

Methods of

Measurement on receivers for television broadcast transmissions —

Part 7: HDTV displays

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ICS 33.160.20

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National foreword

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Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, the EN title page, pages 2 to 56 and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

This British Standard, having been prepared under the direction of the Electrotechnical Sector Board, was published under the authority of the Standards Board and comes into effect on 15 July 1997

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ISBN 0 580 27736 4

Amendments issued since publication

Amd. No.	Date	Comments

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ICS 33.160.20

Descriptors: Television receivers, HDTV, display devices, LCD, electrical properties, measurements, tests, characteristics, images, synchronisation, quality, luminance, colours

English version

Methods of measurement on receivers for television Part 7: HDTV displays

(IEC 60107-7:1997)

Méthodes de mesures pour les
récepteurs de télévision
Partie 7: Dispositifs de
visualisation TVHD
(CEI 60107-7:1997)

Meßverfahren für Empfänger von
Fernseh-Rundfunksendungen
Teil 7: HDTV-Wiedergabeeinrichtungen
(IEC 60107-7:1997)

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Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CENELEC member.

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European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

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Foreword

The text of document 100A/23/FDIS, future edition 1 of IEC 60107-7, prepared by SC 100A, Multimedia end-user equipment, of IEC TC 100, Audio, video and multimedia systems and equipment, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as EN 60107-7 on 1997-03-11.

The following dates were fixed:

- latest date by which the EN has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 1997-12-01
- latest date by which the national standards conflicting with the EN have to be withdrawn (dow) 1997-12-01

Annexes designated “normative” are part of the body of the standard.

Annexes designated “informative” are given for information only.

In this standard, Annex ZA is normative and Annex A informative.

Annex ZA has been added by CENELEC.

Endorsement notice

The text of the International Standard IEC 60107-7:1997 was approved by CENELEC as a European Standard without any modification.

In the official version, for Annex A, Bibliography, the following note has to be added for the standard indicated:

IEC 65 NOTE Harmonized, together with its amendments 1:1987, 2:1989 and 3:1992, as EN 60065:1993 (modified).

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1 General

1.1 Scope and object

This part of IEC 107 deals with the standard conditions and methods of measurement on high definition television (HDTV) displays. Such displays may be used as an integral part of an HDTV receiver for direct off-air reception, reception via cabled networks, or as a monitor for pre-recorded video, home movies and games, among other applications.

This standard deals with the determination of performance, and permits the comparison of equipment by listing the characteristics which are useful for specifications and by laying down uniform methods of measurement for these characteristics. Performance requirements are not specified.

This standard does not deal with general safety matters, for which reference should be made to IEC 65 [1]¹⁾ or other appropriate IEC safety standards.

NOTE Methods of measurement on wide-screen displays for conventional television signals are dealt with in IEC 60107-1.

1.2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of IEC 107. At the time of publication, the editions indicated were valid. All normative documents are subject to revision, and parties to agreements based on this part of IEC 107 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. Members of ISO and IEC maintain registers of currently valid International Standards.

IEC 68, *Environmental testing*.

IEC 68-1:1988, *Environmental testing — Part 1: General and guidance*.

IEC 60107-1:1997, *Methods of measurement on receivers for television broadcast transmissions — Part 1: General considerations — Measurements at radio and video frequencies*.

IEC 60107-2:1997, *Methods of measurement on receivers for television broadcast transmissions — Part 2: Audio channels — General methods and methods for monophonic channels*.

ITU-R Recommendation BT.471-1:1994, *Nomenclature and description of colour bar signals*.

1.3 Definitions

For the purpose of this part of IEC 107, the following definitions apply:

1.3.1

HDTV display

integral part of an HDTV receiver or a monitor for displaying picture information carried by the HDTV video signals defined in the Recommendation ITU-R BT.709-1 [2] or similar signals with an aspect ratio of 16 : 9

it may include audio amplifiers and loudspeakers

NOTE 1 The ITU-R Recommendation BT.709-1 [2] defines basic parameters of HDTV signals and their signal formats for 1125/60/2:1 and 1250/50/2:1 systems.

