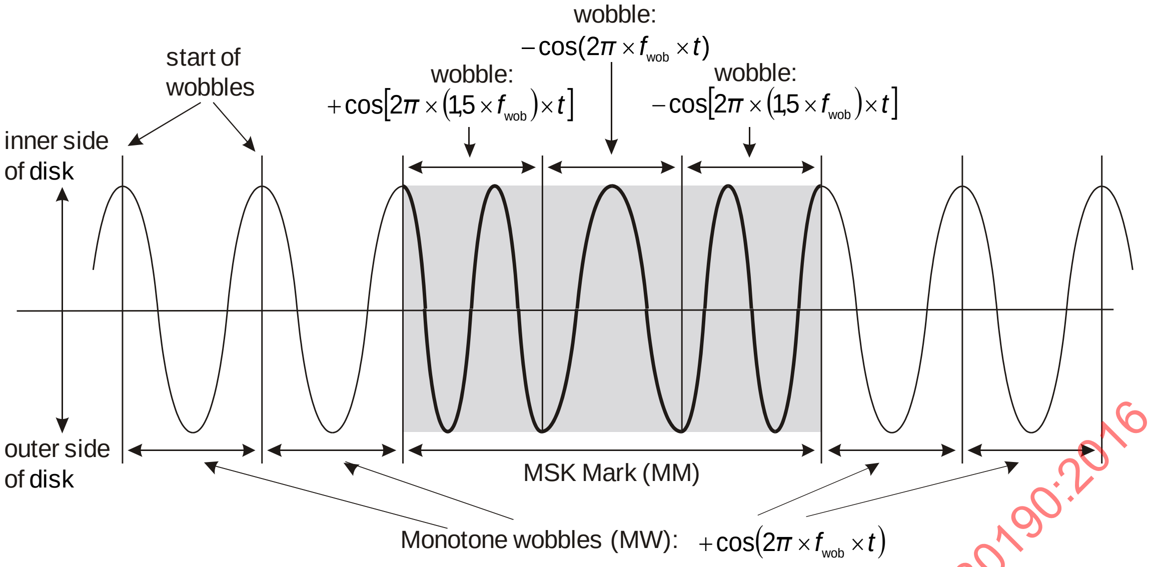

Figure 64 — Definition of MSK Mark (on Groove)

15.6.2.3 HMW modulation

HMW modulation is applied by replacing a number of consecutive Monotone Wobbles with the same number of Saw-Tooth Wobbles (STW). A Saw-Tooth Wobble is formed by combining the basic cosine with a sine wave of twice the frequency.

$\cos(2\pi \times f_{wob} \times t) \pm a \times \sin[2\pi \times (2 \times f_{wob}) \times t]$ in which $a = 0{,}25$

Such a combination of a cosine with the fundamental frequency and a certain amount of second harmonic represents a first-order approximation of a saw-tooth wave. The “+” or “–” sign creates a left or right inclination, where the “+” sign is used to represent the bit value ONE and the “–” sign is used to represent the bit value ZERO (see Figure 65).

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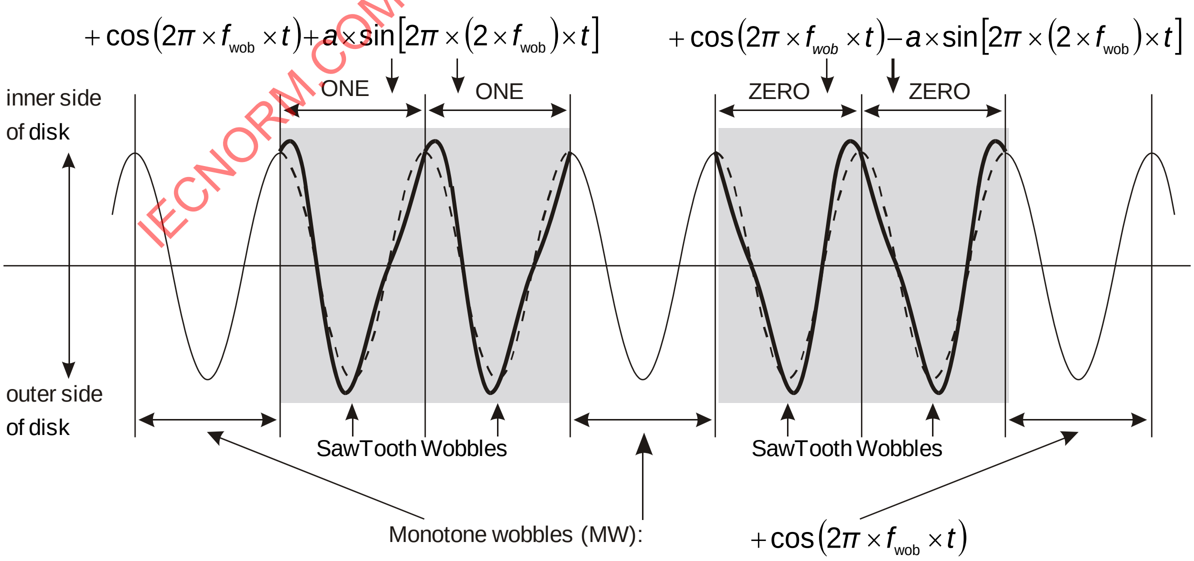

Figure 65 — Definition of Saw-Tooth Wobbles (on Groove)

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15.6.3 Wobble polarity

When Push-Pull polarity (see 26.1) is negative, then the Wobbled Groove shall start its first wobble deviation towards the outer side of the disk.

When Push-Pull polarity (see 26.1) is positive, then the Wobbled Groove shall start its first wobble deviation towards inner side of the disk.

15.7 ADIP information

15.7.1 General

Data to be recorded onto the disk shall be aligned with the ADIP addresses modulated in the wobble. Therefore 56 NWLs shall correspond to 2 Recording Frames (see 13.16). Each group of such 56 NWLs is called an ADIP Unit (see Figure 66).

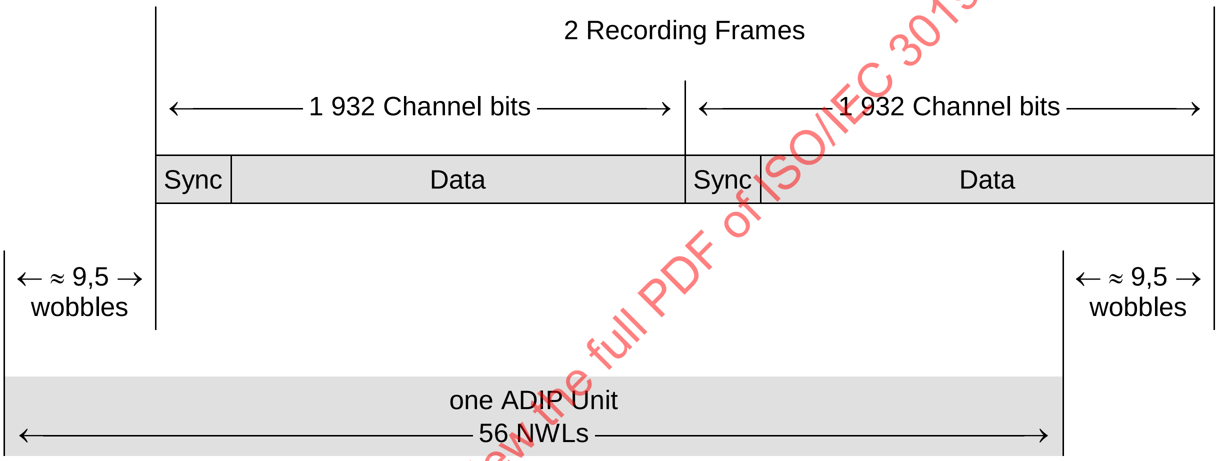

Figure 66 — General ADIP structure

15.7.2 ADIP-Unit Types

By inserting MMs into the 56 NWLs of an ADIP Unit with unique distances between adjacent MMs, different types of ADIP Units can be created.

The ADIP Units representing a data bit are additionally modulated with STWs.

Furthermore a reference STW Unit is defined. Each type of ADIP Unit starts with an MM.

The following types of ADIP Units are defined (see Figure 67).

Monotone Unit: consisting of one MM followed by 53 MWs
Reference Unit: consisting of one MM followed by 15 MWs, 37 STWs and one MW
Sync_0 Unit: consisting of one MM followed by 13 MWs, one MM, 7 MWs, one MM and 27 MWs
Sync_1 Unit: consisting of one MM followed by 15 MWs, one MM, 7 MWs, one MM and 25 MWs
Sync_2 Unit: consisting of one MM followed by 17 MWs, one MM, 7 MWs, one MM and 23 MWs
Sync_3 Unit: consisting of one MM followed by 19 MWs, one MM, 7 MWs, one MM and 21 MWs
Data_*x* Unit: with *x* representing 1 or 0:
- **Data_1 Unit**: consisting of one MM followed by 9 MWs, one MM, 3 MWs, 37 STWs and one MW
- **Data_0 Unit**: consisting of one MM followed by 11 MWs, one MM, one MW, 37 STWs and one MW

The 4 Sync Units are used for synchronization purposes while the Data_1 Unit is used to represent the bit value ONE, and the Data_0 Unit is used to represent the bit value ZERO.

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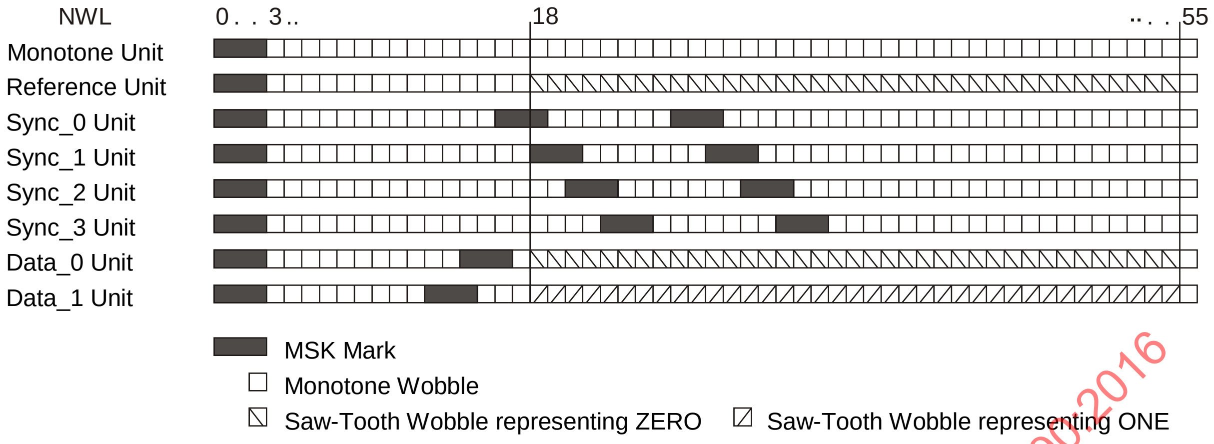

Figure 67 — ADIP-Unit Types

15.7.3 ADIP word structure

83 ADIP Units are grouped into one ADIP word. This means that 3 ADIP words correspond to 3 × 83 × 2 = 498 Recording Frames, which is equivalent to one Recording-Unit Block (RUB) (see 14.2).

Each ADIP word shall be constructed as indicated in Figure 68.

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ADIP Unit number	ADIP-Unit Type	ADIP nibble bit number	ADIP code-word nibble number
0	Monotone	---	---
1	Sync_0	---	
2	Monotone	---	
3	Sync_1	---	
4	Monotone	---	
5	Sync_2	---	
6	Monotone	---	
7	Sync_3	---	
8	Reference	---	
9	Data_*x*	b_3	c_0
10	Data_*x*	b_2	
11	Data_*x*	b_1	
12	Data_*x*	b_0	
13	Reference	---	---
14	Data_*x*	b_3	c_1
15	Data_*x*	b_2	
16	Data_*x*	b_1	
17	Data_*x*	b_0	
18	Reference	---	---
:	:	:	:
$8 + i \times 5$	Reference	---	---
$9 + i \times 5$	Data_*x*	b_3	c_i
$10 + i \times 5$	Data_*x*	b_2	
$11 + i \times 5$	Data_*x*	b_1	
$12 + i \times 5$	Data_*x*	b_0	
:	:	:	:
78	Reference	---	---
79	Data_*x*	b_3	c_{14}
80	Data_*x*	b_2	
81	Data_*x*	b_1	
82	Data_*x*	b_0	

Figure 68 — ADIP word structure

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15.7.4 ADIP data structure

15.7.4.1 General

Each ADIP word contains a total of 60 bits, which form a code word according to a non-systematic Reed-Solomon Error-Correction Code. This code word is constructed from 36 information bits. Before encoding the information, the 36 information bits are ordered into 9 4-bit nibbles, n_0 to n_8, as defined in the array of Figure 69.

Nibble	b_3	b_2	b_1	b_0		
n_0	AA23	AA22	AA21	AA20	↑	
n_1	AA19	AA18	:	:	*6 nibbles*	ADIP address
:	:	:	:	:		
n_5	AA3	:	:	AA0	↓	
n_6	AX11	:	:	:	↑	
:	:	:	:	:	*3 nibbles*	AUX data
n_8	AX3	:	:	AX0	↓	

Figure 69 — ADIP-information structure

The nibbles n_0 to n_8 are transcoded to nibbles c_0 to c_{14} by an error correction system (see 15.7.5). Because this error-correction system is non-systematic, there is no simple direct relationship between the bits in the information array and the coded bits in the ADIP Unit.

15.7.4.2 ADIP-information bit assignments

The information contained in the ADIP data bits shall be as follows.

- **AA23..AA0**: These 24 bits shall contain the Physical ADIP Address (PAA). AA23 shall be the msb and AA0 shall be the lsb. This address shall consist of three parts.
  - **AA23..AA21**: These 3 bits shall indicate the Layer number and shall be set to: 000 on Layer L0 and to 001 on Layer L1. All other settings shall be Reserved.
  - **AA20..AA2**: These 19 bits shall contain a sequential number, which shall increase by one after each 3 consecutive ADIP words (synchronized to the RUB's, see 14.2).
  - **AA1,AA0**: These 2 bits shall be set to 00, 01 and 10 consecutively in 3 successive ADIP words corresponding to one RUB. The setting 11 shall not be used.

The first address in the Information Zone on Layer L0 shall be such that the first address in the Data Zone, which is PAA 02 00 00h, is located at radius $24{,}0^{0,0}_{-0,1}$ mm.

The last address of the Data Zone on Layer L0 (LAA) shall be located at a radius <58,1 mm.

The first address of the Data Zone on Layer L1 (FAA) shall be located at a radius <58,1 mm.

The last address of the Data Zone on Layer L1 (3D FF FEh) shall be located at radius $24{,}0^{0,0}_{-0,1}$ mm.

- **AX11..AX0**: These 12 bits contain auxiliary information about the disk.
  - In the Data Zone(s) and the Outer Zone(s) of the disk, the auxiliary bits shall be set to ZERO.
  - In the Inner Zone(s) of the disk, the auxiliary bits shall be used as follows:

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— AX11..AX0 from 96 consecutive ADIP words (equivalent to 32 RUBs), shall form one ADIP Aux Frame with 144 bytes.

— The first bits of each ADIP Aux Frame shall be located in an ADIP word with a PAA that is a multiple of 128 (PAA = xxxx xxxx xxxx xxxx x000 0000).

— The content of the 144 bytes are defined in 15.8.

15.7.4.3 Relation between Physical ADIP Addresses on Layer L0 and Layer L1

There shall be a fixed relation between the PAAs on Layer L0 and Layer L1. The PAAs on Layer L0 and Layer L1 located at the same radius (having the same distance in number of ADIP words from their respective Inner Zone) shall have inverted bits AA20 to AA2 (see Figure 70).

In this way, the PAAs on Layer L1 increase from the outside towards the inside of the disk, which is in the tracking direction. Simultaneously the inverted address bits AA20..AA2 of PAA1 have the same relation with the radius as the equivalent non-inverted bits on Layer L0.

	Layer number	Sequence number	Intra-RUB number
PAA_0 on Layer L0	AA23 .. AA21 = 000	AA20 .. AA2	AA1,AA0 = 00,01,10 from inner to outer
PAA_1 on Layer L1	AA23 .. AA21 = 001	$\overline{AA20} .. \overline{AA2}$	AA1,AA0 = 00,01,10 from outer to inner

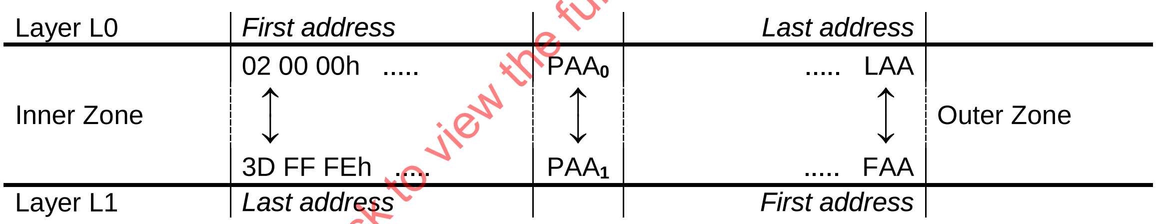

Figure 70 — Illustration of PAA relation between Layer L0 and Layer L1

Mathematically this can be expressed in the following way.

After adding C0 00 01h to PAA_0, all 24 bits are inverted resulting directly in the full corresponding address PAA_1 on Layer L1.

Mathematically: $PAA_1 = \overline{PAA_0 + C0\,00\,01h}$.

(The addition of 1 corrects for the order of the intra-RUB numbers, while the addition of C0 00 00h takes care of the correct Layer number.)

In this way, the last address of Data Zone 1 can be derived as follows: 3D FF FEh = $\overline{02\,00\,00h + C0\,00\,01h}$, and the first address of Data Zone 1 is: FAA = $\overline{LAA + C0\,00\,01h}$.

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15.7.5 ADIP error correction

The error-correction system is a nibble-based, (15,9,7) non-systematic Reed-Solomon (RS) code defined over the finite field GF(2^4). The total number of nibbles in a code word is 15, the code words are calculated from 9 information nibbles and the minimum distance of this code is 7.

The non-zero elements of the finite field GF(2^4) are generated by a primitive element α, where α is a root of the primitive polynomial $p(x)$.

$$p(x) = x^4 + x + 1$$

The symbols of GF(2^4) are represented by nibbles (groups of 4 bits), using the polynomial-base representation, with (α^3, α^2, α, 1) as a basis. The root α is thus represented as

$$\alpha = 0010$$

The code word, represented by the vector (c_0 c_1 .. c_{13} c_{14}), can be calculated from the information symbols n_0 to n_8 with the following formula:

$$C(x) = \sum_{i=0}^{14} c_i \times x^{14-i} = \sum_{i=0}^{7} n_i \times g^{(i)}(x) + n_8 \times g_p(x)$$

where $g_p(x)$ is the parent generator polynomial

$$g_p(x) = \prod_{i=0}^{13} \left(x - \alpha^i\right).$$

and $g^{(i)}(x)$ is a specific generator polynomial for each symbol n_i (i = 0 .. 7).
$g^{(i)}(x)$ is derived from the parent generator polynomial $g_p(x)$ by removing one of the zeroes z_i of $g_p(x)$ and normalizing the result such that $g^{(i)}(z_i) = 1$. The zero z_i to be removed is given by the formula below.

$$z_i = \alpha^{i+6}$$

The generator polynomials are then calculated as follows.

$$g^{(i)}(x) = \frac{\tilde{g}^{(i)}(x)}{\beta_i}$$

where $\tilde{g}^{(i)}(x) = \dfrac{g_p(x)}{x - z_i}$ and $\beta_i = \tilde{g}^{(i)}[z_i]$.

Before recording on the disk, all bits of the nibbles c_9 to c_{14} shall be inverted.

Remark 1:

Because the code is non-systematic, an additional calculation is needed to derive the information symbols from the corrected code-word symbols after standard RS-decoding.

The information symbols n_0 to n_7 can be obtained by evaluating the corrected code word $C(x)$ in the zero corresponding to the information symbol, i.e. by calculating a syndrome.

$$n_i = S_{i+6} = C\left(\alpha^{i+6}\right) = \sum_{j=0}^{14} c_{14-j} \times \alpha^{(i+6) \times j}$$

n_8 is a systematic symbol and can be obtained from $C(x)$ directly by copying symbol c_0.

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Remark 2:

Each information symbol n_i corresponds to a zero in the parent generator polynomial $g_p(x)$. This Figure 71 gives the corresponding zero factor for each information symbol (note that n_8 does not have a corresponding zero).

Symbol	Corresponding zero factor
	$(x - \alpha^0)$
	$(x - \alpha^1)$
	$(x - \alpha^2)$
	$(x - \alpha^3)$
	$(x - \alpha^4)$
	$(x - \alpha^5)$
n_0	$(x - \alpha^6)$
n_1	$(x - \alpha^7)$
n_2	$(x - \alpha^8)$
n_3	$(x - \alpha^9)$
n_4	$(x - \alpha^{10})$
n_5	$(x - \alpha^{11})$
n_6	$(x - \alpha^{12})$
n_7	$(x - \alpha^{13})$

Figure 71 — Corresponding zero factor for each information symbol

If an information symbol is known and its corresponding zero extends the existing series of zeroes corresponding to $(x - \alpha^0)$ .. $(x - \alpha^5)$ .. , the Hamming distance will increase. For instance if n_0 is known, the Hamming distance will become $d = 8$. If both n_0 and n_1 are known, the Hamming distance will become d = 9 etc.

In other words: prior knowledge of information symbols can increase the Hamming distance of the code. Because the addresses in the ADIP increase linearly, such prior knowledge is present.

This phenomenon can be used for additional checking of the reliability of the decoding result.

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15.8 Disk Information in ADIP Aux Frame

15.8.1 General

The information nibbles from the auxiliary fields of 96 consecutive ADIP words are grouped into frames of bytes and carry several disk parameters. The nibbles are re-ordered into bytes according to Figure 72. Several Disk-Information (DI) Aux Frames can be grouped into a DI Block. All Disk-Information Blocks shall have the same content.

Byte number	b_7	b_6	b_5	b_4	b_3	b_2	b_1	b_0
0	AX11 word 1	AX10 word 1	AX9 word 1	AX8 word 1	AX7 word 1	AX6 word 1	AX5 word 1	AX4 word 1
1	AX3 word 1	AX2 word 1	AX1 word 1	AX0 word 1	AX11 word 2	AX10 word 2	AX9 word 2	AX8 word 2
2	AX7 word 2	AX6 word 2	AX5 word 2	AX4 word 2	AX3 word 2	AX2 word 2	AX1 word 2	AX0 word 2
3	AX11 word 3	AX10 word 3	AX9 word 3	AX8 word 3	AX7 word 3	AX6 word 3	AX5 word 3	AX4 word 3
:								
:								
141	AX11 word 95	AX10 word 95	AX9 word 95	AX8 word 95	AX7 word 95	AX6 word 95	AX5 word 95	AX4 word 95
142	AX3 word 95	AX2 word 95	AX1 word 95	AX0 word 95	AX11 word 96	AX10 word 96	AX9 word 96	AX8 word 96
143	AX7 word 96	AX6 word 96	AX5 word 96	AX4 word 96	AX3 word 96	AX2 word 96	AX1 word 96	AX0 word 96

Figure 72 — ADIP Aux Frame byte ordering

15.8.2 Error protection for Disk-Information Aux Frames

The DI Aux Frames are protected by a Long-Distance RS Error-Correction Code according to 13.7. Because such a Long-Distance Code is built up from 248 bytes, 104 dummy bytes (not recorded on the disk) are added to complete the Long-Distance DI Aux Frame code-words (see Figure 73). Bytes $e_{0,L}$ .. $e_{103,L}$ in 13.7 represent the dummy bytes (all set to FFh), bytes $e_{104,L}$ ..$e_{215,L}$ represent the Disk-Information bytes, and bytes $p_{216,L}$ .. $p_{247,L}$ represent the Parity bytes.

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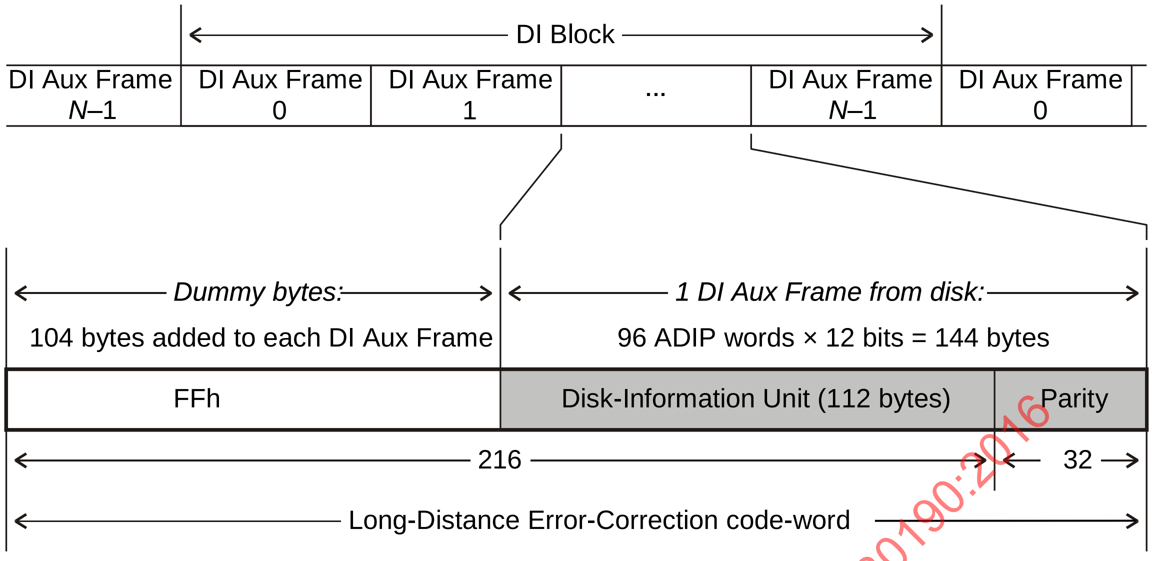

Figure 73 — Disk-Information structure and error-correction format

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15.8.3 Disk-Information data structure

15.8.3.1 General

A DI Block can consist of a multiple of 144-byte Aux DI Frames (see Figure 73). If needed, additional DI Aux Frames, up to a maximum total of 31 can be used. Each Recording Layer shall carry the same DI Blocks with the same DI Aux Frames.

The sequence of DI Aux Frames shall be repeated throughout the Inner Zones, starting with DI Aux Frame 0 from PAA 01 B8 00h on Layer L0 and from PAA 3E 00 00h on Layer L1.

In Protection-Zone 2 of Layer L0 (see Figure 84) and Buffer Zone/OPC1/Buffer Zone of Layer L1 (see Figure 85) the auxiliary bits can be set to ZERO or can contain DI Aux Frames (such that the sequence is contiguous with a DI Aux Frame 0 at the addresses specified above).

The 112 Disk-Information bytes in each DI Aux Frame are called a Disk-Information (DI) Unit. Each DI Unit shall start with 8 bytes, forming the DI-Unit header (see 15.8.3.2).

DI Units can contain different sets of parameters, such as different write strategies. To distinguish DI Units that have different definitions for their content, a unique identification of such DI Units is needed.

Byte 2 in the DI-Unit header, the DI-Format Number, shall be used for this purpose. With this byte, 256 types of DI Units with different content can be distinguished.

If the number of parameters of a single set do not fit in one DI Unit, such a set shall be stored in multiple consecutive DI Units, in which case bit b_7 of byte 6 indicates that the next DI Unit in the sequence is a continuation of the actual one.

Usage of DI Units for write strategy is given in 15.8.3.7.

In future extensions of this International Standard, additional DI Aux Frames may be needed, e.g. to define higher Recording Velocities and new write strategies. Whenever new DI Aux Frames are added, the existing ones can still be used if appropriate, and in that way backwards compatibility with existing drives can be facilitated. Each drive should check all DI Aux Frames present on the disk and, based on the DI-Format Number (byte 2) and the indicated Recording Velocity (bytes 32 to 35), only use the ones that it is supporting (see also 15.8.3.7).

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15.8.3.2 General definitions for DI Unit

Each DI Unit shall consist of a header, a body and a footer as depicted in Figure 74.

	Byte number	Content	Number of bytes
Header	0 to 1	Disk-Information identifier	2
	2	DI-Format Number	1
	3	Number of DI Aux Frames in each DI Block (5 bits) Number of the layer to which this DI Unit applies (3 bits)	1
	4	Reserved	1
	5	DI-Unit sequence number in DI Block	1
	6	Continuation flag (1 bit) Number of DI bytes in use in this DI Unit (7 bits)	1
	7	Reserved	1
Body	8 to 99	DI-Unit content	92
Footer	100 to 105	Disk-Manufacturer ID	6
	106 to 108	Media-Type ID	3
	109 to 110	Time stamp	2
	111	Product Revision number	1

Figure 74 —General DI-Unit format

Bytes 0 to 1: **Disk-Information identifier**

These 2 bytes shall be set to 44 49h, representing the characters “DI”.

Byte 2: **DI-Format Number**

This byte shall identify the content of the DI Unit or DI Unit set (see description of byte 6).

For disks with BCA code, the msb of this byte shall be set to ZERO.

For disks without BCA code, the msb of this byte shall be set to ONE.

NOTE The DI-Format Number only defines the content of the DI Unit and has no relation with the Class number and the Version number as defined in byte 11.

In the future, this International standard may be extended to allow for new features, such as higher Recording Velocities or higher data densities. To prevent backwards-compatibility problems of such newer disks with older drives as much as possible, a Class number and a Version number have been introduced.

The Class number will be incremented if a BD Layer according to the new specifications should not be accessed by legacy drives at all, neither for reading nor for writing (e.g. to prevent possible damage to the disk or to the drive).

If the read compatibility can be made to conform to an existing Class, no new Class number is needed.

The Version number will be incremented if the new specifications imply an extension/change for which no Class-number update is needed (read compatibility is maintained), but which new specifications will result in a write-compatibility break. Although such a BD Layer is carrying a higher Version number, it still could contain a DI Unit according to a previously defined DI Format, if this layer can be recorded according to the write strategy as defined in such DI Unit.

As a consequence of this, drives should always check for the presence of a DI Unit with a DI-Format number known to the drive. In such cases, the recording parameters (such as e.g. Recording Velocities, recording power, timing requirements) needed to set the related write strategy can be checked and if these are within the capabilities of the drive, the drive should accept the disk for recording.

By using the Class number and the Version number as described above, backwards compatibility of future disks can be maximized while still preventing possible damage to disks and drives.

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Each Layer Type (defined by bytes 8 to 10) has its own independent DI-Format numbering. The DI-Format Number is also an indication for the write-strategy type, which is specified in the DI Unit.

Byte 3: **Number of DI Aux Frames in each DI Block / Number of the layer to which this DI Unit applies**

Bits b_7 to b_3: These 5 bits shall specify the number of DI Aux Frames N in each DI Block ($1 \le N \le 31$).

Bits b_2 to b_0: These 3 bits shall specify the number of the Recording Layer to which the specifications in this DI Unit apply.

Byte 4: **Reserved**

This byte shall be set to 00h.

Byte 5: **DI-Unit sequence number in DI Block**

This byte specifies the sequential DI-Unit number within the DI Block.

It shall be set to a number n, where n indicates the actual number of the DI Unit within the actual DI Block ($0 \le n \le N–1$).

The sequence of DI Units shall be ordered (see Figure 75) first according to increasing Nominal Recording Velocity (byte 32 to 33), second within each sequence of DI Units with the same Nominal Recording Velocity, according to ascending Layer number (byte 3) and third according to the preference of the write strategy (identified by the DI-Format Number, but need not be in the sequence of DI-Format Numbers).

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Sequence number	Recording Velocity	Layer number	Write strategy
0	v_1	0	preferred WS
1			alternative WS
:		1	preferred WS
k–1			alternative WS
k		:	preferred WS
:			alternative WS
:		k–1	preferred WS
2k–1			alternative WS
2k	$v_2 > v_1$	0	most preferred WS :
:		:	:
: :		k–1	: least preferred WS
:	$v_3 > v_2$	0	:
:	:	:	:
N–1	etc.	etc.	:

Figure 75 — Example of DI-Block sequence

Byte 6: **Continuation flag / Number of DI bytes in use in this DI Unit**

Bit b_7: This bit specifies whether the parameter set in this DI Unit is continued in the next DI Unit or if the next DI Unit is the start of a new set of parameters.

It shall be set to

ZERO if the next DI Unit is the start of a new set of parameters, or

ONE if the parameter set in this DI Unit is continued in the next DI Unit (see Figure 76).

Bits b_6 to b_0: These 7 bits shall indicate the number of bytes in use in the actual DI Unit up to the last unused (Reserved) bytes immediately preceding the footer (see e.g. Figure 77).

