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INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

Electronic displays –
Part 3-5: Evaluation of optical performance – Colour capabilities

IEC 62977-3-5:2023-09(en-fr)

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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

Draft	Report on voting
110/1547/FDIS	110/1563/RVD

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

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

This document contains attached files in the form of Microsoft Excel spreadsheet and App installer. These files are intended to be used as a complement and do not form an integral part of the standard.

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INTRODUCTION

The standards in IEC TC 110 that have been mainly concerned with the measurement and evaluation of electronic displays refer to a set of methods and procedures that are similarly performed at the condition of the display system complying with the standard requirement.

This document is intended to describe colour and chromaticity capabilities at the system condition set to the required usage, together with suitable precautions and diagnostics, as a reference for R&D engineers, third party experts and reviewers to avoid miscommunication and duplication of efforts among them.

In this document, the methods are available for the verification or test purpose of the display product development or evaluation by the users. The aim of this document is to evaluate the available range of chromaticity and colour.

Introduction of the optical measurements of electronic displays (OPTs) 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 standards production easier, faster and thus more effective.

The basic application comparison with the related documents is summarized in Table 1. The display system means an integrated product with device hardware, firmware or application software, or both. The display system characteristics addressed in this part of IEC 62977 are normally evaluated at the R&D stage or product sample test purpose rather than for quality assurance in mass-production.

Table 1 – Application comparison with the related documents

	IEC 62977-2-1	IEC TS 62977-3-1	IEC 62977-3-5
Application	Display device module and display system	Display device module and display system	Display device module and display system
Purpose	Fundamental optical capabilities of displays with unbounded input signals	Viewing directional colour deviation of displays with unbounded input signals	Colour and chromaticity capabilities of displays with unbounded input signals
Usage	Mass-production and sample test	Sample test	Sample test
Colour and chromaticity dependence on viewing direction	Measures luminance and chromaticity variation with viewing direction	ΔE between the normal and a viewing direction based on relative deviation from the reference white at the viewing direction	Absolute chromaticity difference by $\Delta u'v'$ between the normal and a viewing direction
		ΔE calculated based on the reference white at each viewing direction	$\Delta u'v'$ not influenced by the white of each viewing direction
Chromaticity gamut area	The three primary colours (RGB) measured at the screen centre and parallel to the display normal	-	60 points connecting the RGB primaries Primary colour mixture by location Intersection and directional gamut area
Colour reproduction accuracy	-	-	Normal direction and viewing directional variation
Colour gamut volume	Total volume in normal direction	-	Directional volume Intersection volume

ELECTRONIC DISPLAYS –

Part 3-5: Evaluation of optical performance – Colour capabilities

1 Scope

This part of IEC 62977 specifies standard evaluation methods for determining the colour capabilities of electronic display modules and systems with respect to colour accuracy, colour gamut volume, and their intersection with a reference colour space. Also included is evaluation with respect to the chromaticity gamut area. These methods apply to emissive and transmissive direct view displays that render real 2D images on a flat panel or on a curved panel with a local radius of curvature larger than 1 500 mm. This document evaluates the optical characteristics of these displays under darkroom conditions. This document applies to the testing of display performance in response to standard analogue or digital input signals that are not absolute luminance encoded. The input signal is relative RGB without metadata information that codes for real luminance, colour space or colour coordinates. These methods are limited to input signals with typical opto-electronic transfer functions (OETFs) such as defined in IEC 61966-2-1, Recommendation ITU-R BT.601 [18][1], Recommendation ITU-R BT.709, and Recommendation ITU-R BT.2020. The tests in this document are not suitable for use with HDR input signals.

NOTE A flat panel or flat panel display is a display with a planar surface that emits light from the surface. The display can consist of light valves modulating a backlight or be self-luminous. Emissive, transmissive, or reflective hybrid displays can be non-planar panel, non-planar panel displays, curved (design) panel, or curved (design) panel displays.

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

IEC 62977-2-1:2021, *Electronic displays – Part 2-1: Measurements of optical characteristics – Fundamental measurements*

IEC TS 62977-3-1:2019, *Electronic displays – Part 3-1: Evaluation of optical performances – Colour difference based viewing direction dependence*

IEC 61747-30-4, *Liquid crystal display devices – Part 30-4: Measuring methods for liquid crystal display modules – Dynamic backlight units*

IEC 62341-6-3:2017, *Organic light emitting diode (OLED) displays – Part 6-3: Measuring methods of image quality*

CIE 015:2018, *Colorimetry*

CIE 168:2005, *Criteria for the evaluation of extended-gamut colour encodings*

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1 Numbers in square brackets refer to the Bibliography.

