INTERNATIONAL STANDARD

ISO/IEC 16448

Second edition
2002-04-15

Information technology — 120 mm DVD — Read-only disk

Technologies de l'information — Disque DVD de diamètre 120 mm — *Disque DVD à lecture seule*

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Foreword

ISO (the International Organization for Standardization) and IEC (the International Electrotechnical Commission) form the specialized system for worldwide standardization. National bodies that are members of ISO or IEC participate in the development of International Standards through technical committees established by the respective organization to deal with particular fields of technical activity. ISO and IEC technical committees collaborate in fields of mutual interest. Other international organizations, governmental and non-governmental, in liaison with ISO and IEC, also take part in the work. In the field of information technology, ISO and IEC have established a joint technical committee, ISO/IEC JTC 1.

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

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

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

ISO/IEC 16448 was prepared by ECMA (as Standard ECMA-267) and was adopted, under a special “fast-track procedure”, by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, in parallel with its approval of national bodies of ISO and IEC.

This second edition cancels and replaces the first edition (ISO/IEC 16448:1999), which has been technically revised.

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

Information technology — 120 mm DVD — Read-only disk

Section 1 - General

1 Scope

This International Standard specifies the mechanical, physical and optical characteristics of a 120 mm, read-only optical disk to enable the interchange of such disks. It specifies the quality of the recorded signals, the format of the data and the recording method, thereby allowing for information interchange by means of such disks. This disk is identified as DVD - Read-Only Disk.

This International Standard specifies

- four related but different Types of this disk (see clause 7),
- 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 the data from the disk.

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

2 Conformance

2.1 Optical Disk

A claim of conformance shall specify the Type of the disk. An optical disk shall be in conformance with this International Standard if it meets the 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 four Types of optical disk according to 2.1.

3 Normative reference

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

IEC 60950-1:2001, *Information technology equipment – Safety – Part 1: General requirements*

4 Terms and definitions

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

4.1 Adhesive layer

A layer of adhesive material bonding together the two parts of the disk.

4.2 Channel bit

The elements by which, after modulation, the binary values ZERO and ONE are represented on the disk by pits.

4.3 Clamping Zone

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

4.4 Digital Sum Value (DSV)

The arithmetic sum obtained from a bit stream by allocating the decimal value 1 to bits set to ONE and the decimal value -1 to bits set to ZERO.

4.5 Disk Reference Plane

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

4.6 Dual Layer disk

A optical disk with one or two entrance surface(s), in which each entrance surface gives access to a different pair of recorded layers.

4.7 Dummy substrate

A layer which may be transparent or not, provided for the mechanical support of the disk and/or of a recorded layer.

4.8 Entrance surface

The surface of the disk onto which the optical beam first impinges.

4.9 Optical disk

A disk that accepts and retains information in the form of pits in a recorded layer that can be read by an optical beam.

4.10 Physical sector number

A serial number allocated to physical sectors on the disk.

4.11 Read-only disk

An optical disk in which the information has been recorded when manufacturing the disk. The information cannot be modified and can only be read from the disk.

4.12 Recorded layer

A layer of the disk on, or in, which data is recorded.

4.13 Reed-Solomon code

An error detection and/or correction code for the correction of errors.

4.14 Reserved field

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

4.15 Sector

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

4.16 Single Layer disk

An optical disk with one or two entrance surface(s), in which each entrance surface gives access to a different recorded layer.

4.17 Spacer

In the case of Dual Layer disks, the transparent layer placed between the two recorded layers accessible through the same entrance surface.

4.18 Substrate

A transparent layer of the disk, provided for mechanical support of the recorded layer(s), through which the optical beam can access the recorded layer(s).

4.19 Track

A 360° turn of a continuous spiral.

4.20 Track pitch

The distance between the centrelines of a pair of adjacent physical tracks, measured in radial direction.

4.21 Zone

An annular area of the disk.

5 Conventions and notations

5.1 Representation of numbers

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

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

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

The setting of bits is denoted by ZERO and ONE.

