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Information technology — Guidance on measurement techniques for 90 mm optical disk cartridges

Technologies de l'information — Lignes directrices pour les techniques de mesurage des cartouches de disque optique de diamètre 90 mm

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Contents

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Annexes

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 main task of technical committees is to prepare International Standards, but in exceptional circumstances a technical committee may propose the publication of a Technical Report of one of the following types:

— type 1, when the required support cannot be obtained for the publication of an International Standard, despite repeated efforts;

— type 2, when the subject is still under technical development or where for any other reason there is the future but not immediate possibility of an agreement on an International Standard;

— type 3, when a technical committee has collected data of a different kind from that which is normally published as an International Standard ("state of the art", for example).

Technical Reports of types 1 and 2 are subject to review within three years of publication, to decide whether they can be transformed into International Standards. Technical Reports of type 3 do not necessarily have to be reviewed until the data they provide are considered to be no longer valid or useful.

ISO/IEC TR 13841, which is a Technical Report of type 3, was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*.

Information technology - Guidance on measurement techniques for 90 mm optical disk cartridges

1 General

1.1 Scope

This technical report provides Guidance on Measurement Techniques for 90 mm Rewritable/Read-only Optical Disk Cartridges.

1.2 Purpose

This technical report provides guidance on measurement techniques which are not well understood in industry. The basic concept of this report is to aid in the understanding of interchangeability between disks and drives. This report gives guidance and provides some examples of measurement techniques to aid this understanding.

1.3 Reference

ISO/IEC 10090:1992, *Information technology — 90 mm optical disk cartridges, rewritable and read only, for data interchange.*

1.4 Definitions

The definitions of this report are the same as the definitions of ISO/IEC 10090.

2 Measurement environments

2.1 General

This report recommends 3 kinds of measurement environments. Each clause in section 5 may use 1 of 3 measurement environments as specified in this section. Basically, Measurement environment A is used for each clause in section 5 unless noted. Additional environments or conditions are recommended in each clause.

2.2 Measurement environment A

Measurement environment A is the same as the testing environment of ISO/IEC 10090 i.e.

temperature	: 23 °C±2 °C
relative humidity	: 45% to 55%
atmospheric pressure	: 60 kPa to 106 kPa
air cleanliness	: Class 100 000
magnetic field strength	: 32 000 A/m max.

2.3 Measurement environments B

Measurement environments B are used for the highest temperature marginal test

temperature	: 50 °C±2 °C
relative humidity	: Not significant on this environment
atmospheric pressure	: Not significant on this environment
air cleanliness	: Class 100 000
magnetic field strength	: 32 000 A/m max. (unless noted)

2.4 Measurement environments C

Measurement environments C are used for temperature marginal tests. The range of these environments are the same as the operating environment of ISO/IEC 10090.

temperature	: 5°C±2 °C, 23°C±2 °C,50°C±2 °C
relative humidity	: Not significant in this environment
atmospheric pressure	: Not significant in this environment
air cleanliness	: Class 100 000
magnetic field strength	: 32 000 A/m max. (unless noted)

3 Measurement set up

3.1 General

An optical drive which is used for measuring disks should be calibrated before measuring disks. A typical calibration disk which is suitable for laser power calibration is mentioned in 3.3.

3.2 Measurement accuracy

The measuring equipment should have high reproducibility and repeatability and the recommended performance tolerance ratio (P/T) ;

$$P/T = 6*SD/Tolerance < 0{,}2$$

where SD is the standard deviation and Tolerance is the upper limit minus the lower limit of the specification.

For example:

In the case of reflectance

$$P/T = 6* SD/(0{,}29-0{,}14) < 0{,}2 \text{ i.e. } SD < 0{,}005$$

In the case of single ended specifications, the system should be capable of resolving the number of significant digits in the parameter specification.

3.3 Calibration disk

The laser power of the optical drive and/or the measurement equipment on the recording layer can be calibrated from the calibration disk which is provided by the Reliability Center for Electronic Components of Japan (RCJ)

Note - This calibration disk cartridge has been established by RCJ, 1-1-2 Hachiman Higashikurume Tokyo, Japan, and can be ordered under Part number JCM6272 until 2002.

3.4 Measurement area

ISO/IEC 10090 requires disks to satisfy specifications in all the areas of the disk unless noted. (See annex R in ISO/IEC 10090). This report shows the most critical measurement areas in each clause, as follows:

(A) Innermost diameter is critical (R=24mm) for Read power, NBSNR, Signal from headers (I_{vfo} , I_{dmax}/I_{dmin}), Push-pull signal and cross-track signal in ROM area

(B) Correspond to control track data (R=24mm, 30mm, 40mm) Write power, Erase power

(C) Outermost diameter is critical (R=40mm) for Tilt, Axial and radial accelerations,

(D) Outermost and innermost diameters are critical (R=24mm, 40mm) for Reflectance, Imbalance of the MO signal

(E) Inner and outer test zones and control zones. Signal from grooves and headers

3.5 Reference Servo

ISO/IEC 10090 specifies a disk rotational frequency of 30Hz for testing conditions and specifies the transfer functions of the Reference Servo for axial and radial tracking of the recording layer. (See 9.5 and 11.4 of ISO/IEC 10090.)