	:	
	Byte 2 = .. Byte 3 = *N* / Layer L0 Byte 5 = *n*–1 Byte 6, bit b_7 = 0	end of preceding parameter set
↑ Parameter set for Layer L1 spans 3 DI Units ↓	Byte 2 = x Byte 3 = *N* / Layer L1 Byte 5 = *n* **Byte 6, bit b_7 = 1**	start of actual parameter set : : :
	Byte 2 = x Byte 3 = *N* / Layer L1 Byte 5 = *n*+1 **Byte 6, bit b_7 = 1**	: continuation of actual parameter set :
	Byte 2 = x Byte 3 = *N* / Layer L1 Byte 5 = *n*+2 **Byte 6, bit b_7 = 0**	: : : end of actual parameter set
	Byte 2 = .. Byte 3 = *N* / Layer L0 Byte 5 = *n*+3 Byte 6, bit b_7 = ..	start of next parameter set
	:	

Figure 76 — Example of DI-Unit extension

Byte 7: **Reserved**

This byte shall be set to 00h.

Bytes 8 to 99: **DI-Unit content**

These 92 bytes shall store the specific content of the DI Unit, such as e.g. general disk parameters, read/write powers and write-strategy parameters.

Bytes 100 to 105: **Disk-Manufacturer ID**

The format and the content of these 6 bytes require agreement between the interchange parties, else these bytes shall be set to all 00h.

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Bytes 106 to 108: **Media-Type ID**

The format and the content of these 3 bytes require agreement between the interchange parties, else these bytes shall be set to all 00h.

Bytes 109 to 110: **Time stamp**

These 2 bytes provide information about the production date of the Master disk from which this disk has been replicated. All disks with the same Disk-Manufacturer ID and the same Media-Type ID, regardless of the Time stamp, shall have the same recording properties (only minor differences are allowed: the Time stamp shall be irrelevant for recorders).

Bits b_7 to b_0 of byte 109 plus bits b_7 to b_4 of byte 110 shall form one 12-bit binary number representing the year of production.

Bits b_3 to b_0 of byte 110 shall form one 4-bit binary number representing the month of production.

If the Time stamp is not used, both bytes shall be set 00h.

Byte 111: **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 the Product Revision numbers, shall 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. This International Standard does not specify the format and the content of this byte. It shall be ignored in interchange.

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15.8.3.3 Definitions for DI format 1 (N–1 write strategy)

The content of the body of DI Units according to format 1 shall be as depicted in Figure 77.

Byte number	Content	Number of bytes
0 to 7	DI-Unit header	8
8 to 10	BD Layer-Type identifier	3
11	Disk size/Class/Version	1
12	BD structure	1
13	Channel-bit length	1
14	Push-Pull polarity flag bits	1
15	Recorded-Mark polarity flag bits	1
16	BCA descriptor	1
17	Maximum transfer rate	1
18 to 23	Reserved	6
24 to 31	Data-Zone allocation	8
32 to 35	Recording Velocities	4
36 to 39	Maximum dc read powers	4
40 to 43	Maximum HF-modulated read powers	4
44 to 47	Reserved	4
48 to 55	Write-power settings	8
56	T_{MP} write multi-pulse duration	1
57 to 68	dT_{top} first-write-pulse start time	12
69 to 92	T_{top} first-write-pulse duration	24
93 to 94	T_{LP} last-pulse duration	2
95 to 97	dT_S start time of Space-level	3
98 to 99	Unused = all 00h	2
100 to 111	DI-Unit footer	12

Figure 77 — Content of Disk Information for DI format 1

Bytes 0 to 1: **Disk-Information identifier**

See 15.8.3.2.

Byte 2: **DI-Format Number**

This byte shall be set to 01h for disks with BCA code.

This byte shall be set to 81h for disks without BCA code.

Byte 3: **Number of DI Aux Frames in each DI Block / Number of the layer to which this DI Unit applies**

See 15.8.3.2.

Byte 4: **Reserved**

See 15.8.3.2.

Byte 5: **DI-Unit sequence number in DI Block**

See 15.8.3.2.

Byte 6: **Continuation flag/Number of DI bytes in use in this DI Unit**

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This byte shall be set to 62h indicating that the first 98 bytes of the DI Unit are used and that there is no continuation in the next DI Unit. All remaining bytes of the DI-Unit body (excluding the bytes in the DI-Unit footer) are unused and shall be set to 00h.

Byte 7: **Reserved**

See 15.8.3.2.

Bytes 8 to 10: **BD Layer-Type identifier**

These 3 bytes identify the type of the BD Layer to which this DI Unit applies and shall be set to 42 44 52h, representing the characters “BDR” in each Recordable Layer.

Byte 11: **Disk size/Class/Version**

Bits b_7 to b_6: These 2 bits specify the disk size. They shall be set to 00, indicating a 120 mm disk.

Bits b_5 to b_4: These 2 bits specify the Class number. The Class number identifies BD Layers of the same Layer Type but with different basic specifications.

BD Layers according to this International Standard shall have these bits set to 00.

Drives that are not familiar with a particular Class of layers should not access the Data Zone of such layers (neither for reading nor for writing).

Bits b_3 to b_0: These 4 bits specify the Version number. They shall be set to 0001, indicating a layer according to this International Standard.

Byte 12: **BD structure**

Bits b_7 to b_4: These 4 bits specify the total number of BD Recording/Recorded Layers on the disk.

On SL disks they shall be set to 0001, indicating one Recording Layer.

On DL disks they shall be set to 0010, indicating two Recording Layers.

Bits b_3 to b_0: These 4 bits specify the type of BD Recording/Recorded Layer to which this DI Unit applies.

Bits b_3 to b_0 shall be set to 0010, indicating a recordable Recording Layer.

Byte 13: **Channel-bit length**

Bits b_7 to b_4: These 4 bits shall be set to 0000.

Bits b_3 to b_0: These 4 bits specify the main data Channel-bit length, which shall be the same on all BD Recording Layers.

They shall be set to

0001: indicating a Channel-bit length of 74,5 nm (25,0 GB per layer),

other settings: Reserved.

Byte 14: **Push-Pull polarity flag bits**

Bit b_i **:** Each bit b_i shall specify the polarity of the Push-Pull signal on Recording Layer L*i* (see 26.1). They shall be set to

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ZERO: indicating that the Push-Pull polarity on Layer L*i* is positive,

ONE: indicating that the Push-Pull polarity on Layer L*i* is negative.

For Recording Layers that are not present, bit b_i shall be set to ZERO.

Byte 15: Recorded-Mark polarity flag bits

Bit b_i **:** Each bit b_i shall specify the polarity of the Recorded Marks on Recording Layer L*i*.

They shall be set to

ZERO: indicating a Layer Type on which Recorded Marks have a lower reflectivity than the Unrecorded Layer (HTL disks),

ONE: indicating a Layer Type on which Recorded Marks have a higher reflectivity than the Unrecorded Layer (LTH disks).

For Recording Layers that are not present, bit b_i shall be set to ZERO.

Byte 16: BCA descriptor

Bits b_7 to b_4: These 4 bits shall be Reserved.

Bits b_3 to b_0: These 4 bits shall indicate the presence of a BCA code on this disk:

0000: indicates that there is no BCA code,

0001: indicates that BCA code is present,

other settings: Reserved.

Byte 17: Maximum transfer rate

This byte specifies the maximum read transfer rate needed by the Application as a number *n* such that

n = maximum read transfer rate in Mbit/s ($n \leq 255$; M = 10^6),

n shall be set to 00h, indicating no maximum transfer rate is specified

Bytes 18 to 23: Reserved

These bytes shall all be set to 00h.

Bytes 24 to 31: Data-Zone allocation

Bytes 24 to 27: These bytes specify the first Physical ADIP Address of the Data Zone of the related layer.

In each DI Unit relating to Layer L0 these bytes shall be set to 00 02 00 00h, indicating PAA 131 072 as the first PAA of Data Zone 0.

In each DI Unit relating to Layer L1 these bytes shall be set to a value FAA, which shall be 00 26 B1 80h for a disk with a User-Data capacity of 25,0 GB per layer, indicating FAA as the first PAA of Data Zone 1.

Bytes 28 to 31: These bytes specify the last Physical ADIP Address of the Data Zone of the related layer.

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In each DI Unit relating to Layer L0 these bytes shall be set to a value LAA, which shall be 00 19 4E 7Eh for a disk with a User-Data capacity of 25,0 GB per layer, indicating LAA as the last PAA of Data Zone 0.

In each DI Unit relating to Layer L1 these bytes shall be set to 00 3D FF FEh, indicating PAA 4 063 230 as the last PAA of Data Zone 1.

Bytes 32 to 35: **Recording Velocities**

Byte 32 to 33: These bytes specify the Nominal Recording Velocity, to be used with the parameters as defined in this DI Unit, as a 2-byte binary number (byte 32 is MSB).

It shall specify the Nominal Recording Velocity as a number *n* such that

$$n = 100 \times V_{\mathbf{nom}}$$

n shall be equal to

01 ECh to indicate a Nominal Recording Velocity of 4,92 m/s,

or:

03 D7h to indicate a Nominal Recording Velocity of 9,83 m/s,

Byte 34: This byte specifies the Maximum Recording Velocity, to be used with the parameters as defined in this DI Unit.

It shall specify the Maximum Recording Velocity as a number *n* such that

$$n = 100 \times V_{\mathbf{max}} / V_{\mathbf{nom}} \ (n \geq 100).$$

Here *n* shall be equal to 64h to indicate a Maximum Recording Velocity equal to the Nominal Recording Velocity.

Byte 35: This byte specifies the Minimum Recording Velocity, to be used with the parameters as defined in this DI Unit).

It shall specify the Minimum Recording Velocity as a number *n* such that

$$n = 100 \times V_{\mathbf{min}} / V_{\mathbf{nom}} \ (n \leq 100).$$

Here *n* shall be equal to 64h to indicate a Minimum Recording Velocity equal to the Nominal Recording Velocity.

Bytes 36 to 39: **Maximum dc read power**

The maximum read power is defined as the maximum optical power on the Entrance surface of the disk, at which at least 10^6 successive reads can be applied without degrading the recorded signals (see 30.6). Maximum read powers in 15.8.3.3 shall be greater than or equal to the read powers defined in 30.6. By default, the powers defined in 30.6 shall be used.

Byte 36: This byte shall specify the maximum dc read power P_r at the Reference Velocity, in milliwatts, as a number *n* such that

$$n = 100 \times P_r.$$

Bytes 37 to 39: These bytes each shall specify the maximum dc read power P_r, at a read velocity corresponding to the Nominal Recording Velocity, as defined in byte 32 and 33 of this DI Unit**,** in milliwatts, as a number *n* such that

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$n = 100 \times P_r$.

NOTE For reading at lower velocities than the lowest specified velocity, a reduction of the read power might be necessary to guarantee stability of the recordings on the disk.

Bytes 40 to 43: Maximum HF-modulated read powers

The maximum read power is defined as the maximum optical power on the Entrance surface of the disk, at which at least 10^6 successive reads can be applied without degrading the recorded signals (see 30.6). Maximum read powers in 15.8.3.3 shall be greater than or equal to the read powers defined in 30.6. By default, the powers defined in 30.6 shall be used.

Byte 40: This byte shall specify the maximum HF-modulated read power P_r at the Reference Velocity, in milliwatts, as a number n such that

$n = 100 \times P_r$.

Bytes 41 to 43: These bytes each shall specify the maximum HF-modulated read power P_r, at a read velocity corresponding to the Nominal Recording Velocity as defined in byte 32 and 33 of this DI Unit, in milliwatts, as a number n such that

$n = 100 \times P_r$.

NOTE For reading at lower velocities than the lowest specified velocity, a reduction of the read power might be necessary to guarantee stability of the recordings on the disk.

Bytes 44 to 47: Reserved

These bytes shall all be set to 00h.

Bytes 48 to 55: Write-power settings

Byte 48: $\boldsymbol{P_{IND}}$: P_{IND} can be used as a starting value for the determination of P_{target} in the OPC procedure (see Annex G).

This byte shall specify the indicative value P_{IND} of P_{target}, in milliwatts, as a number n such that

$n = 20 \times P_{IND}$.

Byte 49: $\boldsymbol{m_{IND}}$: m_{IND} can be used as a starting value for the determination of P_{target} in the OPC procedure (see Annex G).

This byte shall specify the modulation at P_{IND}, as determined by the media manufacturer, as a number n such that

$n = 200 \times m_{IND}$.

Byte 50: $\boldsymbol{\rho}$: This byte shall specify the write-power multiplication factor ρ, used in the OPC algorithm (see Annex G), as a number n such that

$n = 100 \times \rho$.

Byte 51: $\boldsymbol{\varepsilon_{BW}}$: This byte shall specify the write-bias/write-peak power ratio ε_{BW}, used in the OPC algorithm (see Annex G), as a number n such that

$n = 200 \times \varepsilon_{BW}$.

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Byte 52: ε_C: This byte shall specify the cooling/write-peak power ratio ε_C, used in the OPC algorithm (see Annex G), as a number n such that

$$n = 200 \times \varepsilon_C.$$

Byte 53: ε_S: This byte shall specify the Space/write-peak power ratio ε_S, used in the OPC algorithm (see Annex G), as a number n such that

$$n = 200 \times \varepsilon_S.$$

Byte 54: κ: This byte shall specify the target value for κ, used in the OPC procedure (see Annex G), as a number n such that

$$n = 20 \times \kappa.$$

Byte 55: β: This byte shall specify the target value for β, used in the alternative OPC procedure (see Annex G), as a number n such that

$$n = 500 \times (\beta + 0{,}2).$$

Byte 56: **T_{MP} write multi-pulse duration**

This byte specifies the duration of the second and higher pulses of the multi-pulse train of the N–1 write strategy, for recording Marks (see Annex F).

The multi-pulse duration T_{MP} consists of two contributions: a variable part and a fixed part ($T_{MP} = T_{MP,var} + T_{MP,fix}$).

The first 4 bits (bits b_7 to b_4) of this byte shall specify the variable part, as a fraction of the actual Channel-bit clock period, as an unsigned binary number p such that

$$p = 16 \times \frac{T_{MP,var}}{T_W} \quad (0 \le p \le 15).$$

The last 4 bits (bits b_3 to b_0) of this byte shall specify the fixed part as a fraction of T_X, where T_X = 15,15 ns at 1×V_{ref} or T_X = 7,58 ns at 2×V_{ref}. The value is expressed as an unsigned binary number q such that

$$q = 16 \times \frac{T_{MP,fix}}{T_X} \quad (0 \le q \le 15).$$

Bytes 57 to 68: **dT_{top} first-write-pulse start time.**

The first 5 bits (bits b_7 to b_3) of these bytes shall specify the start time of the first pulse of the multi-pulse train, of the N–1 write strategy, for recording Marks with run-lengths of 2T, 3T and ≥ 4T that succeed a Space with a run-length of 2T, 3T, 4T or ≥ 5T (see Annex F).

The first pulse start time dT_{top} is expressed as a fraction of the actual Channel-bit clock period as a signed two's-complement binary number i such that

$$i = 16 \times \frac{dT_{top}}{T_W} \quad (-14 \le i \le 15).$$

The last 3 bits (bits b_2 to b_0) of these bytes shall be Reserved.

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Bytes 57 to 60: These bytes specify the start time of the first pulse of the multi-pulse train for recording Marks with run-lengths ≥ 4T that succeed a Space with a run-length of 2T, 3T, 4T or ≥5T, relative to the trailing edge of the first Channel bit of the data pulse (positive values are leading, negative values are lagging; see Annex F).

Byte 57 shall represent the start time of the first pulse for recording Marks with run-lengths ≥4T that succeed a Space with a run-lengths ≥5T.

Byte 58 shall represent the start time of the first pulse for recording Marks with run-lengths ≥4T that succeed a Space with a run-length of 4T.

Byte 59 shall represent the start time of the first pulse for recording Marks with run-lengths ≥4T that succeed a Space with a run-length of 3T.

Byte 60 shall represent the start time of the first pulse for recording Marks with run-lengths ≥4T that succeed a Space with a run-length of 2T.

Bytes 61 to 64: These bytes specify the start time of the first pulse of the multi-pulse train for recording Marks with run-length of 3T that succeed a Space with a run-length of 2T, 3T, 4T or ≥5T, relative to the trailing edge of the first Channel bit of the data pulse (positive values are leading, negative values are lagging; see Annex F).

Byte 61 shall represent the start time of the first pulse for recording Marks with a run-length of 3T that succeed a Space with a run-length ≥5T.

Byte 62 shall represent the start time of the first pulse for recording Marks with a run-length of 3T that succeed a Space with a run-length of 4T.

Byte 63 shall represent the start time of the first pulse for recording Marks with a run-length of 3T that succeed a Space with a run-length of 3T.

Byte 64 shall represent the start time of the first pulse for recording Marks with a run-length of 3T that succeed a Space with a run-length of 2T.

Bytes 65 to 68: These bytes specify the start time of the first pulse of the multi-pulse train for recording Marks with run-length of 2T that succeed a Space with run-lengths of 2T, 3T, 4T or ≥5T, relative to the trailing edge of the first Channel bit of the data pulse (positive values are leading, negative values are lagging; see Annex F).

Byte 65 shall represent the start time of the first pulse for recording Marks with a run-length of 2T that succeed a Space with a run-length ≥5T .

Byte 66 shall represent the start time of the first pulse for recording Marks with a run-length of 2T that succeed a Space with a run-length of 4T.

Byte 67 shall represent the start time of the first pulse for recording Marks with a run-length of 2T that succeed a Space with a run-length of 3T.

Byte 68 shall represent the start time of the first pulse for recording Marks with a run-length of 2T that succeed a Space with a run-length of 2T.

Bytes 69 to 92: **T_{top} first-write-pulse duration**.

These bytes specify the duration of the first pulse of the multi-pulse train, of the N–1 write strategy, for recording Marks with run-lengths 2T, 3T and ≥4T that succeed a Space with a run-length of 2T, 3T, 4T or ≥5T. (see Annex F).

The first pulse duration T_{top} consists of two contributions: a variable part and a fixed part (T_{top}= $T_{top,var}$ + $T_{top,fix}$).

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For each of the byte fields *f* to *f* +1, with *f* = 69, 71, ….91 the following values are defined:

Byte *f*: The first 5 bits (bits b_7 to b_3) of this byte shall specify the variable part, as a fraction of the actual Channel-bit clock period, as an unsigned binary number *j* such that

$$j = 16 \times \frac{T_{\text{top,var}}}{T_W} \qquad (0 \leq j \leq 30).$$

The last 3 bits (bits b_2 to b_0) of this byte shall be Reserved.

Byte (*f* +1): The first 5 bits (bits b_7 to b_3) of this byte shall specify the fixed part as a fraction of T_X, where T_X = 15,15 ns at 1×V_{ref} or T_X = 7,58 ns at 2×V_{ref}. The value is expressed as an unsigned binary number *k* such that

$$k = 16 \times \frac{T_{\text{top,fix}}}{T_X} \qquad (0 \leq k \leq 30).$$

The last 3 bits (bits b_2 to b_0) of this byte shall be Reserved.

Bytes 69 to 76: These bytes specify the duration of the first pulse of the multi-pulse train for recording Marks with run-lengths ≥4T that succeed a Space with a run-length of 2T, 3T, 4T or ≥5T (see Annex F).

Byte 69 and 70 shall represent the duration of the first pulse for recording Marks with run-lengths ≥4T that succeed a Space with a run-length ≥5T.

Byte 71 and 72 shall represent the duration of the first pulse for recording Marks with run-lengths ≥4T that succeed a Space with a run-length of 4T.

Byte 73 and 74 shall represent the duration of the first pulse for recording Marks with run-lengths ≥4T that succeed a Space with a run-length of 3T.

Byte 75 and 76 shall represent the duration of the first pulse for recording Marks with run-lengths ≥4T that succeed a Space with a run-length of 2T.

Bytes 77 to 84: These bytes specify the duration of the first pulse of the multi-pulse train for recording Marks with a run-length of 3T that succeed a Space with a run-length of 2T, 3T, 4T or ≥5T (see Annex F).

Byte 77 and 78 shall represent the duration of the first pulse for recording Marks with a run-length of 3T that succeed a Space with a run-length ≥5T.

Byte 79 and 80 shall represent the duration of the first pulse for recording Marks with a run-length of 3T that succeed a Space with a run-length of 4T.

Byte 81 and 82 shall represent the duration of the first pulse for recording Marks with a run-length of 3T that succeed a Space with a run-length of 3T.

Byte 83 and 84 shall represent the duration of the first pulse for recording Marks with a run-length of 3T that succeed a Space with a run-length of 2T.

Bytes 85 to 92: These bytes specify the duration of the first pulse of the multi-pulse train for recording Marks with a run-length of 2T that succeed a Space with a run-lengths of 2T, 3T, 4T or ≥5T (see Annex F).

Byte 85 and 86 shall represent the duration of the first pulse for recording Marks with a run-length of 2T that succeed a Space with a run-length ≥5T.

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Byte 87 and 88 shall represent the duration of the first pulse for recording Marks with a run-length of 2T that succeed a Space with a run-length of 4T.

Byte 89 and 90 shall represent the duration of the first pulse for recording Marks with a run-length of 2T that succeed a Space with a run-length of 3T.

Byte 91 and 92 shall represent the duration of the first pulse for recording Marks with a run-length of 2T that succeed a Space with a run-length of 2T.

Bytes 93 to 94: **T_{LP} last-pulse duration.**

These bytes specify the last-pulse length of the multi-pulse train, of the N–1 write strategy, for recording Marks with run-lengths of 3T and ≥4T (see Annex F).

The last-pulse duration T_{LP} consists of two contributions: a variable part and a fixed part ($T_{LP} = T_{LP,var} + T_{LP,fix}$).

The first 4 bits (bits b_7 to b_4) of this byte shall specify the variable part, as a fraction of the actual Channel-bit clock period, as an unsigned binary number *s* such that

$$s = 16 \times \frac{T_{LP,var}}{T_W} \qquad (0 \le s \le 15).$$

The last 4 bits (bits b_3 to b_0) of this byte shall specify the fixed part as a fraction of T_X, where T_X = 15,15 ns at 1×V_{ref} or T_X = 7,58 ns at 2×V_{ref}. The value is expressed as an unsigned binary number *t* such that

$$t = 16 \times \frac{T_{LP,fix}}{T_X} \qquad (0 \le t \le 15).$$

Byte 93: This byte shall specify the duration of the last pulse of the multi-pulse train for recording Marks with run-lengths ≥ 4T (see Annex F).

Byte 94: This byte shall specify the duration of the last pulse of the multi-pulse train for recording Marks with a run-length of 3T (see Annex F).

Bytes 95 to 97: **dT_S start time of Space level.**

The first 6 bits (bits b_7 to b_2) of these bytes shall specify the start time of the Space level of the N–1 write strategy, succeeding the recording Marks with run-lengths of 2T, 3T and ≥ 4T (positive values are leading, negative values are lagging; see Annex F).

The start time of the Space level dT_S is expressed as a fraction of the actual Channel-bit clock period as a signed two's-complement binary number *u* such that

$$u = 16 \times \frac{dT_S}{T_W} \qquad (-24 \le u \le 15).$$

The last 2 bits (bits b_1 to b_0) of these bytes shall be Reserved.

Byte 95: This byte shall specify the start time of the Space level, of the N–1 write strategy, succeeding the recording Marks with run-lengths ≥4T.

Byte 96: This byte shall specify the start time of the Space level, of the N–1 write strategy, succeeding the recording Marks with a run-length of 3T.

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Byte 97: This byte shall specify the start time of the Space level, of the N–1 write strategy, succeeding the recording Marks with a run-length of 2T.

Bytes 98 to 99: Unused

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15.8.3.4 Definitions for DI format 2 (N/2 write strategy)

The content of the body of DI Units according to format 2 shall be as depicted in Figure 78.

Byte number	Content	Number of bytes
0 to 7	DI-Unit header	8
8 to 10	BD Layer-Type identifier	3
11	Disk size/Class/Version	1
12	BD structure	1
13	Channel-bit length	1
14	Push-Pull polarity flag bits	1
15	Recorded-Mark polarity flag bits	1
16	BCA descriptor	1
17	Maximum transfer rate	1
18 to 23	Reserved	6
24 to 31	Data-Zone allocation	8
32 to 35	Recording Velocities	4
36 to 39	Maximum dc read powers	4
40 to 43	Maximum HF-modulated read powers	4
44 to 47	Reserved	4
48 to 55	Write-power settings	8
56 to 57	T_{MP} write multi-pulse duration	2
58 to 61	dT_{top} first-write-pulse start time	4
62 to 69	T_{top} first-write-pulse duration	8
70 to 73	T_{LP} last-pulse duration	4
74 to 77	dT_{S} start time of Space-level	4
78 to 99	Unused = all 00h	22
100 to 111	DI-Unit footer	12

Figure 78 — Content of Disk Information for DI format 2

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Bytes 0 to 1: **Disk-Information identifier**

See 15.8.3.2.

Byte 2: **DI-Format Number**

This byte shall be set to 02h for disks with BCA code.

This byte shall be set to 82h for disks without BCA code.

Byte 3: **Number of DI Aux Frames in each DI Block / Number of the layer to which this DI Unit applies**

See 15.8.3.2.

Byte 4: **Reserved**

See 15.8.3.2.

Byte 5: **DI-Unit sequence number in DI Block**

See 15.8.3.2.

Byte 6: **Continuation flag/Number of DI bytes in use in this DI Unit**

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This byte shall be set to 4Eh indicating that the first 78 bytes of the DI Unit are used and that there is no continuation in the next DI Unit. All remaining bytes of the DI-Unit body (excluding the bytes in the DI-Unit footer) are unused and shall be set to 00h.

Byte 7: **Reserved**

See 15.8.3.2.

Bytes 8 to 10: **BD Layer-Type identifier**

These 3 bytes identify the type of the BD Layer to which this DI Unit applies and shall be set to 42 44 52h, representing the characters "BDR" in each Recordable Layer.

Byte 11: **Disk size/Class/Version**

Bits b_7 to b_6: These 2 bits specify the disk size. They shall be set to 00, indicating a 120 mm disk.

Bits b_5 to b_4: These 2 bits specify the Class number. The Class number identifies BD Layers of the same Layer Type but with different basic specifications.

BD Layers according to this International Standard shall have these bits set to 00.

Drives that are not familiar with a particular Class of layers should not access the Data Zone of such layers (neither for reading, nor for writing).

Bits b_3 to b_0: These 4 bits specify the Version number. They shall be set to 0001, indicating a layer according to this International Standard.

Byte 12: **BD structure**

Bits b_7 to b_4: These 4 bits specify the total number of BD Recording/Recorded Layers on the disk.

On SL disks they shall be set to 0001, indicating one Recording Layer.

On DL disks they shall be set to 0010, indicating two Recording Layers.

Bits b_3 to b_0: These 4 bits specify the type of BD Recording/Recorded Layer to which this DI Unit applies.

Bits b_3 to b_0 shall be set to 0010, indicating a recordable Recording Layer.

Byte 13: **Channel-bit length**

Bits b_7 to b_4: These 4 bits shall be set to 0000.

Bits b_3 to b_0: These 4 bits specify the main data Channel-bit length, which shall be the same on all BD Recording Layers.

They shall be set to

0001: indicating a Channel-bit length of 74,5 nm (25,0 GB per layer),

other settings: Reserved.

Byte 14: **Push-Pull polarity flag bits**

Bit b_i : Each bit b_i shall specify the polarity of the Push-Pull signal on Recording Layer L*i* (see 26.1). They shall be set to

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ZERO: indicating that the Push-Pull polarity on Layer L*i* is positive,

ONE: indicating that the Push-Pull polarity on Layer L*i* is negative.

For Recording Layers that are not present, bit b_i shall be set to ZERO.

Byte 15: **Recorded-Mark polarity flag bits**

Bit b_i : Each bit b_i shall specify the polarity of the Recorded Marks on Recording Layer L*i*.

They shall be set to

ZERO: indicating a Layer Type on which Recorded Marks have a lower reflectivity than the Unrecorded Layer (HTL disks),

ONE: indicating a Layer Type on which Recorded Marks have a higher reflectivity than the Unrecorded Layer (LTH disks).

For Recording Layers that are not present, bit b_i shall be set to ZERO.

Byte 16: **BCA descriptor**

Bits b_7 to b_4: These 4 bits shall be Reserved.

Bits b_3 to b_0: These 4 bits shall indicate the presence of a BCA code on this disk:

0000: indicates that there is no BCA code,

0001: indicates that BCA code is present,

other settings: Reserved.

Byte 17: **Maximum transfer rate**

This byte specifies the maximum read transfer rate needed by the Application as a number *n* such that

n = maximum read transfer rate in Mbit/s ($n \leq 255$; $M = 10^6$),

n shall be set to 00h, indicating no maximum transfer rate is specified.

Bytes 18 to 23: **Reserved**

These bytes shall be set to all 00h.

Bytes 24 to 31: **Data-Zone allocation**

Bytes 24 to 27: These bytes specify the first Physical ADIP Address of the Data Zone of the related layer.

In each DI Unit relating to Layer L0 these bytes shall be set to 00 02 00 00h, indicating PAA 131 072 as the first PAA of Data Zone 0.

In each DI Unit relating to Layer L1 these bytes shall be set to a value FAA, which shall be 00 26 B1 80h for a disk with a User Data capacity of 25,0 GB per layer indicating FAA as the first PAA of Data Zone 1.

Bytes 28 to 31: These bytes specify the last Physical ADIP Address of the Data Zone of the related layer.

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In each DI Unit relating to Layer L0 these bytes shall be set to a value LAA, which shall be 00 19 4E 7Eh for a disk with a User Data capacity of 25,0 GB per layer, indicating LAA as the last PAA of Data Zone 0.

In each DI Unit relating to Layer L1 these bytes shall be set to 00 3D FF FEh, indicating PAA 4 063 230 as the last PAA of Data Zone 1.

Bytes 32 to 35: Recording Velocities

Byte 32 to 33: These bytes specify the Nominal Recording Velocity, to be used with the Parameters as defined in this DI Unit, as a 2-byte binary number (byte 32 is MSB).

It shall specify the Nominal Recording Velocity as a number n such that

$n = 100 \times V_{nom}$

n shall be equal to

01 ECh to indicate a Nominal Recording Velocity of 4,92 m/s,

or:

03 D7h to indicate a Nominal Recording Velocity of 9,83 m/s.

Byte 34: This byte specifies the Maximum Recording Velocity, to be used with the parameters as defined in this DI Unit.

It shall specify the Maximum Recording Velocity as a number n such that

$n = 100 \times V_{max} / V_{nom}$ ($n \geq 100$).

Here n shall be equal to 64h to indicate a Maximum Recording Velocity equal to the Nominal Recording Velocity.

Byte 35: This byte specifies the Minimum Recording Velocity, to be used with the parameters as defined in this DI Unit.

It shall specify the Minimum Recording Velocity as a number n such that

$n = 100 \times V_{min} / V_{nom}$ ($n \leq 100$).

Here n shall be equal to 64h to indicate a Minimum Recording Velocity equal to the Nominal Recording Velocity.

Bytes 36 to 39: Maximum dc read powers

The maximum read power is defined as the maximum optical power, on the Entrance surface of the disk, at which at least 10^6 successive reads can be applied without degrading the recorded signals (see 30.6). Maximum read powers in 15.8.3.4 shall be greater than or equal to the read powers defined in 30.6. By default, the powers defined in 30.6 shall be used.

Byte 36 : This byte shall specify the maximum dc read power P_r at the Reference Velocity, in milliwatts, as a number n such that

$n = 100 \times P_r$.

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Bytes 37 to 39: These bytes each shall specify the maximum dc read power P_r, at a read velocity corresponding to the Nominal Recording Velocity as defined in byte 32 and 33 of this DI Unit, in milliwatts, as a number n such that

$$n = 100 \times P_r.$$

NOTE For reading at lower velocities than the lowest specified velocity, a reduction of the read power might be necessary to guarantee stability of the recordings on the disk.

Bytes 40 to 43: Maximum HF-modulated read powers

The maximum read power is defined as the maximum optical power on the Entrance surface of the disk, at which at least 10^6 successive reads can be applied without degrading the recorded signals (see 30.6). Maximum read powers in 15.8.3.4 shall be greater than or equal to the read powers defined in 30.6. By default, the powers defined in 30.6 shall be used.

Byte 40: This byte shall specify the maximum HF-modulated read-power P_r at the Reference Velocity, in milliwatts, as a number n such that

$$n = 100 \times P_r.$$

Bytes 41 to 43: These bytes each shall specify the maximum HF-modulated read-power P_r, at a read velocity corresponding to the Nominal Recording Velocity as defined in byte 32 and 33 of this DI Unit, in milliwatts, as a number n such that

$$n = 100 \times P_r.$$

NOTE For reading at lower velocities than the lowest specified velocity, a reduction of the read power might be necessary to guarantee stability of the recordings on the disk.

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Bytes 44 to 47: Reserved

These bytes shall be set to all 00h.