Recommendation ITU-R BT.709, *Parameter values for the HDTV standards for production and international programme exchange*

Recommendation ITU-R BT.2020, *Parameter values for ultra-high definition television systems for production and international programme exchange*

SMPTE ST 431-1:2006, *D-Cinema Quality – Screen Luminance Level, Chromaticity and Uniformity*

3 Terms, definitions and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the following terms and definitions 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
chromaticity gamut intersection area
area defined by the intersection between the chromaticity gamuts of the display and a standard colour space such as Recommendation ITU-R BT.709

Note 1 to entry: Colour and colour gamut are described and calculated three-dimensionally. The chromaticity area was used in lieu of colour gamut for legacy displays that were additive. However, modern displays are not necessarily additive so a distinction between chromaticity and colour is necessary [24].

3.1.2
colour gamut intersection volume
volume defined by the intersection between the colour gamuts of the display and a standard colour space such as Recommendation ITU-R BT.709

Note 1 to entry: The colour gamut intersection can be represented by the ratio of the intersecting volume to the volume of a reference colour space such as Recommendation ITU-R BT.709 (see CIE 168).

3.1.3
white balance
DUT mode or condition that attempts to adjust the incoming white signal (R = G = B = maximum code value) so that a pre-defined white point is achieved

Note 1 to entry: The pre-defined white point can be expressed in terms of standard CIE illuminants, for example D50, D65, or D93 [22].

3.1.4
$\Delta E_{00,D50}$
colour difference calculated based on adaptation to D50 using CIE 1931 colour-matching functions (CMFs)

Note 1 to entry: $\Delta E_{00,D50}$ calculation used in this document uses a 2° observer, and is different from CIE ΔE_{00}.

Note 2 to entry: For the formula of CIE ΔE_{00}, see CIE 015 or ISO/CIE 11664-6 [31].

3.2 Abbreviated terms

ABC automatic brightness control

NOTE "Brightness" is a popular term describing DUT luminance control, not brightness adjustment by changing the tone curve (gain control).

ALC automatic light control

ALS ambient light sensor

APL average picture level

CAT chromatic adaptation transform

CIELAB CIE 1976 $L^*a^*b^*$

CMF colour-matching function

DUT device under test

EOTF electro-optical transfer function

LMD light measurement device

LUT look-up table

OETF opto-electronic transfer function

OLED organic light emitting diode

OPT optical measurement of electronic displays

RGB red, green and blue

RGBCMY red, green, blue, cyan, magenta and yellow

SLET stray light elimination tube

sRGB standard RGB colour space defined in IEC 61966-2-1 (sRGB has the same colour gamut as the gamut of Recommendation ITU-R BT.709)

WCG wide colour gamut

4 Standard measuring equipment

4.1 Video signal generator

A digital video signal generator with unbounded RGB output is used and the colour depth should be at least 8 bits per colour, but it can also be smaller for devices under test (DUTs) that do not support 8-bit input.

4.2 Conditions of measuring equipment

Refer to IEC 62977-2-1:2021, 5.3.4.

4.3 Test equipment block diagram

The setup of a telescopic LMD is shown in Figure 1. The optical axis of the LMD shall be centred on the screen and parallel to the display screen normal. The general conditions of the measuring equipment such as angular aperture are specified in IEC 62977-2-1. The block diagram of the close-up type LMD is shown in Figure 2. The close-up type light measurement device (LMD) can be used in order to save room space. The measurement distance is in accordance with the distance specified by the manufacturer. The input optics shall meet the requirements as indicated in 4.2. A close-up type LMD shall never touch the DUT surface, and the accuracy of the close-up type LMD shall be verified by a telescopic spectroradiometer.

The measuring layout for the directional viewing measurement shall be applied by the movement of the LMD or rotation of the display in the horizontal viewing direction as shown in Figure 3a) and b), where the vertical arrangement for the vertical viewing direction is also possible. Otherwise, the spherical coordinate system as shown in Figure 3c) shall be applied (refer to IEC TS 62977-3-1:2019, 6.1, and IEC 62977-2-1:2021, 5.6 and 6.10).