During the measurement of the signals, the radial tracking error between the focus of the optical beam and the center of a track is made smaller than during the measurement of the radial acceleration. This is achieved by a strong servo as provided in 20.2.4. Therefore the 0,1 µm value of the radial tracking error is increased below the acceleration cross-over frequency and is not changed in the frequency range higher than the acceleration cross-over frequency. There are various strong servos using various phase compensators. If one uses the same type of compensator (C=3) as the reference servo, the 0 cross frequency of this strong servo on the rotational speed of 30 Hz is 1 500 Hz. And this strong servo has an acceleration cross-over frequency of 870 Hz.

For other rotational frequencies, see table 1.

Table 1. Constants table for the measurement servos

Rot. freq.	0 cross freq. for reference servo (Hz)		Acceleration at low frequency (m/s^2)		Example servo for signals.				Cross over freq. (Hz)
					0 cross freq. (Hz)		Acceleration (m/s^2)		
	Axial	Radial	Axial	Radial	Axial	Radial	Axial	radial	Radial
30 Hz	870	1230	10,0	3,0	870	1500	10,0	3,0	870
40 Hz	**1160**	**1640**	18,0	5,3	1160	2000	18,0	5,3	1160
50 Hz	**1450**	**2050**	28,0	8,3	1450	2500	28,0	8,3	1450
60 Hz	**1740**	**2460**	40,0	12,0	1740	3000	40,0	12,0	1740

Note: The **bold values** are the values calculated for the reference servo.

4 Items for measurement techniques

4.1 General

The following list shows the status of each item. The list classifies these items into 2 groups :

1) guidance on definition and measurement techniques,
2) guidance on measurement techniques.

4.2 List of measurement items

Clause number in ISO/IEC 10090	Title	Status	Clause number
10.4.5	Shutter opening force	(1)	5.1
12.2	Clamping force	(2)	5.2
11.4.9	Tilt	(1)	5.3
11.4.8	Radial and axial acceleration	(2)	5.4
11.5.4	Reflectance	(2)	5.5
12.3	Capture cylinder	(2)	5.6
21	Signals from grooves	(2)	5.7
22	Signals from headers	(2)	5.8
24.2.2	Read power	(1)	5.9
24.3.2/24.4.1	Write power and Erase power	(1)	5.10
25.2	Imbalance of the MO	(2)	5.11
26.2	Narrow-band signal-to-noise ratio	(2)	5.12

5 Measurement techniques

5.1 Shutter opening force

5.1.1 Definition

The shutter opening force is defined as the maximum force including shutter weight and friction between the cartridge and shutter when opening and/or closing the shutter. It is measured as the force in pushing or pulling the shutter parallel to the shutter movement. But the friction force caused by the shutter-opener in the drive mechanism is not included in the definition.

5.1.2 Measurement procedure

The measurement is done by using a tension gauge as shown in figure 1. This measurement method does not include shutter weight. Therefore, the shutter weight must be added to the result of the measurement. Another method and measurement data are shown in annex H.