Bytes 48 to 55: Write-power settings

Byte 48: $\boldsymbol{P_{IND}}$**:** P_{IND} can be used as a starting value for the determination of P_{target} in the OPC procedure (see Annex G).

This byte shall specify the indicative value P_{IND} of P_{target}, in milliwatts, as a number n such that

$$n = 20 \times P_{IND}.$$

Byte 49: $\boldsymbol{m_{IND}}$**:** m_{IND} can be used as a starting value for the determination of P_{target} in the OPC procedure (see Annex G).

This byte shall specify the modulation at P_{IND}, as determined by the media manufacturer, as a number n such that

$$n = 200 \times m_{IND}.$$

Byte 50: $\boldsymbol{\rho}$**:** This byte shall specify the write-power multiplication factor ρ, used in the OPC algorithm (see Annex G), as a number n such that

$$n = 100 \times \rho.$$

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Byte 51: ε_{BW}: This byte shall specify the write-bias/write-peak power ratio ε_{BW}, used in the OPC algorithm (see Annex G), as a number n such that

$$n = 200 \times \varepsilon_{BW}.$$

Byte 52: ε_C: This byte shall specify the cooling/write-peak power ratio ε_C, used in the OPC algorithm (see Annex G), as a number n such that

$$n = 200 \times \varepsilon_C.$$

Byte 53: ε_S: This byte specifies the Space/write-peak power ratio ε_S, used in the OPC algorithm (see Annex G), as a number n such that

$$n = 200 \times \varepsilon_S.$$

Byte 54: κ: This byte shall specify the target value for κ, used in the OPC procedure (see Annex G), as a number n such that

$$n = 20 \times \kappa.$$

Byte 55: β: This byte shall specify the target value for β, used in the alternative OPC procedure (see Annex G), as a number n such that

$$n = 500 \times (\beta + 0.2).$$

Bytes 56 to 57: T_{MP} write multi-pulse duration

These bytes specify the duration of the second and higher pulses of the multi-pulse train, of the N/2 write strategy, for recording Marks (see Annex F).

The multi-pulse duration T_{MP} consists of two contributions: a variable part and a fixed part($T_{MP} = T_{MP,var} + T_{MP,fix}$).

Byte 56: The first 5 bits (bits b_7 to b_3) of this byte shall specify the variable part, expressed as a fraction of the actual Channel-bit clock period, as an unsigned binary number p such that

$$p = 16 \times \frac{T_{MP,var}}{T_W} \qquad (0 \le p \le 31).$$

The last 3 bits (bits b_2 to b_0) of this byte shall be Reserved.

Byte 57: The first 5 bits (bits b_7 to b_3) of these bytes specify the fixed part, expressed as a fraction of T_X, where T_X = 15,15 ns at 1×V_{ref} or T_X = 7,58 ns at 2×V_{ref}. The value is expressed as an unsigned binary number q such that

$$q = 16 \times \frac{T_{MP,fix}}{T_X} \qquad (0 \le q \le 31).$$

The last 3 bits (bits b_2 to b_0) of this byte shall be Reserved.

Bytes 58 to 61: dT_{top} first-write-pulse start time

These bytes specify the start time of the first pulse of the multi-pulse train, of the N/2 write strategy, for recording Marks with run-lengths of 2T, 3T, [4T, 6T, 8T], and [5T, 7T, 9T] (positive values are leading, negative values are lagging, see Annex F).

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The first-pulse start time dT_{top} is expressed as a fraction of the actual Channel-bit clock period as a signed two's- complement binary number i such that

$$i = 16 \times \frac{dT_{top}}{T_W} \qquad (-16 \le i \le 15).$$

The last 3 bits (bits b_2 to b_0) of these bytes shall be Reserved.

Byte 58: The first 5 bits (bits b_7 to b_3) of this byte shall specify the start time of the first pulse of the multi-pulse train for recording Marks with run-lengths of [5T, 7T, 9T] relative to the trailing edge of the first Channel bit of the data pulse (positive values are leading, negative values are lagging; see Annex F).

Byte 59: The first 5 bits (bits b_7 to b_3) of this byte shall specify the start time of the first pulse of the multi-pulse train for recording Marks with run-lengths of [4T, 6T, 8T] relative to the trailing edge of the first Channel bit of the data pulse (positive values are leading, negative values are lagging; see Annex F).

Byte 60: The first 5 bits (bits b_7 to b_3) of this byte shall specify the start time of the first pulse of the multi-pulse train for recording Marks with a run-length of 3T relative to the trailing edge of the first Channel bit of the data pulse (positive values are leading, negative values are lagging; see Annex F).

Byte 61: The first 5 bits (bits b_7 to b_3) of this byte shall specify the start time of the first pulse of the multi-pulse train for recording Marks with a run-length of 2T relative to the trailing edge of the first Channel bit of the data pulse (positive values are leading, negative values are lagging; see Annex F).

Bytes 62 to 69: **T_{top} first-write-pulse duration**

These bytes specify the duration of the first pulse of the multi-pulse train, of the N/2 write strategy, for recording Marks with run-lengths of 2T, 3T, [4T, 6T, 8T] and [5T, 7T, 9T]. (see Annex F).

The first-pulse duration T_{top} consists of two contributions: a variable part and a fixed part ($T_{top} = T_{top,var} + T_{top,fix}$).

For each of the byte fields f to f +1, with f = 62, 64, 66 and 68, the following values are defined:

Byte *f*: The first 6 bits (bits b_7 to b_2) of this byte shall represent the variable part, expressed as a fraction of the actual Channel-bit clock period, as an unsigned binary number j such that

$$j = 16 \times \frac{T_{top,var}}{T_W} \qquad (0 \le j \le 46).$$

The last 2 bits (bits b_1 to b_0) of this byte shall be Reserved.

Byte (*f* +1): The first 6 bits (bits b_7 to b_2) of this byte shall represent the fixed part, as a fraction of T_X where T_X = 15,15 ns at 1×V_{ref} or T_X = 7,58 ns at 2×V_{ref}. The value is expressed as an unsigned binary number k such that

$$k = 16 \times \frac{T_{top,fix}}{T_X} \qquad (0 \le k \le 46).$$

The last 2 bits (bits b_1 to b_0) of this byte shall be Reserved.

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Bytes 62 to 63: These bytes shall specify the duration of the first pulse of the multi-pulse train, of the N/2 write strategy, for recording Marks with run-lengths of [5T, 7T, 9T] (see Annex F).

Bytes 64 to 65: These bytes shall specify the duration of the first pulse of the multi-pulse train, of the N/2 write strategy, for recording Marks with run-lengths of [4T, 6T, 8T] (see Annex F).

Bytes 66 to 67: These bytes shall specify the duration of the first pulse of the multi-pulse train, of the N/2 write strategy, for recording Marks with a run-length of 3T (see Annex F).

Bytes 68 to 69: These bytes shall specify the duration of the first pulse of the multi-pulse train, of the N/2 write strategy, for recording Marks with a run-length of 2T (see Annex F).

Bytes 70 to 73: **T_{LP} last-pulse duration**

These bytes specify the last-pulse length of the multi-pulse train, of the N/2 write strategy, for recording Marks with run-lengths of [4T, 6T, 8T], and [5T, 7T, 9T]; (see Annex F).

The last-pulse duration T_{LP} consists of two contributions: a variable part and a fixed part ($T_{LP} = T_{LP,var} + T_{LP,fix}$).

For each of the byte fields *f* to *f* +1, with *f* = 70, 72, the following values are defined:

Byte *f*: The first 5 bits (bits b_7 to b_3) of this byte shall represent the variable part, expressed as a fraction of the actual Channel-bit clock period, as an unsigned binary number *s* such that

$$s = 16 \times \frac{T_{LP,var}}{T_W} \qquad (0 \le s \le 31).$$

The last 3 bits (bits b_2 to b_0) of this byte shall be Reserved.

Byte (*f* +1): The first 5 bits (bits b_7 to b_3) of this byte shall represent the fixed part, as a fraction of T_X, where T_X = 15,15 ns at 1×V_{ref} or T_X = 7,58 ns at 2×V_{ref}. The value is expressed as an unsigned binary number *t* such that

$$t = 16 \times \frac{T_{LP,fix}}{T_X} \qquad (0 \le t \le 31).$$

The last 3 bits (bits b_2 to b_0) of this byte shall be Reserved.

Bytes 70 to 71: These bytes shall specify the duration of the last pulse of the multi-pulse train, of the N/2 write strategy, for recording Marks with run-lengths of [5T, 7T, 9T] (see Annex F)

Bytes 72 to 73: These bytes shall specify the duration of the last pulse of the multi-pulse train, of the N/2 write strategy, for recording Marks with run-lengths of [4T, 6T, 8T] (see Annex F).

Bytes 74 to 77: **dT_S start time of Space level**

The first 6 bits (bits b_7 to b_2) of these bytes shall specify the start time of the Space level, of the N/2 write strategy, succeeding the recording Marks with run-lengths of 2T, 3T, [4T, 6T, 8T] and [5T, 7T, 9T] (positive values are leading, negative values are lagging, see Annex F).

The start time of the Space level dT_S is expressed as a fraction of the actual Channel-bit clock period as a signed two's-complement binary number *u* such that

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$$u = 16 \times \frac{dT_s}{T_W} \qquad (-31 \le u \le 15).$$

The last 2 bits (bits b_1 to b_0) of these bytes shall be Reserved.

Byte 74: This byte shall specify the start time of the Space level of the N/2 write strategy succeeding the recording Marks with run-lengths of [5T, 7T, 9T].

Byte 75: This byte shall specify the start time of the Space level of the N/2 write strategy succeeding the recording Marks with run-lengths of [4T, 6T, 8T].

Byte 76: This byte shall specify the start time of the Space level of the N/2 write strategy succeeding the recording Marks with a run-length of 3T.

Byte 77: This byte shall specify the start time of the Space level of the N/2 write strategy succeeding the recording Marks with a run-length of 2T.

Bytes 78 to 99: Unused

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15.8.3.5 Definition for DI format 3 (Castle write strategy)

The content of the body of DI Units according to format 3 shall be as depicted in Figure 79.

Byte number	Content	Number of bytes
0 to 7	DI-Unit header	8
8 to 10	BD Layer-Type identifier	3
11	Disk size/Class/Version	1
12	BD structure	1
13	Channel-bit length	1
14	Push-Pull polarity flag bits	1
15	Recorded Mark polarity flag bits	1
16	BCA descriptor	1
17	Maximum transfer rate	1
18 to 23	Reserved	6
24 to 31	Data-Zone allocation	8
32 to 35	Recording Velocities	4
36 to 39	Maximum dc read powers	4
40 to 43	Maximum HF-modulated read powers	4
44 to 46	Reserved	3
47 to 55	Write-power settings	9
56 to 58	dT_C cooling-level start time	3
59 to 67	dT_{top} start time of T_{top} level	9
68 to 76	T_{top} level duration	9
77	T_{LP} last-pulse-level duration	1
78 to 80	dT_S start time of Space-level	3
81 to 99	Unused = all 00h	19
100 to 111	DI-Unit footer	12

Figure 79 — Content of Disk Information for DI format 3

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Bytes 0 to 1: **Disk-Information identifier**

See 15.8.3.2.

Byte 2: **DI-Format Number**

This byte shall be set to 03h for disks with BCA code.

This byte shall be set to 83h for disks without BCA code.

Byte 3: **Number of DI Aux Frames in each DI Block / Number of the layer to which this DI Unit applies**

See 15.8.3.2.

Byte 4: **Reserved.**

See 15.8.3.2.

Byte 5: **DI-Unit sequence number in DI Block**

See 15.8.3.2.

Byte 6: **Continuation flag / Number of DI bytes in use in this DI Unit**

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This byte shall be set to 51h indicating that the first 81 bytes of the DI Unit are used and that there is no continuation in the next DI Unit. All remaining bytes of the DI-Unit body (excluding the bytes in the DI–Unit footer) are unused and shall be set to 00h.

Byte 7: **Reserved**

See 15.8.3.2.

Bytes 8 to 10: **BD Layer-Type identifier**

These 3 bytes identify the type of the BD Layer to which this DI Unit applies and shall be set to 42 44 52h, representing the characters “BDR” in each Recordable Layer.

Byte 11: **Disk size/Class/Version**

Bits b_7 to b_6: These 2 bits specify the disk size. They shall be set to 00, indicating a 120 mm disk.

Bits b_5 to b_4: These 2 bits specify the Class number. The Class number identifies BD Layers of the same Layer Type but with different basic specifications.

BD Layers according to this International Standard shall have these bits set to 00.

Drives that are not familiar with a particular Class of layers should not access the Data Zone of such layers (neither for reading, nor for writing).

Bits b_3 to b_0: These 4 bits specify the Version number. They shall be set to 0001, indicating a layer according to this International Standard.

Byte 12: **BD structure**

Bits b_7 to b_4: These 4 bits specify the total number of BD Recording/Recorded Layers on the disk.

On SL disks they shall be set to 0001, indicating one Recording Layer.

On DL disks they shall be set to 0010, indicating two Recording Layers.

Bits b_3 to b_0: These 4 bits specify the type of BD Recording/Recorded Layer to which this DI Unit applies.

On disks bits b_3 to b_0 shall be set to 0010, indicating a recordable Recording Layer.

Byte 13: **Channel-bit length**

Bits b_7 to b_4: These 4 bits shall be set to 0000.

Bits b_3 to b_0: These 4 bits specify the main data Channel-bit length, which shall be the same on all BD Recording Layers.

They shall be set to

0001: indicating a Channel-bit length of 74,5 nm (25,0 GB per layer),

other settings: Reserved.

Byte 14: **Push-Pull polarity flag bits**

Bit b_i **:** Each bit b_i shall specify the polarity of the Push-Pull signal on Recording Layer L*i* (see 26.1). They shall be set to

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ZERO: indicating that the Push-Pull polarity on Layer L*i* is positive,

ONE: indicating that the Push-Pull polarity on Layer L*i* is negative.

For Recording Layers that are not present, bit b_i shall be set to ZERO.

Byte 15: Recorded-Mark polarity flag bits

Bit b_i **:** Each bit b_i shall specify the polarity of Recorded Marks on Recording Layer L*i*. They shall be set to

ZERO: indicating a Layer Type on which Recorded Marks have a lower reflectivity than the Unrecorded Layer (HTL disks),

ONE: indicating a Layer Type on which Recorded Marks have a higher reflectivity than the Unrecorded Layer (LTH disks).

For Recording Layers that are not present, bit b_i shall be set to ZERO.

Byte 16: BCA descriptor

Bits b_7 to b_4: These 4 bits shall be Reserved.

Bits b_3 to b_0: These 4 bits shall indicate the presence of a BCA code on this disk:

0000: indicates that there is no BCA code,

0001: indicates that BCA code is present,

other settings, Reserved.

Byte 17: Maximum transfer rate

This byte specifies the maximum read transfer rate needed by the Application as a number *n* such that

n = maximum read transfer rate in Mbit/s ($n \leq 255$; M = 10^6).

n shall be set to 00h, indicating no maximum transfer rate is specified.

Bytes 18 to 23: Reserved

These bytes shall be set to all 00h.

Bytes 24 to 31: Data-Zone allocation

Bytes 24 to 27: These bytes specify the first Physical ADIP Address of the Data Zone of the related layer.

In each DI Unit relating to Layer L0 these bytes shall be set to 00 02 00 00h, indicating PAA 131 072 as the first PAA of Data Zone 0.

In each DI Unit relating to Layer L1 these bytes shall be set to a value FAA, which shall be 00 26 B1 80h for a disk with a User Data capacity of 25,0 GB per layer, indicating FAA as the first PAA of Data Zone 1.

Bytes 28 to 31: These bytes specify the last Physical ADIP Address of the Data Zone of the related layer.

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In each DI Unit relating to Layer L0 these bytes shall be set to a value LAA, which shall be 00 19 4E 7Eh for a disk with a User Data capacity of 25,0 GB per layer, indicating LAA as the last PAA of Data Zone 0.

In each DI Unit relating to Layer L1 these bytes shall be set to 00 3D FF FEh, indicating PAA 4 063 230 as the last PAA of Data Zone 1.

Bytes 32 to 35: Recording Velocities

Bytes 32 to 33: These bytes specify the Nominal Recording Velocity, to be used with the Parameters as defined in this DI Unit, as a 2-byte binary number (byte 32 is MSB).

It shall specify the Nominal Recording Velocity as a number *n* such that

$$n = 100 \times V_{nom}$$

n shall be equal to

01 ECh to indicate a Nominal Recording Velocity of 9,83 m/s,

or:

03 D7h to indicate a Nominal Recording Velocity of 19,68 m/s,

or:

0B 86h to indicate a Nominal Recording Velocity of 29,50 m/s.

Byte 34: This byte specifies the Maximum Recording Velocity, to be used with the parameters as defined in this DI Unit.

It shall specify the Maximum Recording Velocity as a number *n* such that

$$n = 100 \times V_{max} / V_{nom} \ (n \geq 100).$$

Here *n* shall be equal to 64h to indicate a Maximum Recording Velocity equal to the Nominal Recording Velocity.

Byte 35: This byte specifies the Minimum Recording Velocity, to be used with the parameters as defined in this DI Unit).

It shall specify the Minimum Recording Velocity as a number *n* such that

$$n = 100 \times V_{min} / V_{nom} \ (n \leq 100).$$

Here *n* shall be equal to 64h to indicate a Minimum Recording Velocity equal to the Nominal Recording Velocity.

Bytes 36 to 39: Maximum dc read powers

The maximum read power is defined as the maximum optical power on the Entrance surface of the disk, at which at least 10^6 successive reads can be applied without degrading the recorded signals (see 30.6). Maximum read powers in 15.8.3.5 shall be greater than or equal to the read powers defined in 30.6. By default, the powers defined in 30.6 shall be used.

Byte 36 : This byte shall specify the maximum dc read power P_r at the Reference Velocity, in milliwatts, as a number *n* such that

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$n = 100 \times P_r$.

Bytes 37 to 39: These bytes each shall specify the maximum dc read power P_r, at a read velocity corresponding to the Nominal Recording Velocity as defined in byte 32 and 33 of this DI Unit, in milliwatts, as a number *n* such that

$n = 100 \times P_r$.

NOTE For reading at lower velocities than the lowest specified velocity, a reduction of the read power might be necessary to guarantee stability of the recordings on the disk.

Bytes 40 to 43: Maximum HF-modulated read powers

The maximum read power is defined as the maximum optical power on the Entrance surface of the disk, at which at least 10^6 successive reads can be applied without degrading the recorded signals (see 30.6). Maximum read powers in 15.8.3.5 shall be greater than or equal to the read powers defined in 30.6. By default, the powers defined in 30.6 shall be used.

Byte 40: This byte shall specify the maximum HF-modulated read power P_r at the Reference Velocity, in milliwatts, as a number n such that

$n = 100 \times P_r$.

Bytes 41 to 43: These bytes each shall specify the maximum HF-modulated read power P_r, at a read velocity corresponding to the Nominal Recording Velocity as defined in byte 32 and 33 of this DI Unit, in milliwatts, as a number *n* such that

$n = 100 \times P_r$.

NOTE For reading at lower velocities than the lowest specified velocity, a reduction of the read power might be necessary to guarantee stability of the recordings on the disk.

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Bytes 44 to 46: Reserved

These bytes shall be set to all 00h.

Bytes 47 to 55: Write-power settings

Byte 47 to 48: P_{IND}: P_{IND} can be used as a starting value for the determination of P_{target} in the OPC procedure (see Annex G).

These bytes shall specify the indicative value P_{IND} of P_{target}, in milliwatts, as a number *n* such that

$n = 20 \times P_{IND}$.

Bit b_7 of Byte 47 is msb and bit b_0 of Byte 48 is lsb.

Byte 49: m_{IND}: m_{IND} can be used as a starting value for the determination of P_{target} in the OPC procedure (see Annex G).

This byte shall specify the modulation at P_{IND}, as determined by the media manufacturer, as a number *n* such that

$n = 200 \times m_{IND}$.

Byte 50: ρ: This byte shall specify the write-power multiplication factor ρ, used in the OPC algorithm (see Annex G), as a number *n* such that

$n = 100 \times \rho$.

Byte 51: **ε_M:** This byte shall specify the middle/write-peak power ratio ε_M, used in the OPC algorithm (see Annex G), as a number *n* such that

$n = 200 \times \varepsilon_M$.

Byte 52: **ε_C:** This byte shall specify the cooling/write-peak power ratio ε_C, used in the OPC algorithm (see Annex G), as a number *n* such that

$n = 200 \times \varepsilon_C$.

Byte 53: **ε_S:** This byte shall specify the Space/write-peak power ratio ε_S, used in the OPC algorithm (see Annex G), as a number *n* such that

$n = 200 \times \varepsilon_S$.

Byte 54: **κ:** This byte shall specify the target value for κ, used in the OPC procedure (see Annex G), as a number *n* such that

$n = 20 \times \kappa$.

Byte 55: **β:** This byte shall specify the target value for β, used in the alternative OPC procedure (see Annex G), as a number *n* such that

$n = 500 \times (\beta + 0{,}2)$.

Bytes 56 to 58: dT_C cooling-level start time

These bytes specify the cooling-level start time for writing pulse, of the Castle write strategy, for recording Marks with run-lengths of 3T, 4T and ≥5T (see Annex F).

The first 6 bits (bits b_7 to b_2) of these bytes shall specify the start time as a fraction of the actual Channel-bit clock period as a signed two's-complement binary number *k* such that

$$k = 16 \times \frac{dT_C}{T_W} \left(-31 \le k \le 8 \right).$$

The last 2 bits (bits b_1 to b_0) of these bytes shall be Reserved.

Byte 56: This byte shall specify the start time of the cooling level of the writing pulse, of the Castle write strategy, for recording Marks with run-lengths ≥5T.

Byte 57: This byte shall specify the start time of the cooling level of the writing pulse, of the Castle write strategy, for recording Marks with a run-length of 4T.

Byte 58: This byte shall specify the start time of the cooling level of the writing pulse, of the Castle write strategy, for recording Marks with a run-length of 3T.

Bytes 59 to 67: dT_{top} start time of T_{top} level

The first 5 bits (bits b_7 to b_3) of these bytes shall specify the start time of the T_{top} part of the writing pulse, of the Castle write strategy, for recording Marks with run-lengths 2T, 3T and ≥4T that succeed a Space with run-lengths of 2T, 3T, or ≥4T (see Annex F).

The first-pulse start time dT_{top} is expressed as a fraction of the actual Channel-bit clock period as a signed two's-complement binary number *i* such that

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$$i = 16 \times \frac{dT_{top}}{T_W} \left(-16 \le i \le 15 \right).$$

The last 3 bits (bits b_2 to b_0) of these bytes shall be Reserved.

Bytes 59 to 61: These bytes specify the start time of the first pulse of the multi-pulse train for recording Marks with run-lengths ≥4T that succeed a Space with run-lengths of 2T, 3T, or ≥4T Space, relative to the trailing edge of the first Channel bit of the data pulse (positive values are leading, negative values are lagging; see Annex F).

Byte 59 shall represent the start time of the first pulse for recording Marks with run-lengths ≥4T that succeed a Space with a run-length ≥4T.

Byte 60 shall represent the start time of the first pulse for recording Marks with run-lengths ≥4T that succeed a Space with a run-length of 3T.

Byte 61 shall represent the start time of the first pulse for recording Marks with run-lengths ≥4T that succeed a Space with a run-length of 2T.

Bytes 62 to 64: These bytes specify the start time of the first pulse of the multi-pulse train for recording Marks of a run-length of 3T that succeed a Space with a run-length of 2T, 3T or ≥4T, relative to the trailing edge of the first Channel bit of the data pulse (positive values are leading, negative values are lagging; see Annex F).

Byte 62 shall represent the start time of the first pulse for recording Marks with a run-length of 3T that succeed a Space with a run-length ≥4T.

Byte 63 shall represent the start time of the first pulse for recording Marks with a run-length of 3T that succeed a Space with a run-length of 3T .

Byte 64 shall represent the start time of the first pulse for recording Marks with a run-length of 3T that succeed a Space with a run-length of 2T.

Bytes 65 to 67: These bytes specify the start time of the first pulse of the multi-pulse train for recording Marks with a run-length of 2T that succeed a Space with a run-length of 2T, 3T or ≥4T , relative to the trailing edge of the first Channel bit of the data pulse (positive values are leading, negative values are lagging; see Annex F).

Byte 65 shall represent the start time of the first pulse for recording Marks with a run-length of 2T that succeed a Space with a run-length ≥4T.

Byte 66 shall represent the start time of the first pulse for recording Marks with a run-length of 2T that succeed a Space with a run-length of 3T.

Byte 67 shall represent the start time of the first pulse for recording Marks with a run-length of 2T that succeed a Space with a run-length of 2T.

Bytes 68 to 76: T_{top} level duration

These bytes specify the duration of the T_{top} level of the write pulses, of the Castle write strategy, for recording Marks with run-lengths 2T, 3T and ≥4T that succeed a Space with a run-length of 2T, 3T or ≥4T (see Annex F).

The first 6 bits (bits b_7 to b_2) of these bytes shall specify the length of the T_{top} level, as a fraction of the actual Channel-bit clock period, as an unsigned binary number j such that

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$$j = 16 \times \frac{T_{\text{top}}}{T_{\text{W}}} \left(0 \leq j \leq 46\right).$$

The last 2 bits (bits b_1 to b_0) of these bytes shall be Reserved.

Bytes 68 to 70: These bytes specify the duration of the T_{top} level of the write pulses for recording Marks of run-lengths ≥4T that succeed a Space with a run-lengths of 2T, 3T or ≥4T (see Annex F).

Byte 68 shall represent the duration of the first pulse for recording Marks with run-lengths ≥4T that succeed a Space with a run-length ≥4T.

Byte 69 shall represent the duration of the first pulse for recording Marks with run-lengths ≥4T that succeed a Space with a run-length of 3T.

Byte 70 shall represent the duration of the first pulse for recording Marks with run-lengths ≥4T that succeed a Space with a run-length of 2T.

Bytes 71 to 73: These bytes specify the duration of the first pulse of the multi-pulse train for recording Marks with a run-length of 3T that succeed a Space with a run-lengths of 2T, 3T or ≥4T (see Annex F).

Byte 71 shall represent the duration of the first pulse for recording Marks with a run-length of 3T that succeed a Space with a run-length ≥4T.

Byte 72 shall represent the duration of the first pulse for recording Marks with a run-length of 3T that succeed a Space with a run-length of 3T.

Byte 73 shall represent the duration of the first pulse for recording Marks with a run-length of 3T that succeed a Space with a run-length of 2T

Bytes 74 to 76: These bytes specify the duration of the first pulse of the multi-pulse train for recording of Marks with a run-length of 2T that succeed a Space with a run-length of 2T, 3T or ≥4T (see Annex F).

Byte 74 shall represent the duration of the first pulse for recording Marks with a run-length of 2T that succeed a Space with a run-length ≥4T.

Byte 75 shall represent the duration of the first pulse for recording Marks with a run-length of 2T that succeed a Space with a run-length of 3T.

Byte 76 shall represent the duration of the first pulse for recording Marks with a run-length of 2T that succeed a Space with a run-length of 2T Space.

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Byte 77: ***T_{LP}* last-pulse-level duration**

This byte specifies the last-pulse-level length of the write pulses, of the Castle write strategy, for recording Marks with run-lengths ≥4T (see Annex F).

The first 5 bits (bits b_7 to b_3) of this byte shall specify the length of T_{LP}, as a fraction of the actual Channel-bit clock period, as an unsigned binary number *s* such that

$$s = 16 \times \frac{T_{\text{LP}}}{T_{\text{W}}} \left(0 \leq s \leq 31\right).$$

The last 3 bits (bits b_2 to b_0) of this byte shall be Reserved.

Bytes 78 to 80: ***dT_S* start time of Space level**

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The first 6 bits (bits b_7 to b_2) of this byte shall specify the start time of the Space level, of the Castle write strategy, succeeding the recording of Marks with run-lengths of 2T, 3T and ≥4T (positive values are leading, negative values are lagging; see Annex F).

The start time of the Space level dT_S is expressed as a fraction of the actual Channel-bit clock period as a signed two's-complement binary number u such that

$$u = 16 \times \frac{dT_s}{T_W} \quad (-31 \le u \le 15).$$

The last 2 bits (bits b_1 to b_0) of these bytes shall be Reserved.

Byte 78: This byte shall specify the start time of the Space level of the writing pulse, of the Castle write strategy, succeeding the recording of Marks with run-lengths ≥4T.

Byte 79: This byte shall specify the start time of the Space level of the writing pulse, of the Castle write strategy, succeeding the recording of Marks with a run-length of 3T.

Byte 80: This byte shall specify the start time of the Space level of the writing pulse, of the Castle write strategy, succeeding the recording of Marks with a run-length of 2T.

Bytes 81 to 99: Unused

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15.8.3.6 Write-strategy requirements

The write-strategy requirements for disks according to this specification are depicted in Figure 80.

Disk type	Recording Velocity	Write strategy		
		N-1	N/2	Castle
HTL	1x	Mandatory	Optional	—
	2x	Optional[a]	Optional[a]	Optional
	4x	—	—	Mandatory
	6x	—	—	Mandatory
LTH	1x	Mandatory	Optional	—
	2x	Optional[a]	Optional[a]	Optional
	4x	—	—	Mandatory
	6x	—	—	Mandatory

— Not allowed in this International Standard.
Castle write strategy is allowed for 4x and 6x disks only.
See also Figure 5.
[a] At least one of the two write strategies shall be present and they shall be defined as most-preferred write strategy for compatibility with 2x only devices.

Figure 80 — Write-strategy type requirements

15.8.3.7 Usage of DI Units for write strategy

By using the concept of multiple DI Units, identified by their DI-Format Number(byte 2), the BD system facilitates the (future) use of disks with different Recording Velocities and with one, two or more Recording Layers, while keeping backwards compatibility in the best possible way.

Generally, each different Recording Velocity might need a different write strategy (different set of parameters), which write strategy furthermore can depend on the applied technology.

Additionally, each Recording Layer might need a different set of values for the write-strategy parameters.

Examples of DI sequence for 2x disks, 4x disks and 6x disks

2x disks

So-called “2x” disks (applicable Recording Velocities shall be one time the Reference Velocity and two times the Reference Velocity), can have one (SL disk) or two (DL disk) Recording Layer(s).

These disks shall contain at least 2 DI Units for each Recording Layer, one containing the parameters for 1x Recording Velocity and the other containing the parameters for 2x Recording Velocity (see Figure 81).

Additional DI Units, containing alternative write-strategy parameter sets, may be added in order of preference (see Figure 75).

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In the DI Unit defining the parameters for 1x Recording Velocity, bytes 32 to 35 are set as follows.

— Bytes 32 to 33: These bytes are set to 01 ECh to indicate a Nominal Recording Velocity of 4,92 m/s.

— Byte 34: This byte is set to 64h to indicate a Maximum Recording Velocity equal to the Nominal Recording Velocity.

— Byte 35: This byte is set to 64h to indicate a Minimum Recording Velocity equal to the Nominal Recording Velocity.

In the DI Unit defining the parameters for 2x Recording Velocity, byte 32 to 35 are set as follows.

— Bytes 32 to 33: These bytes are set to 03 D7h to indicate a Nominal Recording Velocity of 9,83 m/s.

— Byte 34: This byte is set to 64h to indicate a Maximum Recording Velocity equal to the Nominal Recording Velocity.

— Byte 35: This byte is set to 64h to indicate a Minimum Recording Velocity equal to the Nominal Recording Velocity.

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2x disk (SL) with 1x N–1 & 2x N/2 write strategy

byte 2: DI-Format Number	1
byte 3: :# of DIs / L#	2/0
byte 4: ---	00h
byte 5: sequence #	0
msb of byte 6:	0
byte 32 to 35: Velocity	1x
byte 36 to 85: WS	N–1

byte 2: DI-Format Number	2
byte 3: :# of DIs / L#	2/0
byte 4: ---	00h
byte 5: sequence #	1
msb of byte 6:	0
byte 32 to 35: Velocity	2x
byte 36 to 77: WS	N/2

REPEAT

2x disk (DL) with 1x & 2x N–1 (Layer L0) and 1x N–1 & 2x N/2 (Layer L1) write strategy

byte 2: DI-Format Number	1
byte 3: # of DIs / L#	4/0
byte 4: ---	00h
byte 5: sequence #	0
msb of byte 6:	0
byte 32 to 35: Velocity	1x
byte 36 to 85: WS	N–1

byte 2: DI-Format Number	1
byte 3: # of DIs / L#	4/1
byte 4: ---	00h
byte 5: sequence #	1
msb of byte 6:	0
byte 32 to 35: Velocity	1x
byte 36 to 85: WS	N–1

byte 2: DI-Format Number	1
byte 3: # of DIs / L#	4/0
byte 4: ---	00h
byte 5: sequence #	2
msb of byte 6:	0
byte 32 to 35: Velocity	2x
byte 36 to 85: WS	N–1

byte 2: DI-Format Number	2
byte 3: # of DIs / L#	4/1
byte 4: ---	00h
byte 5: sequence #	3
msb of byte 6:	0
byte 32 to 35: Velocity	2x
byte 36 to 77: WS	N/2

REPEAT

Figure 81 — Example of DI sequence for 2x disks

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4x disks

Parameters in this International Standard have been defined for so-called “4x” disks (applicable Recording Velocities shall be one time, two times and four times the Reference Velocity), which can have one (SL disk) or two (DL disk) Recording Layer(s) (see Figure 82). Each Recording Layer shall fulfill the write-strategy requirements as indicated in Figure 80.