NOTE 2 Conventional television displays with an aspect ratio of 16 : 9 are not dealt with by this standard. This type of display is dealt with by the future IEC/FDIS 107-1.

1.3.2

luminance

in a given direction, the luminous intensity per unit of projected area of any surface as viewed for that direction

the luminance value is expressed in candela per square metre

1.3.3

chromaticity

property of colour stimulus defined by its chromaticity co-ordinates (x , y) of the CIE 1931 standard colorimetric system [3], or chromaticity co-ordinates (u' , v') of the CIE 1976 uniform chromaticity system [3]

¹⁾ Figures in square brackets refer to the bibliography given in Annex A

1.4 Types of displays

HDTV displays in this standard include direct-view types using a cathode ray tube (CRT) and liquid crystal display (LCD), and projection types using CRTs and LCDs.

It is assumed that the displays are equipped with input terminals for analogue baseband signals.

2 General notes on measurements

2.1 General

Measurement shall be made in accordance with the following conditions to ensure repeatable results.

If audio channels and loudspeakers are provided, characteristics of the audio channels shall be measured by the methods specified in IEC 60107-2.

2.1.1 Operation conditions

Unless specified otherwise in the relevant clauses, both the audio and picture parts shall be in operation and the scanning circuits shall be properly synchronized. The contrast and brightness controls should be set at the standard settings specified in 2.5. If different values are used, they shall be noted with the results.

2.1.2 Presentation of results

Measurement results shall be listed in a table or presented graphically. However, the relationship between two or more quantities is often more clearly represented in a graph than as a table.

When the results of a point-by-point measurement for an individual sample are presented as a continuous curve in a graph, the measured points shall be clearly indicated. Extrapolated, theoretical or other information presented, but not based on direct measurement, shall be clearly distinguished from measured curves, for example by another style of drawing. Linear or logarithmic scales are recommended for graphical presentation. Linear decibel scales are equivalent to logarithmic scales.

If deviations from the recommended method are adopted, these shall be clearly stated with the results. When known, the accuracy of measuring instruments shall also be given.

2.1.3 Environmental conditions

Measurements and mechanical checks may be carried out at any combination of temperature, humidity and pressure within the following limits:

- ambient temperature: 15 °C to 35 °C, preferably 20 °C;
- relative humidity: 25 % to 75 %;
- air pressure: 86 kPa to 106 kPa.

If the manufacturer finds it necessary to specify climatic conditions differing from the above, these should be chosen from IEC 68-1 and the measurements shall be made under these specified conditions.

The conditions mentioned above represent those under which the equipment is required to meet its specifications. Over a wider range, the equipment may operate but not meet all of its specifications and it may be permissible to store the equipment under much more extreme conditions. For more complete discussion of these concepts, reference should be made to IEC 68.

2.1.4 Precautions during measurement

When carrying out measurements, all test conditions or operations which may lead to damage of the display shall be avoided. This applies particularly to sensitive, solid-state devices and similar constructions.

If a protective cover is removed and parts that are directly connected to the mains become accessible, the equipment shall be connected to the a.c. mains via a safety transformer, the secondary winding of which is insulated in accordance with the principle of double insulation.

It shall be ascertained that the use of a safety transformer does not influence the receiver properties to be measured. In particular, the internal impedance of the safety transformer shall be sufficiently low for the behaviour of the display to be the same as when directly connected to the mains supply.

2.1.5 Power supply

Measurements of the display characteristics shall be carried out at the rated voltage of the power supply. The fluctuation of the power supply voltage during the tests shall not exceed $\pm 2\%$. When a.c. mains are used, the frequency fluctuation and the harmonic components of the power supply shall not exceed $\pm 2\%$ and 5% respectively.