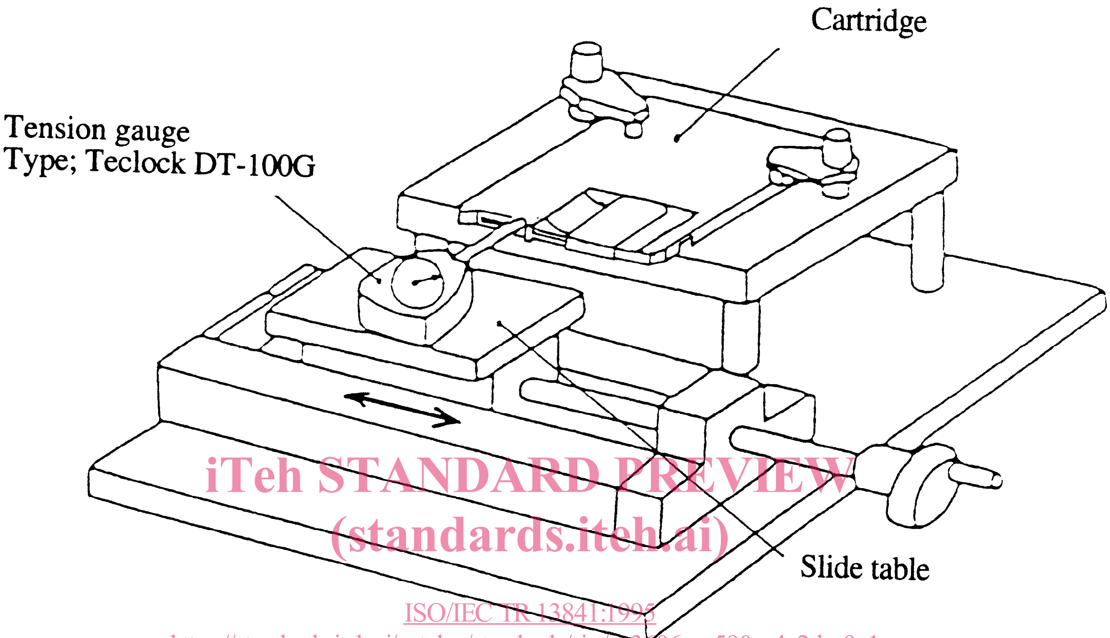


Figure 1 - An example of measurement setup

5.2 Clamping force

5.2.1 Introduction

The maximum allowable force is within a range from clamping a disk without deterioration mechanical characteristics of the disk to unloading the disk by a force of the loading motor or mechanism. The clamping force is checked by the disk with an upper or lower limit of hub which meets the requirement of annex K in ISO/IEC 10090. This item is determined by the drive design.

5.2.2 Measurement procedure

1. Prepare the magnetizable material for a hub which is able to provide the adsorbent force of 4,5 N on the tester in annex K in ISO/IEC 10090.
2. Adhere the material on the non-magnetizable hub with height accuracy of 1,20±0,01 mm including parallelism of the substrate and the material.
3. Clamp the disk on the turntable of the test drive.
4. Measure the clamping force by pulling off the disk.

5.3 Tilt

5.3.1 Introduction

Tilt is defined as the angle between the reference plane of a disk and the entrance surface in the text of the ISO/IEC 10090. The accuracy of the substrate thickness is also considered when the reflectance light is utilized from the recording layer in the real measurement. There exist several methods and this report shows following two methods of the measurement. The first method is of the similar method defined in the sentence of the ISO/IEC 10090, that is, to measure the tilt with a parallel light beam directly. The second one is to measure the tilt with a special head utilized over the measurement of the mechanical characteristics.

5.3.2 Measurement method 1

This has been used for long time and the principle of the measurement is depicted in figure 3. When a small He-Ne laser, for example, is used as a light source, the spot size of the measurement is approximately 1 mm. Therefore, this method is mostly close to the sentence defined in ISO/IEC 10090. However, following conditions should be considered in this measurement.

(A) The spot size should be kept in the range of 1 mm when the outermost area is measured.

(B) The error increase depends on the substrate thickness, when the tilt increases.

5.3.3 Measurement method 2

This is a method to measure tilt by the axial deflection values. In order to measure the axial deflection, the position of the objective lens is detected either with a head, which is specially designed within a micro-sensor or by an electric current to the lens actuator. These methods are more convenient for measurement method 1 because the other mechanical characteristics are also measured simultaneously. The method to determine a tilt by the axial deflection is explained in figure 2. Assuming a small square within a few mm^2 as a flat plane, the tilt along the radius (ϕ_r) or along tangential (ϕ_θ) direction is calculated by the axial direction difference of separated two points (A1, B1 or A2, A1) and the distance (l_r or l_θ) respectively.

Tangential tilt angle $\phi_\theta = \tan - 1(\Delta d\theta / l_\theta)$

$= \tan - 1((DA1-DA2)/ l)$

Radial tilt angle $\phi_r = \tan - 1(\Delta dr / l_r)$

$= \tan - 1((DA1-DB1)/ l_r)$

Therefore, compounded solid angle (tilt angle) is,

Tilt angle $|\phi| = \mathrm{SQRT}\ (\phi_\theta{}^2 + \phi_r{}^2)$

However, this equation must be used carefully for the following reasons.

(A) Tilt is determined by the axial deflection difference as function of the distance. That is, the shorter the distance of the separated points (l_θ,l_r) is, the more estimated error increases. Oppositely, in the case of the longer distance, the surface roughness disturbs the measurement. Therefore, the measurement conditions must be well considered.

(B) The axial deflection value of 5 µm should correspond to 5 mrad of the specification when tilt is measured every 1 mm pitch. Therefore, the measurement accuracy must be also considered.

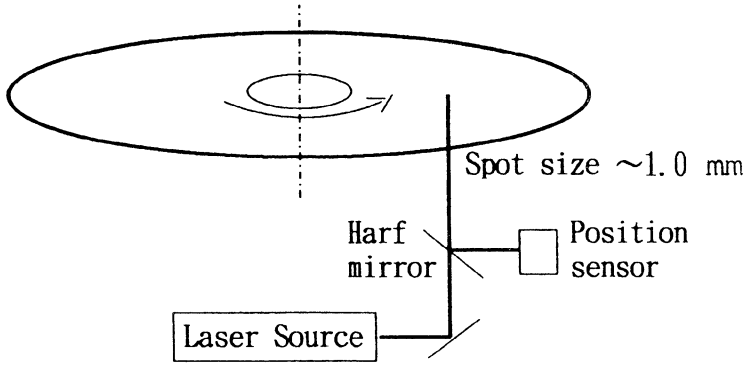


Figure 2 - Direct measuring of tilt (Measurement method 1)