These disks shall contain at least 3 DI Units for each Recording Layer, one containing the parameters for 1x Recording Velocity, one containing the parameters for 2x Recording Velocity one containing the parameters for 4x Recording Velocity. Additional DI Units, containing alternative write-strategy parameter sets, may be added in order of preference (see Figure 75).

In the DI Unit defining the 1x recording parameters, bytes 32 to 35 are set as follows.

— Bytes 32 to 33: These bytes are set to 01 ECh to indicate a Nominal Recording Velocity of 4,92 m/s.

— Byte 34: This byte is set to 64h to indicate a Maximum Recording Velocity equal to the Nominal Recording Velocity.

— Byte 35: This byte is set to 64h to indicate a Minimum Recording Velocity equal to the Nominal Recording Velocity.

In the DI Unit defining the 2x recording parameters for 2x Recording Velocity, bytes 32 to 35 are set as follows.

— Bytes 32 to 33: These bytes are set to 03 D7h to indicate a Nominal Recording Velocity of 9,83 m/s.

— Byte 34: This byte is set to 64h to indicate a Maximum Recording Velocity equal to the Nominal Recording Velocity.

— Byte 35: This byte is set to 64h to indicate a Minimum Recording Velocity equal to the Nominal Recording Velocity.

In the DI Unit defining the 4x recording parameters for 4x Recording Velocity, bytes 32 to 35 are set as follows.

— Byte 32 to 33: These bytes are set to 07 B0h to indicate a Nominal Recording Velocity of 19,68 m/s.

— Byte 34: This byte is set to 64h to indicate a Maximum Recording Velocity equal to the Nominal Recording Velocity.

— Byte 35: This byte is set to 64h to indicate a Minimum Recording Velocity equal to the Nominal Recording Velocity.

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4x disk (SL) with 1x N–1 & 2x N/2 & 4x Castle write strategy

byte 2: DI-Format Number	1
byte 3: :# of DIs / L#	3/0
byte 4: ---	00h
byte 5: sequence #	0
msb of byte 6:	0
byte 32 to 35: Velocity	1x
byte 36 to 85: WS	N–1

byte 2: DI-Format Number	2
byte 3: :# of DIs / L#	3/0
byte 4: ---	00h
byte 5: sequence #	1
msb of byte 6:	0
byte 32 to 35: Velocity	2x
byte 36 to 77: WS	N/2

byte 2: DI-Format Number	3
byte 3: :# of DIs / L#	3/0
byte 4: ---	00h
byte 5: sequence #	2
msb of byte 6:	0
byte 32 to 35: Velocity	4x
byte 36 to 80: WS	Castle

REPEAT

4x disks (DL) with 1x & 2x N–1 & 4x Castle (Layer L0) and 1x N–1 & 2x N/2 & 4x Castle (Layer L1) write strategy

byte 2: DI-Format Number	1
byte 3: # of DIs / L#	6/0
byte 4: ---	00h
byte 5: sequence #	0
msb of byte 6:	0
byte 32 to 35: Velocity	1x
byte 36 to 85: WS	N–1

byte 2: DI-Format Number	1
byte 3: # of DIs / L#	6/1
byte 4: ---	00h
byte 5: sequence #	1
msb of byte 6:	0
byte 32 to 35: Velocity	1x
byte 36 to 85: WS	N–1

byte 2: DI-Format Number	1
byte 3: # of DIs / L#	6/0
byte 4: ---	00h
byte 5: sequence #	2
msb of byte 6:	0
byte 32 to 35: Velocity	2x
byte 36 to 85: WS	N–1

byte 2: DI-Format Number	2
byte 3: # of DIs / L#	6/1
byte 4: ---	00h
byte 5: sequence #	3
msb of byte 6:	0
byte 32 to 35: Velocity	2x
byte 36 to 77: WS	N/2

byte 2: DI-Format Number	3
byte 3: # of DIs / L#	6/0
byte 4: ---	00h
byte 5: sequence #	4
msb of byte 6:	0
byte 32 to 35: Velocity	4x
byte 36 to 80: WS	Castle

byte 2: DI-Format Number	3
byte 3: # of DIs / L#	6/1
byte 4: ---	00h
byte 5: sequence #	5
msb of byte 6:	0
byte 32 to 35: Velocity	4x
byte 36 to 80: WS	Castle

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Figure 82 — Example of DI sequence for 4x disks

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6x disks

Parameters in this International Standard have been defined for so-called “6x” disks (applicable Recording Velocities shall be one time, two times, four times and six times the Reference Velocity), which can have one (SL disk) or two (DL disk) Recording Layer(s) (see Figure 83). Each Recording Layer shall fulfill the write-strategy requirements as indicated in Figure 80.

These disks shall contain at least 4 DI Units for each Recording Layer, one containing the parameters for 1x Recording Velocity, one containing the parameters for 2x Recording Velocity, one containing the parameters for 4x Recording Velocity and one containing the parameters for 6x Recording Velocity. Additional DI Units, containing alternative write-strategy parameter sets, may be added in order of preference (see Figure 75).

In the DI Unit defining the 1x recording parameters for 1x Recording Velocity, bytes 32 to 35 are set as follows.

— Bytes 32 to 33: These bytes are set to 01 ECh to indicate a Nominal Recording Velocity of 4,92 m/s.

— Byte 34: This byte is set to 64h to indicate a Maximum Recording Velocity equal to the Nominal Recording Velocity.

— Byte 35: This byte is set to 64h to indicate a Minimum Recording Velocity equal to the Nominal Recording Velocity.

In the DI Unit defining the 2x recording parameters for 2x Recording Velocity, bytes 32 to 35 are set as follows.

— Bytes 32 to 33: These bytes are set to 03 D7h to indicate a Nominal Recording Velocity of 9,83 m/s.

— Byte 34: This byte is set to 64h to indicate a Maximum Recording Velocity equal to the Nominal Recording Velocity.

— Byte 35: This byte is set to 64h to indicate a Minimum Recording Velocity equal to the Nominal Recording Velocity.

In the DI Unit defining the 4x recording parameters for 4x Recording Velocity, bytes 32 to 35 are set as follows.

— Bytes 32 to 33: These bytes are set to 07 B0h to indicate a Nominal Recording Velocity of 19,68 m/s.

— Byte 34: This byte is set to 64h to indicate a Maximum Recording Velocity equal to the Nominal Recording Velocity.

— Byte 35: This byte is set to 64h to indicate a Minimum Recording Velocity equal to the Nominal Recording Velocity.

In the DI Unit defining the 6x recording parameters for 6x Recording Velocity, bytes 32 to 35 are set as follows.

— Bytes 32 to 33: These bytes are set to 0B 86h to indicate a Nominal Recording Velocity of 29,50 m/s.

— Byte 34: This byte is set to 64h to indicate a Maximum Recording Velocity equal to the Nominal Recording Velocity.

— Byte 35: This byte is set to 64h to indicate a Minimum Recording Velocity equal to the Nominal Recording Velocity.

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6x disk with 1x N–1 & 2x N/2 & 4x & 6x Castle write strategy	
byte 2: DI-Format Number	1
byte 3: :# of DIs / L#	4/0
byte 4: ---	00h
byte 5: sequence #	0
msb of byte 6:	0
byte 32 to 35: Velocity	1x
byte 36 to 85: WS	N–1
byte 2: DI-Format Number	2
byte 3: :# of DIs / L#	4/0
byte 4: ---	00h
byte 5: sequence #	1
msb of byte 6:	0
byte 32 to 35: Velocity	2x
byte 36 to 77: WS	N/2
byte 2: DI-Format Number	3
byte 3: :# of DIs / L#	4/0
byte 4: ---	00h
byte 5: sequence #	2
msb of byte 6:	0
byte 32 to 35: Velocity	4x
byte 36 to 80: WS	Castle
byte 2: DI-Format Number	3
byte 3: :# of DIs / L#	4/0
byte 4: ---	00h
byte 5: sequence #	3
msb of byte 6:	0
byte 32 to 35: Velocity	6x
byte 36 to 80: WS	Castle
REPEAT	

6x disk with 1x & 2x N–1 & 4x & 6x Castle (Layer L0) and 1x N–1 & 2x N/2 & 4x & 6x Castle (Layer L1) write strategy	
byte 2: DI-Format Number	1
byte 3: # of DIs / L#	8/0
byte 4: ---	00h
byte 5: sequence #	0
msb of byte 6:	0
byte 32 to 35: Velocity	1x
byte 36 to 85: WS	N–1
byte 2: DI-Format Number	1
byte 3: # of DIs / L#	8/1
byte 4: ---	00h
byte 5: sequence #	1
msb of byte 6:	0
byte 32 to 35: Velocity	1x
byte 36 to 85: WS	N–1
byte 2: DI-Format Number	1
byte 3: # of DIs / L#	8/0
byte 4: ---	00h
byte 5: sequence #	2
msb of byte 6:	0
byte 32 to 35: Velocity	2x
byte 36 to 85: WS	N–1
byte 2: DI-Format Number	2
byte 3: # of DIs / L#	8/1
byte 4: ---	00h
byte 5: sequence #	3
msb of byte 6:	0
byte 32 to 35: Velocity	2x
byte 36 to 77: WS	N/2

byte 2: DI-Format Number	3
byte 3: # of DIs / L#	8/0
byte 4: ---	00h
byte 5: sequence #	4
msb of byte 6:	0
byte 32 to 35: Velocity	4x
byte 36 to 80: WS	Castle
byte 2: DI-Format Number	3
byte 3: # of DIs / L#	8/1
byte 4: ---	00h
byte 5: sequence #	5
msb of byte 6:	0
byte 32 to 35: Velocity	4x
byte 36 to 80: WS	Castle
byte 2: DI-Format Number	3
byte 3: # of DIs / L#	8/0
byte 4: ---	00h
byte 5: sequence #	6
msb of byte 6:	0
byte 32 to 35: Velocity	6x
byte 36 to 80: WS	Castle
byte 2: DI-Format Number	3
byte 3: # of DIs / L#	8/1
byte 4: ---	00h
byte 5: sequence #	7
msb of byte 6:	0
byte 32 to 35: Velocity	6x
byte 36 to 80: WS	Castle
REPEAT	

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Figure 83 — Example of DI sequence for 6x disks

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16 General description of Information Zone

16.1 General

The Information Zone, which contains all information on the disk that is relevant for data interchange, is located in the Information Area extending from d_9 to d_{10}. (see 10.8.1 and Figure 16).

The inner part of Inner Zone 0 (Protection-Zone 1 + PIC) shall contain HFM Groove which can carry replicated information about the disk. The other parts of Inner Zone(s), Data Zone(s) and Outer Zone(s) constitute the Recordable Area in which the information can be recorded on the Wobbled Groove(s).

16.2 Format of Information Zone on Single-Layer disk

For consistency reasons, the sole Recording Layer on an SL disk is also called Layer L0.

The Information Zone on SL disks is divided in three parts: a Lead-in Zone (part of Inner Zone 0), a Data Zone 0 and a Lead-out Zone (Outer Zone 0) (see Figure 84).

The Data Zone is intended for recording User Data. The Lead-in Zone contains replicated and Recordable Control Information and an area for disk and drive testing. The Lead-out Zone allows for a smooth runout and also contains Control Information.

16.3 Format of Information Zone on Dual-Layer disk

The Information Zone on DL disks is divided in six parts: a Lead-in Zone (part of Inner Zone 0), a Data Zone 0 and an Outer Zone 0 on Layer L0 and an Outer Zone 1, a Data Zone 1 and a Lead-out Zone (part of Inner Zone 1) on Layer L1 (see Figure 84 and Figure 85).

Data Zone 0 and Data Zone 1 are intended for recording User Data. The Lead-in Zone and Lead-out Zone contain replicated and Recordable Control Information and an area for disk and drive testing. Outer Zone 0 and Outer Zone 1 allow for a smooth run-in/runout for their respective layer and also contain Control Information.

17 Layout of Recordable Area of Information Zone

The Recordable Area of the Information Zone is constituted from parts of the Inner Zone(s), the Data Zone(s) and the Outer Zone(s). The starting radii for the Zones indicated in Figure 84 are the nominal values of the centre of the first/last Groove Track in those Zones.

The Physical ADIP Addresses (PAA) shown in Figure 84 are the first/last addresses in the Groove Tracks of each Zone. Also the numbers of Physical Clusters (RUBs) that can be recorded per Zone are indicated.

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The values given in the table of Figure 84 are for a disk capacity of 25,0 Gbytes or 50,0 Gbytes.

Layer L0				Descrip-tion	Nominal starting radius (mm)	First PAA of Zone : Last PAA of Zone	Number of Phys. Clusters
First transition Area	ending radius 11,5 mm						
Clamping Zone	starting radius 11,5 mm ending radius 16,5 mm						
Second transition Area	starting radius 16,5 mm ending radius 21,0 mm						
Information Area	starting radius 21,0 mm	*"wide pitch" Groove*	**BCA**				
	Information Zone (↓ tracking direction)	***Embossed HFM*** *(HFM Groove)*		Protection-Zone 1	22,2	---	---
				PIC	22,512	(First AUN = 00 0D 8E C0h : Last AUN = 00 0D A3 FEh)	2 720 (×4KB)
		Recordable *(Wobbled Groove)*	**Lead-in Zone (part of Inner Zone 0)**	Protection-Zone 2	23,252	01 B4 80h : 01 B7 FEh	224
				INFO 2	23,289	01 B8 00h : 01 BB FEh	256
				OPC 0	23,329	01 BC 00h : 01 DB FEh	2 048
				TDMA 0	23,647	01 DC 00h : 01 FB FEh	2 048
				INFO 1	23,961	01 FC 00h : 01 FF FEh	256
			Data Zone 0		24,000	02 00 00h : : LAA	381 856
			Lead-out Zone / Outer Zone 0	INFO 3/4	58,000	LAA + 2h : : LAA + 4 30h	268
				DCZ 0	58,017	LAA + 4 32h : LAA + C 30h	512
				Protection-Zone 3	58,049	LAA + C 32h :	---
	ending radius 58,5 mm						
Rim Area	starting radius 58,5 mm						

Figure 84 — Layout of Information Zone on Layer L0

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The values given in the table of Figure 85 are for a disk capacity of 50,0 Gbytes.

Layer L1				Descrip-tion	Nominal ending radius (mm)	Last PAA of Zone : First PAA of Zone	Number of Phys. Clusters
Information Area	ending radius 21,0 mm	*"wide pitch" Groove*					
	tracking direction ↑ Information Zone ↑	*Wobbled Groove*		Protection -Zone 1	22,2	: 3E 94 00h	---
		Recordable (*Wobbled Groove*)	**Lead-out Zone (part of Inner Zone 1)**	Buffer Zone	22,512	3E 93 FEh : 3E 7E 00h	1 408
				OPC 1	22,740	3E 7D FEh : 3E 5E 00h	2 048
				Buffer Zone	23,067	3E 5D FEh : 3E 48 00h	1 408
				INFO 2	23,289	3E 47 FEh : 3E 44 00h	256
				TDMA 1	23,329	3E 43 FEh : 3E 24 00h	2 048
				Reserved	23,647	3E 23 FEh : 3E 04 00h	2 048
				INFO 1	23,961	3E 03 FEh : 3E 00 00h	256
			Data Zone 1		24,000	3D FF FEh : : FAA [a]	381 856
			Outer Zone 1	INFO 3/4	58,000	FAA – 2h : FAA – 4 30h	268
				DCZ 1	58,017	FAA – 4 32h : FAA – C 30h	512
				Protection -Zone 3	58,049	FAA – C 32h :	---
	starting radius 58,5 mm						

[a] FAA = $\overline{\text{LAA + C0 00 01h}}$ (see 15.7.4.3)

Figure 85 — Layout of Information Zone on Layer L1

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Physical-Sector numbering

A Cluster contains 32 Physical Sectors, and each Physical Sector contains 2K data bytes. Although their numbers are not included in the data recorded on the disk, each Physical Sector is associated with a (virtual) Physical-Sector Number (PSN).

The PSNs increase by one for each successive Physical Sector in the tracking direction of the related Recording Layer.

The PSN of the first Physical Sector of each Physical Cluster is a multiple of 32.

Bits PS_{31} to PS_{27} of the PSN shall be Reserved.

Bits PS_{26} to PS_{24} of the PSN shall be set to the Layer number.

The first PSN in the Data Zone 0 is 00 10 00 00h.

The last PSN in the Data Zone 0 is 8 × LAA + 15, which is 00 CA 73 FFh on a 25,0 GB and 50,0 GB disk.

The first PSN in the Data Zone 1 is 8 × FAA, which is 01 35 8C 00h on a 50,0 GB disk.

The last PSN in the Data Zone 1 is 01 EF FF FFh.

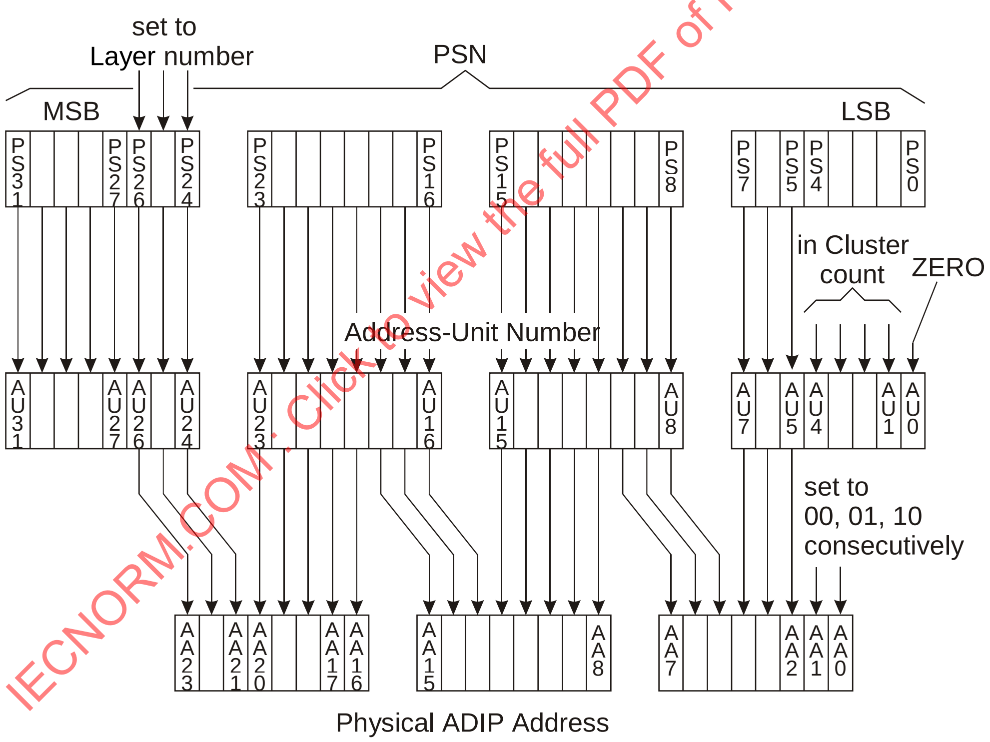

Figure 86 — Physical ADIP Addresses derived from PSNs

These PSNs are converted to Address-Unit Numbers, which shall be recorded in the BIS columns of the ECC Clusters (see 13.9.2).

Finally, a Physical ADIP Address is derived from the PSN/AUN as defined in Figure 86. This PAA identifies the location on the disk where the data has to be recorded.

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18 Inner Zone

18.1 General

On Layer L0 the innermost Zone of the Information Zone is called the Lead-in Zone. On Layer L1, the innermost Zone of the Information Zone is called the Lead-out Zone.

Inner Zone 0 contains an Embossed HFM Area and a Recordable Area. Inner Zone 1 contains an embossed wobbled part and a Recordable Area (see Figure 87 and Figure 88).

In the Embossed HFM Area on Layer L0, all Groove shall be encoded according to the format defined in 15.5.

On Layer L0 this encoding shall start at a radius $22{,}2^{\,0{,}0}_{-0{,}1}$ mm, such that the AUN of the first Cluster shall be AUN = 00 0D 85 F4h.

The addressees shall be continuously increasing as described in 15.5.3.2, and shall end with AUN = 00 0D A3 FEh in the last 4K Cluster at the outermost radius of the PIC Zone.

In Protection-Zone 1 of Inner Zone 0, the content of the Data Frames can be set to all 00h or it can be equal to the content in the PIC Zone.

The Protection-Zone 1 is intended to protect against overwriting of the PIC Zone by BCA code.

In the Permanent Information & Control data (PIC) Zone(s), general information about the disk and various other information can be stored in the Embossed HFM Groove.

In the Recordable Area and the Wobbled Groove Area (Protection-Zone 1 on Layer L1), all Groove(s) shall be wobbled as defined in 15.6.

The Recordable Area of the Inner Zone(s) is used to execute OPC (Optimum Power Control) procedures and to store specific information about the disk, such as Disk Management Information and Control Information. Also a Zone has been reserved where drives can store their own specific information.

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Inner Zone 0		Description	First PAA of Zone	Number of Phys.Clusters	Purpose
Embossed HFM		Protection-Zone 1	---	---	---
		PIC	---	---	Permanent Information & Control data Zone
↓ Recordable ↓ *tracking direction*	---	Protection-Zone 2	01 B4 80h	224	---
	INFO 2	Reserved 8	01 B8 00h	32	future extension
		Reserved 7	01 B8 80h	32	future extension
		Reserved 6	01 B9 00h	32	future extension
		Reserved 5	01 B9 80h	32	future extension
		PAC 2	01 BA 00h	32	Physical-Access Control
		DMA 2	01 BA 80h	32	Disk Management
		Control Data 2	01 BB 00h	32	data information
		Buffer 2	01 BB 80h	32	---
	OPC 0	Test Zone	01 BC 00h	2 044	OPC testing
		OPC 0 Buffer	01 DB F0h	4	buffer
	TDMA 0	---	01 DC 00h	2 048	Temporary DM Area
	INFO 1	Pre-write Area	01 FC 00h	32	Drive calibration
		Drive Area	01 FC 80h	32	Drive-specific information
		Drive Area	01 FD 00h	32	Drive-specific information
		Drive Area	01 FD 80h	32	Drive-specific information
		Drive Area	01 FE 00h	32	Drive-specific information
		DMA 1	01 FE 80h	32	Disk Management
		Control Data 1	01 FF 00h	32	data information
		PAC 1	01 FF 80h	32	Physical-Access Control
		(Data Zone 0)	02 00 00h		

Figure 87 — Inner Zone 0 (Lead-in Zone)

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Inner Zone 1		Description	First PAA of Zone	Number of Phys.Clusters	Purpose
		(Data Zone 1)			
	INFO 1	PAC 1	3E 00 00h	32	Physical-Access Control
		Control Data 1	3E 00 80h	32	data information
		DMA 1	3E 01 00h	32	Disk Management
		Drive Area	3E 01 80h	32	Drive-specific information
		Drive Area	3E 02 00h	32	Drive-specific information
		Drive Area	3E 02 80h	32	Drive-specific information
		Drive Area	3E 03 00h	32	Drive-specific information
		Pre-write Area	3E 03 80h	32	Drive calibration
	Reserved	---	3E 04 00h	2 048	future extension
	TDMA 1	---	3E 24 00h	2 048	Temporary DM Area
↓	INFO 2	Buffer 2	3E 44 00h	32	---
Recordable		Control Data 2	3E 44 80h	32	data information
↓		DMA 2	3E 45 00h	32	Disk Management
		PAC 2	3E 45 80h	32	Physical-Access Control
		Reserved 5	3E 46 00h	32	future extension
		Reserved 6	3E 46 80h	32	future extension
		Reserved 7	3E 47 00h	32	future extension
tracking direction		Reserved 8	3E 47 80h	32	future extension
	Buffer	---	3E 48 00h	1 408	---
	OPC 1	Test Zone	3E 5E 00h	2 048	OPC testing
	Buffer	---	3E 7E 00h	1 408	---
Wobbled Groove		Protection-Zone 1	---	---	---

Figure 88 — Inner Zone 1 (Lead-out Zone)

18.2 Permanent Information & Control data (PIC) Zone

18.2.1 General

The Permanent Information & Control data (PIC) Zone is an Embossed HFM Area with data for various purposes, such as Disk Information. If no specific PIC is supplied, all User Data bytes (before scrambling) shall be set to 00h. Permanent Information & Control data (PIC) is only present on Layer L0.

18.2.2 Content of PIC Zone

The PIC Zone shall consist of five repetitions of a PIC-Info Fragment, where each PIC-Info Fragment consists of 544 PIC Clusters (for a total of 2 720, see Figure 89). The PIC Clusters shall be formatted as described in 15.5.

The PIC-Info Fragments shall start on Layer L0 at AUNs: 00 0D 8E C0h, 00 0D 93 00h, 00 0D 97 40h, 00 0D 9B 80h and 00 0D 9F C0h

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PIC-Info Fragment number	PIC-Cluster number	AUN on Layer L0
	0	00 0D 8E C0h
	1	00 0D 8E C2h
IF0	2	00 0D 8E C4h
	:	:
	543	00 0D 92 FEh
	0	00 0D 93 00h
IF1	:	:
	543	00 0D 97 3Eh
	0	00 0D 97 40h
IF2	:	:
	543	00 0D 9B 7Eh
	0	00 0D 9B 80h
IF3	:	:
	543	00 0D 9F BEh
	0	00 0D 9F C0h
IF4	:	:
	543	00 0D A3 FEh

Figure 89 — PIC Zone

The first PIC Cluster of each Info Fragment shall contain a copy of the Disk-Information Block as contained in the ADIP Aux Frames (see 15.8.3 and Figure 90). Only the first 112 bytes of each Disk-Information Aux Frame shall be included (excluding the 32 parity bytes). If less than 32 DI Units are present, then the remaining bytes up to byte 3 584 shall be set to 00h.

The last 512 bytes of the first PIC Cluster of each Info Fragment shall contain the Emergency-Brake data set (see 18.2.3 and Figure 90).

Byte Position in PIC Cluster	Content	Number of bytes
0 to 111	DI Unit 0	112
112 to 223	DI Unit 1	112
:	:	112 × 28
3 360 to 3 471	DI Unit 30	112
3 472 to 3 583	Reserved	112
3 584 to 4 095	EB Data Set	512

Figure 90 — First PIC Cluster of each Info Fragment

All other PIC Clusters shall be Reserved unless otherwise specified by the Application.

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18.2.3 Emergency Brake

As a protective measure, a data set is defined that can be used by specific drive models to recognize disks that need special handling to prevent destructive malfunction.

This data is called Emergency Brake (EB) data.

EB data is specified in bytes 3 584 to 4 095 of the first PIC Cluster of each Info Fragment. It consists of an EB Header, EB-data field(s) and an EB Footer. EB-data fields shall be included only upon mutual agreement, between the disk manufacturer and the drive manufacturer involved, that specific drives require special actions when handling such disks, e.g. to prevent damage to the disk or the drive. Up to a maximum of 62 EB-data fields may be applied.

The Emergency-Brake data shall be implemented as depicted in Figure 91.

Byte number	Function	Definition	Number of bytes
3 584 to 3 585	EB Header	Identifier	2
3 586		Version	1
3 587		Reserved	1
3 588		List length	1
3 589 to 3 591		Reserved	3
3 592 to 3 593	EB Data field 1	Drive-Manufacturer ID	2
3 594 to 3 595		Drive Model	2
3 596 to 3 597		Firmware Version	2
3 598 to 3 599		Drive Actions	2
: :	: :	: :	: :
$(3\,584 + i \times 8)$ to $(3\,584 + i \times 8) + 1$	EB Data field i $(1 \leq i \leq N)$	Drive-Manufacturer ID	2
$(3\,584 + i \times 8) + 2$ to $(3\,584 + i \times 8) + 3$		Drive Model	2
$(3\,584 + i \times 8) + 4$ to $(3\,584 + i \times 8) + 5$		Firmware Version	2
$(3\,584 + i \times 8) + 6$ to $(3\,584 + i \times 8) + 7$		Drive Actions	2
: :	: :	: :	: :
$(3\,584 + N \times 8)$ to $(3\,584 + N \times 8) + 1$	EB Data Field N $(N \leq 62)$	Drive-Manufacturer ID	2
$(3\,584 + N \times 8) + 2$ to $(3\,584 + N \times 8) + 3$		Drive Model	2
$(3\,584 + N \times 8) + 4$ to $(3\,584 + N \times 8) + 5$		Firmware Version	2
$(3\,584 + N \times 8) + 6$ to $(3\,584 + N \times 8) + 7$		Drive Actions	2
$[3\,584 + (N+1) \times 8]$ to $[3\,584 + (N+1) \times 8] + 7$	EB Footer	Terminator	8
$[3\,584 + (N+2) \times 8]$ to 4 095	Unused	Reserved	$512 - (N+2) \times 8$

Figure 91 — Definition of Emergency-Brake data

Bytes 3 584 to 3 585: EB Identifier

These bytes shall be set to 45 42h, representing the characters “EB”.

Byte 3 586: EB Version

This byte shall be set to 01h, representing Version 1 of the Emergency Brake format.

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Byte 3 587: Reserved

This byte shall be set to 00h.

Byte 3 588: EB list length N

This byte shall represent the number of EB-data fields.

This byte shall be set to 00h when no EB-data fields are present.

Bytes 3 589 to 3 591: Reserved

These bytes shall be set to 00 00 00h.

Bytes $(3\,584 + i \times 8)$ to $(3\,584 + i \times 8) + 1$ $(1 \leq i \leq N)$: Drive-Manufacturer ID

The format and the content of these 2 bytes require agreement between the interchange parties, else these bytes shall be set to all 00h.

Bytes $(3\,584 + i \times 8) + 2$ to $(3\,584 + i \times 8) + 3$ $(1 \leq i \leq N)$: Drive-Model Number

These 2 bytes represent the Drive-Model Number and shall be defined by the drive manufacturer. This International Standard does not specify the format and content of these bytes. It shall be ignored in interchange.

Bytes $(3\,584 + i \times 8) + 4$ to $(3\,584 + i \times 8) + 5$ $(1 \leq i \leq N)$: Drive-Firmware Version

These 2 bytes represent the Drive-Firmware Version and shall be defined by the drive manufacturer. This International Standard does not specify the format and content of these bytes. It shall be ignored in interchange.

Bytes $(3\,584 + i \times 8) + 6$ to $(3\,584 + i \times 8) + 7$ $(1 \leq i \leq N)$: Drive-Manufacturer Actions

These 2 bytes represent the actions to be performed by the drive model to handle this disk. These bytes shall be defined by the drive manufacturer. This International Standard does not specify the format and the content of these bytes. It shall be ignored in interchange.

Bytes $[3\,584 + (N+1) \times 8]$ to $[3\,584 + (N+1) \times 8] + 7$ $(0 \leq N \leq 62)$: EB Terminator

These bytes shall be set to FF FF FF FF FF FF FF FFh to indicate the end of the EB data.

Bytes $[3\,584 + (N+2) \times 8]$ to 4 095 $(0 \leq N \leq 62)$: Reserved

These bytes shall be Reserved.

18.3 Recordable Area of Inner Zone 0

18.3.1 Protection-Zone 2

This Zone comprising 224 Physical Clusters starts at PAA 01 B4 80h and is intended to be a buffer Zone for the transition from the Embossed HFM Area to the Recordable Area (see 15.4.4).

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18.3.2 INFO 2/Reserved 8

This Zone comprising 32 Physical Clusters starts at PAA 01 B8 00h and is Application dependent.

For disks with BCA code, this Zone shall be left unrecorded unless otherwise specified by the Application.

For disks without BCA code, this Zone shall be recorded all 00h before being shipped.

18.3.3 INFO 2/Reserved 7

This Zone comprising 32 Physical Clusters starts at PAA 01 B8 80h and shall be left unrecorded.

18.3.4 INFO 2/Reserved 6

This Zone comprising 32 Physical Clusters starts at PAA 01 B9 00h and shall be left unrecorded.

18.3.5 INFO 2/Reserved 5

This Zone comprising 32 Physical Clusters starts at PAA 01 B9 80h and is Application dependent.

For disks with BCA code, this Zone shall be left unrecorded unless otherwise specified by the Application.

For disks without BCA code, this Zone shall be recorded all 00h before being shipped.

18.3.6 INFO 2/PAC 2

This Zone comprising 32 Physical Clusters starts at PAA 01 BA 00h on Layer L0 and is intended to be used for storing Physical-Access Control (PAC) Clusters (see 21.2). Unused Clusters in this Zone shall be left unrecorded.