To determine the influence of variations in the supply voltages on the display characteristics, supplementary measurements may be needed at overvoltages and undervoltages, these being chosen appropriately with due regard to the manufacturer's specifications.

2.1.6 Stabilization period

In order to ensure that when measurement begins, characteristics do not change significantly with time, the display shall be operated under standard measuring conditions for a sufficient period to permit the characteristics to stabilize.

2.1.7 Test room

Measurements shall be carried out in a room that is not subject to disturbing external interference from electromagnetic fields. If interference may effect the results, the measurements shall be carried out in a screened room.

2.2 Input signals

2.2.1 Video signals

Input video signals to the display shall be $Y P_B P_R$ component signals where

- Y is the luminance signal;
- P_B is the B-Y signal;
- P_R is the R-Y signal.

The synchronizing signal shall be a composite sync signal consisting of tri-level, bipolar line synchronizing pulses and field synchronizing pulses.

The Y signal shall be accompanied by the synchronizing signal.

Some displays may require R, G, and B signals instead of the $Y P_B P_R$ component signals. Such displays require that the synchronizing signal or line and field driving pulses be separate.

NOTE Some displays can be operated by negative synchronizing pulses.

2.3 Test signals

2.3.1 Video test signals (general remarks)

Waveforms of test signals and test patterns shown in this clause are examples; however, other signals with similar characteristics may also be used.

The amplitude of a picture component is measured from the blanking level and expressed as a percentage to the amplitude of the reference white level. The black level coincides with the blanking level.

The white reference level can be obtained from the Y signals for composite test patterns, colour bars and staircase signals, which are defined in this subclause.

NOTE In order to avoid excessive overshoots of the signal waveform which may occur in the display under test, high-frequency components of the video signal beyond the nominal frequency bandwidth of the system should be attenuated by suitable low-pass filters.

2.3.1.1 Composite test pattern signal

A composite test pattern signal comprises a combination of monochrome and colour signal components that offer as much information as possible on the performance of the displays. Such a pattern should include at least the following items:

- circles and equidistant horizontal and vertical lines for linearity and colour convergence checks;
- a marking to check the visible picture size (see 4.1.3);
- a known brightness scale comprising 5 to 10 brightness steps for gradation checks;

- vertical and horizontal definition wedges in the centre and in the four corners of the picture area;
- vertical bars of different widths or a wedge and horizontal blocks giving black-white and white-black transitions for checking overshoot, reflections and low-frequency response;
- areas at the reference white level and black level to check the maximum and minimum brightness of the picture;
- coloured areas to check decoding operation, colour transitions and luminance/chrominance time equalization.

An average picture level (APL) of the pattern signal should be approximately 50 %.

2.3.1.2 Colour bar signal

A colour bar signal consists of vertical bands of colours in order of descending luminance, left to right, as defined in Recommendation ITU-R BT.471-1. For the measurements of the display, a 100 % colour bar signal consisting of (100/0/100/0) bars shall be used (for the nomenclature of bars, refer to ITU-R BT.471-1).

R, G and B primary bar signals are shown in Figure 1.

Y, P_B and P_R bar signals shall comply with the HDTV standard used. Waveforms of the signals are shown in Figure 2.

2.3.1.3 Black and white cross-hatch pattern signals

The white cross-hatch pattern signal produces a white cross-hatch on a black background and the black cross-hatch pattern signal produces a black cross-hatch on a white background.

The white cross-hatch pattern is used to measure convergence errors or registration errors of displays, and the black cross-hatch pattern is used as a scale for locating a point on the screen and other purposes.

The cross-hatch pattern consists of equidistant horizontal and vertical lines which form rectangular windows. The screen has 13 and 21 lines, respectively, as shown in Figure 3.

These patterns require Y signal only.

2.3.1.4 Full white and full black signals

The full white and full black signals are flat level Y signals whose amplitudes are set at 100 % and 0 % as shown in Figure 4.

These signals are used to measure luminance and other characteristics of a display.