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

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

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

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

5.2 Names

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

6 List of acronyms

BCA	Burst-Cutting Area
BP	Byte Position
BPF	Band Pass Filter
CLV	Constant Linear Velocity
CPR_MAI	Copyright Management Information
DCC	DC Component (suppress control)
DL	Dual Layer
DPD	Differential Phase Detection
DSV	Digital Sum Value
ECC	Error Correction Code
EDC	Error Detection Code
EQ	Equalizer
FWHM	Full Width at Half Maximum
HF	High Frequency
ID	Identification Data
IED	ID Error Detection (code)
IR	Index of Refraction
LPF	Low-Pass Filter
LSB	Least Significant Byte

MSB	Most Significant Byte
NRZ	Non Return to Zero
NRZI	Non Return to Zero Inverted
OTP	Opposite Track Path
PBS	Polarizing Beam Splitter
PE	Phase Encoding
PI	Parity (of the) Inner (code)
PLL	Phase-Locked Loop
PO	Parity (of the) Outer (code)
PTP	Parallel Track Path
PUH	Pick-Up Head
RIN	Relative Intensity Noise
RS	Reed-Solomon (code)
RZ	Return to Zero
SL	Single Layer
SYNC Code	Synchronisation Code
lsb	least significant bit
msb	most significant bit

7 General description of the disk

The optical disk that is the subject of this International Standard consists of two substrates bonded together by an adhesive layer, so that the recorded layers are on the inside (See annex N). The centring of the disk is performed on the edge of the centre hole of the assembled disk on the side currently read. Clamping is performed in the Clamping Zone. This International Standard specifies the following Types.

Type A consists of a substrate, a single recorded layer and a dummy substrate. The recorded layer can be accessed from one side only. The nominal capacity is 4,7 Gbytes.

Type B consist of two substrates, and two recorded layers. From one side of the disk, only one of these recorded layers can be accessed. The nominal capacity is 9,4 Gbytes.

Type C consists of a substrate, a dummy substrate and two recorded layers with a spacer between them. Both recorded layers can be accessed from one side only. The nominal capacity is 8,5 Gbytes.

Type D consists of two substrates, each having two recorded layers with a spacer between these two recorded layers. From one side of the disk, only one pair of recorded layers can be accessed. The nominal capacity is 17,0 Gbytes.

Figure 1 shows schematically these four Types. Types A and B are Single Layer (SL) disks and Types C and D are Dual Layer (DL) disks. The two layers of DL disks are identified as Layer 0 and Layer 1. Layer 0 is the layer nearer to the entrance surface. Types A and C are 1-sided disks, Types B and D are 2-sided disks.

In Type C the function of the adhesive layer can be provided by the spacer between the two recorded layers where Layer 1 is placed, for instance embossed, on the dummy substrate.