18.3.7 INFO 2/DMA 2

This Zone comprising 32 Physical Clusters starts at PAA 01 BA 80h and is intended for use by the Disk Management system. Until the disk is closed (see 22.6), these Clusters shall be left unrecorded.

18.3.8 INFO 2/Control Data 2

This Zone comprising 32 Physical Clusters starts at PAA 01 BB 00h on Layer L0 and at PAA 3E 44 80h on Layer L1 and is intended to store Control Information. Unused Clusters shall be left unrecorded until the disk is closed.

18.3.9 INFO 2/Buffer 2

This Zone comprising 32 Physical Clusters starts at PAA 01 BB 80h and shall be left unrecorded.

18.3.10 OPC 0/Test Zone

The Test Zone comprising 2 044 Physical Clusters starts at PAA 01 BC 00h and is reserved for testing and/or OPC procedures. The OPC 0 Area shall be used according to 18.3.11.

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18.3.11 Usage of OPC Areas

18.3.11.1 OPC procedure order

The OPC Areas shall be used consecutively in descending PAA order. The first area used for an OPC procedure ends at the end of the last PAA. The last usable Physical Cluster of the OPC Area is located at the first PAA of the OPC Area (see Figure 92).

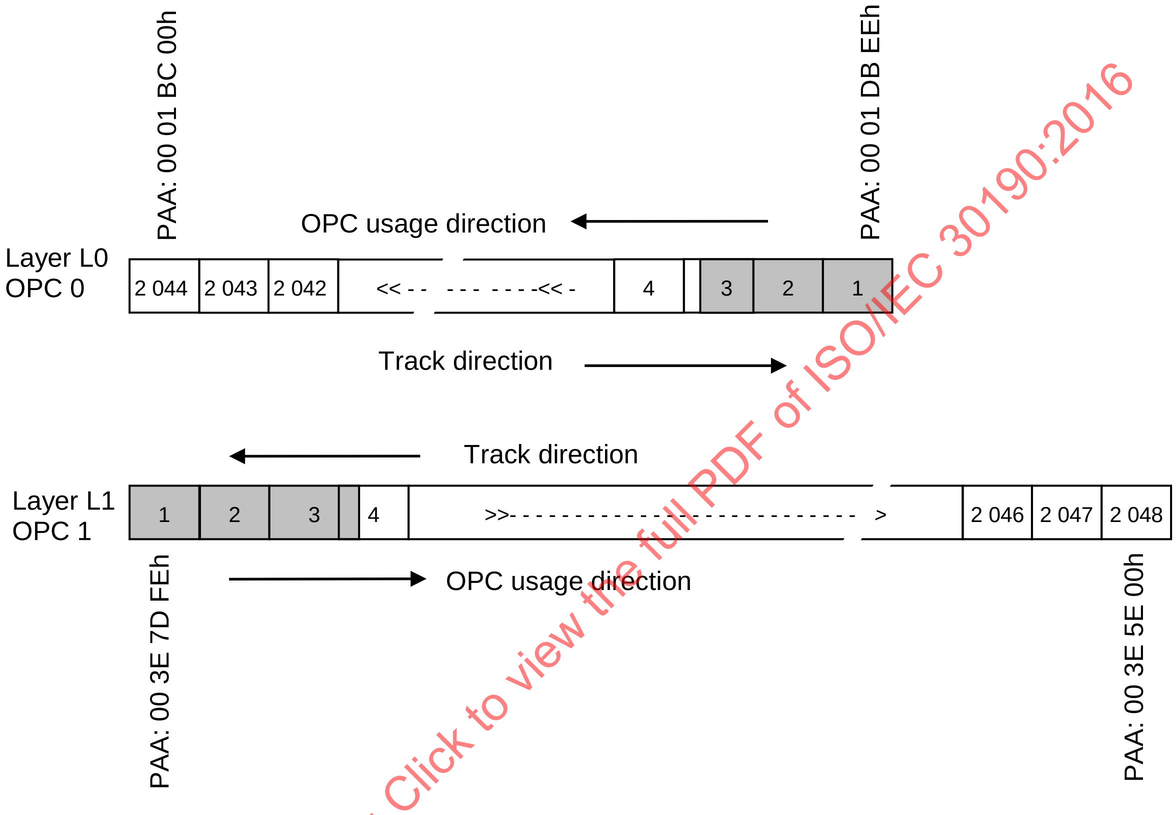

Figure 92 — Direction of usage of OPC Area of Layer L0 and Layer L1

18.3.11.2 OPC Physical Cluster usage

The length of one OPC procedure may be chosen by the drive and is not restricted to an integer number of Physical Clusters (see Figure 93). The transition between the used and unused OPC Area shall be indicated by an OPC Marker. The distance between any two consecutive OPC Markers shall not exceed 16 Physical Clusters. In case an OPC procedure needs more than 16 Physical Clusters, OPC Markers shall be inserted to fulfill this requirement. The OPC Marker shall have a length of at least 868 NWLs (equal to one AUN) and its modulation shall be such that $I_{8pp}/I_{8H} \geq 0{,}30$.

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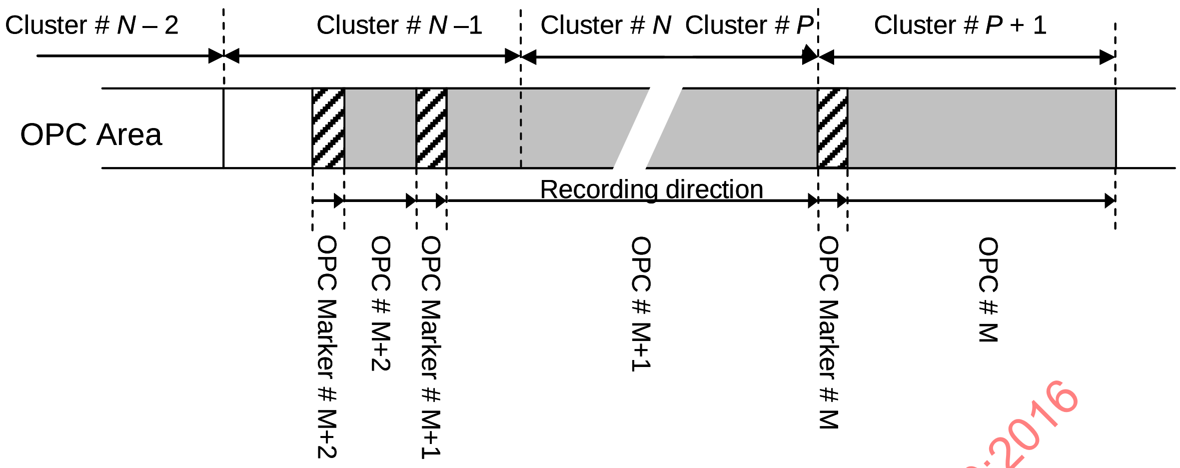

OPC #*M* occupies exactly one Cluster, OPC #*M*+1 exceeds one Cluster, OPC #*M*+2 is smaller than one Cluster.

Figure 93 — Example of position of OPC Markers

18.3.11.3 OPC update in TDMA

Each OPC procedure shall be completed by updating the corresponding “next available PSN of Test Zone on Layer L*n* in the TDDS, see 22.4.4.

18.3.12 OPC 0/OPC 0 Buffer

This Zone comprising 4 Physical Clusters starts at PAA 01 DB F0h and is intended as a buffer Zone for the transition from OPC 0 Area to the TDMA 0 Area and shall be left unrecorded.

18.3.13 TDMA 0

This Zone comprising 2 048 Physical Clusters starts at PAA 01 DC 00h and is intended for use as a temporary DM Area.

18.3.14 INFO 1/Pre-write Area

This Zone comprising 32 Physical Clusters starts at PAA 01 FC 00h and all 32 Physical Clusters shall be recorded by the first drive that writes on Layer L0 and shall contain all 00h.

Drives that write the INFO 1 / Pre-write Area shall update Pre-write Area flags of the TDDS (see 22.4.4).

18.3.15 INFO 1/Drive Area

18.3.15.1 General

The use of this Zone, divided into four parts of 32 Physical Clusters each, starting at PAA 01 FC 80h is optional.

This Zone can be used by drives to store Drive-specific Information, restricted to be used only by the drive that has created the information. To guarantee that drives can allocate their own information, the following format shall be used. These Clusters in this Zone shall be ignored in interchange.

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18.3.15.2 Format of Drive-specific Information

Each Drive-specific Information shall be contained in one 2K Data Frame. The first 128 bytes of such a Data Frame shall contain a signature of the drive that has created the related Data Frame, according to the following format:

— 48 bytes for the Manufacturers name, represented by characters from the ISO 646 character set;

— 48 bytes of additional identification, represented by characters from the ISO 646 character set;

— 32 bytes for a unique serial number of the drive.

The format of the remaining 1 920 bytes of the Data Frame is not defined and can be chosen freely by each drive designer.

The Drive-specific Information of the last 32 drives that have used this option shall be stored in the newest recorded Physical Cluster. Each time a new drive is going to write its Drive-specific Information in a new Physical Cluster, the oldest Drive-specific Information located in Data Frame 31 of the last Physical Cluster is removed, the content of Data Frames 0 to 30 in the last Physical Cluster are copied into Data Frames 1 to 31 in the new Physical Cluster and the new information is written in Data Frame 0 in the new Physical Cluster (see Figure 94). Initially, the Physical Cluster starting at PAA 01 FC 80h shall be used to store the Drive-specific Information.

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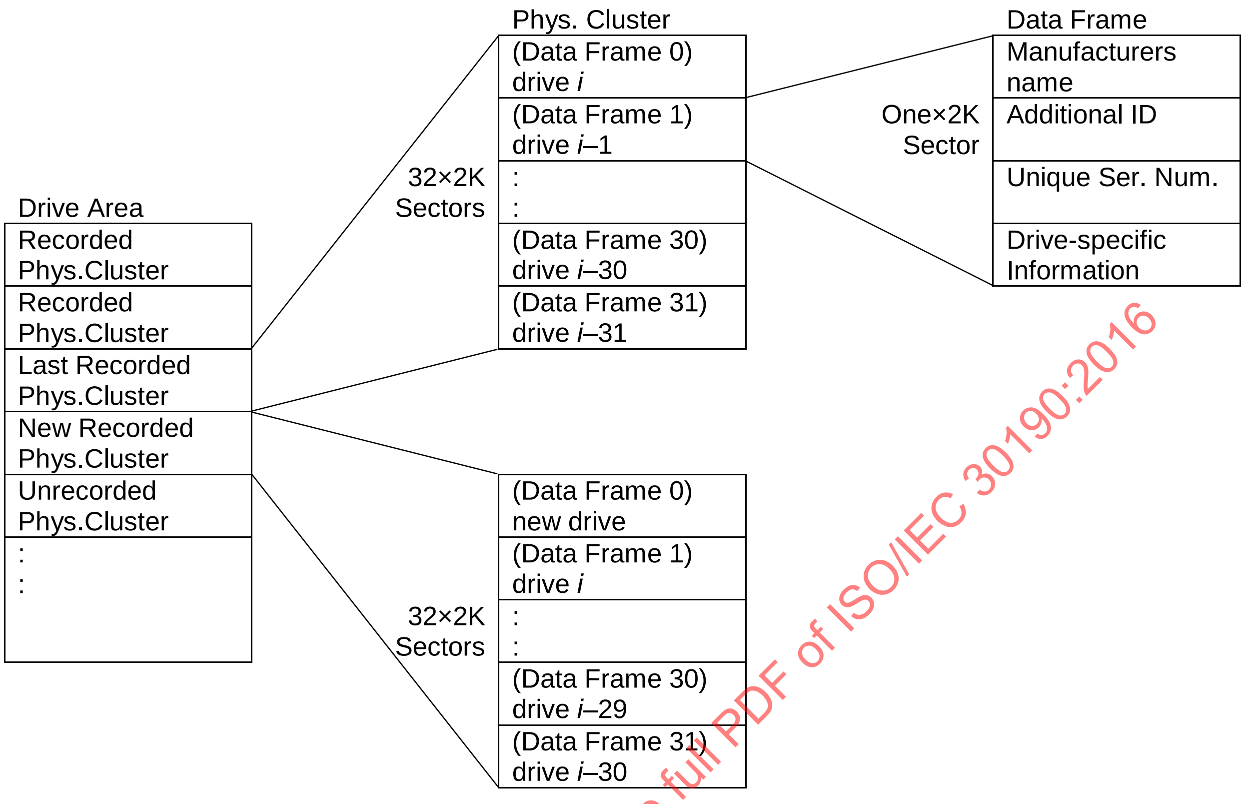

Figure 94 — Format of Drive Area (example)

18.3.16 INFO 1/DMA 1

This Zone comprising 32 Physical Clusters starts at PAA 01 FE 80h and is intended for use by the Disk Management system. Until the disk is closed (see 22.6), these Clusters shall be left unrecorded.

18.3.17 INFO 1/Control Data 1

This Zone comprising 32 Physical Clusters starts at PAA 01 FF 00h on Layer L0 and at PAA 3E 00 80h on Layer L1 and is intended to store Control Information. Unused Clusters shall be left unrecorded until the disk is closed.

18.3.18 INFO 1/PAC 1

This Zone comprising 32 Physical Clusters starts at PAA 01 FF 80h on Layer L0 and is intended to be used for storing Physical-Access Control (PAC) Clusters (see 21.2). Unused Clusters in this Zone shall be left unrecorded.

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18.4 Recordable Area of Inner Zone 1

18.4.1 Buffer

This Zone comprising 1 408 Physical Clusters starts at PAA 3E 7E 00h and shall be left unrecorded.

18.4.2 OPC 1

This Zone comprising 2 048 Physical Clusters starts at PAA 3E 5E 00h is reserved for testing and OPC procedures. The OPC 1 Area shall be used according 18.3.11.

18.4.3 Buffer

This Zone comprising 1 408 Physical Clusters starts at PAA 3E 48 00h and shall be left unrecorded.

18.4.4 INFO 2/Reserved 8

This Zone comprising 32 Physical Clusters starts at PAA 3E 47 80h and is Application dependent.

For disks with BCA code, this Zone shall be left unrecorded unless otherwise specified by the Application.

For disks without BCA code, this Zone shall be recorded all 00h before being shipped.

18.4.5 INFO 2/Reserved 7

This Zone comprising 32 Physical Clusters starts at PAA 3E 47 00h and shall be left unrecorded.

18.4.6 INFO 2/Reserved 6

This Zone comprising 32 Physical Clusters starts at PAA 3E 46 80h and shall be left unrecorded.

18.4.7 INFO 2/Reserved 5

This Zone comprising 32 Physical Clusters starts at PAA 3E 46 00h and is Application dependent.

For disks with BCA code, this Zone shall be left unrecorded unless otherwise specified by the Application.

For disks without BCA code, this Zone shall be recorded all 00h before being shipped.

18.4.8 INFO 2/PAC 2

This Zone comprising 32 Physical Clusters starts at PAA 3E 45 80h on Layer L1 and is intended to be used for storing Physical-Access Control (PAC) Clusters (see 21.2). Unused Clusters in this Zone shall be left unrecorded.

18.4.9 INFO 2/DMA 2

This Zone comprising 32 Physical Clusters starts at PAA 3E 45 00h and is intended for use by the Disk Management system. Until the disk is closed (see 22.6), these Clusters shall be left unrecorded.

18.4.10 INFO 2/Control Data 2

This Zone comprising 32 Physical Clusters starts at PAA 3E 44 80h and is intended to store Control Information. Unused Clusters shall be left unrecorded until the disk is closed.

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18.4.11 INFO 2/Buffer 2

This Zone comprising 32 Physical Clusters starts at PAA 3E 44 00h and shall be left unrecorded.

18.4.12 TDMA 1

This Zone comprising 2 048 Physical Clusters starts at PAA 3E 24 00h and is intended for use as a Temporary DM Area.

18.4.13 Reserved

This Zone comprising 2 048 Physical Clusters starts at PAA 3E 04 00h and shall be left unrecorded.

18.4.14 INFO 1/Pre-write Area

This Zone comprising 32 Physical Clusters starts at PAA 3E 03 80h and all 32 Physical Clusters shall be recorded by the first drive that writes on Layer L1 and shall contain all 00h. Drives that write the INFO 1/Pre-write Area shall update Pre-write Area flags of the TDDS (see 22.4.4).

18.4.15 INFO 1/Drive Area

The use of this Zone, divided into four parts of 32 Physical Clusters, starting at PAA 3E 01 80h is optional.

This Zone can be used by drives to store Drive-specific Information, restricted to be used only by the drive that had created the information. To guarantee that drives can allocate their own information, the format specified in 18.3.15 shall be used. The Clusters in this Zone shall be ignored in interchange.

18.4.16 INFO 1/DMA 1

This Zone comprising 32 Physical Clusters starts at PAA 3E 01 00h and is intended for use by the Disk Management system. Until the disk is closed (see 22.6), these Clusters shall be left unrecorded.

18.4.17 INFO 1/Control Data 1

This Zone comprising 32 Physical Clusters starts at PAA 3E 00 80h and is intended to store Control Information.

Unused Clusters shall be left unrecorded until the disk is closed.

18.4.18 INFO 1/PAC 1

This Zone comprising 32 Physical Clusters starts at PAA 3E 00 00h on Layer L1 and is intended to be used for storing Physical-Access Control (PAC) Clusters (see 21.2). Unused Clusters in this Zone shall be left unrecorded.

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19 Data Zone

On an SL disk the Data Zone can contain a total of 381 856 Clusters of User Data, which results in a 25,0 GB disk.

On a DL disk the Data Zones can contain a total of 763 712 Clusters of User Data, which results in a 50,0 GB disk.

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20 Outer Zone(s)

20.1 General

On an SL disk, the outermost Zone of the Information Zone functions Lead-out Zone.

On a DL disk, Outer Zone 0 and Outer Zone 1 function as a transition area between the Data Zones on Layer L0 and Layer L1 (see Figure 95 and Figure 96).

Outer Zone 0		Description	First PAA of Zone	Number of Phys.Clusters	Purpose
↓ Recordable ↓ *tracking direction*	INFO 3	Buffer 4	LAA + 2h	32	---
		DMA 3	LAA + 82h	32	Disk Management
		Control Data 3	LAA + 1 02h	32	data information
	---	Angular buffer	LAA + 1 82h	76	---
	INFO 4	DMA 4	LAA + 2 B2h	32	Disk Management
		Control Data 4	LAA + 3 32h	32	data information
		Buffer 6	LAA + 3 B2h	32	---
	DCZ0	Test Zone	LAA + 4 32h	512	Drive calibration
	---	Protection-Zone 3	LAA + C 32h	---	---

Figure 95 — Outer Zone 0 / Lead-out Zone

Outer Zone 1		Description	First PAA of Zone	Number of Phys.Clusters	Purpose
	---	Protection-Zone 3	---	---	---
↓ Recordable ↓ *tracking direction*	DCZ1	Test Zone	FAA – C 30h	512	Drive calibration
	INFO 4	Buffer 6	FAA – 4 30h	32	---
		Control Data 4	FAA – 3 B0h	32	data information
		DMA 4	FAA – 3 30h	32	Disk Management
	---	Angular buffer	FAA – 2 B0h	76	---
	INFO 3	Control Data 3	FAA – 1 80h	32	data information
		DMA 3	FAA – 1 00h	32	Disk Management
		Buffer 4	FAA – 80h	32	---

Figure 96 — Outer Zone 1

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20.2 Recordable Area of Outer Zone(s)

20.2.1 INFO 3/Buffer 4

This Zone comprising 32 Physical Clusters shall be left unrecorded.

20.2.2 INFO 3/DMA 3

This Zone comprising 32 Physical Clusters is intended for use by the Disk Management system. Until the disk is closed (see 22.6), these Clusters shall be left unrecorded.

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20.2.3 INFO 3/Control Data 3

This Zone comprising 32 Physical Clusters is intended to store Control Information. Unused Clusters shall be left unrecorded until the disk is closed.

20.2.4 Angular buffer

This Zone comprising 76 Physical Clusters shall be left unrecorded.

20.2.5 INFO 4/DMA 4

This Zone comprising 32 Physical Clusters is intended for use by the Disk Management system. Until the disk is closed (see 22.6), these Clusters shall be left unrecorded.

20.2.6 INFO 4/Control Data 4

This Zone comprising 32 Physical Clusters is intended to store Control Information. Unused Clusters shall be left unrecorded until the disk is closed.

20.2.7 INFO 4/Buffer 6

This Zone comprising 32 Physical Clusters shall be left unrecorded.

20.2.8 DCZ 0/Test Zone and DCZ 1 / Test Zone

These Test Zones comprising 512 Physical Clusters are reserved for drive calibrations. The DCZ Areas shall be used according to 20.2.9.

20.2.9 Usage of DCZ Area

20.2.9.1 DCZ procedure order

The Drive-Calibration Zone shall be used consecutively in descending PAA order. The first area used for a calibration procedure ends at the end of the last PAA. The last usable Physical Cluster of the DCZ Area is located at the first PAA of the DCZ Area (see Figure 97).

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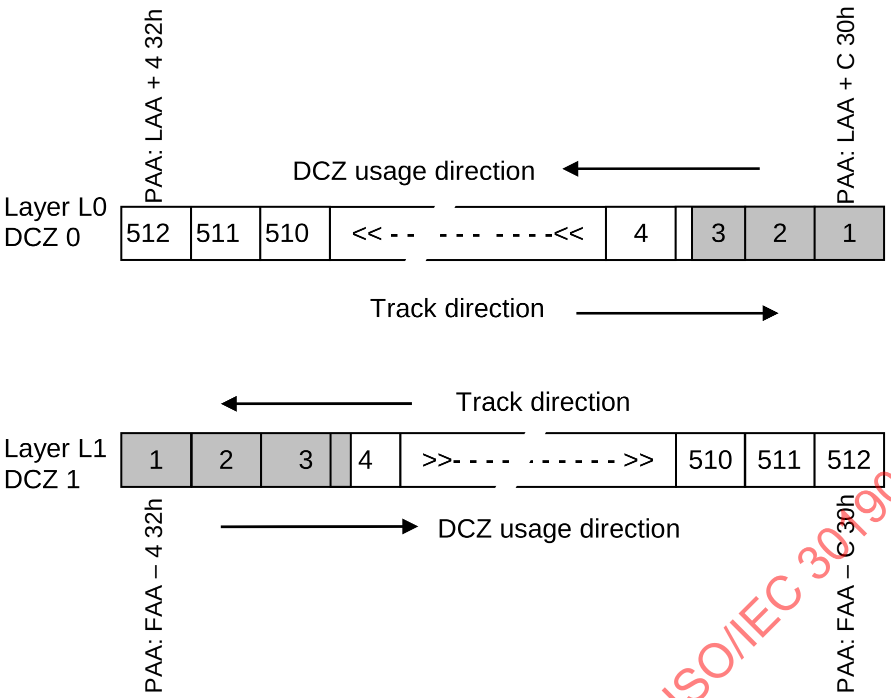
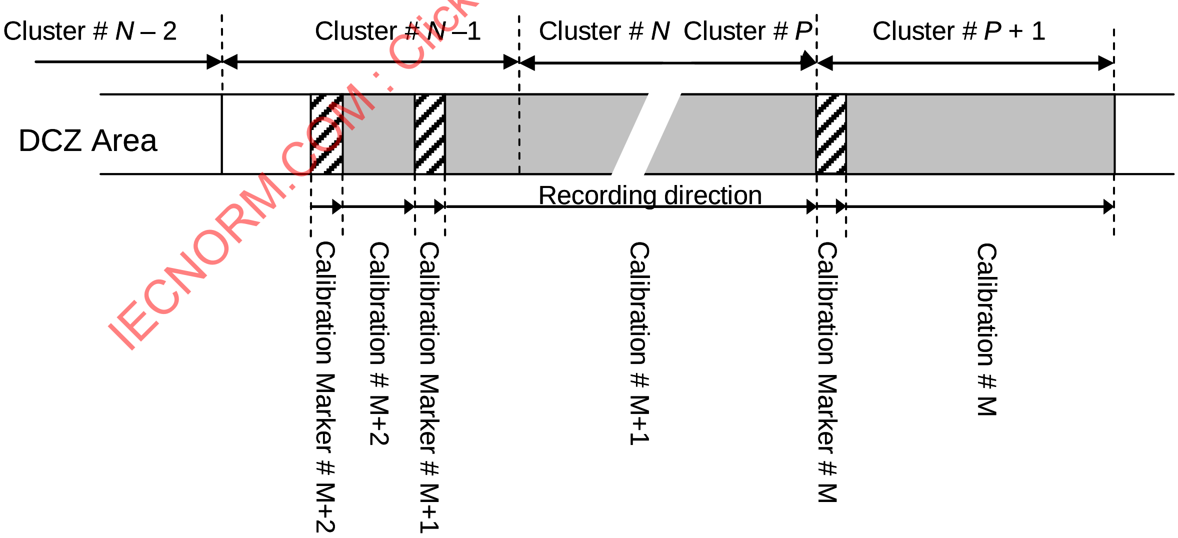


Figure 97 — Direction of usage of DCZ Area of Layer L0 and Layer L1

20.2.9.2 DCZ Physical Cluster usage

The length of one calibration procedure may be chosen by the drive and is not restricted to an integer number of Physical Clusters (see Figure 98). The transition between used and unused Calibration Areas shall be indicated by a Calibration Marker. The distance between any two consecutive Calibration Markers shall not exceed 16 Physical Clusters. In case a calibration procedure needs more than 16 Physical Clusters, Calibration Markers shall be inserted to fulfill this requirement. The Calibration Marker shall have a length of at least 868 NWLs (equal to one AUN) and its modulation shall be such that $I_{8pp}/I_{8H} \geq 0{,}30$.



Calibration #*M* occupies exactly one Cluster; Calibration #*M*+1 exceeds one Cluster; Calibration #*M*+2 is smaller than one Cluster.

Figure 98 — Example of position of Calibration Markers

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20.2.9.3 Update of TDMA

Each calibration procedure performed at any of the DCZ Zones shall be completed by updating the corresponding next available PSN of Drive-Calibration Zone on Layer L*n* in the TDDS, see 22.4.4.

20.2.10 Protection-Zone 3

This Zone contains an Unrecorded Groove.

All ADIP Units in the Grooves in this Zone shall be modulated by MSK-cos only and not by HMW (see 15.6.2).

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21 Physical-Access Control Clusters

21.1 General

Physical-Access Control (PAC) Clusters provide a structure on the disk for the exchange of additional information between interchange parties. PAC Clusters shall be recorded in the INFO 1 / PAC 1 Zone and backup copies shall be recorded in the INFO 2/PAC 2 Zone. All PAC Clusters shall have the same format for their first 384 data bytes, which constitute the PAC Header.

In the future new PACs can be defined for specific applications/functions.

Drives designed before the introduction date of a new PACs will, in general, not be able to interpret it and therefore shall treat such a PAC as a so-called “Unknown PAC”. By obeying standard “Unknown-PAC Rules”, defined in the header of the PACs, compatibility problems and unwanted destruction of data for specific applications can be avoided as much as possible.

Drives designed after the introduction date of a new PAC can be assumed to be familiar with the specific application/function connected to the new PAC. Such drives can therefore ignore the “Unknown-PAC Rules” and apply the rules defined in the “PAC-specific information” fields of the PAC. For such “Known PACs” there are no physical-access restrictions unless specified otherwise in the “PAC-specific information” fields.

21.2 Layout of PAC Zones

On SL disks, the INFO 1/PAC 1 and INFO 2/PAC 2 Zones each form one area of 32 Clusters available for the storage of PAC.

On DL disks, the INFO 1/PAC 1 Zones on Layer L0 and Layer L1 form one area of 64 Clusters available for the storage of PAC, and the INFO 2/PAC 2 Zones on Layer L0 and Layer L1 form another area of 64 Clusters available for the storage of PAC.

Each PAC Cluster shall be recorded in both Zones INFO 1/PAC 1 and INFO 2/PAC 2, so there will always be two copies of each PAC Cluster recorded. A PAC shall always be updated first in the INFO 1/PAC 1 Zone and then be copied to the INFO 2/PAC 2 Zone, which eases the handling of possible power-down failures. The PAC-Update Count of the PAC Cluster recorded in the INFO 2/PAC 2 Zone shall be the same as the PAC-Update Count of the PAC Cluster recorded in the INFO 1/PAC 1 Zone.

The status of all locations in both the INFO 1/PAC 1 and INFO 2/PAC 2 Zones shall be indicated in the TDDS (see 22.4.4) by a 2-bit pattern as follows:

$b_{(n+1)}, b_n$	Content in PAC location
00	unrecorded (also to be used if layer not present)
01	--- (this bit setting is Reserved)
10	contains an invalid PAC [a]
11	contains a valid PAC
[a] PAC Clusters with status 10 as indicated in the TDDS are not allowed to be transferred outside the drive (independent on the setting of bit b_0 and b_1 of the Unknown-PAC Rules)	

Figure 99 — Status of PAC locations

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If the PAC Cluster is found to be defective during recording, then the defective Cluster shall be skipped and indicated as invalid in the TDDS (see Figure 99). A replacement PAC shall be recorded in the next available Cluster.

If a PAC has to be updated, the new version of the PAC shall be recorded in the next available Cluster and the previous location containing the old version of the PAC shall be indicated as invalid in the TDDS.

21.3 General structure of PAC Clusters

The User Data of PAC Clusters shall be formatted according to Figure 100. The first 384 bytes constitute the PAC Header.

Data Frame	Byte position in Data Frame	Content	Number of bytes
0	0 to 2	PAC_ID	3
0	3	PAC format	1
0	4 to 7	PAC-Update Count	4
0	8 to 11	Unknown-PAC Rules	4
0	12	Unknown-PAC Entire_Disk_Flags	1
0	13 to 14	Reserved	2
0	15	number of Segments	1
0	16 to 23	Segment_0	8
0	24 to 31	Segment_1	8
0	32 to 263	:	29 × 8
0	264 to 271	Segment_31	8
0	272 to 383	Reserved	112
0	384	Known-PAC Entire_Disk_Flags	1
0	385 to 387	Reserved	3
0	388 to 2 047	PAC-specific information	1 660
1	0 to 2 047	PAC-specific information	2 048
:	:	:	:
30	0 to 2 047	PAC-specific information	2 048
31	0 to 2 047	Reserved	2 048

Figure 100 — General layout of PAC Clusters

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The **PAC_ID** shall identify the specific type of PAC Cluster.

— If set to 49 53 31h, the PAC Cluster is the IS1 PAC as defined in 21.4.

— If set to 49 53 32h, the PAC Cluster is the IS2 PAC as defined in 21.4.

Other values for the PAC_ID can be assigned in future releases of this International Standard.

Each new PAC added to the INFO 1/PAC 1 Zone or INFO 2/PAC 2 Zone shall be recorded in the first available Cluster in these Zones (indicated by status 00 in the TDDS (see Figure 99).

The **PAC-format** field shall indicate the version number of the specific PAC.

The **PAC-Update Count** shall specify the total number of update operations of the current PAC. This field shall be set to 00 00 00 00h during the first format operation only, and it shall be incremented by one each time the current PAC is updated.

The **Unknown-PAC Rules** shall specify the required actions when the content and use of the PAC are unknown (i.e. the PAC_ID is not set to a known value). These bytes form a field consisting of 32 individual bits

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(bit b_{31} shall be the msb of byte 8 and bit b_0 shall be the lsb of byte 11). The actions described below shall be taken (when the PAC is unknown) for any Cluster contained within the related area (see Figure 101). The actions described for the User-Data Area shall be taken only within the specified Segments, if Segments have been defined; else these actions shall be taken for any Cluster contained within the full User-Data Area.

If a drive encounters multiple unknown PACs on one disk, it shall use the OR-function of the Unknown-PAC Rules (in other words, if one of the PACs excludes an action, the same rule of the other PACs is irrelevant).

Area		Bits	Control type	Mandatory setting
		b_{31} to b_{24}	Reserved	0000 0000
INFO 2	Reserved 8	b_{23}	write	-
		b_{22}	read	-
	Reserved 7	b_{21}	write	ONE
		b_{20}	read	-
	Reserved 6	b_{19}	write	ONE
		b_{18}	read	-
	Reserved 5	b_{17}	write	-
		b_{16}	read	-
INFO 1	Drive Area (part 4)	b_{15}	write	ZERO
		b_{14}	read	ZERO
	Drive Area (part 3)	b_{13}	write	ZERO
		b_{12}	read	ZERO
	Drive Area (part 2)	b_{11}	write	ZERO
		b_{10}	read	ZERO
	Drive Area (part 1)	b_9	write	ZERO
		b_8	read	ZERO
TDMA Zones (not including the TDDS; see 22.6.2.1)		b_7	write	-
		b_6	Reserved unless otherwise specified by the Application	-
INFO 1,2,3,4	Control-Data Zones	b_5	write	-
		b_4	read	-
Data Zones	User-Data Area / Segments	b_3	write	-
		b_2	read	-
INFO 1&2	PAC Cluster	b_1	write	-
		b_0	read	-
"-" no mandatory setting specified,as well ZERO as ONE can be allowed depending on specific PAC				

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Figure 101 — General bit assignments for Unknown-PAC Rules

For **all Zones/areas**, except the PAC Cluster, the bits have the following meaning.