2.3.1.5 White window signal

The white window signal is a Y signal which produces a white rectangular window on a black background as shown in Figure 5. The width of the window is half the picture height. The signal amplitude of the window is variable from 10 % to 100 %.

This signal is used to measure luminance of a display.

2.3.1.6 Black and white window signal

The black and white window signal is a Y signal which produces a white rectangular window and four black rectangular windows on the 50 % grey background as shown in Figure 6.

The size of the windows is 2/15th of the picture height.

This signal is used to measure contrast of a display.

NOTE This signal is adopted by the ITU-R Recommendation BT.815-1 [4]. Detailed parameters of the signal are described in this Recommendation.

2.3.1.7 Line and window signal

The line and window signal is a Y signal which consists of two vertical white lines placed at the left and right sides of the picture and a window placed at the centre as shown in Figure 7. The background is set at black level.

This signal is used to measure local picture distortion due to variation of the CRT beam current.

2.3.1.8 Composite sine-wave signal

The composite sine-wave signal consists of a variable-frequency sine-wave component superimposed on a 50 % Y level with a peak-to-peak amplitude of 40 % as shown in Figure 8. The frequency of the sine-wave is variable from 100 kHz to 30 MHz.

This signal is mainly used to measure amplitude-frequency response of the luminance channel.

2.3.1.9 Multiburst signal

The multiburst signal comprises a white reference pulse and seven bursts of discrete frequencies from 1 MHz to 30 MHz. The frequency bursts having a peak-to-peak value of 40 % are superimposed on a 50 % Y level. Its waveform is shown in Figure 9.

This signal is used to measure amplitude-frequency response of the luminance channel.

2.3.1.10 2T pulse and bar signal

The pulse and bar signal is composed of a sine-squared pulse and a sine-squared bar on the same line. The pulse width at the half amplitude and the rise time of the bar are equal to $2T$:

$$2T = \frac{1}{f_v}$$

where

f_v is the nominal frequency bandwidth of the video signal;

$2T = 33$ ns for a 30 MHz bandwidth.

Duration of the bar is $36/128$ H when measured at its half amplitude (H equals the line scan period).

A line-time waveform of the signal is shown in Figure 10.

This signal is used to measure linear waveform response of the video channel.

2.3.1.11 Horizontal bar signal

The horizontal bar signal is a Y signal which produces a horizontal white bar, whose width is equal to one half of the picture height, on the black background as shown in Figure 11.

This signal is used to measure low-frequency square-wave response of the video channel.

2.3.1.12 Staircase signal and APL-variable staircase signal

Generally a staircase signal with a five-riser is used as the test signal.

A line-time waveform of the five-riser signal is shown in Figure 12a.

The APL-variable staircase signal is composed of the staircase signal of one line and flat level signals of four lines. The average picture level of the total signal can be adjusted in a range of 10 % to 90 % by varying the amplitude of the flat level signals from 0 % to 100 %. A waveform of the signal is shown in Figure 12b.

These signals are used to measure line-time non-linearity of the video channel.

2.3.1.13 PLUGE signal

The signal arranges narrow black horizontal stripes on the left-hand side, two black stripes on the right-hand side and a white window on the black background as shown in Figure 13. The levels of the left and right stripes are alternately set at 11 and 21 measured with an eight bit quantizing level, while the levels of the white and black correspond to 235 and 16, respectively.

This signal is used to set the black level and to measure the peak white level.

NOTE This signal is adopted by the ITU-R as Recommendation BT.814-1 [5]. Detailed parameters of the signal are described in this Recommendation.

The acronym, PLUGE, is derived from "Picture Line-up Generating Equipment".

2.3.1.14 Checkered pattern signal

The checkered pattern comprises checkered patterns on the left and right sides and a vertical line in the middle as shown in Figure 14. The background of the pattern is set at a 25 % level. The checker consists of black and white square blocks with a width of one ninth of the picture height.

This pattern is used to test the pulling on whites.