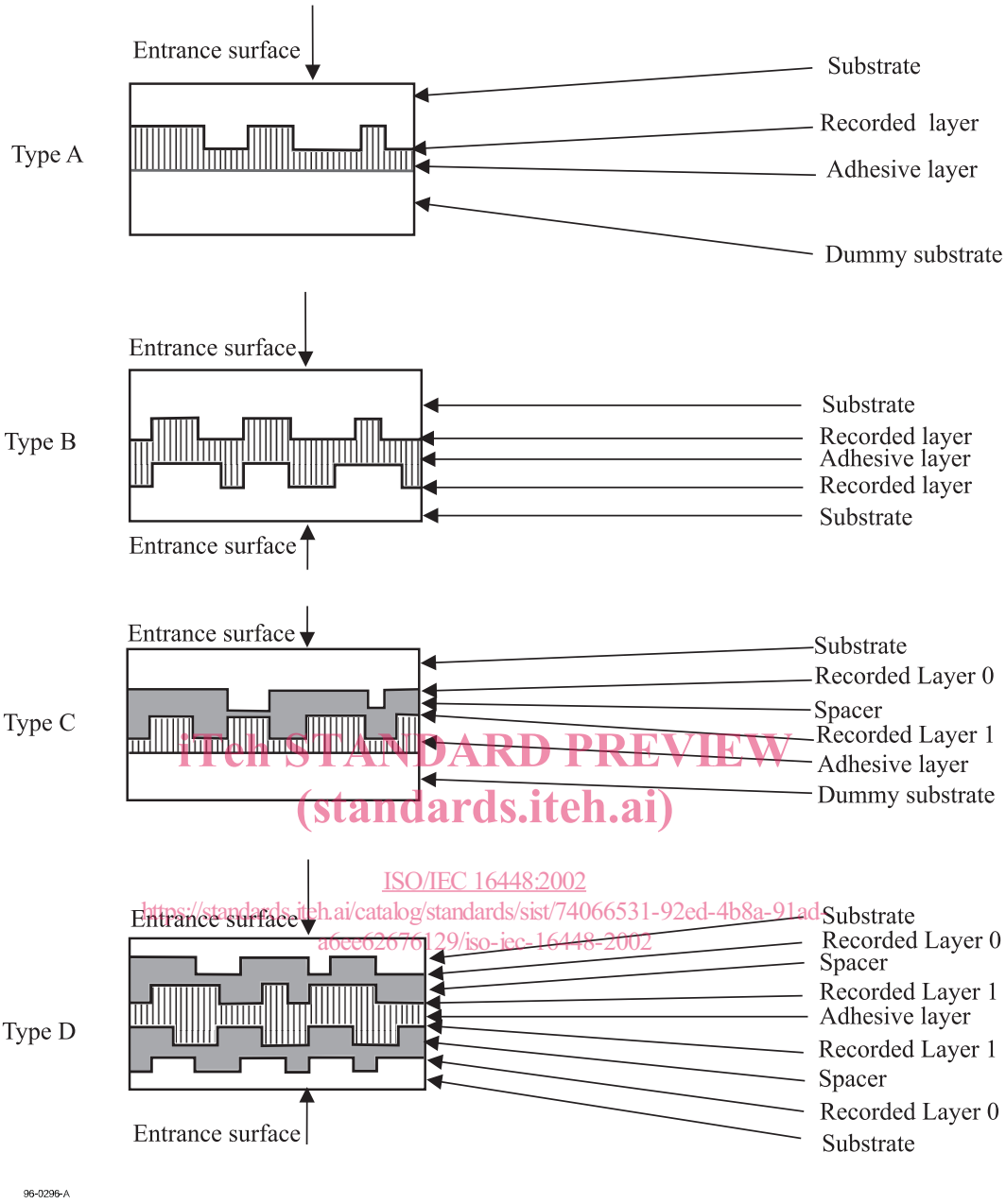


Figure 1 - Types of 120 mm DVD - Read-Only disks

8 General requirements

8.1 Environments

8.1.1 Test environment

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

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

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

8.1.2 Operating environment

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

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

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

temperature	: -25 °C to 70 °C
relative humidity	: 3 % to 95 %
absolute humidity	: 0,5 g/m^3 to 60 g/m^3
sudden change of temperature	: 50 °C max.
sudden change of relative humidity	: 30 % max.

There shall be no condensation of moisture on the disk.

8.1.3 Storage environment

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

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

8.1.4 Transportation

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

8.2 Safety requirements

The disk shall satisfy the requirements of IEC 60950-1, when used in the intended manner or in any foreseeable use in an information system.

8.3 Flammability

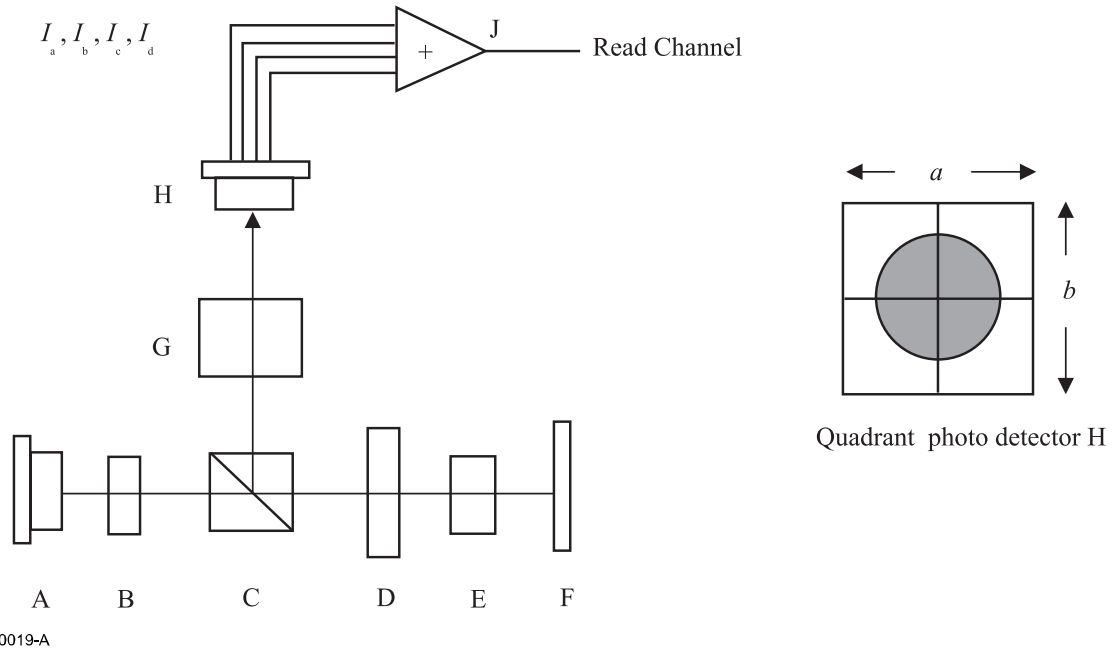
The disk shall be made from materials that comply with the flammability class for HB materials, or better, as specified in IEC 60950-1.