— Control type = **write**

  — If set to ZERO: indicating that writing in the related **Zone/area** is allowed.

  — If set to ONE: indicating that writing in the related **Zone/area** shall not be allowed.

— Control type = **read**

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— If set to ZERO: indicating that reading in the related **Zone/area** is allowed.

— If set to ONE: indicating that reading in the related **Zone/area** shall not be allowed.

The meaning of "reading shall not be allowed" in this context is the data content of the Clusters in the related Area(s) are not allowed to be transferred outside the drive.

For the **PAC Cluster**, the bits have the following meaning.

— Control type = **write**

  — If set to ZERO: indicating that re-writing the current PAC Cluster or changing its status bits in the TDDS is allowed.

  — If set to ONE: indicating that re-writing the current PAC Cluster and changing its status bits in the TDDS shall not be allowed.

— Control type = **read**

  — If set to ZERO: indicating that reading and transferring the content of the current Cluster outside the drive is allowed.

  — If set to ONE: indicating that the content of the current PAC Cluster, except for the first 384 bytes of the first Data Frame, shall not be transferred outside the drive, to be enforced by setting all bytes not belonging to the PAC Header to 00h before passing the content of the Cluster.

The **Unknown-PAC Entire_Disk_Flags byte** specifies Unknown-PAC Rules that cover the entire disk.

— Bits b_7 to b_1: These bits shall be Reserved.

— Bit b_0: This bit shall be set ONE, indicating Re-initialization is not possible.

The **number of Segments** shall specify the total number N ($0 \le N \le 32$) of Segments specified in the current PAC.

Moreover the total number of Segments defined for all PACs on a disk shall not exceed 32.

$$\left[\sum_{\text{over all PACs}} \text{number of Segments in PAC}_i \le 32 \right]$$

The **Segment_*i*** field shall specify the starting and ending address of a contiguous range of Clusters, called a Segment.

Segments shall be assigned, starting from Segment_0 to Segment_(N–1) ($N \le 32$). Segments specified within one PAC shall not overlap and shall be sorted in ascending order according to their addresses. Segments shall only start and end at Cluster boundaries. All Segment_*i* fields, where $i \ge N$, shall be set to all 00h.

— The first 4 bytes of a Segment_*i* field, if used, shall contain the first PSN of the first Cluster belonging to the Segment.

— The last 4 bytes shall contain the last PSN of the last Cluster belonging to the Segment.

These Segments shall only be applied to the Unknown-PAC Rules. If overlapping Segments in different PAC Clusters are encountered, the drive shall apply the OR-function to the related Unknown-PAC Rules in the overlap areas.

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The **Known-PAC Entire_Disk_Flags byte** specifies rules for the entire disk in case the drive is able to interpret the PAC.

— Bits b_7 to b_1: These bits shall be Reserved.

— Bit b_0: This bit shall be set ONE, indicating Re-initialization is not possible

21.4 IS1 and IS2 PAC Clusters

The IS1 PAC and IS2 PAC may be recorded on an Unrecorded disk. When BCA code is not recorded on an Unrecorded disk, IS1/IS2 PAC structures shall be recorded in INFO 1/PAC 1 and INFO 2/PAC 2 before being shipped. When BCA code is recorded on an Unrecorded disk, IS1/IS2 PAC structures shall not be recorded.

The layout of the IS1 PAC and IS2 PAC Cluster shall be formatted as depicted in Figure 102.

Data Frame	Byte position in Data Frame	Content	Number of bytes
0	0 to 2	PAC_ID	3
0	3	PAC format	1
0	4 to 7	PAC-Update Count	4
0	8 to 11	Unknown-PAC Rules	4
0	12	Unknown-PAC Entire_Disk_Flags	1
0	13 to 14	Reserved	2
0	15	number of Segments	1
0	16 to 23	Segment_0	8
0	24 to 31	Segment_1	8
0	32 to 263	:	29 × 8
0	264 to 271	Segment_31	8
0	272 to 383	Reserved	112
0	384	Known-PAC Entire_Disk_Flags	1
0	385 to 2 047	Reserved	1 663
1	0 to 2 047	Reserved	2 048
:	:	:	:
31	0 to 2 047	Reserved	2 048

Figure 102 — General layout of IS1 and IS2 PAC Clusters

The **PAC_ID** shall be set to 49 53 31h, representing the characters “IS1” for IS1 PAC. The **PAC_ID** shall be set to 49 53 32h, representing the characters “IS2” for IS2 PAC.

The **PAC-format** field shall be set to 00h for both PACs, indicating this is a Version 0.

The **PAC-Update Count** shall be set to 00 00 00 00h for both PACs.

The **Unknown-PAC Rules** shall be set 00 AA 00 00h for IS1 PAC and shall be set 00 AA 00 CBh for IS2 PAC.

The **Unknown-PAC Entire_Disk_Flags byte** shall be set to 01h for both PACs.

The **number of Segments** shall be set to 00h for both PACs.

The **Segment_*i*** fields shall all be set to all 00h for both PACs.

The **Known-PAC Entire_Disk_Flags byte** shall be set to 01h for both PACs.

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22 Disk Management

22.1 General

Disk Management defines and controls method of recording User Data on the disk.

22.2 Recording Management

The BD Recordable system supports a Sequential-Recording Mode (SRM), which is managed by means of a Sequential-Recording Range Information (SRRI) structure.

22.2.1 Sequential-Recording Mode (SRM)

The disk has a continuous area, referred to as the Sequential-Recording Ranges (SRR). Inside the SRR, the User Data shall be recorded sequentially in the direction of increasing addresses.

Information about the location and status of the SRR shall be stored in a Sequential-Recording Range Information (SRRI) structure. The SRRI shall be recorded in Temporary Disk-Management Areas (TDMAs) (see 22.3). On a Recorded disk, the final SRRI is recorded in a Disk-Management Area (DMA).

The SRR shall start at a Cluster boundary and has only one point from where new data can be recorded

22.2.2 Recording User Data in SRR

During continuous sequential recording, User Data, presented by the host in 2KB Logical Sectors, shall be added immediately after the last-written Sector in the SRR. However, when the host computer asks for the next address available for recording in the SRR, the drive shall return the first PSN of the next–available, completely-Unrecorded Cluster in the SRR. This address is called the Next-Writable Address (NWA). During the sequential recording process, the NWA is dynamically incremented in units of Physical Clusters, according to the size of the written User Data.

When sequential recording is terminated and the size of the User Data is not matching with the boundaries of a Physical Cluster, the remaining part of the last Physical Cluster shall be padded with ZERO data, where each individual Data Frame containing Padding data shall be identified by setting its status bits $Sa_{i,1}/Sa_{i,0}$ to 11 (see 13.9.2.5). The NWA shall point to the first Sector of the next Unrecorded Cluster.

The SRR entry (see 22.4.6.4) contains a Last-Recorded User-Data Address (LRA), indicating the last Sector in the SRR filled with User Data (non-Padding data) (see Figure 103).

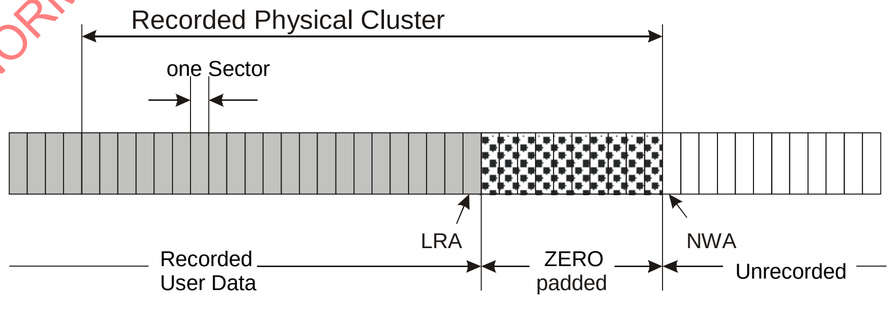

Figure 103 — Example of last RUB with Recorded User Data and padded ZEROs

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22.2.3 SRR status

An SRR can have one of the following states:

— Open: the SRR has a valid NWA and data can be appended;

— Closed: the SRR does not have an NWA and appending data is not allowed.

The number of Open SRR shall be one. During recording in the DMA of the disk the SRR shall have the status Closed

22.2.4 Closing SRR

When an Open SRR was closed, the Open SRR number bytes shall be set to 00h (see 22.4.6.3). Optionally, one or more Clusters can be padded with all bytes set to 00h and the status bits $Sa_{i,1}/Sa_{i,0}$ for all Data Frames set to 11.

It is not necessary to record the remaining Unrecorded Clusters of the SRR on closing. The LRA of the Closed SRR shall be correct.

22.3 Temporary Disk-Management Areas (TDMA)

22.3.1 General

The Recording-Management Information may need to be updated many times during use. For this purpose, a special area is available in the Lead-in/Lead-out Zone called the Temporary Disk-Management Area (TDMA).

For an SL disk, this area is located in the Lead-in Zone and called TDMA 0. For a DL disk, there is the same TDMA 0 in the Lead-in Zone of Layer L0 and a second area, called TDMA 1, in the Lead-out Zone of Layer L1. Both TDMA 0 and TDMA 1 shall have a fixed size of 2 048 Physical Clusters.

In the case of a DL disk, TDMA 0 and TDMA 1 shall be used sequentially in the following order: TDMA 0 → TDMA 1

Each TDMA shall be filled contiguously and in the direction of ascending PSNs. All elements of the actual TDMS (see 22.4.2) shall be located in one TDMA. If insufficient space is left in the actual TDMA, then a new complete TDMS set shall be created in the next available TDMA, and the indicator for this next TDMA (see 22.3.2) shall be recorded.

All remaining unused Clusters in a full TDMA shall be recorded with all 00h data while the status bits $Sa_{i,1}/Sa_{i,0}$ for all Data Frames shall be set to 11.

22.3.2 TDMA Access indicators

To find out quickly which TDMA is currently in use, the first Clusters of TDMA 0 shall be used as indicators. On an SL disk the first 3 Clusters shall be reserved for this purpose and on a DL disk the first 6 Clusters. These TDMA Access indicator Clusters shall be used in the direction of descending addresses as indicated in Figure 104.

If TDMA1 is in use, (TDMA 0 having been completely used) then an indicator for TDMA 1 shall be recorded.

When the disk is closed also the first indicator Cluster of TDMA 0, indicating the DMA, shall be recorded.

Moreover, to find out quickly the location of the TDMA that is currently in use, the TDMA Access indicator Clusters shall contain the TDDS according to the status of the disk at the moment when the TDMA Access indicator Cluster was recorded. For robustness, all 32 Data Frames in the indicator Clusters shall contain a copy of the first TDDS recorded in the TDMA related to the actual indicator Cluster. The first indicator Cluster of TDMA 0, indicating that the DMA has been recorded, shall contain 32 repetitions of the DDS as this is recorded in DMA 1 (see 22.6.3).

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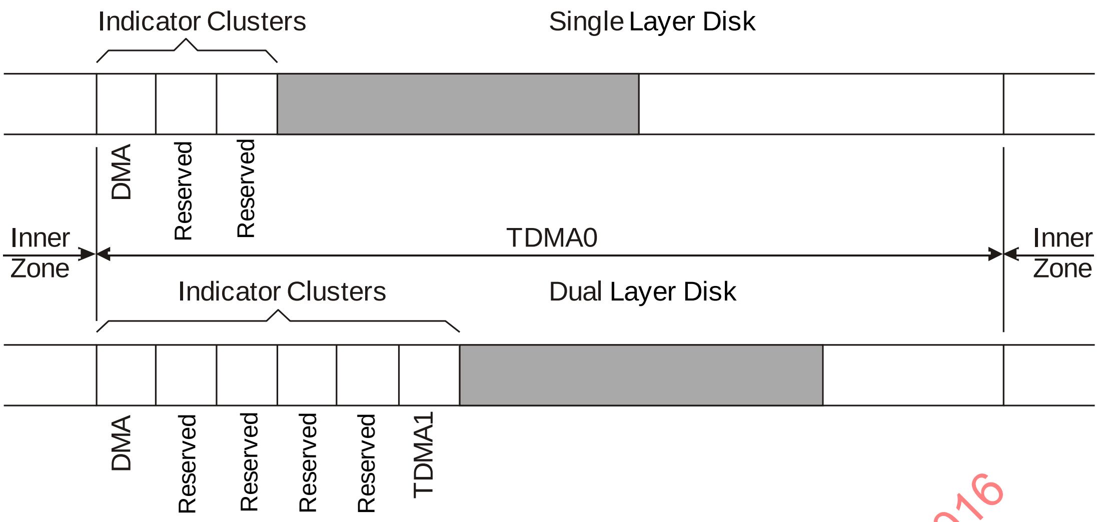

Figure 104 — TDMA indicator Clusters

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22.4 Disk-Management Structure (DMS)

22.4.1 General

The DMS holds structures for Disk-Management and Recording-Mode information. There are two kinds of Disk-Management Structures.

— Disk-Management Structures (DMS; see 22.6.3), recorded in the DMA Zones when a disk is closed (to preserve all Disk Management information contained in the last Temporary Disk-Management Structure).

— Temporary Disk-Management Structures (TDMS), recorded in the TDMA Zones as long as the disk has not been closed.

22.4.2 Temporary Disk-Management Structure (TDMS)

The Temporary Disk-Management Structure consists of the following three elements depending on the recording mode. All of these elements shall be present in the same TDMA *n* that is actually in use.

For Sequential-Recording Mode, the TDMS consists of the following:
— Temporary Disk-Definition Structure (TDDS);
— Temporary Defect List (TDFL);
— Sequential-Recording Range Information (SRRI).

The last Data Frame of the last of the Clusters constituting a TDMS Update Unit shall always contain a TDDS. This TDDS contains pointers to the latest recorded TDFL Clusters and SRRI. After an update of one or more of these elements, the TDDS pointers shall be updated.

The TDMS shall consist of the latest recorded versions of the TDDS, the TDFL and the SRRI.

The TDMS Update Units shall be recorded sequentially in the direction of ascending PSNs in each TDMA (see 22.3). If a Physical Cluster is perceived as defective during recording, this Cluster shall be skipped and the data recording shall continue in the next available Physical Cluster in the TDMA. If defective Clusters are detected immediately after writing of the full TDMS Update Unit (verify-after-write) then it is allowed to only rewrite the defective Clusters and the last Cluster of the TDMS Update Unit (for updating of the TDFL pointers in the TDDS) at the next available locations (as a consequence of this the order of the TDFL Clusters as recorded on the disk need not to be the same as their order in the Defect List. This last one shall be indicated by the pointers in the TDDS).

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22.4.3 TDMS in Sequential-Recording Mode

In the Sequential-Recording Mode, the TDMS Update Units for the SRRI shall always contain a Temporary Disk-Definition Structure (TDDS) in the last Data Sector and a Sequential-Recording Range Information (SRRI) Block in the Sectors immediately preceding the TDDS (see Figure 105). The SRRI Block shall start at a Sector boundary and the length of the SRRI Block is limited to 31 Data Sectors. The SRRI Block is terminated with an SRRI terminator (see Figure 114).

Cluster	Data Frame	Content
One Cluster	0 .. 29	Set to 00h
	30	**SRRI** (one Sector)
	31	**TDDS** (one Sector)

Figure 105 — Example of TDMS Update Unit for SRRI for SRM

The TDFL always starts in the first Data Sector of the first Cluster of a TDMS Update Unit (see Figure 106). The TDFL shall be terminated with a Defect-List Terminator (see Figure 112). The last Data Sector of the Cluster of the TDMS Update Unit for the TDFL shall contain a TDDS. If both the SRRI and TDFL are recorded, the two structures can be combined in one TDMS Update Unit as indicated in Figure 106, where the TDFL is located at the top of the TDMS Update Unit and the SRRI at the bottom, immediately preceding the TDDS.

Cluster	Data Frame	Content
One Cluster	0	**TDFL** (one Sector)
	1 .. 29	Set to 00h
	30	**SRRI** (one Sector)
	31	**TDDS** (one Sector)

Single-Cluster TDMS Update Unit

Figure 106 — Examples of combined TDMS Update Units for SRM

22.4.4 Temporary Disk-Definition Structure (TDDS)

The TDDS contains information about the format and status of the disk. The last recorded TDDS is the anchor to the addresses of the other parts/elements of the TDMS. Pointers in the TDDS shall only point to addresses of previously written structures (no forward pointers), which all shall be in the same TDMA *n* as the TDDS itself. The format of the TDDS is defined in Figure 107.

The **TDDS Identifier** shall be set to 44 53h, representing the characters “DS”.

The **TDDS format** field shall be set to 00h, identifying a TDDS.

The **TDDS-Update Count** shall specify the total number of update operations on TDDS. This field shall be set to 00 00 00 00h during the initialization operation, and shall be incremented by one each time a TDDS is recorded on the disk.

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Data Frame	Byte position in Data Frame	Content	Number of bytes
31	0 to 1	TDDS identifier	2
31	2	TDDS format	1
31	3	Reserved	1
31	4 to 7	TDDS-Update Count	4
31	8 to 15	Reserved	8
31	16 to 19	First PSN of Drive Area (P_DA)	4
31	20 to 23	Reserved	4
31	24 to 27	First PSN of Defect List (P_DFL)	4
31	28 to 31	Reserved	4
31	32 to 35	Location of LSN 0 of User-Data Area	4
31	36 to 39	Last LSN of User-Data Area	4
31	40 to 51	Reserved unless otherwise specified by the Application.	12
31	52	Flag A	1
31	53 to 55	Reserved	3
31	56	Pre-write Area flags	1
31	57 to 63	Reserved	7
31	64 to 71	Status bits of INFO 1/PAC 1 locations on Layer L0	8
31	72 to 79	Status bits of INFO 2/PAC 2 locations on Layer L0	8
31	80 to 87	Status bits of INFO 1/PAC 1 locations on Layer L1	8
31	88 to 95	Status bits of INFO 2/PAC 2 locations on Layer L1	8
31	96 to 1 023	Reserved	928
31	1 024	Recording Mode	1
31	1 025 to 1 027	Reserved unless otherwise specified by the Application.	3
31	1 028 to 1 031	Reserved	4
31	1 032 to 1 035	Last-Recorded Address of User-Data Area	4
31	1 036 to 1 039	Reserved	4
31	1 040 to 1 051	Reserved unless otherwise specified by the Application.	12
31	1 052 to 1 087	Reserved	36
31	1 088 to 1 091	Next available PSN of Test Zone on Layer L0 (P_TZ0)	4
31	1 092 to 1 095	Next available PSN of Test Zone on Layer L1 (P_TZ1)	4
31	1 096 to 1 103	Reserved	8
31	1 104 to 1 107	Next available PSN of Drive-Calibration Zone on Layer L0 (P_CZ0)	4
31	1 108 to 1 111	Next available PSN of Drive-Calibration Zone on Layer L1 (P_CZ1)	4
31	1 112 to 1 119	Reserved	8
31	1 120 to 1 123	First PSN of first Cluster of Defect List (P_first DFL)	4
31	1 124 to 1 151	Reserved unless otherwise specified by the Application.	28
31	1 152 to 1 183	Reserved	32
31	1 184 to 1 187	First PSN of Sequential-Recording Range Information (P_SRRI)	4
31	1 188 to 1 191	Reserved unless otherwise specified by the Application.	4
31	1 192 to 1 215	Reserved	24
31	1 216 to 1 231	Reserved unless otherwise specified by the Application.	16
31	1 232 to 1 915	Reserved	684
31	1 916 to 1 919	Reserved unless otherwise specified by the Application.	4
31	1 920 to 2 047	Drive ID: Manufacturers Name Additional ID Unique Serial Number	48 48 32

Figure 107 — Format of TDDS

The **First PSN of Drive Area** field shall specify the first PSN of the Cluster that contains the latest Drive-specific Information Frames. If the Drive Area is unrecorded, this field shall be set to 00 00 00 00h.

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The **First PSN of Defect-List** field shall be set to 00 00 00 00h in all TDDS Sectors appearing in the TDMAs.

When the disk is being closed and the final DDS is written in the DMA, this field shall specify the first PSN of the first Defect List that can be retrieved error free in the DMA Zone containing the particular DDS. If no Defect List could be stored error free, this field shall be set to FF FF FF FFh.

The **Location of LSN 0 of User-Data Area** field shall specify the PSN of the first User Data Frame in the first Cluster and shall be set to 00 10 00 00h unless otherwise specified by the Application.

The **Last LSN of User-Data Area** field shall specify the Logical-Sector Number (LSN) (see Clause 23) of the last Sector available for the storage of User Data and shall be set to 00 BA 73 FFh for SL disk and 01 74 E7 FFh for a DL disk unless otherwise specified by the Application.

The 8-bit **Flag A** field specifies the status of the SL disk or DL disk. This byte shall be set 03h on SL disks and 0Fh on DL disks unless otherwise specified by the Application.

The 8-bit **Pre-write Area flags** field specifies the status of the INFO 1/Pre-write Areas for each Recording Layer. If the Pre-write Area on Layer *i* is recorded then bit b_i shall set to ONE, else bit b_i shall be set to ZERO.

The **Status bits of INFO 1/PAC 1 locations on Layer L0** field shall specify the recording status of all 32 Clusters in the INFO 1/PAC 1 Zone on Layer L0 (see Figure 108). The bit pairs shall be set as defined in 21.2.

Byte position	Bits	INFO 1/PAC 1 location PAA
64	b_7 b_6	01 FF 80h
64	b_5 b_4	01 FF 84h
64	b_3 b_2	01 FF 88h
64	b_1 b_0	01 FF 8Ch
65	b_7 b_6	01 FF 90h
:	:	:
:	:	:
70	b_1 b_0	01 FF ECh
71	b_7 b_6	01 FF F0h
71	b_5 b_4	01 FF F4h
71	b_3 b_2	01 FF F8h
71	b_1 b_0	01 FF FCh

Figure 108 — Status bits and related INFO 1/PAC 1 address locations on Layer L0

The **Status bits of INFO 2/PAC 2 locations on Layer L0** field shall specify the recording status of all 32 Clusters in the INFO 2/PAC 2 Zone on Layer L0 (see Figure 109). The bit pairs shall be set as defined in 21.2.

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Byte position	Bits	INFO 2/PAC 2 location PAA
72	b_7 b_6	01 BA 00h
72	b_5 b_4	01 BA 04h
72	b_3 b_2	01 BA 08h
72	b_1 b_0	01 BA 0Ch
73	b_7 b_6	01 BA 10h
:	:	:
:	:	:
78	b_1 b_0	01 BA 6Ch
79	b_7 b_6	01 BA 70h
79	b_5 b_4	01 BA 74h
79	b_3 b_2	01 BA 78h
79	b_1 b_0	01 BA 7Ch

Figure 109 — Status bits and related INFO 2/PAC 2 address locations on Layer L0

The **Status bits of INFO 1/PAC 1 locations on Layer L1** field shall specify the recording status of all 32 Clusters in the INFO 1/PAC 1 Zone on Layer L1 (see Figure 110). The bit pairs shall be set as defined in 21.2.

Byte position	Bits	INFO 1/PAC 1 location PAA
80	b_7 b_6	3E 00 00h
80	b_5 b_4	3E 00 04h
80	b_3 b_2	3E 00 08h
80	b_1 b_0	3E 00 0Ch
81	b_7 b_6	3E 00 10h
:	:	:
:	:	:
86	b_1 b_0	3E 00 6Ch
87	b_7 b_6	3E 00 70h
87	b_5 b_4	3E 00 74h
87	b_3 b_2	3E 00 78h
87	b_1 b_0	3E 00 7Ch

Figure 110 — Status bits and related INFO 1/PAC 1 address locations on Layer L1

The **Status bits of INFO 2/PAC 2 locations on Layer L1** field shall specify the recording status of all 32 Clusters in the INFO 2/PAC 2 Zone on Layer L1 (see Figure 111). The bit pairs shall be set as defined in 21.2.

Byte position	Bits	INFO 2/PAC 2 location PAA
88	b_7 b_6	3E 45 80h
88	b_5 b_4	3E 45 84h
88	b_3 b_2	3E 45 88h
88	b_1 b_0	3E 45 8Ch
89	b_7 b_6	3E 45 90h
:	:	:
:	:	:
94	b_1 b_0	3E 45 ECh
95	b_7 b_6	3E 45 F0h
95	b_5 b_4	3E 45 F4h
95	b_3 b_2	3E 45 F8h
95	b_1 b_0	3E 45 FCh

Figure 111 — Status bits and related INFO 2/PAC 2 address locations on Layer L1

The **Recording-Mode field** specifies the mode in which User Data is going to be recorded in the User-Data Area. This field shall be set to 00h to indicate Sequential-Recording Mode unless otherwise specified by the Application.

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The **Last-Recorded Address of User-Data Area** field shall specify the PSN of the highest numbered Physical Sector in the User-Data Area recorded with data supplied by the host. This address shall be equal to the LRA of the highest numbered SRR containing User Data (see 22.4.6.4). If no User Data is recorded in User-Data Area, the value of this field shall be set to 00 00 00 00h.

The **Next available PSN of Test Zone on Layer L0** field shall specify the first PSN of the next usable Cluster available for testing and OPC procedures in the Test Zone on Layer L0. The initial value for this field in case of an unused Test Zone is 00 0E DF 60h (the highest addressed 4 Clusters of the Test Zone on Layer L0 shall be reserved as a Buffer Zone). If the Test Zone on Layer L0 has no free Cluster, this field shall be set to FF FF FF FFh.

NOTE If an OPC procedure fails, the drive might not be able to correctly update the TDMS.

The **Next available PSN of Test Zone on Layer L1** field shall specify the first PSN of the next usable Cluster available for testing and OPC procedures in the Test Zone on Layer L1. In case of an SL disk, this field shall be set to 00 00 00 00h. The initial value for this field in case of an unused Test Zone is 01 F3 EF E0h. If the Test Zone on Layer L1 has no free Cluster, this field shall be set to FF FF FF FFh.

NOTE If an OPC procedure fails, the drive might not be able to correctly update the TDMS.

The **Next available PSN of Drive-Calibration Zone on Layer L0** field shall specify the first PSN of the next usable Cluster available for drive calibration procedures in the Drive-Calibration Zone on Layer L0. The initial value for this field in case of an unused Drive-Calibration Zone is 8 × (LAA + C 2Eh). If the Drive-Calibration Zone on Layer L0 has no free Cluster, this field shall be set to FF FF FF FFh.

NOTE If an OPC procedure fails, the drive might not be able to correctly update the DCZ.

The **Next available PSN of Drive-Calibration Zone on Layer L1** field shall specify the first PSN of the next usable Cluster available for drive calibration procedures in the Drive-Calibration Zone on Layer L1. In case of an SL disk, this field shall be set to 00 00 00 00h. The initial value for this field in case of an unused Drive-Calibration Zone is 8 × (FAA – 4 34h). If the Drive-Calibration Zone on Layer L1 has no free Cluster, this field shall be set to FF FF FF FFh.

NOTE If an OPC procedure fails, the drive might not be able to correctly update the DCZ.

The **First PSN of first Cluster of Defect-List** field shall specify the first PSN of the first Cluster of the latest Temporary Defect List in the TDMA Zone.

The **First PSN of Sequential-Recording Range Information** field shall indicate the PSN of the first Sector of the latest Sequential-Recording Range Information in the TDMA Zone.

The **Drive ID: Manufacturers Name/Additional ID/Unique Serial Number** fields shall uniquely identify the drive that has recorded this TDDS. These 128 bytes shall contain a drive signature according to the following format (see 18.3.15: Drive Area):

— 48 bytes Manufacturers Name, represented by characters from the ISO 646 character set;
— 48 bytes Additional Identification, represented by characters from the ISO 646 character set;
— 32 bytes Unique Serial Number of the drive.

22.4.5 Temporary Defect List (TDFL)

22.4.5.1 General

The first Data Frame of the TDFL contains the Defect-List Header followed by a List of Defects. The List of Defects shall be terminated by a Defect-List Terminator.

The List of Defects is Reserved unless otherwise specified by the Application.

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22.4.5.2 TDFL data structure

The TDFL Data Frame shall be composed as shown in Figure 112.

Data Frame	Byte position in Data Frame	Content	Number of bytes
0	0 to 63	Defect-List Header	64
	64 to 71	Defect-List Terminator	8
	72 to 2 047	set 00h	1 976

Figure 112 — Format of Temporary Defect List

The **Defect-List Header** (DLH) identifies the Defect List and contains information about the composition of the List of Defects (see 22.4.5.3).

The **Defect-List Terminator** closes the List of Defects and shall be written immediately following the actual last entry in the List of Defects. The Defect-List Terminator shall be located in the last Data Frame of the TDFL (see 22.4.5.4).

All remaining bytes following the Defect-List Terminator in the last Data Frame shall be set to 00h.

22.4.5.3 Defect-List Header

Figure 113 shows the format of the Defect-List Header.

Data Frame	Byte position in Data Frame	Content	Number of bytes
0	0 to 1	DFL identifier	2
0	2	DFL format	1
0	3	Reserved	1
0	4 to 7	DFL-Update Count	4
0	8 to 11	Reserved	4
0	12 to 23	Reserved unless otherwise specified by the Application	12
0	24 to 63	Reserved	40

Figure 113 — Format of Defect-List Header

The **DFL Identifier** shall be set to 44 4Ch, representing the characters “DL”.

The **DFL format** field shall be set to 00h, identifying a DFL.

The **DFL-Update Count** shall specify the total number of update operations of the Defect List. This field shall be set to 00 00 00 00h during the Initialization operation, and shall be incremented by one each time the DFL is recorded on the disk.

22.4.5.4 Defect-List Terminator

The **Defect-List Terminator** shall be composed of two 4-byte parts:

— the first 4 bytes shall be set FF FF FF FFh;

— the second 4 bytes shall be equal to the TDFL-Update Count in the header of the TDFL (can be used to check the validity of the Defect List).

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22.4.6 Sequential-Recording Range Information (SRRI)

22.4.6.1 General

The SRRI Structure specifies the recording status for Sequential-Recording Mode (SRM). One structure covers both SL and DL disks. The data structure of the SRRI is described in 22.4.6.2.

22.4.6.2 SRRI data Structure

The SRRI structure, consisting of one Sector, contains an SRRI Header followed by a list of SRR entries. An SRRI terminator shall terminate the List of SRR entries.

Relative Data Frame	Byte position in Data Frame	Content	Number of bytes
30	0 to 63	SRRI Header	64
	64 to 71	SRR entry	8
	72 to 79	SRRI Terminator	8
	80 to 2 047	set 00h	1 968
31		(TDDS)	

Figure 114 — Format of SRRI table

The **SRRI Header** identifies the SRRI and contains information about the composition of the List of SRR entries (see 22.4.6.3).

The **SRR entry** contains a list of SRRs and their related information (see 22.4.6.4). The number of SRRs is one unless otherwise specified by the Application.

The **SRRI Terminator** closes the List of SRR entries and shall be written immediately following the actual last entry in the List of SRR entries (see 22.4.6.5).

All remaining bytes following the SRRI Terminator until the Data Frame boundary shall be set to 00h.

22.4.6.3 SRRI Header

The SRRI Header shall be composed as shown in Figure 115.

Relative Data Frame	Byte position in Data Frame	Content	Number of bytes
30	0 to 1	SRRI identifier	2
	2	SRRI format	1
	3	Reserved	1
	4 to 7	SRRI-Update Count	4
	8 to 11	Reserved	4
	12 to 15	number of SRR entries	4
	16	number of Open SRRs	1
	17 to 19	Reserved	3
	20 to 21	Open SRR number	2
	22 to 51	Reserved unless otherwise specified by the Application	30
	52 to 63	Reserved	12

Figure 115 — SRRI Header

The **SRRI Identifier** field shall be set to 53 52h, representing the characters “SR”.

The **SRRI format** field shall be set to 00h, identifying an SRRI.

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The **SRRI-Update Count** shall specify the total number of update operations of the SRRI structure. This field shall be set to 00 00 00 00h during the Initialization operation, and shall be incremented by one each time the SRRI structure is updated.

The **number of SRR entries** shall indicate the total number of SRR entries in the SRRI. The number of SRRs is one unless otherwise specified by the Application.

The **number of Open SRRs** field shall indicate the number of SRRs with status Open. The maximum value of this field is one unless otherwise specified by the Application. The value of this field shall be set to 00h after the disk is recorded.

The **Open SRR number** shall indicate all SRR numbers with status Open.

22.4.6.4 SRR entry

The **SRR entry** shall be formatted as shown in Figure 116.

SRR entry consists of 8 bytes and is recorded contiguously.