2.3.2 Audio test signals

- a) 1 kHz sine-wave signal
- b) Frequency-variable sine-wave signal

The sine-wave signal operates in a frequency range of 50 Hz to 15 kHz.

2.4 Test instruments

2.4.1 Video test signal generator

The video test signal generator shall be capable of generating the test signals specified in 2.3.1 in the form of $Y_{PB}P_R$ component signals of the system for which the display under test is designed.

Measurements of the colour difference channel require the test signal with a single colour component (R, G or B). Measurements of the synchronizing range require a test generator with variable line and field frequencies.

2.4.2 Audio test signal generator

The audio test signal generator shall be capable of generating the test signals specified in 2.3.2 with an output level of 0,5 V r.m.s. across 47 k Ω .

2.4.3 Oscilloscope

A conventional oscilloscope covering the video frequency range can be used. It is, however, necessary to prepare a very low capacitance probe when measuring the characteristics of the video channel at the CRT electrodes.

2.4.4 Luminance meter and colorimeter

The luminance meter (photometer) shall be capable of measuring the luminance of a small area on the screen within a range of 0,2 cd/m² to about 1 000 cd/m².

The colorimeter shall be capable of measuring the chromaticity of a small area on the screen as chromaticity co-ordinates (x, y) or (u', v') at a luminance level lower than 2 cd/m². For precise measurement of the chromaticity co-ordinates, a colorimeter of spectrometer type is required.

The area should be a circle with a diameter less than 4 % of the screen width.

When measuring projection type displays and LCD displays, the luminance and chromaticity are measured at a location away from the screen. For this purpose, meters with a telescopic lens are required.

2.4.5 Other optical measuring instruments

A sliding gauge or a cathetometer is required for measuring geometric distortion of the picture. When measuring viewing angles of projection and LCD displays, it is necessary to set the luminance meter on a stand with the scales of azimuth and elevation angles. When measuring a screen gain of a projector, an illuminance meter may be required.

2.4.6 Measurement set-up

A notional block diagram of the measurement set-up is shown in Figure 15.

2.5 Standard measuring conditions

Unless otherwise specified, the conditions described in this subclause shall be applied.

2.5.1 Standard input signal levels

The input voltage of each video signal shall comprise the following values at the baseband signal input terminal:

- $Y_{PB}P_R$ component signals Y: 700 mV (without sync),
 P_B : ± 350 mV (without sync),
 P_R : ± 350 mV (without sync),

when measured with a 100 % colour bar signal. The Y signal shall be combined with the sync signal;

- sync signal (tri-level): ± 300 mV.

The time difference between Y, P_B and P_R signals at the input terminals shall be within 3 ns. Care should be taken that if separate cables are used to connect output terminals of the video test signal generator and input terminals of the display, the cables are of the same type and with equal length.

If R, G, B signals are required, their levels shall be 700 mV for a white reference signal without sync signals.

The standard input voltage of the audio signal of an audio channel shall be 500 mV r.m.s. at the audio signal input terminal at 1 kHz.

2.5.2 Standard output signal levels

2.5.2.1 *Standard audio output signal levels*

The standard output power of an audio channel shall be a power 10 dB lower than the rated output power at 1 kHz when terminated with a resistor equal to the impedance of the speaker measured at 1 kHz.

2.5.3 Standard display settings

2.5.3.1 *Input signal levels*

The standard levels specified in 2.5.1. shall be used.

2.5.3.2 *Contrast and brightness of the picture*

Contrast and brightness controls shall be set to their normal positions when these are recommended, or preset by the manufacturer. If such positions are not given, the contrast and brightness controls shall be adjusted using the composite test pattern for optimum picture quality, and the settings shall be stated with the results.

The contrast setting and the video output voltage for the display under these conditions are defined as “**normal contrast setting**” and “**normal brightness setting**”, respectively.