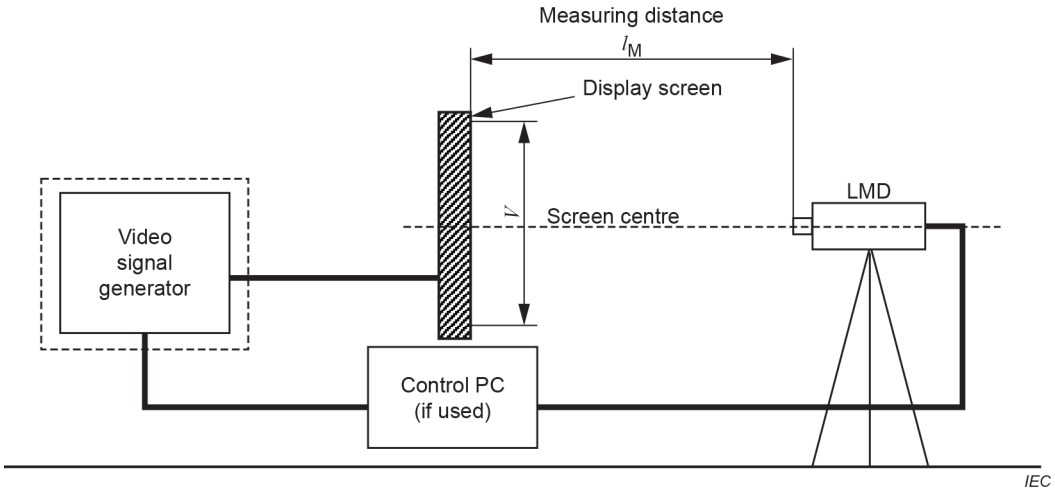


Figure 1 – Measuring layout for a telescopic LMD

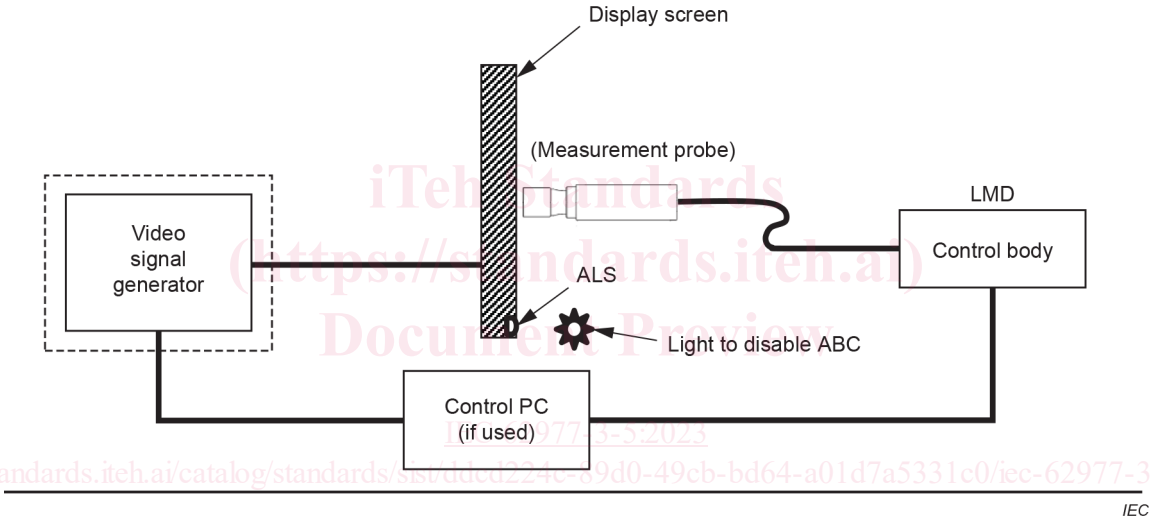
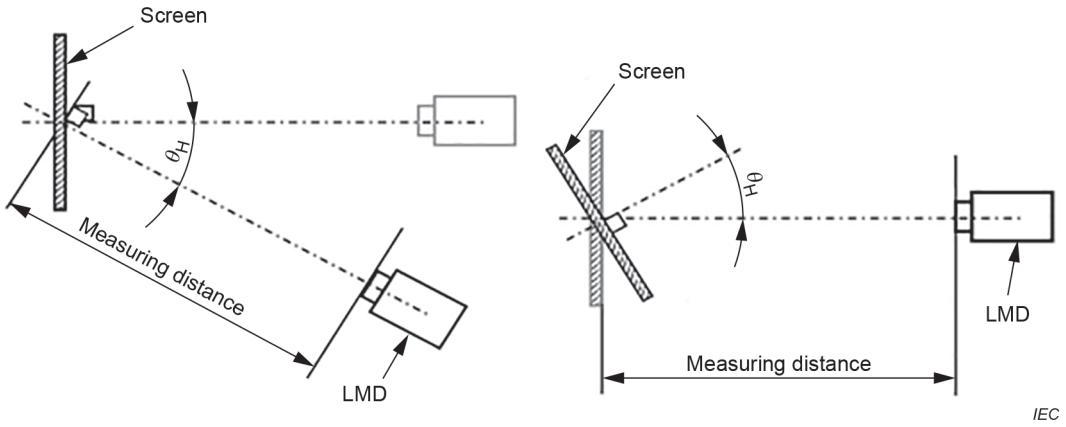
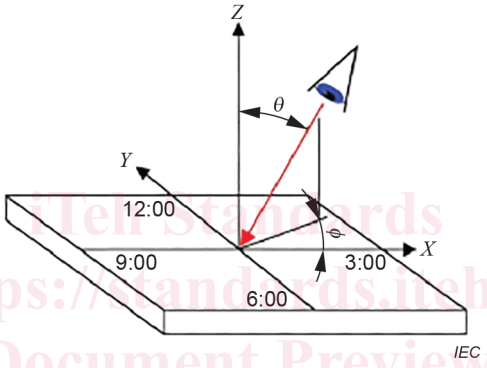