The bytes of the SRR entry are converted into a 64-bit sequence with the msb first. The List of SRR entries shall be sorted in ascending order as if each entry were a single 64-bit unsigned integer. SRR numbers shall be assigned as one unless otherwise specified by the Application.

byte 0/bit 7..4 of SRR entry	byte 0/bit 3..0 & byte 1 to 3 of SRR entry	byte 4/bit 7 of SRR entry	byte 4/bit 6..4 of SRR entry	byte 4/bit 3..0 & byte 5 to 7 of SRR entry
b_{63} .. b_{60}	b_{59} .. b_{32}	b_{31}	b_{30} .. b_{28}	b_{27} .. b_{0}
Reserved	Starting PSN of the SRR	Session start	Reserved	LRA in the SRR

Figure 116 — SRR entry

The **Starting PSN of the SRR** shall specify the first PSN of the first Cluster of the SRR and shall be set to 00 10 00 00h unless otherwise specified by the Application.

The **Session start** bit shall indicate if this SRR is the first SRR in a Session and shall be set to ONE unless otherwise specified by the Application.

The **LRA in the SRR** shall specify the PSN of the last Sector in the SRR recorded with data supplied by the host For an empty SRR, the value of this field shall be set to 0 00 00 00h. For an Open SRR, the relation between *NWA* and *LRA* shall be given by the following fomula:

$NWA = 32 \times [\text{floor}(LRA/32) + 1]$ if the $LRA \neq 0\ 00\ 00\ 00\text{h}$;
NWA = Start PSN of the SRR if the $LRA = 0\ 00\ 00\ 00\text{h}$.

22.4.6.5 SRRI Terminator

The SRRI Terminator shall be composed of the following two 4-byte parts:

— the first 4 bytes shall be set FF FF FF FFh;

— the second 4 bytes shall be equal to the SRRI-Update Count in the header of the SRRI structure.

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22.5 Unrecorded (blank) disk structure

22.5.1 General

Some Zones of a Unrecorded disk may be pre-recorded before shipment of the disk. The status of Zones on an Unrecorded (blank) disk is summarized in 22.5.

22.5.2 Pre-recorded Areas on Unrecorded disk

The Areas on the Unrecorded (blank) disk that are specified in Figure 117 and Figure 118 may be pre-recorded.

Zone name	Description	First PAA of Zone	Number of Phys.Clusters	Pre-recorded condition	Reference
BCA	BCA			either[a]	See Clause 35
PIC	PIC	---	---	recorded	---
INFO 2	Reserved 8	01 B8 00h	32	either[a]	See 18.3.2
	Reserved 7	01 B8 80h	32	unrecorded	---
	Reserved 6	01 B9 00h	32	unrecorded	---
	Reserved 5	01 B9 80h	32	either[a]	See 18.3.5
	PAC 2	01 BA 00h	32	either[a]	See 18.3.6
	DMA 2	01 BA 80h	32	unrecorded	---
	Control Data 2	01 BB 00h	32	unrecorded	---
	Buffer 2	01 BB 80h	32	unrecorded	---
OPC 0	Test Zone	01 BC 00h	2 044	either[a]	See 18.3.10
	OPC 0 Buffer	01 DB F0h	4	unrecorded	---
TDMA 0	---	01 DC 00h	2 048	either[a]	See 18.3.13
INFO 1	Pre-write Area	01 FC 00h	32	either[a]	See 18.3.14
	Drive Area	01 FC 80h	32	unrecorded	---
	Drive Area	01 FD 00h	32	unrecorded	---
	Drive Area	01 FD 80h	32	unrecorded	---
	Drive Area	01 FE 00h	32	unrecorded	---
	DMA 1	01 FE 80h	32	unrecorded	---
	Control Data 1	01 FF 00h	32	unrecorded	---
	PAC 1	01 FF 80h	32	either[a]	See 18.3.18
	(Data Zone 0)	02 00 00h		unrecorded	---

[a] means that the Zone may or may not be pre-recorded according to its description.

Figure 117 — Pre-recorded Areas of Inner Zone 0 (Lead-in Zone)

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	Description	First PAA of Zone	Number of Phys.Clusters	Pre-recorded condition	Reference
	(Data Zone 1)			unrecorded	---
INFO 1	PAC 1	3E 00 00h	32	either [a]	See 18.4.18
	Control Data 1	3E 00 80h	32	unrecorded	---
	DMA 1	3E 01 00h	32	unrecorded	---
	Drive Area	3E 01 80h	32	unrecorded	---
	Drive Area	3E 02 00h	32	unrecorded	---
	Drive Area	3E 02 80h	32	unrecorded	---
	Drive Area	3E 03 00h	32	unrecorded	---
	Pre-write Area	3E 03 80h	32	either [a]	See 18.4.14
Reserved	---	3E 04 00h	2 048	unrecorded	---
TDMA 1	---	3E 24 00h	2 048	unrecorded	See 18.4.12
INFO 2	Buffer 2	3E 44 00h	32	unrecorded	---
	Control Data 2	3E 44 80h	32	unrecorded	---
	DMA 2	3E 45 00h	32	unrecorded	---
	PAC 2	3E 45 80h	32	either [a]	See 18.4.8
	Reserved 5	3E 46 00h	32	either [a]	See 18.4.7
	Reserved 6	3E 46 80h	32	unrecorded	---
	Reserved 7	3E 47 00h	32	unrecorded	---
	Reserved 8	3E 47 80h	32	either [a]	See 18.4.4
Buffer	---	3E 48 00h	1 408	unrecorded	---
OPC 1	Test Zone	3E 5E 00h	2 048	either [a]	See 18.4.2
Buffer	---	3E 7E 00h	1 408	unrecorded	---
	Protection Zone 1	---	---	---	---

[a] means that the Zone may or may not be pre-recorded according to its description.

Figure 118 — Pre-recorded Areas of the Inner Zone 1 (Lead-out Zone)

22.5.3 Pre-recorded BCA

BCA code may or may not be recorded. The BCA code is not recorded unless otherwise specified by the Application. The modulation and format of the BCA code are not specified in this International Standard (see Clause 35).

22.5.4 Pre-recorded INFO 2/Reserved 5, Reserved 8 and Pre-recorded INFO 1/Pre-write Area

When BCA code is not recorded on an Unrecorded disk, INFO 2/Reserved 5, Reserved 8 and INFO 1/Pre-write Area in both Inner Zone 0 and Inner Zone 1 are recorded with all 00h. When BCA code is recorded on an Unrecorded disk, these Zones are unrecorded (see 18.3.5, 18.4.7, 18.3.2, 18.4.4, 18.3.14 and 18.4.14).

22.5.5 Pre-recorded INFO 1/PAC 1 and Pre-recorded INFO 2/PAC 2

When BCA code is not recorded on an Unrecorded disk, IS1/IS2 PAC structures are recorded in INFO 1/PAC 1 and INFO 2/PAC 2. When BCA code is recorded on an Unrecorded disk, these Zones are unrecorded and IS1/IS2 PAC structures are not recorded (see 21.4).

22.5.6 OPC 0/Test Zone and OPC 1/Test Zone

When BCA code is not recorded on an Unrecorded disk, some Clusters in OPC 0 Test Zone and OPC 1 Test Zone may be used to perform OPC to record the Pre-recorded Zones (see 18.3.10 and 18.4.2).

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22.5.7 TDMA 0

When BCA code is not recorded on an Unrecorded disk, Zones that specified in Figure 117 and 118 may be recorded. When some Zones are recorded on the Unrecorded disk, TDMS in the TDMA 0 is recorded to specify the following:

— zones are recorded;

— an empty SRR is created from LSN 0;

— some OPC Clusters are used.

22.5.8 Initialization of disk

BD Recordable disks are initialized before use. When a Temporary Disk-Management Structure and Pre-write Area(s) (see 18.3.14 and 18.4.14) are not recorded on an Unrecorded disk, these areas shall be recorded before recording in the User-Data Area.

A newly created TDMS shall have all Update-Count fields set to ZERO. The TDMS shall be recorded starting from the first Cluster following the TDMA Access Indicators of TDMA 0.

BD Recordable disks may be formatted for the Sequential-Recording Mode unless otherwise specified by the Application. A newly created a single-Cluster TDMS contains the following elements (see 22.4.3 and Figure 106):

— an empty TDFL, containing only a header, no DFL entries and a Terminator;

— an SRRI with at least one Open SRR (the first SRRI entry shall have the Session start bit set to ONE);

— a TDDS with all relevant information like (see Figure 107).

22.6 Recorded (Closed) disk structure

22.6.1 General

The Recorded disk structure is summarised in 22.6. When data recording on an Unrecorded disk is finished, the areas of the disk shall be recorded as specified. If all Clusters in all TDMAs have been used, the disk shall be considered a Recorded disk.

The 4 DMA Zones of a Recorded disk and the DMA Access Indicator (see 22.3.2) shall be recorded (closed).

22.6.2 DMA Zones

The structures in the DMA Zone describes the exact status of the disk at the moment when data recording was finished. The SRR status shall be set to Closed, the TDMS structures shall be updated and written to the TDMA on the Recorded disk. Optionally, all remaining Clusters in the TDMAs can be recorded with all 00h data (see Figure 119).

Other unwritten areas on the disk need not to be recorded.

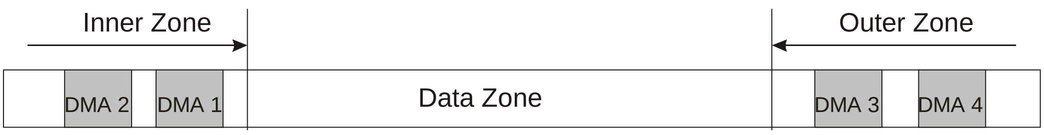

Figure 119 — Disk-Management Areas

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The DMAs 1, 2, 3 and 4 shall be recorded with copies of the information contained in the latest TDMS.

The DDS in the DMA Zones preserves the references to these TDMS.

22.6.3 Disk-Management Structures (DMS)

22.6.3.1 General

A Disk-Management Structure (DMS) is made up of a Disk-Definition Structure (DDS) and a Defect List (DFL). The DDS is combined in one Cluster with an SRRI and shall be repeated for robustness reasons. The DFL consists of 4 consecutive Clusters on an SL disk and 8 consecutive Clusters on a DL disk and can be repeated seven times.

All four occurrences of the DMS, recorded in the DMA Zones in the Inner and Outer Zone(s), shall contain the same information, except for the First PSN of Defect List (see 22.4.4, byte 24 of Data Frame 0 of the DDS).

The DMA Zones shall be updated in the order DMA 1, DMA 2, DMA 3 and DMA 4 for ease of handling possible power-down failures.

22.6.3.2 Disk-Management Structure (DMS) on SL disk

On an SL disk the DMAs consist of 32 consecutive Clusters as indicated in Figure 120.

Tracking direction →

Layer L0	Cluster 1	Cluster 2	Cluster 3	...	Cluster 31	Cluster 32

Figure 120 — Clusters of DMAs on SL disk

The DDS + SRRI shall be repeatedly recorded in the first 4 Clusters of each DMA. The DFL is recorded in Clusters 5 to 8 of each DMA and may be optionally repeated in the Clusters 9 to 32 (if no repetition is applied, Clusters 9 to 32 shall contain all 00h) (see Figure 121).

Cluster 1 to 4	DDS + SRRI	four repetitions
Cluster 5 to 8	1st position of DFL	DFL
Cluster 9 to 12	2nd position of DFL	optional copy of DFL or 00h
Cluster 13 to 16	3rd position of DFL	optional copy of DFL or 00h
:	:	:
Cluster 29 to 32	7th position of DFL	optional copy of DFL or 00h

Figure 121 — Example of DMA Zone on SL disk

The first Data Frame 0 of each of the Clusters 1 to 4 is designated as the DDS and shall contain a copy of the latest TDDS, except for the First PSN of Defect List, which address shall be set to the first PSN of Cluster 5, 9 .. or 29 of the DMA Zone containing this DDS. The indicated address shall identify the occurrence of the first full DFL that can be retrieved error free.

Data Frames 1 (see 22.4.3) of each of the Clusters 1 to 4 are designated as the SRRI and shall contain a copy of the latest SRRI from the TDMS. All remaining Data Frames 2 to 31 shall contain all 00h.

The DFL, recorded in Clusters 5 to 8, shall contain a copy of the latest TDFL, which TDFL shall be padded with ZERO data up to a length of 4 Clusters. The DFL may be repeated for robustness reasons in each following group of 4 Clusters in each DMA.

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22.6.3.3 Disk-Management Structure (DMS) on DL disk

On a DL disk, the DMAs consist of 64 Clusters divided over the two Recording Layers as indicated in Figure 122.

Tracking direction →

Layer L0	Cluster 1	Cluster 2	Cluster 3	...	Cluster 31	Cluster 32
Layer L1	Cluster 64	Cluster 63	...	Cluster 35	Cluster 34	Cluster 33

← Tracking direction

Figure 122 — Clusters of DMAs on DL disk

The DDS + SRRI shall be repeatedly recorded (see Figure 123) in the first 4 Clusters of each DMA. The DFL is recorded in Clusters 9 to 16 of each DMA and may be optionally repeated in the Clusters 17 to 64 (if no repetition is applied, Clusters 17 to 64 shall contain all 00h).

Cluster 1 to 4	DDS + SRRI	four repetition
Cluster 5 to 8	Reserved	
Cluster 9 to 16	1st position of DFL	DFL
Cluster 17 to 24	2nd position of DFL	optional copy of DFL or 00h
Cluster 25 to 32	3rd position of DFL	optional copy of DFL or 00h
:	:	:
Cluster 57 to 64	7th position of DFL	optional copy of DFL or 00h

Figure 123 — Example of DMA Zone on DL disk

The first Data Frame 0 of each of the Clusters 1 to 4 is designated as the DDS and shall contain a copy of the latest TDDS, except for the First PSN of Defect List, which address shall be set to the first PSN of Cluster 9, 17 .. or 57 of the DMA Zone containing this DDS. The indicated address shall identify the occurrence of the first full DFL that can be retrieved error free.

Data Frames 1 (see 22.4.3) of each of the Clusters 1 to 4 is designated as the SRRI and shall contain a copy of the latest SRRI from the TDMS. All remaining Data Frames 2 to 31 shall contain all 00h.

The DFL, recorded in Clusters 9 to 16, shall contain a copy of the latest TDFL, which TDFL shall be padded with ZERO data up to a length of 8 Clusters. The DFL may be repeated for robustness reasons in each following group of 8 Clusters in each DMA Zone.

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23 Assignment of Logical-Sector Numbers (LSNs)

Logical-Sector Numbers shall be assigned contiguously over all Clusters available for storage of User Data, starting from LSN 0 and increasing by one for each successive User Data Frame (see Figure 124).

LSN 0 is assigned to the first User Data Frame in the first Cluster after the Lead-in Zone,
(at PSN = 1 048 576).

The last LSN on Layer L0 is equal to 8 × LAA + 15 – 1 048 576 and is assigned to the last User Data Frame in the last Cluster before the Outer Zone 0
(at PSN = 8 × LAA + 15 = *X*).

The first LSN on Layer L1 shall be one higher than the last LSN on Layer L0 and is assigned to the first User Data Frame in the first Cluster after the Outer Zone 1
(at PSN = 8 × FAA = $\overline{X}$ + FE 00 00 00h).

The last LSN on Layer L1 is equal to 16 × LAA + 31 – 2 097 152 and is assigned to the last User Data Frame in the last Cluster before the Lead-in Zone
(at PSN = 01 EF FF FFh).

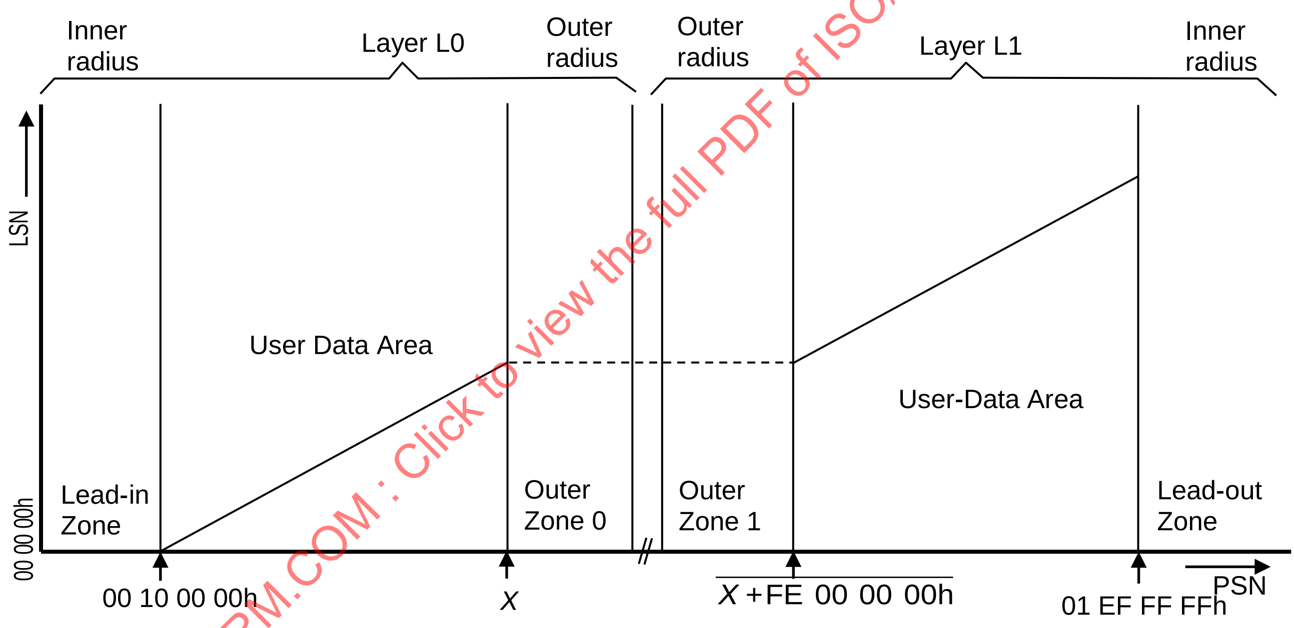

Figure 124 — Assignment of Logical-Sector Numbers

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24 Characteristics of Grooved Areas

The signal values specified in Clauses 24 to 27 are valid for all disk capacities, unless specified otherwise.

In this International Standard, the following two types of signals are distinguished:

— signals generated by the Groove structures on the disk;

— signals generated by User-written Marks.

In Clauses 25 to 27, the signals generated by the Groove structures are defined and specified (the format of the Grooves has been defined in Clause 15).

All requirements in Clauses 25 to 27 shall be fulfilled in all layers independent of the recording status of other Recording Layer (whether unrecorded, recorded or partially recorded) from the inner radius of the Embossed HFM Area(s) (start/end of the PIC Zone) at nominal radius 22,4 mm up to the inner radius of the Outer Zone(s) + 20 µm (d_{DZO}/2 + 20 µm). It is recommended that the requirements are also fulfilled in the remainder of the Outer Zone(s).

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25 Method of testing for Grooved Area

25.1 General

The tests shall be performed in the Recordable Areas. The write and read operations necessary for the tests shall be made on the same Reference drive.

When measuring the signals, the influence of local defects, such as dust and scratches, are excluded. Local defects might cause tracking errors, or uncorrectable Data (see Clause 34).

25.2 Environment

All signals shall be within their specified ranges if the disk is in its range of allowed environmental conditions as defined in 8.1.1.

25.3 Reference drive

25.3.1 General

All signals shall be measured in the appropriate channels of a Reference drive as specified in Clause 9 and in Annex H.

25.3.2 Read power

The read power is the optical power, incident on the Entrance surface of the disk and only used for reading the information. The read power shall be (0,35 ± 0,1) mW for an SL disk and (0,70 ± 0,1) mW for a DL disk.

25.3.3 Read channels

The drive shall have two read channels as defined in 9.5 and 9.6. The HF signal from the HF read channel shall not be equalized, except when measuring jitter (see Annex H).

For measurement of the Push-Pull signals, the radial PP read channels shall be filtered by a first order LPF with f_{-3dB} = 30 kHz.

For measurement of the wobble signals, the radial PP read channels shall be filtered by a first order LPF with f_{-3dB} = 8 MHz.

25.3.4 Tracking requirements

During the writing and reading of the signals, the axial tracking error between the focus of the optical beam and the Recording Layer shall be: $e_{max.}$(axial) = 80 nm, and the radial tracking error between the focus of the optical beam and the centre of the Track shall be $e_{max.}$(radial) = 20 nm.

For 4x and 6x disks, local defects that cause large axial tracking errors shall be taken into account as described in Annex I.

25.3.5 Scanning velocities

The actual rotation speed of the disk shall be such that it results in an average Channel-bit rate of 66,000 Mbit/s or an average wobble frequency of 956,522 kHz.

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25.4 Definition of signals

The amplitudes of all signals are linearly related to currents through a photodetector and, therefore, linearly related to the optical power falling on the detector.

Some signals are normalized relative to the total detector current in an Unrecorded, Grooved Area.

This total detector current is referred to as

$$I_G = (I_1 + I_2)_{groove}$$

Push-Pull signal:

The Push-Pull signal is the Low-Pass Filtered sinusoidal difference signal ($I_1 - I_2$) in the radial PP read channel (see Figure 7), when the focus of the optical beam crosses the Tracks. The Push-Pull signal can be used by the drive for radial tracking (see Figure 125).

In general, the difference signal ($I_1 - I_2$) is normalized relative to the Low-Pass Filtered total detector current ($I_1 + I_2$). The peak-to-peak value of this real-time normalized Push-Pull signal is defined as

$$PP_{norm} = \left[\frac{I_1(t) - I_2(t)}{I_1(t) + I_2(t)}\right]_{peak\text{-}peak} \equiv \frac{(I_1 - I_2)_{at\ t_2}}{(I_1 + I_2)_{at\ t_2}} - \frac{(I_1 - I_2)_{at\ t_1}}{(I_1 + I_2)_{at\ t_1}}$$

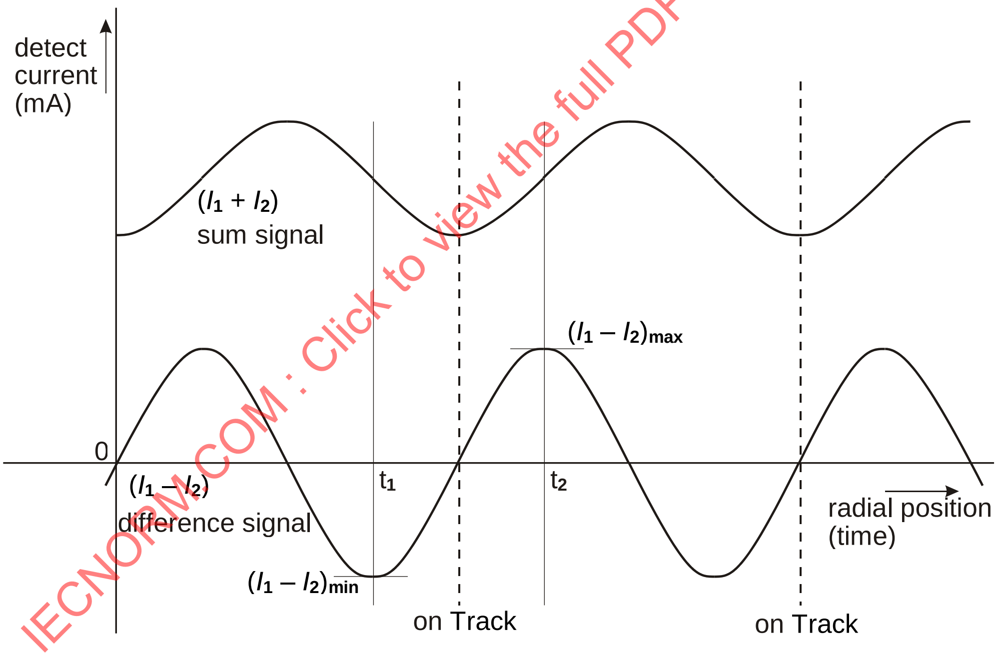

Figure 125 — Definition of Push-Pull signals

Wobble signal

The wobble signal I_{Wpp} is the peak-to-peak value of the sinusoidal difference signal ($I_1 - I_2$) in the radial PP read channel (see Figure 7), when the focus of the optical beam follows the Tracks according to 25.3.4. See also Annex M and Annex E for a measurement method.

The signal shall be normalized by the peak-to-peak value of the Push-Pull signal $(I_1 - I_2)_{pp}$:

$$NWS = \frac{I_{Wpp}}{(I_1 - I_2)_{pp}}$$

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Ratio between normalized Push-Pull of the HFM Groove Area and the Wobbled Groove Area

The ratio between normalized Push-Pull signals of the HFM Groove Area and the Unrecorded Wobbled Groove Area is defined as

$$RHWG = \frac{PP_{\mathrm{norm,HFM}}}{PP_{\mathrm{norm,WG,Unrec}}}$$

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26 Signals from HFM Groove

26.1 Push-Pull polarity

The polarity of the Push-Pull signal is said to be positive if the signal has the same polarity as the Push-Pull signal detected from the following Pit/Groove geometry:

— “On-Groove recording” (see 15.2);

— the single pass phase depth of the Grooves is less than 90°.

If the polarity is opposite to the polarity of the specified case, it is said to be negative.

The polarity of the Push-Pull signal on each Recording Layer of the disk shall be indicated in the Disk Information (see 15.8.3).

26.2 Push-Pull signal

The peak-to-peak value of the real-time normalized Push-Pull signal ($PP_{\mathrm{norm,HFM}}$) shall meet the following requirements:

— in the Embossed HFM Areas $0{,}26 \le PP_{\mathrm{norm,HFM}} \le 0{,}52$.

26.3 Wobble signal

The Normalized HFM-Wobble Signal is a measure of the deviation of the Groove Track from its average centreline. Due to interference with the wobbles of adjacent Tracks, the amplitude of the HFM wobble signal shows a variation (called “wobble beat”).

At locations where the HFM wobble signal shows minimum amplitudes due to the wobble beat, the Normalized HFM-Wobble Signal (*NHWS*) shall be $0{,}30 \le NHWS_{\mathrm{min}} \le 0{,}60$.

At locations where the HFM wobble signal shows maximum amplitudes due to the wobble beat, the Normalized HFM-Wobble Signal shall be $NHWS_{\mathrm{max}} \le 3 \times NHWS_{\mathrm{min}}$.

NOTE Because the shape of the HFM wobble signal detected in the Embossed HFM Areas differs significantly from the wobble signal in the Recordable Areas, the measurement procedure as described in Annex E is not suitable for measuring these HFM wobble signals.

26.4 Jitter of HFM signal

The binarized wobble signal from the HFM Groove represents the embossed HFM information in the PIC Zone. The jitter of the leading edges and the jitter of the trailing edges of this binarized signal shall be measured separately relative to a PLL clock.

Both the leading-edge jitter and the trailing-edge jitter shall be ≤4,5 %.

The jitter shall be measured under the following conditions:

— ac coupling (High-Pass Filter): first order, $f_{-3\mathrm{dB}} = 10$ kHz;

— no equalization;

— normalized by 18T clock period (see 15.5.4.2).

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27 Signals from Wobbled Groove(s)

27.1 Phase depth

The single-pass phase depth of the Groove shall not exceed 90°.

27.2 Push-Pull signal

The peak-to-peak value of the real-time normalized Push-Pull signal ($PP_{\mathbf{norm}}$) shall meet the following requirements in each layer:

— in Unrecorded Areas (all neighboring Tracks unrecorded):

— for HTL disks: $0{,}21 \leq PP_{\mathbf{norm,unrec}}. \leq 0{,}45$;

— for LTH disks: $0{,}21 \leq PP_{\mathbf{norm,unrec}}. \leq 0{,}60$;

— maximum variation of Push-Pull signal within 150 Tracks in Unrecorded Areas:

— for SL disks: $$\frac{(PP_{\text{norm,unrec}})_{\max} - (PP_{\text{norm,unrec}})_{\min}}{(PP_{\text{norm,unrec}})_{\max} + (PP_{\text{norm,unrec}})_{\min}} \leq 0{,}15\ ;$$

— for DL disks: $$\frac{(PP_{\text{norm,unrec}})_{\max} - (PP_{\text{norm,unrec}})_{\min}}{(PP_{\text{norm,unrec}})_{\max} + (PP_{\text{norm,unrec}})_{\min}} \leq 0{,}18\ ;$$

— maximum variation of Push-Pull signal within one layer in Unrecorded Areas:

$$\frac{(PP_{\text{norm,unrec}})_{\max} - (PP_{\text{norm,unrec}})_{\min}}{(PP_{\text{norm,unrec}})_{\max} + (PP_{\text{norm,unrec}})_{\min}} \leq 0{,}25\ ;$$

— in Recorded Areas (all neighboring Tracks recorded):

— for HTL disks: $0{,}21 \leq PP_{\mathbf{norm,rec}}. \leq 0{,}45$;

— for LTH disks: $0{,}21 \leq PP_{\mathbf{norm,rec.}} \leq 0{,}60$;

— ratio of average Push-Pull signals in Recorded and Unrecorded Areas within one layer:

— for HTL disks: $$0{,}75 \leq \frac{PP_{\text{norm,rec}}}{PP_{\text{norm,unrec}}} \leq 1{,}25\ ;$$

— for LTH disks: $$0{,}50 \leq \frac{PP_{\text{norm,rec}}}{PP_{\text{norm,unrec}}} \leq 1{,}0\ .$$

27.3 Wobble signal

27.3.1 General

The normalized wobble signal is a measure of the deviation of the Groove Track from its average centreline. The distance that the actual centre of the Wobbled Groove Track deviates from the average Track centre line can be calculated according to Annex M.

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27.3.2 Measurement of NWS

Due to interference with the wobbles of adjacent Tracks, the amplitude of the wobble signal shows a variation (called "wobble beat"). The wobble signals shall be measured in an Unrecorded Area while continuously tracking the Spiral Groove. A measurement procedure is described in Annex E.

At locations where the wobble signal shows minimum amplitudes (excluding the effects of MSK Marks), the Normalized Wobble Signal shall be $0{,}20 \leq NWS_{min} \leq 0{,}55$.

At locations where the wobble signal shows maximum amplitudes due to the wobble beat, the Normalized Wobble Signal shall be $NWS_{max} \leq 3 \times NWS_{min}$.

27.3.3 Measurement of wobble CNR

The narrow band SNR (or CNR) of the wobble signal after recording, at minimum and the maximum velocities of the disk as defined in 15.8.3, shall be greater than 26 dB at the locations where the wobble signal shows minimum amplitudes.

The carrier shall be measured at 956,5 kHz, and the noise level shall be measured at 500 kHz (see Annex E).

27.3.4 Measurement of harmonic distortion of wobble

To guarantee a minimum quality of the HMW modulation, the Second-Harmonic Distortion of the wobble signal shall be sufficiently low compared to the Second-Harmonic Level originating from the HMW modulation.

The Second-Harmonic Level (*SHL*) and the Second-Harmonic Distortion (*SHD*) shall be determined by measuring the fundamental wobble frequency level and the second harmonic frequency level at two locations of the disk. Both levels shall be measured in the Data Zone and in Protection-Zone 3.

The ratio of the *SHD* and *SHL*, normalized to the local fundamental wobble frequency level, shall meet one of the following requirements:

— *SHD* / *SHL* < –12 dB with zero radial tilt;

— *SHD* / *SHL* < –6 dB within ± 0,70° of radial tilt.

The measurements shall be made using a spectrum analyzer (see Annex E).

27.4 HFM and Wobbled Groove transition requirements

To guarantee a minimum quality of Groove tracking of the HFM Groove and the Wobbled Groove Areas, the ratio of the normalized Push-Pull signals of the HFM Groove and the Unrecorded Wobbled Groove Areas shall fulfill the following requirement:

for LTH disks: $RHWG \geq 0{,}50$.

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28 Characteristics of Recording Layer

The signal values specified in Clauses 28 to 31 are valid for all disk capacities, unless specified otherwise.

In this International Standard, two types of signals are distinguished

— signals generated by Groove structures on the disk, and

— signals generated by User-written Marks.

Clauses 29 to 31 specify a series of tests to assess the recording properties of the Recording Layer, as used for writing data.

All requirements in Clauses 29 to 31 shall be fulfilled in all layers independent of the recording status of other Recording Layer (whether unrecorded, recorded or partially recorded) from the inner radius of the Recordable Area (start/end of the INFO/OPC Zone) at nominal radius 23,2 mm up to the inner radius of the Outer Zone(s) + 20 µm (d_{DZO}/2 + 20 µm). It is recommended that the requirements are also fulfilled in the remainder of the Outer Zone(s).

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29 Method of testing for Recording Layer

29.1 General

The tests shall be performed in the Recordable Areas. The write and read operations necessary for the tests shall be made on the same Reference drive.

When measuring the signals, the influence of local defects, such as dust and scratches, are excluded. Local defects might cause tracking errors, or uncorrectable Data (see Clause 33).

29.2 Environment

All signals shall be within their specified ranges if the disk is in its range of allowed environmental conditions as defined in 8.1.1.