2.5.3.3 *Picture (quality enhancement) control or switch*

The picture (quality enhancement) control or switch, if provided, shall be set at the normal quality position.

2.5.3.4 *Colour (saturation) and hue controls*

The colour (saturation) and hue controls, if provided, shall be set to their normal positions. If such positions are not indicated, these controls shall be set to the best picture quality with the colour bar signal specified in 2.3.1.

2.5.3.5 *Sync control(s)*

The sync control(s), if provided, shall be set at the centre within the pull-in range.

2.5.3.6 *Automatic brightness control*

If provided, the automatic brightness control shall be disabled.

2.5.3.7 *Audio controls*

If audio amplifiers and loudspeakers are provided, the audio controls shall be adjusted as follows:

- the volume control of the audio signal(s) shall be set to obtain the standard audio output specified in 2.5.2.1;
- the tone control of the audio signal(s), if provided, shall be set to the mechanical centre or adjusted to obtain the flattest audio-frequency response at the output;
- the balance control of the stereo sound, if provided, shall be set to obtain equal output for both the left and the right channels.

2.5.3.8 *Other controls*

Other user controls, if provided, shall be set at the positions to obtain the best picture and sound. If internal adjustments such as focus, white balance, purity and convergence are necessary, these shall be set to obtain the best picture quality.

2.5.4 General measurement procedure

Unless otherwise specified, the following measurement procedure shall be applied:

- before starting each measuring item, the display under test is set to the standard display settings specified in 2.5.3 at the rated power supply voltage;
- audio signals are not present unless required in the method of measurement;
- input video signals are in the form of YP_BP_R component signals.

3 Tests under general operating conditions

3.1 Electrical and mechanical performance

3.1.1 Introduction

These tests are intended to check if the display under test has sufficiently normal performance to justify continuing with the detailed measurements described later in this standard.

If any unacceptable performance is found, further measurements should not be carried out. The following are examples of phenomena which are considered to be unacceptable:

- loss of synchronization;
- loss of resolution;
- distortion of grey scale;
- noise effects on picture or sound;
- errors of colour reproduction;
- spurious colour effects;
- audio distortion.

3.1.2 Methods of measurement

3.1.2.1 Performance of user controls

- a) Apply programme signals or test signals in accordance with the television standard to the display at the standard input signal level specified in **2.5.1**.
- b) Check the picture and audio quality and also examine the electrical and mechanical performance and functions of user controls including remote controls at various control settings.

3.1.2.2 Performance for input signal levels

- a) Apply the composite test pattern signal and 1 kHz audio signal(s) to the display at the standard input signal level and set the display to the standard settings specified in **2.5.3**.
- b) Check the operation of the display at levels of ± 3 dB with reference to the standard input levels.

3.1.2.3 Continuous operation

- a) Apply the composite test pattern signal and 1 kHz audio signal(s) to the display at the standard input signal level and set the display to the standard settings specified in **2.5.3**.
- b) Operate the display for six hours and check if unacceptable performance is found.

3.1.2.4 Influence of variations in power supply voltage

Although measurements at the undervoltage and overvoltage are specified for characteristics which may be sensitive to variations in the power supply voltage, other characteristics may also be influenced by these variations. Therefore, the following test shall be carried out:

- a) vary the power supply voltage of the display within a range of the overvoltage and undervoltage and check changes in performance such as loss of picture synchronization, variation of picture size and variation of black level;
- b) if such changes are able to be adjusted by the user controls, readjust them and repeat the test. If normal performance cannot be obtained even when the readjustments are made, or no user controls are provided, note the phenomena.

If necessary, make supplementary measurements for the relevant characteristics at the under- and overvoltages of the power supply.

NOTE The range of the variations is normally ± 10 % of the rated voltage. If different values are specified by the manufacturer, apply such values.