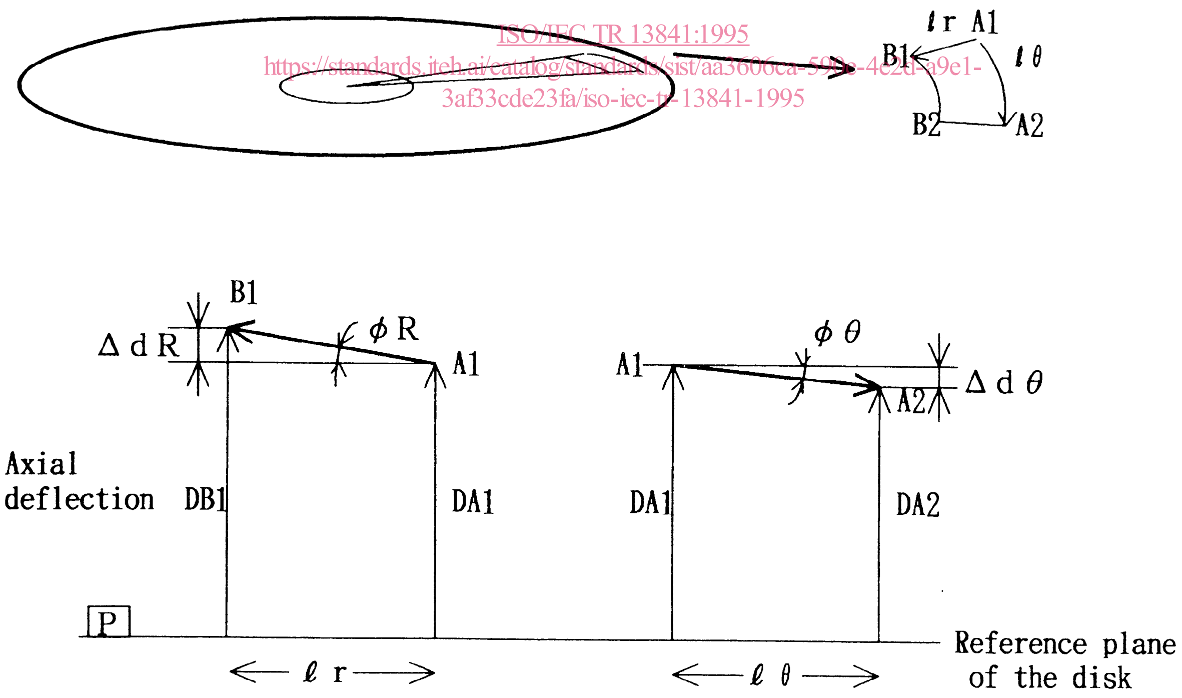


Figure 3 - Measurement tilt calculated by axial deflection (Measurement method 2)

5.4 Axial and Radial acceleration

5.4.1 Introduction

The ISO/IEC 10090 assumes that a light spot traces tracks on a disk by the use of axial and radial servos. Although this tracing must be accurate to the extent that playback is adequately performed, movement in the axial and radial directions can act as an obstacle to this requirement. At low frequencies, in which the servo responds, the object lens traces disk movement and the servo-loop gain decreases the distance between the track and the light spot by a fraction, which means that the fractual distance shows up in tracing performance. On the other hand, at high frequencies in which the servo does not respond, disk movement itself corresponds to tracking performance. As for typical servo characteristics in an optical disk drive, in the range up to the lead break frequency of the phase compensation filter inside the servo loop, doubling the frequency results in 25% of the loop gain. In the same way, when the disk exhibits sinusoidal motion under the condition that the maximum acceleration is constant, the relationship between the frequency and amplitude is such that doubling the frequency results in 25% increase in amplitude. Thus, because servo gain and disk acceleration are given, tracing characteristics can be estimated at low frequencies (see figures 4 and 5). Accordingly, if we limit ourselves to disk acceleration for low frequencies and disk displacement for high frequencies, track tracing performance of the light spot can be determined to a certain extent. However, the following problems arise if we attempt to make them precise rules. First, the necessity of measuring the two physical quantities of acceleration and displacement independent of the frequency can be complicated, and second, excess movement of the object lens near the zero-cross frequency cannot be accurately ascertained by acceleration and displacement. For example, figure 4 shows that the loop gain at 600 Hz allows the acceleration of 17,5 m/s^2 and that the loop gain at 1000 Hz allows the disk displacement of only 0,8 µm. Taking the above into consideration, ISO/IEC 10090 prescribes a servo deviation specification using a reference servo having fixed characteristics. This is chosen because servo deviation appears directly in tracing performance, and consequently the same physical quantity can be evaluated throughout the entire frequency range.

