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BSI Standards Publication

Electronic displays

Part 3-1: Evaluation of optical performances - Colour difference based viewing direction dependence

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National foreword

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Electronic displays –
Part 3-1: Evaluation of optical performances – Colour difference based viewing direction dependence

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ELECTRONIC DISPLAYS –

Part 3-1: Evaluation of optical performances – Colour difference based viewing direction dependence

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Technical specifications are subject to review within three years of publication to decide whether they can be transformed into International Standards.

IEC TS IEC 62977-3-1, which is a technical specification, has been prepared by IEC technical committee 110: Electronic displays.

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The text of this technical specification is based on the following documents:

Draft TS	Report on voting
110/1003/DTS	110/1065/RVDTS

Full information on the voting for the approval of this technical specification can be found in the report on voting indicated in the above table.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all the parts in the IEC 62977 series, under the general title *Electronic displays*, can be found on the IEC website.

Future documents in this series will carry the new general title as cited above. Titles of existing standards in this series will be updated at the time of the next edition.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

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INTRODUCTION

This document aims to provide a measurement method that determines the display angular dependence after colour and white reference adaptation and provides an evaluation of differences in a uniform colour space.

This document facilitates the cross-industry measurement of the viewing direction dependence of colour displays. Several studies [6 to 9][1] have indicated that the contrast ratio (CR > 10:1) is, from a visual quality point of view, not useful to determine the viewing direction range for matrix displays. When colour differences are included in a viewing direction metric, the correlation between the metric value and a visual assessment value is significantly increased [10]. A more recent study [11] revealed that a metric, combining viewing-direction related luminance degradation and colour deviation can accurately predict the relative change in the visual assessment value. This information is the basis for the determination of the viewing direction range, which has relevance from a visual quality point of view.

NOTE "Viewing direction range" is sometimes referred to as "viewing angle". Although technically incorrect, for legacy reasons the terms is considered equivalent.

[1] Numbers in square brackets refer to the Bibliography.

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ELECTRONIC DISPLAYS –

Part 3-1: Evaluation of optical performances – Colour difference based viewing direction dependence

1 Scope

This part of IEC 62977 specifies the evaluation method of the viewing direction characteristics of electronic display devices under dark-room conditions. More specifically, this document focuses on the evaluation of the viewing direction characteristics based on colour difference.

This document applies to colour matrix displays, which are based on transmissive or emissive technologies.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 11664-1, *Colorimetry – Part 1: CIE standard colorimetric observers*

ISO 11664-4, *Colorimetry – Part 4: CIE 1976 L*a*b* Colour space*

ISO/CIE 11664-6:2014, *Colorimetry – Part 6: CIEDE2000 Colour-difference formula*

CIE 159, *A colour appearance model for colour management systems: CIECAM02*

CIE 168, *Criteria for the evaluation of extended-gamut colour encodings*

3 Terms, definitions and abbreviated terms

3.1 General

No terms and definitions are listed in this document.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.2 Abbreviated terms

APL	average pixel loading
CIE	Commission Internationale de L'Eclairage (International Commission on Illumination)
CIEDE2000	CIE 2000 delta-E colour difference system
CIELAB	CIE 1976 (L*a*b*) colour space
CR	contrast ratio

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DUT	device under test
FWHM	full-width-at-half-maximum
LMD	light measuring device
LCD	liquid crystal display
OLED	organic light emitting diode
PDP	plasma display panel

4 Standard measuring equipment and coordinate system

4.1 Light measuring device

The LMD shall be a luminance meter, colorimeter, or a spectroradiometer. For DUTs that have a sharp spectral peak FWHM (i. e. smaller than 20 nm), such as laser displays, LCDs with fluorescent lamp backlights, LEDs with narrow-peak phosphors, quantum-dot phosphors, or narrow-spectrum OLEDs, a spectroradiometer should be used. A filter colorimeter should generally not be used for light sources with sharp spectral peaks. If they are used, the colorimeter shall be calibrated with a narrow bandwidth spectroradiometer to give the same results for the specific spectrum. Report the spectroradiometer characteristics of the spectroradiometer which is used for calibration. For light sources with sharp spectral peaks, the maximum bandwidth of the spectroradiometer shall be ≤ 5 nm. The higher resolution spectrometer produces a more accurate colour measurement, especially for lasers sources. The spectroradiometer shall be capable of measuring spectral radiance over at least the 380 nm to 780 nm wavelength range, with a maximum bandwidth of 10 nm for smooth broadband spectra (i.e. broad spectrum with no sharp spikes)[1].

