IEC 62977-2-2

Edition 1.0 2020-09

INTERNATIONAL STANDARD

colour inside

Electronic displays –
Part 2-2: Measurements of optical characteristics – Ambient performance

IEC 62977-2-2:2020-09(en)

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INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 31.120; 31.260

ISBN 978-2-8322-8816-0

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FOREWORD

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International Standard IEC 62977-2-2 has been prepared by IEC technical committee 110: Electronic displays.

The text of this International Standard is based on the following documents:

FDIS	Report on voting
110/1213/FDIS	110/1232/RVD

Full information on the voting for the approval of this International Standard 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 parts in the IEC 62977 series, published under the general title *Electronic displays*, can be found on the IEC website.

Future standards 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- withdrawn,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 describes the common optical measurement methods applicable in the field of electronic display devices, which overlap with some of the parts of existing documents developed inside TC 110 (IEC 61747-6-2 [17] [1], IEC 62341-6-2 [18], IEC 61988-2-2 [19], IEC 62715-5-1 [20], IEC 62679-3-1 [21]), that describe the optical measurement methods of the individual technologies, such as LCD, OLED, PDP and others. This document on common optical measurement methods is intended to be used as the reference document in future documents and in revisions of existing documents (e.g. IEC 61747-6-2 [17], IEC 62341-6-2 [18], IEC 61988-2-2 [19], IEC 62715-5-1 [20], IEC 62679-3-1 [21]). The existing standards documents will be revised in their maintenance time and they will refer to this document to the largest extent.

All documents in IEC TC 110 that are concerned with the measurement of optical properties of electronic display devices under ambient illumination refer to a set of methods and procedures that are similar to each other, or sometimes even identical. This document is intended to identify these methods and to describe them, together with suitable precautions and diagnostics, as a reference for forthcoming documents to make the work of the involved experts more efficient and to avoid duplication of efforts.

Introduction of the common optical measurement methods (COMMs) is also related to a structure where each kind of optical measurement finds its unambiguous position for identification of similarities to other methods or for clarification of distinctions. This structural classification together with a general taxonomy is supposed to make the process of documents production easier, faster and thus more effective.

The above characteristics are summarized in Table 1. The display characteristics that are addressed in this part of IEC 62977 are indicated by a check mark √ in the table.

1 Numbers in square brackets refer to the Bibliography.

Table 1 – Measurement structure from optical quantities to evaluation and to results (top down)

Variables	**Time**		**Location** (x, y)	**Direction** (θ, ϕ)	**Test pattern, electrical driving, input signal**	**Illumination conditions**	**Temperature, humidity**
Data sampling condition	**Fast**	**Slow**	**Slow**	**Slow**	**Slow** √		
Evaluation							
Results	Transitions from one optical state to another state (for example from test-pattern-1 to test-pattern-2)	Temporal stability (uniformity)	Lateral uniformity	Directional uniformity	Static pattern, √ Characteristic function (electro-optic transfer function, EOTF) Characteristic values (e.g. threshold, saturation)	Darkroom, √ Indoor, Outdoor	Standard environment √
Evaluation 1st order	Turn-on, turn-off, delay (latency) time periods, temporal modulations				Luminance, √ Contrast, √ chromaticity, √ Threshold, saturation values, steepness of transitions, etc.		
Evaluation 2nd order	Flicker prediction, moving picture response time, etc.				EOTF from which the exponent γ is evaluated Chromaticity/ colour gamut area, Colour gamut volume, √		

ELECTRONIC DISPLAYS –

Part 2-2: Measurements of optical characteristics – Ambient performance

1 Scope

This part of IEC 62977 specifies standard measurement conditions and measuring methods for determining the optical characteristics of electronic displays under indoor and outdoor illumination conditions. Standard illumination geometries are specified and the reflection properties of flat screens are determined under those conditions. Reference illumination levels and spectra are used to estimate the photometric and colorimetric characteristics of electronic displays under the same conditions. These methods apply to emissive, transmissive, and reflective displays, or combinations thereof, that render real 2D images on a flat screen.

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.

IEC 60050-845, *International Electrotechnical Vocabulary (IEV) – Part 845: Lighting*

IEC 61966-2-1, *Multimedia systems and equipment – Colour measurement and management – Part 2-1: Colour management – Default RGB colour space – sRGB*

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

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

ISO 15076-1:2010, *Image technology colour management – Architecture, profile format and data structure – Part 1: Based on ICC.1:2010*

CIE 15, *Colorimetry*

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

3 Terms, definitions, abbreviated terms and symbols

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60050-845 and the following apply.

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

3.1.1
signal pixel
smallest encoded picture element in the input image

Note 1 to entry: Signal pixel is defined as the unit of signal resolution.