5.4.2 Measurement system

A measurement system for performing measurements is shown in figure 6 (this figure combines figures C.2 and C.4 of annex C in ISO/IEC 10090). In figure C.2. the output of a non-contact electrostatic capacity sensor is added to the actual servo's error signal and the resultant is input into a filter having the transfer characteristics of the reference servo. For typical non-contact sensors, however, it is not so simple to carry out accurate measurements from low frequencies up to high frequencies. It is generally felt that operation at less than 1 kHz is desirable. As a result, the object lens moves in excess of the disk displacement near the servo's zero-cross frequency, and even if this appears in the error signal, it cannot be compensated by the non-contact sensor's output, and measurement accuracy falls. In figure C.4, the actual servo's transfer function is identified and the servo's error signal is input into a filter whose characteristics represent the multiplication of the inverse of the actual servo's transfer function with the reference servo's transfer function. Here, however, it is generally not easy to measure accurately the servo system transfer characteristics from high frequencies down to low frequencies. In particular, for a leaf-spring type of actuator, resonance frequency due to the spring and the mass of the movable parts of the actuator is several tens of Hz, and characteristics are difficult to identify accurately. Moreover, even for a slide-able type of actuator, the large influence of stick and slip at low frequencies makes it difficult to identify characteristics well. For this reason, using figure C.2 for low frequencies and figure C.4 for high frequencies, a systems proposed in which the output from both of the above can be accurately measured in both the low frequency interval and the high frequency interval independent of frequency. Here, we use well-placed crossover filters having inverse characteristics. These are 1st order filters having cut-off frequencies of 600 Hz. In addition, since object-lens displacement is measured directly in the low frequency interval, the low frequency component of disk displacement stored in memory should be used for feed forward control in the actual servo system. G1 is a sensor-system element transfer function having a band of 100 kHz. G2 and G3 are a servo-loop phase-compensation element and actuator transfer function, respectively, whose characteristics are dependent on the type of equipment used.

5.4.3 Procedure 1: Low-pass measurement system

1a Calibrate non-contact sensor gain

1b Measure error signal gain

Method A (Axial Gain)

- Stop disk.
- Turn axial and radial servos OFF.

- * Coarsely move the disk using a mechanical slow-motion facility and place the disk around the center of the axial error signal e_a .
- * Slowly move the disk using a piezo element and search for the center of the axial error signal e_a
- * When the difference between the axial S-signals for land and groove becomes large, place radial serve ON.
- * Using a piezo element, move the disk ± 1 micron from the center of the error signal and measure the gain at this point.

Method B (Axial Gain)

- * Stop disk.
- * Turn axial and radial servos ON. While applying an offset voltage to z, detect the object lens motion with an electrostatic capacity non-contact sensor and measure the gain at 1 micron.

Method C (Radial Gain)

- * Stop disk.
- * Turn axial servo on.
- * Apply a chopping wave to the radial actuator to move.
- * For the radial error signal e_a obtain a wave form in which the deviation between adjacent periods is within 3%, and treating one period as 1,6 micron, measure the gain at ± 0,1 micron from land centre. Note that by observing the cross-track signal at this time, land and groove can be distinguished.

Method D (Radial Gain)

- * Stop disk.
- * Turn axial and radial servos on. Whole applying an offset voltage to zero, detect the object lens motion with an electrostatic capacity non-contact sensor and measure the gain at 1 micron.

1c Adjust the variable gain AMP so as to match the error signal gain with that of the non-contact sensor. If method B can be used for gain measurement, it is recommended to input a 100Hz sine wave into z and adjust the variable gain so that signal s_m becomes 0.

1d Implementing a reference-servo simulation filter. In order for the $1/(1+H_s)$ filter to accurately simulate low-pass characteristics, and analog filter is preferred despite the fact that a digital filter is relatively easy to construct. Figures 7 and 8 show examples of analog filters for axial use and radial use, respectively. Figures 9 and 10 are the simulation results of each filter.

1e Implementing a low-pass filter A 1st order filter which acts as crossover band-limiting filter having a cut-off frequency of 600 Hz is desirable. The cut-off frequency and gain here must be uniform with the high-pass filter of the high-pass measurement system within an accuracy of 3%.

Caution: When performing measurements while the disk is not revolving, deformation of the illuminated part of theplastic disk substrate can be prevented by lowering laser power.

5.4.4 Procedure 2: High-pass Measurement System

2a Sensor-System gain
Adjust the variable-gain AMP as in the low-pass measurement system.

2b Transfer function derivation

- * Apply an excitation signal from z and measure the transfer characteristics from z to e_a:

  $e_a /z = 1/(1+G_1*G_2*G_3) = 1/(1+H_a)$.

  Measurements should be performed in a frequency domain above 200 Hz since the 600 Hz cut-off high-pass filter is employed here for the high-pass measurements.

- * Determine the transfer function from the transfer characteristics using the curve-fitting function of an FFT analyzer.

Caution: Considering the wide measurement frequency range, measurement accuracy can be improved by varying the excitation signal amplitude in a step-like fashion for each frequency. During measurement, it is necessary to confirm that each section within the servo loop is not being saturated.