9 Reference measurement devices

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

9.1 Pick Up Head (PUH)

The optical system for measuring the optical parameters is shown in figure 2. It shall be such that the detected light reflected from the entrance surface of the disk is minimized so as not influencing the accuracy of measurement. The combination of the polarizing beam splitter C with the quarter-wave plate D separates the incident optical beam and the beam reflected by the optical disk F. The beam splitter C shall have a p-s intensity/reflectance ratio of at least 100. Optics G generates an astigmatic difference and collimates the light reflected by the recorded layer of the optical disk F for astigmatic focusing and read-out. The position of the quadrant photo detector H shall be adjusted so that the light spot becomes a circle the centre of which coincides with the centre of the quadrant photo detector H when the objective lens is focused on the recorded layer. An example of such a photo detector H is shown in figure 2. The dimensions *a* and *b* equal M times 10 μm to 12 μm, where M is the transversal magnification factor from the disk to its conjugate plane near the quadrant photo detector H.



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

Figure 2 - Optical system for PUH

The characteristics of the PUH shall be as follows.

Wavelength (λ)	650 nm ± 5 nm
Polarization	circularly polarized light
Polarizing beam splitter	shall be used unless otherwise stated
Numerical aperture	0,60 ± 0,01
Light intensity at the rim of the pupil of the objective lens	60 % to 70 % of the maximum intensity level in radial direction, and over 90 % of the maximum intensity level in tangential direction
Wave front aberration after passing through an ideal substrate of the single layer disk (Thickness : 0,6 mm and index of refraction : 1,56)	0,033 λ rms max.
Normalized detector size on a disk	100 μm^2 ‹ S / M^2 ‹ 144 μm^2 where S is the total surface of the photo detector of the PUH
Relative intensity noise (RIN) 10 log [(a.c. light power density /Hz) / d.c. light power]	- 134 dB/Hz max.

9.2 Measurement conditions

The measuring conditions for operational signals shall be as follows.

Scanning velocity at a Channel bit rate of 26,15625 Mbits/s	for Single Layer disks: 3,49 m/s ± 0,03 m/s for Dual Layer disks: 3,84 m/s ± 0,03 m/s

Clamping force	2,0 N ± 0,5 N
Taper cone angle	40,0° ± 0,5°, see annex E
CLV servo characteristic	f (-3 dB), closed loop bandwidth : 5 Hz
Focusing method	astigmatic method
Tracking method	differential phase detection

9.3 Normalized servo transfer function

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

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

where

$\omega = 2\pi f$

$\omega_o = 2\pi f_o$

$i = \sqrt{-1}$

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

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

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

9.4 Reference Servo for axial tracking

For an open loop transfer function H of the Reference Servo for axial tracking, $|1+H|$ is limited as schematically shown by the shaded surface of figure 3.