3.1.2
pre-gamma average picture level
average input level of all signal pixels relative to an equivalent white pixel driven by a digital RGB input

Note 1 to entry: Unless otherwise stated, the pre-gamma average picture level (APL) will simply be referred to as average picture level in this document.

Note 2 to entry: The APL will normally be expressed as a percentage, where a full white screen at maximum drive level would be 100 % APL.

Note 3 to entry: The pre-gamma APL is also called gamma-corrected APL in IEC 62087-2 [14]. In addition, it is noted that the tone rendering curve may not have a power law function with a well-defined exponent (gamma).

3.1.3
APL loading
influence of average picture level on display performance, for example luminance

3.2 Abbreviated terms

APL	pre-gamma average picture level
CCT	correlated colour temperature
CIE	Commission Internationale de L'Eclairage (International Commission on Illumination)
CIELAB	CIE 1976 (L*a*b*) colour space
DUT	device under test
EOTF	electro-optic transfer function
FWHM	full-width-at-half-maximum
ILU	integrated lighting unit (e.g. an edge-lit front guide plate)
LCD	liquid crystal display
LED	light emitting diode
LMD	light measuring device
OLED	organic light emitting diode
RGB	red, green, and blue
SDR	standard dynamic range
sRGB	standard RGB colour space defined in IEC 61966-2-1

3.3 Symbols

A list of symbols used in this document is given in Table 2.

Table 2 – Summary of symbols

Symbol	Units	Definition
E	lx	illuminance
$E(\lambda)$	$W \cdot m^{-2} \cdot nm^{-1}$	spectral irradiance
$E_{dir}(\lambda)$	$W \cdot m^{-2} \cdot nm^{-1}$	spectral irradiance from a directed light source at normal incidence
$E_{CIE,dir}(\lambda)$	$W \cdot m^{-2} \cdot nm^{-1}$	spectral irradiance of a CIE standard illuminant from a directed light source at normal incidence
$E_{hemi}(\lambda)$	$W \cdot m^{-2} \cdot nm^{-1}$	spectral irradiance from a hemispherical diffuse light source
$E_{CIE,hemi}(\lambda)$	$W \cdot m^{-2} \cdot nm^{-1}$	spectral irradiance of a CIE standard illuminant from a hemispherical diffuse light source
R_Q		luminous reflectance factor for a rendered display colour Q
$R_Q(\lambda)$		spectral reflectance factor for a rendered display colour Q
ρ_Q		luminous reflectance or diffuse reflectance for a rendered display colour Q
$\rho_Q(\lambda)$		spectral reflectance for a rendered display colour Q
L_Q	$cd \cdot m^{-2}$	darkroom luminance for a rendered display colour Q
$L_Q(\lambda)$	$W \cdot sr^{-1} \cdot m^{-2} \cdot nm^{-1}$	darkroom spectral radiance for a rendered display colour Q
$L_{Q \cdot amb}(\lambda)$	$W \cdot sr^{-1} \cdot m^{-2} \cdot nm^{-1}$	ambient spectral radiance, including reflected and darkroom emitted light, for a rendered display colour Q
$L_{Refl}(\lambda)$	$W \cdot sr^{-1} \cdot m^{-2} \cdot nm^{-1}$	reflected spectral radiance when the reflection coefficients are independent of the rendered display colour Q
X_Q, Y_Q, and Z_Q	$cd \cdot m^{-2}$ for Y_Q	CIE tristimulus values of the rendered display colour Q in a darkroom
$X_{Q,amb}$, $Y_{Q,amb}$, and $Z_{Q,amb}$	$cd \cdot m^{-2}$ for $Y_{Q,amb}$	equivalent CIE tristimulus values, including reflected and darkroom emitted light, for a rendered display colour Q
x_Q, y_Q		CIE 1931 chromaticity coordinates of the rendered display colour Q in a darkroom
$x_{Q,amb}$, $y_{Q,amb}$		equivalent CIE 1931 chromaticity coordinates, including reflected and darkroom emitted light, for a rendered display colour Q

4 Standard measuring conditions

4.1 Standard measuring environmental conditions

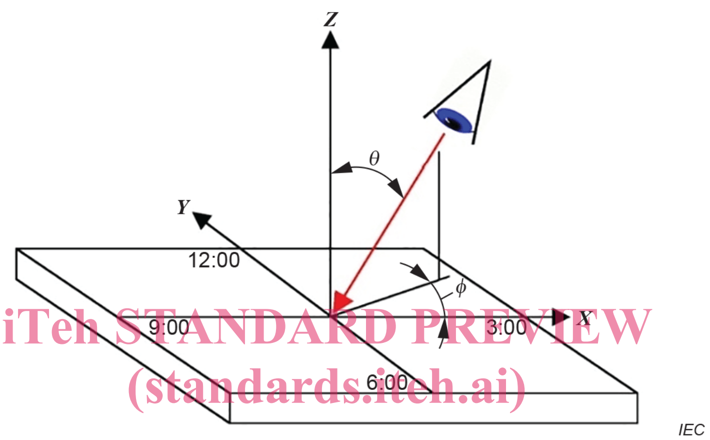
Measurements shall be carried out under the following standard environmental conditions:

- temperature: 25 °C ± 3 °C,
- 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.