Figure 2 – Measuring layout for a close-up type LMD



a) Measurement by moving LMD (top view)

b) Measurement by rotating DUT (top view)



c) Measurement in spherical coordinate system

Figure 3 – Setup for viewing directional measurements

5 Standard measuring conditions

5.1 Standard measuring environmental conditions

The measurements should be carried out under the standard environmental conditions:

– temperature: 25 °C ± 3 °C
– relative humidity: 25 % RH to 85 % RH
– atmospheric pressure: 86 kPa to 106 kPa

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

5.2 Standard measuring darkroom conditions

Refer to IEC 62977-2-1:2021, 5.2.

5.3 Standard setup conditions

The display system shall be warmed up prior to taking measurements. Measurements shall be started after the display 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 will possibly require a loop of colour patterns rendered on the screen during the warm-up period. If the manufacturer specifies a warm-up sequence and duration, apply that prior to displaying the test pattern. 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 for a given display image.

The standard operating status of the display system shall be adjusted by the following sequence.

a) Initialized status

The display system shall be set to the factory (default) setting condition. If the DUT does not have default factory setting conditions, the DUT shall be set to a standard condition or the corresponding mode. Once the mode is selected, the DUT shall remain in that same mode for all measurements. The DUT setup condition, including the selected mode setting, shall be recorded and reported.

b) Adjustment of ambient light control

Turn off the ABC (or ALC) by using the ALS of the DUT. If it cannot be turned off, set a light source with at least 300 lx on the DUT ALS so a measurement can be done with minimal variation of the DUT luminance, and this light source configuration shall be recorded and reported. The light source used to disable the ABC shall be shielded from the DUT measurement area so that it does not influence the LMD measurement of the DUT under the darkroom condition.

c) Setting of energy saving and image retention protection function

Disable the image retention and energy saving functions of the display module via the internal controls. If the display module resets, stop the measurement, disable the image retention and energy saving functions, and retrieve the measurement condition so that the measurement result is not affected by the functions.

d) Adjustment of aspect ratio

The aspect ratio of the input signal shall be adjusted so that it coincides with the physical aspect ratio of the DUT in full screen mode. The display should be operated in a mode that does not have over-scan.

Other conditions are specified in IEC 62977-2-1:2021, 5.3.

5.4 Standard test pattern

Standard test patterns for the measurement shall be the multi-colour test pattern of Figure 4 (example of RGBCMY, Bk, and W input, see IEC 62977-2-1 and [19]) where the average picture level (APL) of the pattern is kept constant at 24,7 % throughout all measured colours. The RGB values of the complementary blocks (indicated by stripes), V'_{Q}, are complementary to the RGB values of the centre test patch:

$$V'_{Q} = \left(2^{N} - 1 - V_{Q}\right) \tag{1}$$

where

Q {R, G, B},

N is the bit depth;

V_{Q} are the RGB values of the centre test patch. To achieve an APL of 24,7 %, the width of each block shall be 2/9 of the screen width.

NOTE APL in this document refers to the pre-gamma average picture level (see IEC 62977-2-1).