4.2 Viewing direction coordinate system

The viewing direction is the direction under which the observer looks at the point of interest on the device under test (DUT). During the measurement, the light-measuring device (LMD) simulates the observer, by aiming the LMD at the point of interest on the DUT from the viewing direction. The viewing direction is defined by two angles: the angle of inclination θ (relative to the surface normal of the DUT) and the angle of rotation φ (also called azimuth angle) as illustrated in Figure 1.

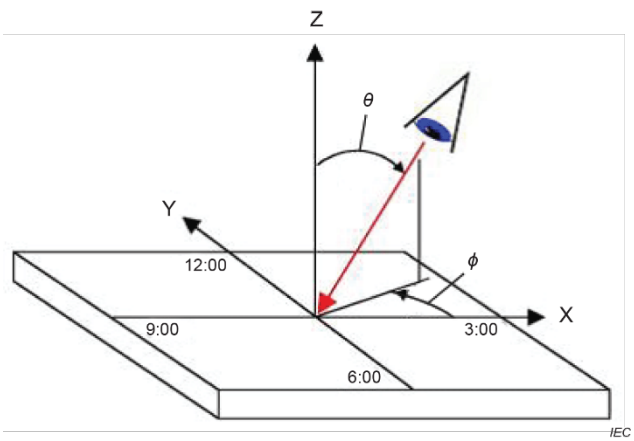

Figure 1 – Illustration of viewing directions θ and ϕ

Although the azimuth angle is measured in the counter clockwise direction, it is related to the directions on a clock face as follows: φ = 0° is the 3-o'clock direction ("right"), φ = 90° the 12-o'clock direction ("top"), φ = 180° the 9-o'clock direction ("left") and φ = 270° the 6-o'clock direction ("bottom").

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NOTE This coordinate system is defined by the angle of inclination and the angle of rotation (azimuth angle) in a polar coordinate system.

5 Measuring conditions

5.1 Standard measuring environmental conditions

Measurements shall be carried out under the standard environmental conditions:

- temperature: 25 ºC ± 3 ºC
- relative humidity: 25 % to 85 %,
- atmospheric pressure: 86 kPa to 106 kPa.

When different environmental conditions are used, they shall be noted in the report.

5.2 Power supply

A driving power supply and driving signal equipment shall be used.

5.3 Warm-up time

Measurements shall start after the displays and measuring instruments achieve stability. The DUT shall be turned on first and operated for at least 30 min prior to the measurement. Some display technologies may require a loop of colour patterns rendered on the screen during the warm-up period. Sufficient warm-up time has been achieved when the luminance of the test feature to be measured varies by less than ±3 % over the entire measurement period (e.g. uniformity measurements) for a given display image.

5.4 Standard measuring dark-room conditions

The luminance contribution from unwanted background illumination reflected off the test display shall be less than 1/20 of the display's black state luminance. The reflected background luminance can often be estimated by turning off the display. When the reflected background luminance and total (reflected plus black) luminance are greater than the sensitivity of the LMD, then it is possible to calculate the black luminance by subtracting the background luminance from the total luminance. If the reflected background luminance and total luminance are similar to the sensitivity limit of the LMD, this shall be reported. In cases where the display has a very low luminance black state, a stray light elimination tube (see ISO 9241-305 [17]) should be used to minimize the contribution of the background illumination [3]. This method can be used to estimate the reflected luminance from the black state luminance.

NOTE Blackout curtains can be used to reduce the reflection from the DUT.

5.5 Standard set-up conditions

5.5.1 General

Standard set-up conditions are given below. Any deviations from these conditions shall be reported.

5.5.2 Adjustment of display

The display shall be configured to the specified settings, and the settings recorded in the test report. These settings shall be held constant for all measurements, unless stated otherwise. It is important, however, to make sure that not only the adjustments are kept constant, but also that the resulting physical quantities remain constant during the measurement. This is not automatically the case because of, for example, warm-up effects or auto-dimming features. Any automatic luminance or gain control shall be turned off. Otherwise it shall be noted in the report. The ambient light (or brightness) control shall be turned off. If that is not possible, it is

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