4.2 Viewing direction and light source coordinate system

The viewing direction is the direction under which the observer looks at the point of interest on the display 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. 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"). The same coordinate system can be used to specify the positioning of the light sources used to represent the ambient lighting environment.



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

Figure 1 – Representation of the viewing direction (direction of measurement) and coordinate system used for light source configuration

4.3 Standard lighting conditions

4.3.1 General

A light source is chosen to provide as broad, stable, and smooth a spectrum as possible in order to reliably measure the spectral reflectance and reflection coefficients of the display surface specific to the geometry of the light source. This document then applies the reflection coefficients to simulate the display performance under the same geometric conditions using an illuminant, that is, a model or measured light source with an illumination level and/or spectrum that could be different from the light source used in the measurement.

An illuminant can be used to represent the use of a display that is viewed indoors (e.g. office), or in direct daylight (outdoors). These environments generally contain a combination of directed and uniform hemispherical diffuse light sources. The visual performance of the display can depend on the type of illumination and measurement geometry. Subclause 4.3 specifies the detailed conditions of the light sources for reflectance measurements under otherwise darkroom conditions.

A warm-up time can be necessary. The light source signal shall remain stable to within ±0,5 % standard deviation within a single measurement, and ±2 % for longer (>30 min) measurements.

4.3.2 Standard measuring darkroom conditions

The influence of unwanted background illumination shall be minimized, typically by illuminating the display in a darkroom. Unwanted background illumination is mainly a consideration for directed light sources, which is often solved by using light sources with spectral irradiance values that are substantially larger than the background. The darkroom spectral radiance contribution from the background illumination, that is, the measured spectral radiance reflected off the DUT, shall be not more than 1/10th of the spectral radiance from the device black state with the illumination source on. If this condition is not satisfied, then background subtraction is required and it shall be noted in the report. In addition, if the sensitivity of the LMD is more than 1/100th of the spectral radiance from the device black state, then the spectral radiance sensitivity limit of the LMD shall be noted in the report.

4.3.3 Standard ambient illumination

The following illumination conditions are specified for the optical measurements of displays under ambient illumination. The ambient illumination shall simulate indoor or outdoor illumination conditions. A combination of a hemispherical diffuse and directed source geometry is generally used to simulate either ambient indoor illumination or outdoor daylight illumination under a clear sky [1] ,[2]. Uniform hemispherical diffuse illumination will be used to simulate the background lighting in a room with the directed light source such as an occluded luminaire in a room, or the hemispherical skylight incident on the display, with the sun occluded. A directed light source in a darkroom will simulate the effect of directional illumination on a display by a luminaire in a room, or from direct sunlight.

The following reference illumination conditions shall be used to simulate indoor and outdoor display viewing environments. Additional conditions can also be used, depending on the use case.

a) Indoor room illumination conditions:

- Uniform hemispherical diffuse illumination – Use a light source closely approximating CIE Standard Illuminant A, CIE Standard Illuminant D65, or CIE Standard Illuminant D50 as defined in CIE 15. For spectral measurements, a spectrally smooth broadband light source (such as an approximation to CIE Standard Illuminant A) shall be used. A measurement of the spectral reflectance factor using a broad light source (such as Illuminant A) enables the indoor photopic and colour metrics to be calculated later for the desired reference spectra (for example CIE D65 Illuminant). The performance metrics shall be calculated using 300 lx for an indoor reading environment [3]. The actual hemispherical diffuse reflectance factor measurement can require higher illumination levels for better measurement accuracy. The results are then scaled down to the required illumination levels.
- Directional illumination – The same source spectra shall be used as with hemispherical diffuse illumination. The indoor room photopic and colour metrics shall be calculated using directional illumination of 200 lx incident on the display surface for an indoor reading environment with the display in the vertical orientation. The actual reflectance factor measurement can require higher illumination levels for better measurement accuracy. The results are then scaled down to the required illumination levels. The directed source shall be 45° above the surface normal (θ_s = 45°) and have an angular subtense of no more than 5°. The angular subtense is defined as the full angle span of the light source from the centre of the display's measurement area.
- Other illumination levels may be used in addition to those defined above for calculating the ambient contrast ratio under indoor illumination conditions. However, approximately 60 % of the total illuminance should be hemispherical diffuse, and 40 % directional illumination. Additional ratios of diffuse to directional illumination may also be measured.