IEC TS 62977-3-1

Edition 1.0 2019-02

TECHNICAL SPECIFICATION

colour inside

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

IEC TS 62977-3-1:2019-02(en)

IEC Central Office
3, rue de Varembé
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
info@iec.ch
www.iec.ch

About the IEC
The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About IEC publications
The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigendum or an amendment might have been published.

IEC publications search - webstore.iec.ch/advsearchform
The advanced search enables to find IEC publications by a variety of criteria (reference number, text, technical committee,…). It also gives information on projects, replaced and withdrawn publications.

IEC Just Published - webstore.iec.ch/justpublished
Stay up to date on all new IEC publications. Just Published details all new publications released. Available online and once a month by email.

IEC Customer Service Centre - webstore.iec.ch/csc
If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: sales@iec.ch.

Electropedia - www.electropedia.org
The world's leading online dictionary on electrotechnology, containing more than 22 000 terminological entries in English and French, with equivalent terms in 16 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

IEC Glossary - std.iec.ch/glossary
67 000 electrotechnical terminology entries in English and French extracted from the Terms and Definitions clause of IEC publications issued since 2002. Some entries have been collected from earlier publications of IEC TC 37, 77, 86 and CISPR.

IEC TS 62977-3-1

Edition 1.0 2019-02

TECHNICAL SPECIFICATION

colour inside

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

INTERNATIONAL ELECTROTECHNICAL COMMISSION

ICS 31.120; 21.260

ISBN 978-2-8322-6515-4

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

____

ELECTRONIC DISPLAYS –

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

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as “IEC Publication(s)”). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
6) All users should ensure that they have the latest edition of this publication.
7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

The main task of IEC technical committees is to prepare International Standards. In exceptional circumstances, a technical committee may propose the publication of a technical specification when

- the required support cannot be obtained for the publication of an International Standard, despite repeated efforts, or
- the subject is still under technical development or where, for any other reason, there is the future but no immediate possibility of an agreement on an International Standard.

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.

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.

A bilingual version of this publication may be issued at a later date.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

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.

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

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.

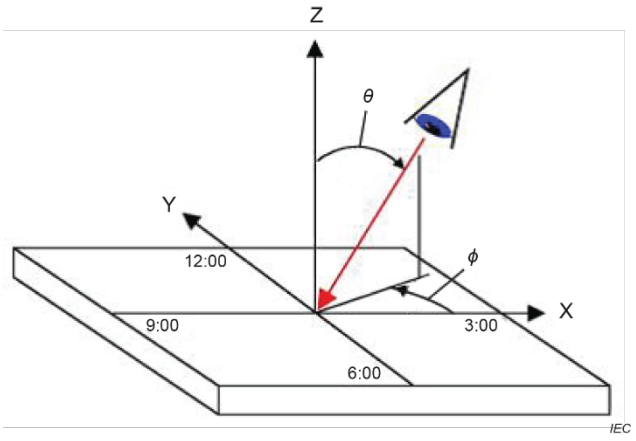


Figure 1 – Illustration of viewing directions θ and ϕ

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").

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

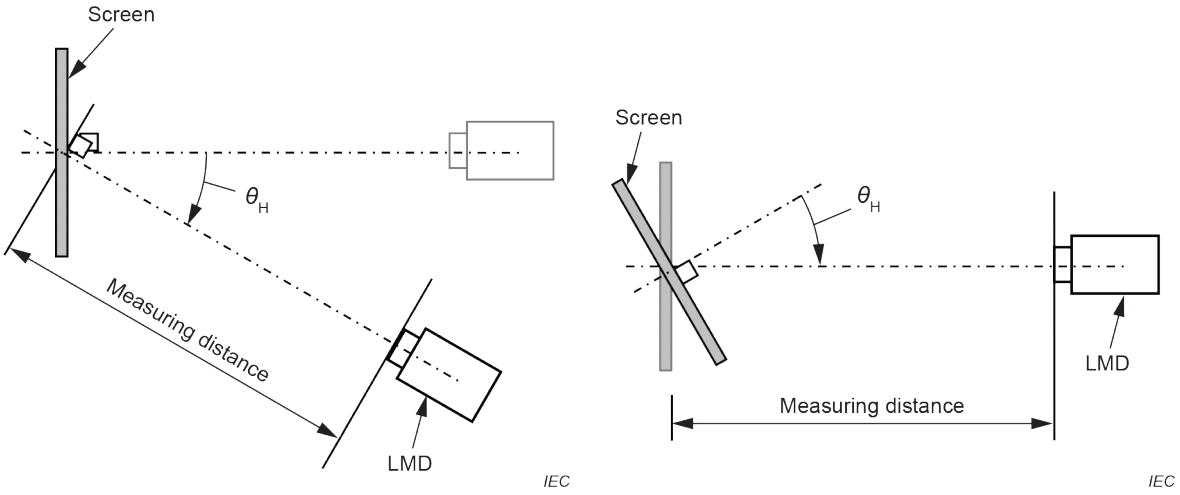
recommended to set it to turn on no lower than 300 lx to minimize the influence of the brightness control. The state of the auto-light control shall be reported. In addition, if the display exhibits image sticking and/or has an auto-dimming feature which reduces the display luminance of a static image after a prolonged time, then at least an 8-s black frame shall be rendered prior to rendering and measuring the desired test pattern. The measurements shall be completed before the dimming feature is triggered. When the display has the option to be set for different viewing modes, the viewing mode shall be defined by the test specification and used with consistency for all measurements. Additional viewing modes can also be measured. The viewing mode used during testing shall be reported. The display should be operated in a mode that does not have overscan.

6 Measurement methods

6.1 Measurement procedures

1) Render the specified test pattern with the required colour Q centred on the display screen. Allow the luminance to stabilize.
2) Align the optical axis of the LMD in the specified direction relative to the display screen and centred on the display screen.
3) Measure the tristimulus values X_Q, Y_Q, Z_Q at the screen centre.
4) Render the specified test pattern with the reference white pattern centred on the display screen. Allow the luminance to stabilize.
5) Measure the tristimulus values X_n, Y_n, Z_n at the screen centre.
6) Repeat the measurement for additional colours.
7) Report the set-up conditions, the test pattern, the colour, and tristimulus values X_Q, Y_Q, Z_Q, X_n, Y_n, Z_n at the specified colour Q, respectively.

To measure the viewing direction dependency, the centre of the screen is measured from the horizontal, vertical, or diagonal viewing directions defined in each measurement method or the relevant specification as shown in Figure 1. Instead of moving the LMD as indicated in Figure 2a) and Figure 3a), the DUT can be tilted vertically or turned horizontally to be measured as shown in Figure 2b) and Figure 3b). The recommended ranges of the direction (θ) are shown in Table 1 and Table 2 for TV in living rooms and for mobile devices, respectively. The horizontal and vertical measuring direction ranges shall be defined by the supplier in the relevant specification, and shall be noted in the report. If the customer/application requires additional direction ranges, they shall be applied and noted in the report.



a) Motion of LMD (top view) **b) Rotation of display (top view)**

Figure 2 – Measuring layout for horizontal viewing direction dependency