2c Implement the $(1+H_a)/(1+H_s)$ correction filter.

2d Implement the high-pass filter

A 1st order filter which acts as a cross over band-limiting filter having a cut-off frequency of 600 Hz is desirable. The cut-off frequency and gain must be uniform with the low-pass filter of the low-pass measurement system within an accuracy of 3%.

5.4.5 Procedure 3: Total measurement system

3a Add the output signal of the low-pass measurement system to the output signal of the high-pass measurement system at the same gain. Under these conditions, rotate the test disk, apply the axial and radial servos and observe the e_S output signal.

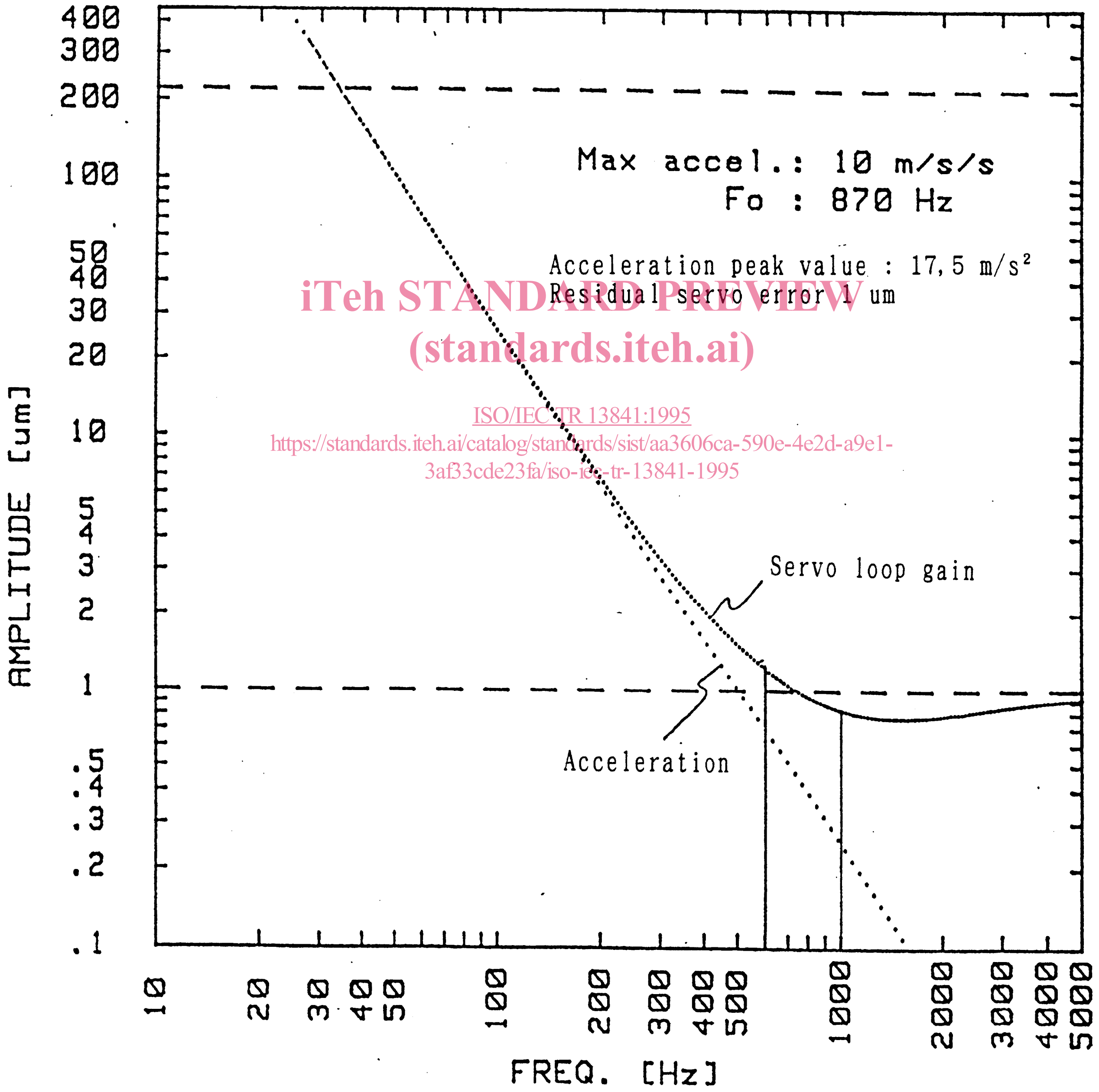
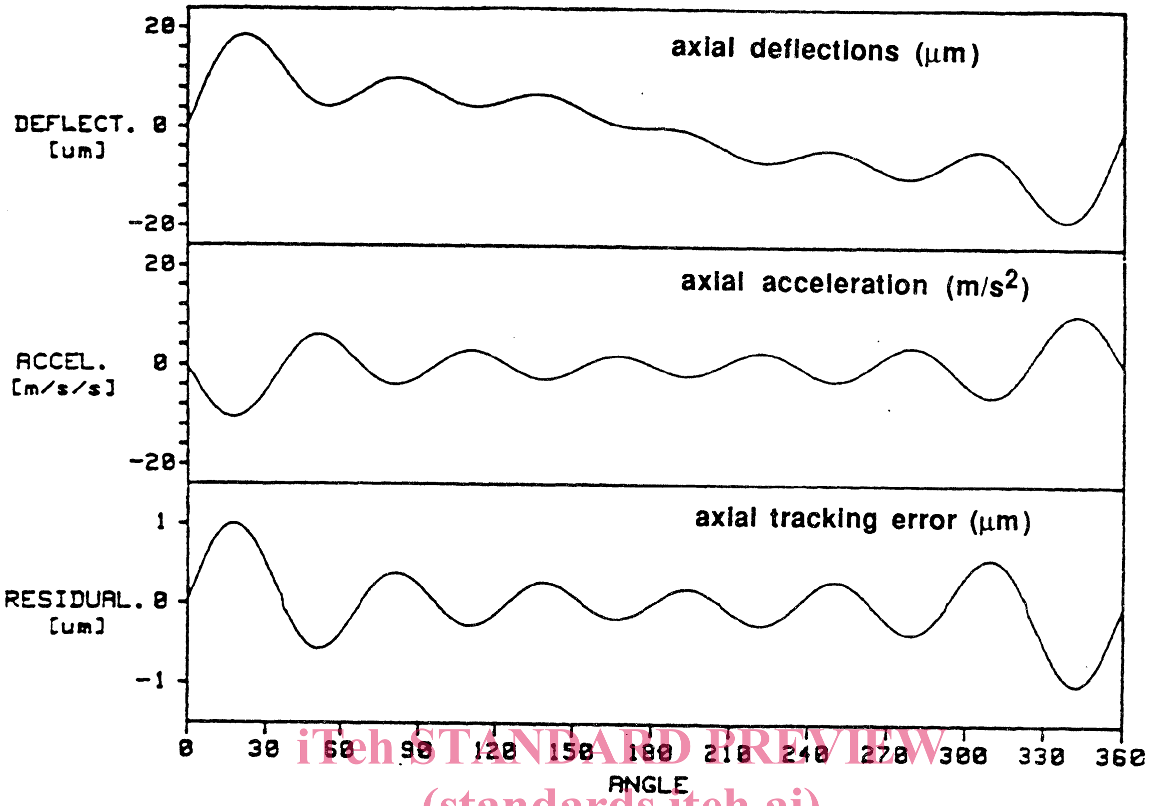