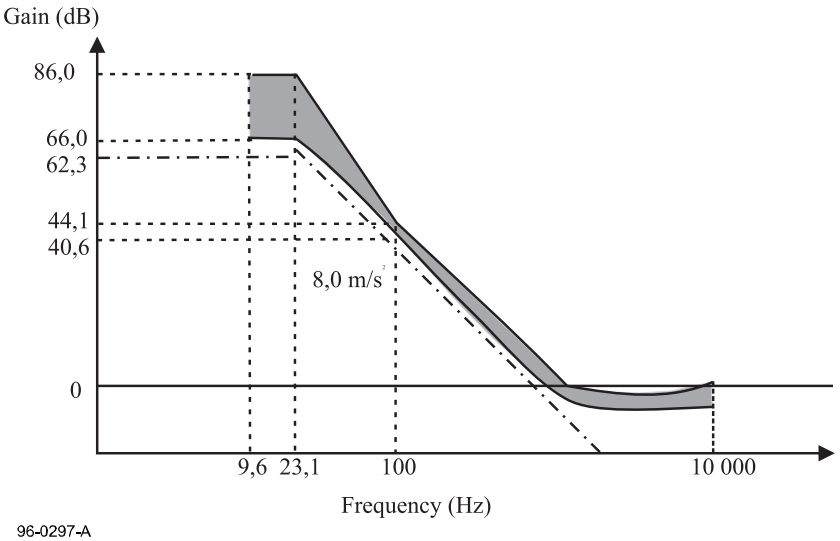


Figure 3 - Reference Servo for axial tracking

Bandwidth 100 Hz to 10 kHz

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

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

$$f_0 = \frac{1}{2\pi}\sqrt{\frac{3\,\alpha_{max}}{e_{max}}} = \frac{1}{2\pi}\sqrt{\frac{8\times1{,}5\times3}{0{,}23\times10^{-6}}} = 2{,}0\ \text{kHz} \qquad \text{(II)}$$

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

Bandwidth 23,1 Hz to 100 Hz

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

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

Bandwidth 9,6 Hz to 23,1 Hz

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

9.5 Reference Servo for radial tracking

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

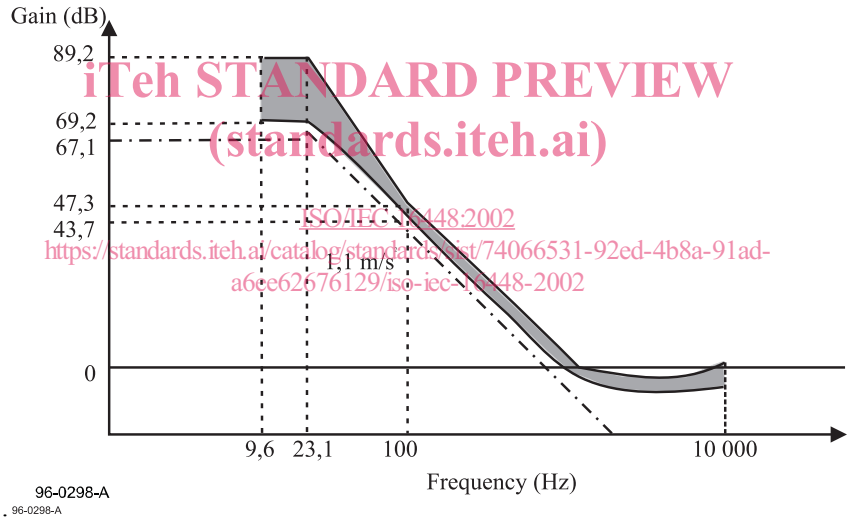


Figure 4 - Reference Servo for Radial Tracking

Bandwidth from 100 Hz to 10 kHz

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

The crossover frequency $f_o = \omega_o / 2\pi$ shall be specified by equation (III), where α_{max} shall be 1,5 times larger than the expected maximum radial acceleration of 1,1 m/s^2. The tracking error e_{max} shall not exceed 0,022 µm.

Thus the crossover frequency f_o shall be

$$f_0 = \frac{1}{2\pi}\sqrt{\frac{3\,\alpha_{max}}{e_{max}}} = \frac{1}{2\pi}\sqrt{\frac{1{,}1\times1{,}5\times3}{0{,}022\times10^{-6}}} = 2{,}4\ \text{kHz} \qquad \text{(III)}$$

The radial tracking error is the peak deviation measured radially inwards or outwards the 0 level.

Bandwidth from 23,1 Hz to 100 Hz

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