3.2 Power consumption

3.2.1 Method of measurement

3.2.1.1 Measuring conditions

- a) Power supply voltage and frequency: rated
- b) Video test signal: colour bar signal

- c) Audio test signal(s): 1 kHz sine-wave signal(s)
- d) Input signal level: standard input signal level

3.2.1.2 Measurement procedure

- a) Set the display under test to the standard settings. The volume control of all the audio channels shall be set to obtain an output power of 50 mW at a 1 kHz single-tone signal.
- b) Measure power consumption of the display with an electrodynamic wattmeter or any other wattmeter of sufficient accuracy.

If any ancillary circuits are included in the display, the power shall be measured with and without loading the circuits.

NOTE If government regulations in the country for which the display is designed to be used specify any other method, the test should be made in accordance with those regulations.

4 Characteristics of displayed pictures

4.1 General properties of the picture

4.1.1 General

The methods described in the following subclauses are applicable to any type of display, except for the characteristics inherent in the display devices. For projection type displays and LCD displays, see 4.3 and 4.4 respectively.

Unless otherwise specified, the display under test is set to the standard display settings specified in 2.5.3. CRT displays may be influenced by the terrestrial magnetic field. For this reason the display under test shall be placed facing either north or south and the CRT shall be sufficiently degaussed before starting the measurements.

Test items including luminance and chromaticity measurements shall be carried out in a darkroom.

4.1.2 Geometrical distortion

4.1.2.1 Introduction

This test measures geometrical non-linearity and outline distortion of a picture displayed on a CRT screen and a picture projected by CRTs or LCDs on a screen.

The outline distortion can be classified into the following shapes:

- first order distortion: trapezium and parallelogram distortion;
- second order distortion: barrel or pincushion distortion;
- third order distortion: S shape distortion;
- fourth order distortion: gull wing (GW) distortion.

Examples of these distortions are given in Figure 16.

Normally, there is no outline distortion higher than the fifth order, but distortion higher than the second order contains first order distortion.

In some cases, distortion of picture shape is recognized within the picture and is called “**inner distortion**”. It mainly appears as the second order distortion. If such distortion is excessive, it should also be measured. The terrestrial magnetic field influences the picture geometries by the first order parallelogram distortion, especially detectable on large CRTs.

The display shall be placed facing either north or south to maximize the influence. If the display is equipped with a compensation circuit for the terrestrial magnetic field, the circuit shall be adjusted before starting the geometry measurement.

4.1.2.2 Methods of measurement

Geometrical distortion is measured by a white cross-hatch pattern signal specified in 2.3.1 and a sliding gauge, cathetometer or camera. When the screen has a curvature, as is the case with a CRT screen, the measurements shall be made on the picture projected to a virtual plane tangential to the centre of the screen face.

Care should be taken when using a camera to measure distortion, since a camera lens itself has geometrical distortion.

4.1.2.2.1 *Measuring conditions*

- a) Video test signal: white cross-hatch pattern signal.
- b) Compensation circuit for the terrestrial magnetic field: if provided, it is adjusted until the horizontal lines of the test pattern on the top and the bottom of the screen are parallel to the screen border.

4.1.2.2.2 *Measurement procedure (geometrical non-linearity)*

- a) Apply the test signal to the display.
- b) Measure distances between two adjacent vertical lines at their intersections with the horizontal centre line of the hatch from the left to the right and calculate a mean distance $\bar{X}_h$ using the following equation:

$$\text{mean horizontal distance } \bar{X}_h = \frac{H_1 + H_2 + \dots + H_n}{n}$$

where

H_1 to H_n are the distances between adjacent vertical lines;

n is the number of distances measured.

- c) Measure distances between two adjacent horizontal lines at their intersections with the vertical centre line of the hatch from the top to the bottom and calculate a mean distance $\bar{X}_v$ using the following equation:

$$\text{mean vertical distance } \bar{X}_v = \frac{V_1 + V_2 + \dots + V_m}{m}$$

where

V_1 to V_m are the distances between adjacent horizontal lines;

m is the number of distances measured.