Figure 4 - Ratio between acceleration and servo loop gain

Case A : A disk with only low frequency components of the axial deflection.



Case B : A disk with low and high frequency components of the axial deflection.

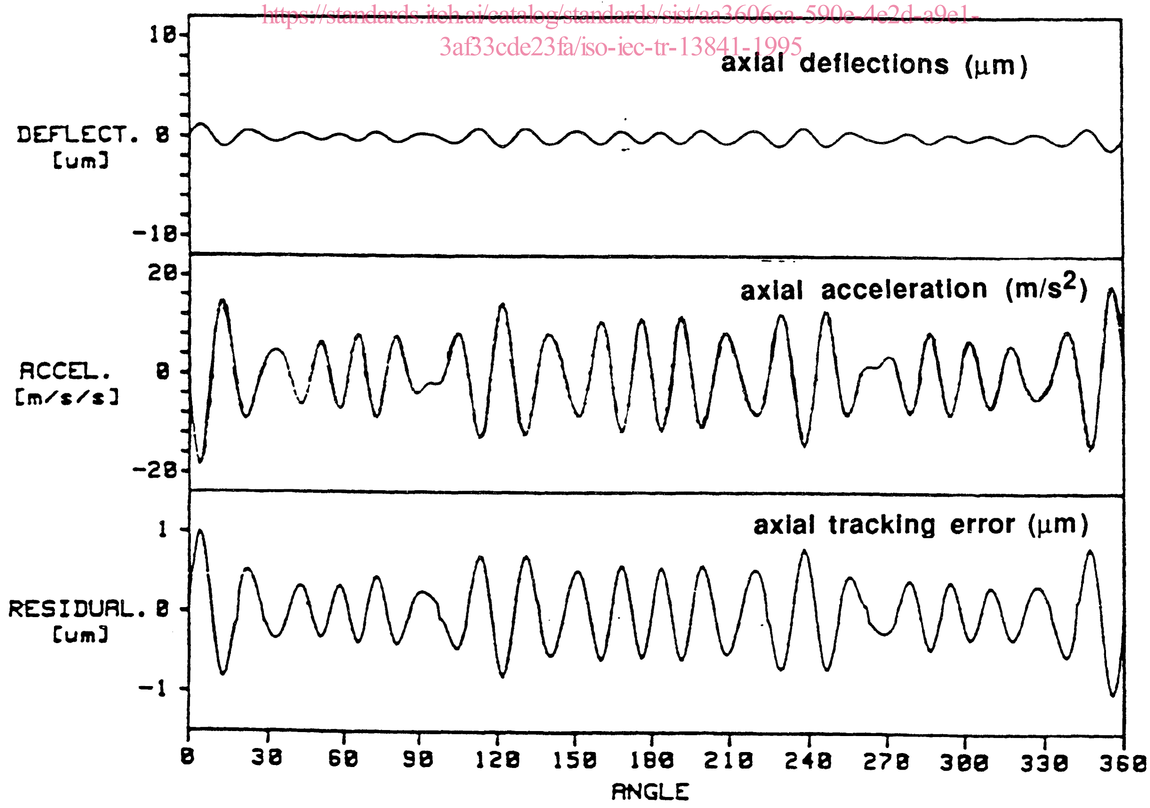


Figure 5 - Simulation of mechanical characteristics of the disk

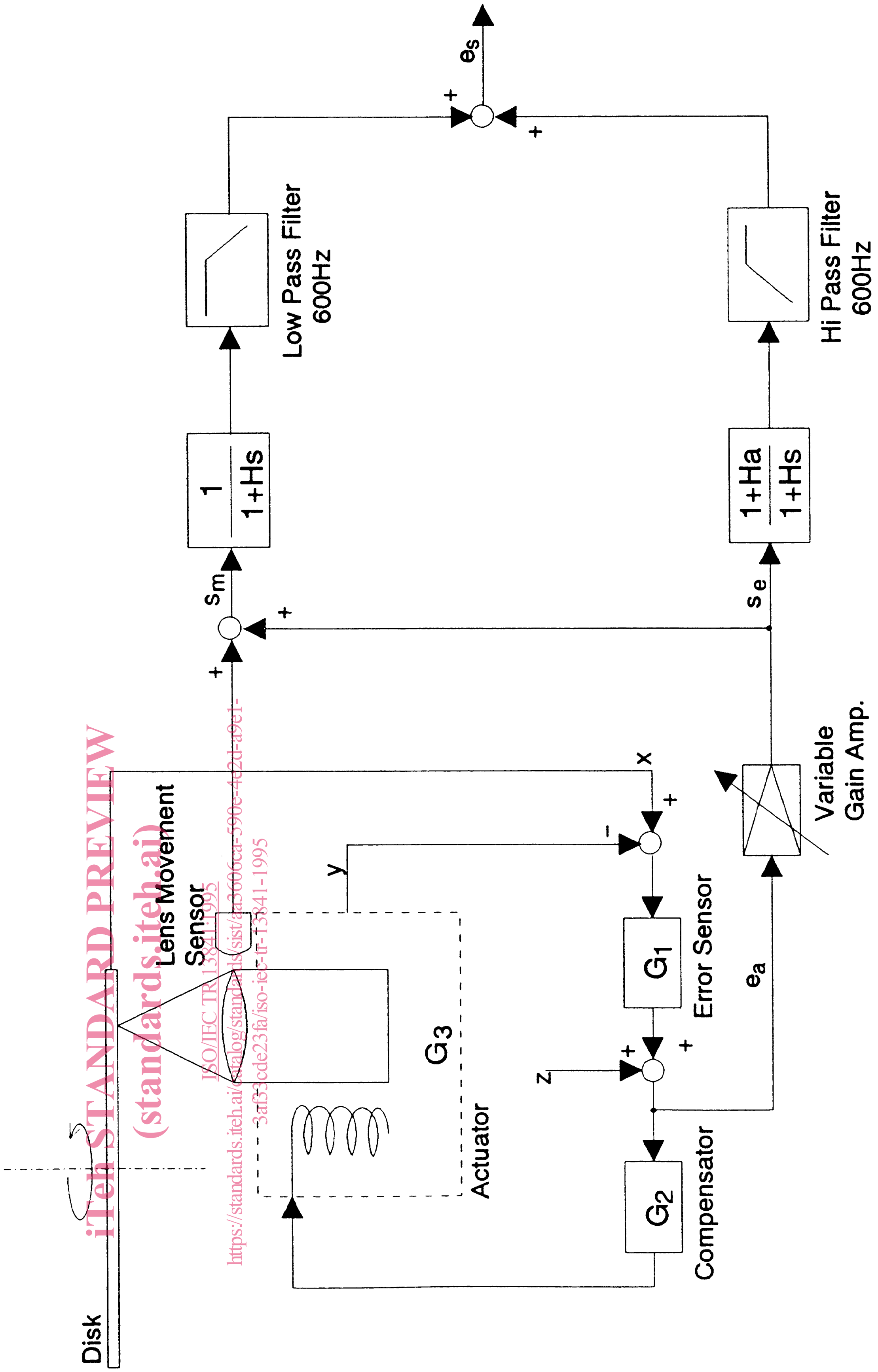


Figure 6 - Measurement system