29.3 Reference drive

29.3.1 General

All signals shall be measured in the appropriate channels of a Reference drive as specified in Clause 9 and in Annex H.

29.3.2 Read power

The read power is the optical power, incident on the Entrance surface of the disk and only used for reading the information. The read power shall be (0,35 ± 0,1) mW for an SL disk and (0,70 ± 0,1) mW for a DL disk.

29.3.3 Read channels

The drive shall have two read channels as defined in 9.5 and 9.6. The HF signal from the HF read channel shall not be equalized, except when measuring jitter (see Annex H).

29.3.4 Tracking requirements

During the writing and reading of the signals, the axial tracking error between the focus of the optical beam and the Recording Layer shall be maximum 55 nm for 2x disks, maximum 80 nm for 4x disks and for 6x disks at radii up to 36 mm. For 6x disks at radii 36 mm and higher, the axial tracking error shall be maximum 80 nm or maximum 110 nm if the disk meets the jitter performance.

The radial tracking error between the focus of the optical beam and the centre of the Track shall be maximum 16 nm for 2x disks, maximum 20 nm for 4x disks and 6x disks.

For 4x and 6x disks, local defects that cause large axial tracking errors shall be taken into account as described in Annex I.

29.3.5 Scanning velocities

Write tests shall be carried out at the velocities defined in the DI Units that are present on the disk (see 15.8.3).

During reading, the actual rotation speed of the disk shall be such, that it results in an average Channel-bit rate of 66,000 Mbit/s or an average wobble frequency of 956,522 kHz.

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29.4 Write conditions

29.4.1 Write-pulse waveform

Marks and Spaces are written on the disk by pulsing a laser. The laser power is modulated according to one of the write-pulse waveforms given in Annex F. A 2T to 9T NRZI run-length is written by applying a multi-pulse train of write pulses.

The laser power during recording has the following four levels, which are the optical powers incident on the Entrance surface of the disk:

— the write-peak power P_W;

— the bias-write power P_{BW} or the middle power P_M;

— the Space power P_S;

— the cooling power P_C.

Marks are created by the write-peak power P_W , Spaces are created by the Space power P_S.

The values of P_W, P_{BW}, P_S, P_M and P_C shall be optimized according to Annex G.

The actual powers P_W, P_{BW}, P_S, P_M and P_C for testing shall be within ±5 % of their optimum values, where P_{BW}, P_C , P_M and P_S shall be proportional to P_W according to the ratios, ε, as specified in the Disk Information (see 15.8.3).

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29.4.2 Write powers

The optimized write powers P_{WO} , P_{BWO} , P_{SO}, P_{MO} and P_{CO} shall meet the conditions as shown in Figure 126.

Velocity	Media Type	High-To-Low (HTL) disks				Low-To-High (LTH) disks			
	Layer	SL		DL		SL		DL	
	Power (mW)	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
1x	P_{WO} (mW)	3,0	6,0	6,0	12,0	3,0	6,0	---	---
	P_{BWO} (mW)	0,10	4,0	0,10	8,0	0,10	4,0	---	---
	P_{SO} (mW)	0,30	4,0	0,60	8,0	0,30	4,0	---	---
	P_{CO} (mW)	0,10	4,0	0,10	8,0	0,10	4,0	---	---
2x	P_{WO} (mW)	3,0	7,0	6,0	14,0	3,0	7,0	---	---
	P_{BWO} (mW)	0,10	7,0	0,10	14,0	0,10	7,0	---	---
	P_{SO} (mW)	0,30	5,4	0,60	10,8	0,30	5,4	---	---
	P_{CO} (mW)	0,10	5,4	0,10	10,8	0,10	5,4	---	---
	P_{MO} (mW)[a]	1,50	7,0	3,0	14,0	---	---	---	---
4x	P_{WO} (mW)	4,0	10,5	7,0	18,0	4,0	10,5	---	---
	P_{BWO} (mW)	---	---	---	---	---	---	---	---
	P_{SO} (mW)	0,30	5,4	0,60	10,8	0,30	5,4	---	---
	P_{CO} (mW)	0,10	5,4	0,10	10,8	0,10	5,4	---	---
	P_{MO} (mW)	2,0	10,5	3,50	18,0	2,0	10,5	---	---
6x	P_{WO} (mW)	5,0	14,0	8,5	22,0	5,0	14,0	---	---
	P_{BWO} (mW)	---	---	---	---	---	---	---	---
	P_{SO} (mW)	0,3	7,2	0,6	13,2	0,3	7,2	---	---
	P_{CO} (mW)	0,1	7,2	0,1	13,2	0,1	7,2	---	---
	P_{MO} (mW)	2,5	14,0	4,2	22,0	2,5	14,0	---	---

[a] Only when Castle strategy is applied.

Figure 126 — Write power requirements for Single and/or Dual Layer LTH and HTL disk

In addition to the conditions shown in Figure 126, the write powers shall be such that

— at $1 \times V_{ref}$: $P_{WO} > P_{SO} \geq P_{CO}$ and $P_{SO} \geq P_{BWO}$;

— at $2 \times V_{ref}$: $P_{WO} > P_{SO} \geq P_{CO}$ and $P_{WO} \geq P_{BWO}$;

— at $4 \times V_{ref}$ and $6 \times V_{ref}$: $P_{WO} \geq P_{MO} > P_{SO} \geq P_{CO}$.

29.4.3 Write conditions for jitter measurement

The test for jitter shall be carried out on any group of five adjacent Tracks, designated (m–2), (m–1), m, (m+1), (m+2) in the Recordable Areas of the disk.

The five Tracks are recorded with random data with a write power $P_W = P_{WO}$ as specified in 29.4.1. To measure the jitter, all five Tracks are written with random data with a write power $P_W = P_{WO}$.

29.5 Definition of signals

The amplitudes of all signals are linearly related to currents through a photodetector and, therefore, linearly related to the optical power falling on the detector.

Jitter
Jitter is the standard deviation σ of the time variations of the transitions in the binary read signal. This binary read signal is obtained by feeding the HF signal from the HF read channel through an equalizer, a LPF and a

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slicer (see Annex H). The jitter of the leading edges and the jitter of the trailing edges is measured separately relative to a PLL clock and normalized by the Channel-bit clock period.

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30 Signals from Recorded Areas

30.1 HF signals

The HF signal is obtained by summing the currents of the four elements of the photodetector. These currents get modulated by the different reflectivity of the Marks and Spaces representing the information on the Recording Layer (see Figure 127).

30.2 Modulated amplitude

The modulated amplitude I_{8pp} is the peak-to-peak value of the HF signal generated by the largest Mark and Space lengths. The peak value I_{8H} is the peak value of the HF signal before ac coupling.

The modulated amplitude I_{2pp} is the peak-to-peak value of the HF signal generated by the smallest Mark and Space lengths. The 0 level is the signal level obtained from the measuring device when no disk is inserted.

NOTE In the Sync patterns, run-lengths of 9T do occur. However, the recurrence of these 9Ts is very low and therefore their influence on the HF peak-to-peak signal is negligible.

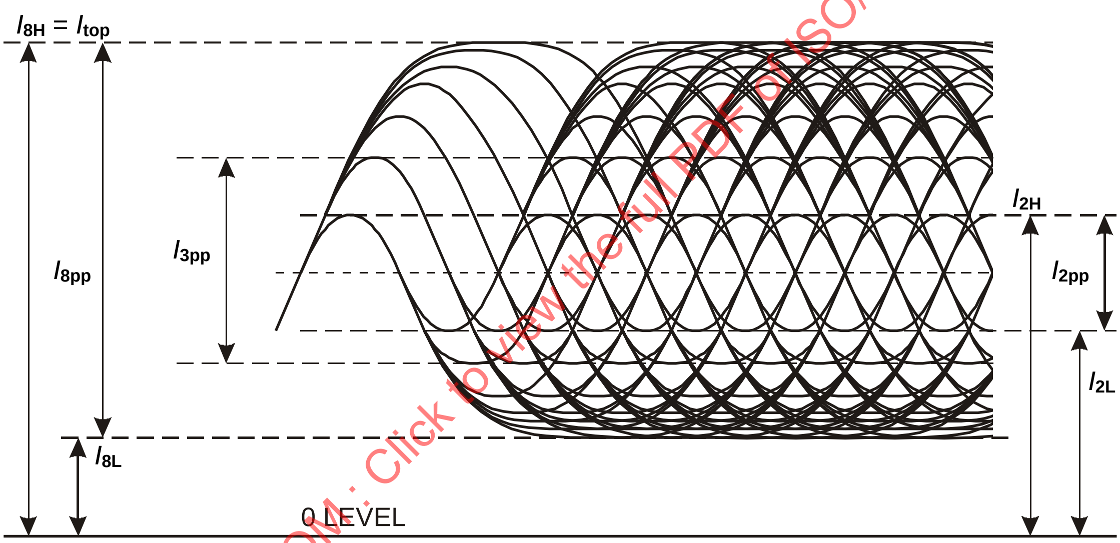

Figure 127 — Schematic representation of HF signal from Marks and Spaces

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Because the I_{2pp} is a relatively small signal, its amplitude can not be determined reliably from a random HF signal. Therefore, it is recommended to record an area with consecutive 2T Marks and Spaces only and to record an area with consecutive 8T Marks and Spaces only. The signals can now be measured accurately with appropriate measuring equipment.

The modulation signals shall meet the following requirements:

— $I_{8pp}/I_{8H} \geq 0{,}40$;

— $I_{3pp}/I_{8pp} \geq 0{,}25$;

— $I_{2pp}/I_{8pp} \geq 0{,}040$ for disks with a capacity of 25,0 GB and 50,0 GB.

The variations of the modulation signals shall be

— $(I_{8Hmax} - I_{8Hmin})/I_{8Hmax} \leq 0{,}33$ within one layer (continuously recorded), and

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— $(I_{8Hmax} - I_{8Hmin})/I_{8Hmax} \leq 0{,}15$ within one revolution (continuously recorded).

For DL disks, the ratio between the modulation signals on Layer L0 and Layer L1 shall be

$- 0{,}25 \leq (I_{8H,L0} - I_{8H,L1}) / (I_{8H,L0} + I_{8H,L1}) \leq + 0{,}25$ (continuously recorded),

where $I_{8H,L0}$ and $I_{8H,L1}$ are measured at the same position, both in radial and in tangential direction.

30.3 Reflectivity-Modulation product

The reflectivity of the disk multiplied by the Modulation (= normalized I_{8pp} modulated amplitude) shall be (see Annex B)

— $RxM = R_{8H} \times \left(\frac{I_{8pp}}{I_{8H}}\right)$, with $0{,}050 \leq RxM \leq 0{,}15$ for SL HTL disks,

$0{,}060 \leq RxM \leq 0{,}18$ for SL LTH disks, and

— $RxM = R_{8H} \times \left(\frac{I_{8pp}}{I_{8H}}\right)$, with $0{,}016 \leq RxM \leq 0{,}048$ for DL disks.

The reflectivity of the disk multiplied by the I_2 resolution (= normalized I_{2pp} modulated amplitude) shall be

— $RxI_2 = R_{8H} \times \left(\frac{I_{2pp}}{I_{8H}}\right)$, $RxI_2 \geq 0{,}0036$ for SL disks with capacity of 25,0 GB, and

— $RxI_2 = R_{8H} \times \left(\frac{I_{2pp}}{I_{8H}}\right)$, $RxI_2 \geq 0{,}0012$ for DL disks with capacity of 50,0 GB.

30.4 Asymmetry

The HF signal asymmetry shall meet the following requirement:

$$-0{,}10 \leq \left(\frac{\frac{I_{8H} + I_{8L}}{2} - \frac{I_{2H} + I_{2L}}{2}}{I_{8pp}}\right) \leq +0{,}15$$

30.5 Jitter

The Tracks on which the jitter is to be measured, shall be recorded as specified in 29.4.3.

The jitter shall be measured on the centre Track *m* of the five recorded Tracks at the Reference Velocity.

Both the leading-edge jitter and the trailing-edge jitter in Track *m* (measured separately) shall fulfill the following requirements.

On an SL disk and on Layer L0 of a DL disk

For all disks, independent on capacity:

— ≤7,0 % when measured using the circuit specified in Annex H and this circuit set to Limit-Equalizer mode, and

— ≤6,5 % when measured using the circuit specified in Annex H and this circuit set to Limit-Equalizer mode, and the edges that are adjacent to a 2T Mark or a 2T Space are not included in the jitter measurement.

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On Layer L1 of a DL disk

For all disks, independent on capacity:

— ≤8,5 % when measured using the circuit specified in Annex H and this circuit set to Limit-Equalizer mode, and

— ≤6,5 % when measured using the circuit specified in Annex H and this circuit set to Limit-Equalizer mode, and the edges that are adjacent to a 2T Mark or a 2T Space are not included in the jitter measurement.

NOTE Not including edges that are adjacent to a 2T Mark or a 2T Space means that in the jitter measurement only those edges are taken into account that are in between an *n*T Mark/Space and an *m*T Space/Mark, with both $n \geq 3$ and $m \geq 3$.

30.6 Read stability

Up to 10^6 successive reads from a single Track with a dc read power as indicated in Figure 128. The disk shall remain within all specifications in the operating environment.

Higher dc read powers shall be applied when specified in DI bytes 36 to 39 (see 15.8.3.3, 15.8.3.4 and 15.8.3.5).

Read Velocity	2x disks		4x disks		6x disks	
	SL	DL	SL	DL	SL	DL
1x	0,40 mW	0,70 mW	0,40 mW	0,70 mW	0,40 mW	0,70 mW
2x	0,45 mW	0,80 mW	0,45 mW	0,80 mW	0,45 mW	0,80 mW
4x	---	---	0,70 mW	1,30 mW	0,70 mW	1,30 mW
6x	---	---	---	---	0,70 mW	1,30 mW

Figure 128 — Read power values for dc read stability testing

Up to 10^6 successive reads from a single Track with an HF-modulated read power as indicated in Figure 129. The disk shall remain within all specifications in the operating environment.

Higher HF read powers shall be applied when specified in DI byes 40 to 43 (see 15.8.3.3, 15.8.3.4 and 15.8.3.5).

Read Velocity	2x disks		4x disks		6x disks	
	SL	DL	SL	DL	SL	DL
1x	0,30 mW	0,60 mW	0,30 mW	0,60 mW	0,30 mW	0,60 mW
2x	0,35 mW	0,70 mW	0,35 mW	0,70 mW	0,35 mW	0,70 mW
4x	---	---	0,60 mW	1,20 mW	0,60 mW	1,20 mW
6x	---	---	---	---	0,60 mW	1,20 mW

Figure 129 — Read power values for HF read stability testing

The modulation should fulfill the following requirements (see Figure 130):

— modulation frequency (= $1/T_{HF\text{-}laser}$) (400 ± 40) MHz;

— pulse width (300 ± 30) ps;

— ratio of peak power and average power 7,0 ± 0,7 at $1\times V_{ref}$ and $2\times V_{ref}$ .4,5 ± 0,5 at $4\times V_{ref}$ and $6\times V_{ref}$;

— bottom level between peaks flat.

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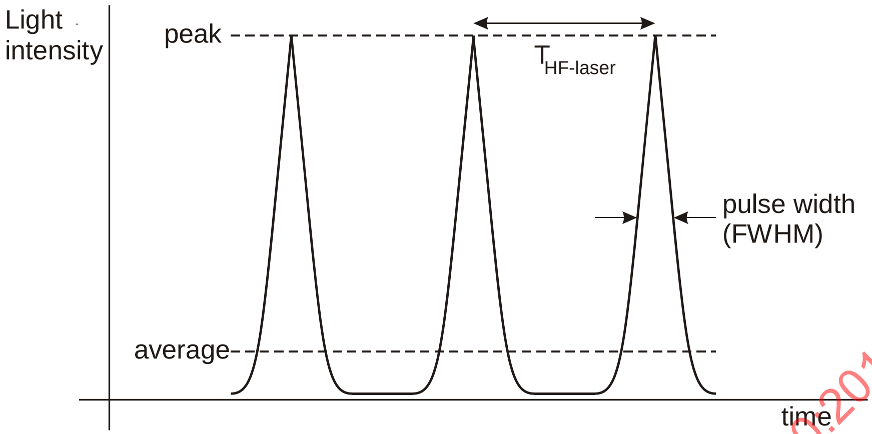

Figure 130 — Schematic representation of light pulses from Laser Diode

Additionally, the SER (see 34.1) shall be < 4,2 × 10^{-3} in any LDC Block.
[Equivalent to <317 counts (= 4,2 × 10^{-3} × 75 392 bytes)].

31 Local defects

Defects on the Recording Layer or in the Transmission Stack, such as “air bubbles” or “black dots” (such as dust enclosures in the Transmission Stack or pin holes in the Reflective Layer) shall not cause any unintended track jumping or uncorrectable errors (see also 33.4 and Clause 34).

The size of such defects shall be

— air bubbles: diameter < 100 µm,

— black dots with birefringence: diameter < 150 µm, and

— black dots without birefringence: diameter < 150 µm.

32 Characteristics of User Data

Clauses 32 to 34 describe a series of measurements to test conformance of the User Data on the disk with this International Standard. They check the legibility of User-written Data. The data is assumed to be arbitrary.

User-written Data may have been written by any drive at any speed in any operating environment.

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33 Method of testing for User Data

33.1 General

The read tests described in Clauses 32 to 34 shall be performed on the Reference drive.

Whereas, Clauses 24 to 30 disregard local defects, Clauses 32 to 34 includes them as unavoidable deterioration of the read signals. The gravity of a defect is determined by the correctability of the ensuing errors by the error detection and correction circuit in the read channel defined below. The requirements in Clauses 32 to 34 define a minimum quality of the data, necessary for data interchange.

33.2 Environment

All signals shall be within their specified ranges if the disk is in its range of allowed environmental conditions as defined in 8.1.1.

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33.3 Reference drive

33.3.1 General

All signals shall be measured in the appropriate channels of a Reference drive as specified in Clause 9.

33.3.2 Read power

The read power is the optical power, incident on the Entrance surface of the disk and only used for reading the information. The read power shall be (0,35 ± 0,1) mW for an SL disk and (0,70 ± 0,1) mW for a DL disk.

33.3.3 Read channels

The drive shall have two read channels as defined in 9.5 and 9.6.

The HF signal from the HF read channel shall be equalized and filtered before processing. The threshold level for converting an HF signal into a binary read signal shall be controlled to minimize the effects of Mark and Space size changes, due to parameter variations during writing. For measurement of disk quality, the characteristics of the equalizer, filter and slicer, as well as the characteristics of the PLL shall be the same as specified in Annex H (Limit Equalizer) for the jitter measurement.

33.3.4 Error correction

Correction of errors in the data bytes shall be carried out by an error detection and correction system based on the definitions in Clause 13.

33.3.5 Tracking requirements

During the measurement of the signals, the axial tracking error between the focus of the optical beam and the Recording Layer shall be maximum 80 nm, and the radial tracking error between the focus of the optical beam and the centre of the Track shall be maximum 20 nm.

For 4x and 6x disks, local defects that cause large axial tracking errors shall be taken into account as described in Annex I.

33.3.6 Scanning velocities

The actual rotation speed of the disk shall be such that it results in an average Channel-bit rate of 66,000 Mbit/s or an average wobble frequency of 956,522 kHz.

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33.4 Definition of signals

Byte error
A byte error occurs when one or more bits in a byte have a wrong value, as detected by the related error detection and/or correction circuits.

Burst error
A burst error is defined to be a sequence of bytes where there are not more than two correct bytes between any two erroneous bytes. For determining burst errors, the bytes shall be ordered in the same sequence as they were recorded on the disk (see 13.1 and 13.8).

The length of a burst error is defined as the total number of bytes counting from the first erroneous byte that is separated by at least three correct bytes from the last preceding erroneous byte, until the last erroneous byte that is separated by at least three correct bytes from the first succeeding erroneous byte.

The number of erroneous bytes in a burst is defined as the actual number of bytes in that burst that are not correct (see example in Figure 131).

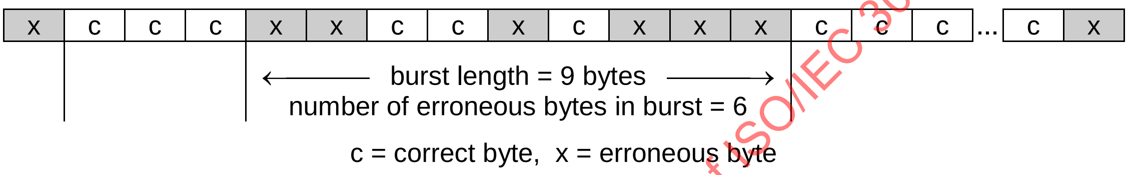

Figure 131 — Example of burst error

Symbol Error Rate:
The Symbol Error Rate (SER) averaged over *N* LDC Blocks is defined as the total number of all erroneous bytes in the selected LDC Blocks divided by the total number of bytes in those LDC Blocks:

$$\frac{\sum_{i=1}^{N} E_{a_i}}{N \times 75\,392}$$

where

E_{a_i} is the number of all erroneous bytes in LDC Block *i;*

N is the number of LDC Blocks.

Random Symbol Error Rate:
The Random Symbol Error Rate is defined as the Symbol Error Rate where all erroneous bytes contained in burst errors of length ≥40 bytes are counted neither in the numerator nor in the denominator of the SER calculation:

$$\frac{\sum_{i=1}^{N} \left(E_{a_i} - E_{b_i}\right)}{N \times 75\,392 - \sum_{i=1}^{N} E_{b_i}}$$

where

E_{a_i} is the number of all erroneous bytes in LDC Block *i;*

E_{b_i} is the number of all erroneous bytes in burst errors ≥ 40 bytes in LDC Block *i;*

N is the number of LDC Blocks.

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34 Minimum quality of recorded information

34.1 Symbol Error Rate

When checking the quality of the disk, including defects, the area selecting for determining the SER shall be written with arbitrary User Data. The SER shall fulfill the requirements as specified in 34.1.

The quality of continuously and discontinuously written sequences

Random SER averaged over any 10 000 consecutive LDC Blocks with the condition that all Blocks are recorded in a continuously written sequence (see Figure 47), in a discontinuously written sequence (see Figure 46) excluding disk defects, shall fulfill the following requirements:

Random SER < $2{,}0 \times 10^{-4}$ averaged over any 10 000 consecutive LDC Blocks.

34.2 Maximum burst errors

In each Recording-Unit Block, the number of burst errors with length ≥40 bytes shall be less than 8 and the sum of the lengths of these burst errors shall be ≤600 bytes.

34.3 User-written Data

User-written Data in a Recording-Unit Block (RUB) as read in the HF read channel shall not contain any byte errors that cannot be corrected by the error correction system defined in Clause 13.

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35 BCA

The Zone between r_1 and r_3 is reserved for use as a Burst-Cutting Area (BCA). (see 15.2 and Figure 54).

The BCA shall be used to add information to the disk after completion of the manufacturing process.

The BCA code can be written by a high-power laser system in the case of Recordable disks.

All information in the BCA code shall be written in CAV mode, where every revolution has exactly the same content, which content shall be radial aligned (see Figure 132).

The BCA code shall be located between radius $21{,}3^{\,0{,}0}_{-0{,}3}$ mm and radius $22{,}0^{+0{,}2}_{\,0{,}0}$ mm on Layer L0. (the BCA code is allowed to overlap the Protection-Zone 1 partially).

No BCA code shall be written on Layer L1, but some effect of writing the BCA code on Layer L0 could be visible on Layer L1.

The BCA code shall be written as a series of low-reflectance stripes arranged in circumferential direction. Each of the stripes shall extend fully across the BCA in the radial direction.

The information in the BCA code can be read by a drive at any radius between radius 21,3 mm and radius 22,0 mm on Layer L0.

The decision to record BCA code is Application dependent. BCA code shall not be recorded in the BCA unless otherwise specified by the Application. The format and the content of the BCA code is defined by agreement between the interchange parties.

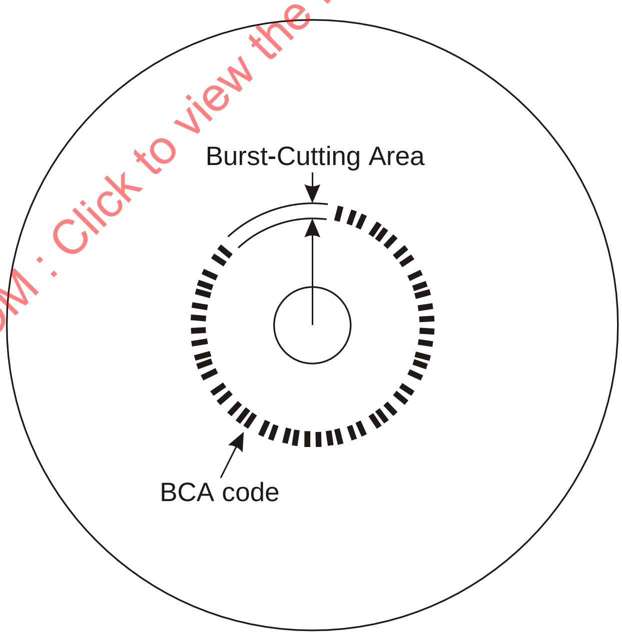

Figure 132 — Schematic representation of BCA

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Annex A
(normative)

Thickness of Transmission Stacks in case of multiple layers

A.1 General

In case the total Transmission Stack consists of k layers, the following procedure shall be applied in determining the thickness of the individual layers:

— the values d_1 .. d_k represent the thicknesses of layers 1 .. k;

— the values n_1 .. n_k represent the refractive indices of layers 1 .. k;

— let $D(n)$ be the nominal thickness at refractive index n according to Figure 19,

then the thickness d_k of layer k should be equal to: $d_k = D(n_k) \times \left(1 - \sum_{i=1}^{k-1} \frac{d_i}{D(n_i)}\right)$.

A.2 Refractive Index n_i of all layers in Cover and Spacer Layers

The refractive index, n_i, of each layer in the Cover and Spacer shall be $1{,}45 \le n_i \le 1{,}70$.

A.3 Thickness variation of Transmission Stack

The Relative Thickness of the Transmission Stack, j, is defined as $RT_j = \sum_{i=1}^{k} \frac{d_i}{D(n_i)}$.

The Relative Thickness RT of the Transmission Stacks, measured over the whole disk, shall fulfill the following requirements:

a) the Relative Thickness RT_0 of the Transmission Stack TS0 shall be: $95 \le 100 \times RT_0 \le 105$;

b) the Relative Thickness RT_1 of the Transmission Stack TS1 shall be: $70 \le 75 \times RT_1 \le 80$.

NOTE The thickness of the Recording Layer is very thin and negligible in the calculation of the thickness in case of Type DL/HTL disk.

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A.4 Example of thickness calculation for SL

Assume a Cover sheet with refractive index n_1 = 1,70 and a nominal thickness of 75 µm is attached to the Substrate by a gluing sheet with a refractive index n_2 = 1,45.

From Figure 19 we can find: $D(n_1)$ = 102,4 and $D(n_2)$ = 98,5.

From the above given formula, we can calculate

$$d_2 = 98{,}5 \times \left(1 - \frac{75}{102{,}4}\right) = 26{,}356 \ \mu\text{m}.$$

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Annex B
(normative)

Measurement of reflectivity

B.1 General

The reflectivity of a disk can be measured in several ways. The two most common methods are

— parallel method, and

— focused method.

The reflectivity of the disk is measured by the focused method with the help of a Reference disk with known reflectivity, while the reflectivity of the Reference disk is calibrated by the parallel method.

When measuring the reflectivity in the focused way, only the light returned by the Reflective Layer of the disk (R_m) will fall onto the photodetector. The reflected light coming from the front surface of the disk and the light coming from the parasitic reflectance's inside the disk will mainly fall outside the photodetector. Because in the parallel method only the "total" reflectance ($R_{//}$) can be measured, a calculation is needed to determine the "main" reflectance from the Reflective Layer.

B.2 Calibration method

A good Reference disk free of birefringence shall be chosen, for instance with a 0,1 mm glass Cover Layer with a golden reflective mirror. This Reference disk shall be measured by a parallel beam as shown in Figure B.1.

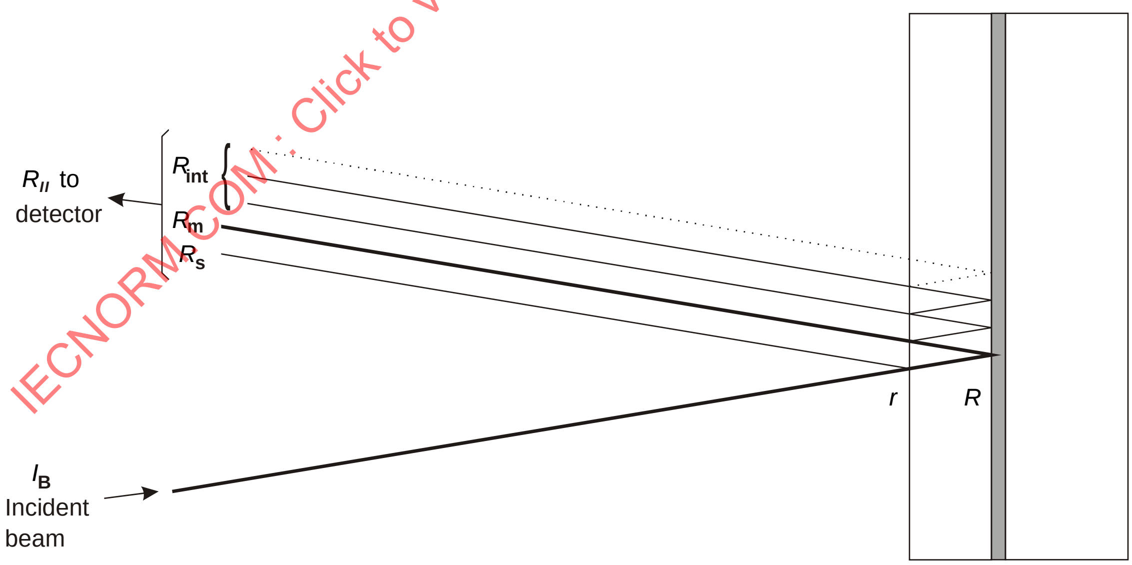

Figure B.1 — Reflectivity calibration

In this figure, the following applies:

R = reflectivity of the Recording Layer (including the double pass Transmission Stack transmission);
r = reflectivity of the Entrance surface;
R_{ref} = reflectivity as measured by the focused beam (is by definition = R_m / I_B);
I_B = incident beam;
R_s = reflectance caused by the reflectivity of the Entrance surface;

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R_m = main reflectance caused by the reflectivity of the Recording Layer;
R_{int} = reflectance caused by the internal reflectance's between the Entrance surface and the Recording Layer,
$R_{//}$ = measured value ($R_s + R_m + R_{int}$).

The reflectivity of the Entrance surface is defined by

$$r = \left(\frac{n-1}{n+1}\right)^2$$

where n is the index of refraction of the Cover Layer.

The main reflectance $R_m = R_{//} - R_s - R_{int}$ which leads to

$$R_{ref} = \frac{R_m}{I_B} = \left[\frac{(1-r)^2 \times \left(\frac{R_{//}}{I_B} - r\right)}{1 - r \times \left(2 - \frac{R_{//}}{I_B}\right)}\right]$$

The Reference disk shall be measured on a Reference drive. The total detector current (the sum of all four quadrants = I_{total}) obtained from the Reference disk, and measured by the focused beam is equated to R_m as determined above.

Now the arrangement is calibrated and the focused reflectivity is a linear function of the reflectivity of the Recording Layer and the double pass Transmission Stack transmission, independently from the reflectivity of the Entrance surface.

B.3 Measuring method

Reflectivity in Unrecorded, virgin Recordable Areas

A method of measuring the reflectivity using the Reference drive.

a) Measure the total detector current $(I_1 + I_2)_{ref}$ from the Reference disk with calibrated reflectivity R_{ref}.

b) Measure the total detector current $(I_1 + I_2)_G$ from a Groove Track in an area of the disk under investigation where the Groove Track and the two adjacent Tracks on each side of the Groove Track never have been recorded.

c) Calculate the unrecorded virgin disk reflectivity $R_{g\text{-}v}$ in the Groove Tracks of the Recordable Area as follows.

$$R_{g-v} = \frac{(I_1 + I_2)_G}{(I_1 + I_2)_{ref}} \times R_{ref}$$

Reflectivity in Recorded Recordable Areas

A method of measuring the reflectivity using the Reference drive.

a) Measure the total detector current $(I_1 + I_2)_{ref}$ from the Reference disk with calibrated reflectivity R_{ref}.

b) Measure I_{8H} from a recorded Groove Track in an area of the disk under investigation where at least the two adjacent Tracks on each side of the Groove Track also have been recorded. Recording of the Tracks shall be done using the optimum powers as determined from the OPC algorithm (see Annex G).

c) Calculate the recorded disk reflectivity R_{8H} in the Groove Tracks of the Recordable Area as follows.

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