- d) Calculate the non-linearity using the following equations:

$$\text{horizontal non-linearity } DH_i = \frac{H_i - \bar{X}_h}{\bar{X}_h}$$

$$\text{vertical non-linearity } DH_j = \frac{V_j - \bar{X}_v}{\bar{X}_v}$$

where

$i = 1$ to n ;

$j = 1$ to m .

- e) The results are plotted on a graph with the distance numbers as abscissa and linearity values on a percentage scale as ordinates.

4.1.2.2.3 *Measurement procedure (outline distortion)*

- a) Mark the corner points A, B, C and D on the largest visible rectangle formed by the test pattern.
- b) Draw the auxiliary lines AB, BC, CD, DA, KF and HE so that AE = EB, BF = FC, CH = HD and DK = KA as shown in Figure 18a. Then draw the line ME', which is orthogonal to line KF, from the crosspoint M of lines KF and HE and measure the angle α between ME' and ME in degrees with a plus or minus sign. The sign is determined as plus when the angle is measured anti-clockwise from ME'.
- c) Measure the distance of the peak of each curve from line AB on the top side contour between A and B and name them as α_i ($i = 1, 2, 3, \dots$) from left to right. If α_i is on the outside of the quadrilateral ABCD, add a plus (+) sign to the measured value and if it is on the inside of ABCD, add a minus (-) sign to the measured value. In some cases, all the values may have the same sign as is shown in Figure 18b.

d) Measure the distance of the peak of each curve from line BC on the right side contour between B and C and name them as b_i from top to bottom. The sign is added to the measured value in the same way as above.

e) Measure the distances c_i on the bottom side and d_i on the left side in a similar manner.

f) If the number i counts to one only, the contour has the second order distortion in which the plus sign corresponds to barrel distortion and the minus sign to pincushion distortion. If i counts up to two, the contour has the third order distortion (S shape distortion) and if i counts up to three, it has the fourth order distortion (GW distortion). If i counts more than three, it is called the higher order distortion.

If the number i counts to two or more, the rate of the distortion shall be calculated at each measured value, and the shape of each contour recorded with a simple sketch.

g) Calculate the distortion using the following equations:

— First order distortion

$$\text{horizontal trapezium distortion} \quad T_H = \frac{AD - BC}{AD + BC} \times 100\%$$

$$\text{vertical trapezium distortion} \quad T_V = \frac{AB - DC}{AB + DC} \times 100\%$$

$$\text{parallelogram distortion} \quad \alpha \text{ degree}$$

— Second or higher order distortion

$$\text{top contour} \quad T_i = \frac{4 a_i}{AD + BC} \times 100\%$$

$$\text{bottom contour} \quad B_i = \frac{4 c_i}{AD + BC} \times 100\%$$

$$\text{left contour} \quad L_i = \frac{4 d_i}{AB + DC} \times 100\%$$

$$\text{right contour} \quad R_i = \frac{4 b_i}{AB + DC} \times 100\%$$

$i = 1$: barrel or pincushion (depending on the sign)

$i = 1$ to 2: S shape

$i = 1$ to 3: GW

The results shall be presented in a table formatted as shown below:

Distortion		i		
Side	Shape	1	2	3
Top		T_1	T_2	T_3
Bottom		B_1	B_2	B_3
Left		L_1	L_2	L_3
Right		R_1	R_2	R_3
NOTE If higher order distortion than the fourth exists, it is calculated and presented in a similar manner.				

4.1.2.2.4 Measurement procedure (inner distortion)

a) Observe the cross-hatch pattern in the quadrilateral ABCD and if a large distortion is found in the left part of the pattern, shown as bending of a vertical line of the hatch, take its intersections with line AB and CD as A' and D' as shown in Figure 19 and count its line number from the left edge. Take points B' and C' in the right part of the pattern and count the line number in the same way.

b) Measure the distance d'_1 of the cross-hatch line from line A'D' and the distance b'_1 from line B'C' in the same way as specified in the outline distortion.