IEC 62341-6-1

Edition 3.0 2022-10

INTERNATIONAL STANDARD

colour inside

Organic light emitting diode (OLED) displays – Part 6-1: Measuring methods of optical and electro-optical parameters

IEC 62341-6-1:2022-10(en)

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INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 31.260

ISBN 978-2-8322-5856-9

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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FOREWORD

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IEC 62341-6-1 has been prepared by IEC technical committee 110: Electronic display devices. It is an International Standard.

This third edition cancels and replaces the second edition published in 2017. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

a) measuring methods for power consumption of displays that have an embedded video connection terminal are added;
b) the contents description including video signal for power consumption is modified.

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

Draft	Report on voting
110/1454/FDIS	110/1471/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/standardsdev/publications.

A list of all the parts in the IEC 62341 series, under the general title *Organic light emitting diode (OLED) displays*, can be found on the IEC website.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under 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- withdrawn,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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ORGANIC LIGHT EMITTING DIODE (OLED) DISPLAYS –

Part 6-1: Measuring methods of optical and electro-optical parameters

1 Scope

This part of IEC 62341 specifies the standard measuring conditions and measuring methods for determining the optical and electro-optical parameters of organic light emitting diode (OLED) display modules, and where specified, OLED display panels. These methods are limited to flat displays measured in a dark room.

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 – Part 850: Lighting* (available at www.electropedia.org)

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

IEC 62341-1-2, *Organic light emitting diode (OLED) displays – Part 1-2: Terminology and letter symbols*

IEC 62341-6-2:2015, *Organic light emitting diode (OLED) displays – Part 6-2: Measuring methods of visual quality and ambient performance*

IEC 62087-3, *Audio, video, and related equipment – Determination of power consumption – Part 3: Television sets*

CIE 15:2004, *Colorimetry,* 3rd edition

CIE S 014-1, *Colorimetry – Part 1: CIE Standard Colorimetric Observers*

3 Terms, definitions, and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60050-845, IEC 62341-1-2, and the following apply.

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

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

3.1.1
signal pixel
smallest encoded picture element in the input image

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.

3.1.3
average luminance level
ALL
average luminance of the input signal on all pixels

Note 1 to entry: ALL, which is calculated by averaging of post-gamma signal pixels, is also called as the post-gamma APL.

3.2 Abbreviated terms

ALL	average luminance level
APL	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
CMY	cyan, magenta, and yellow
DRCR	dark room contrast ratio
DUT	device under test
eDP	embedded display port
LMD	light measuring device
LUT	look-up table
MIPI	mobile industry processor interface
PMOLED	passive matrix organic light-emitting diode
RGB	red, green, and blue
RGBCMY	red, green, blue, cyan, magenta, and yellow
SPD	spectral power distribution
sRGB	standard RGB colour space as defined in IEC 61966-2-1
TCON	timing controller
UCS	uniform chromaticity scale
WRGB	white, red, green, and blue

4 Structure of measuring equipment

The system diagrams and/or operating conditions of the measuring equipment shall comply with the structure specified in each item.

5 Standard measuring conditions

5.1 Standard measuring environmental conditions

Measurements shall be carried out under the standard environmental conditions as follows:

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

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

5.2 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. If these conditions are not satisfied, then background subtraction is required, and it shall be noted in the test report. In addition, if the sensitivity of the LMD is inadequate to measure 1/20 of the black level, then the lower limit of the LMD shall be noted in the test report.

5.3 Standard setup conditions

5.3.1 General

Standard setup conditions are given below in 5.3.2, 5.3.3 and 5.3.4. Any deviations from these conditions shall be reported.

5.3.2 Adjustment of OLED display modules

The display shall be measured at its factory default settings. If other settings are used, they shall be noted 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.

5.3.3 Starting conditions of measurements

Measurements shall be started after the OLED displays and measuring instruments achieve stability. It is recommended that, when the display is first turned on, it be operated for at least 30 min with a loop of colour patterns rendered on the screen. 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 method for a given display image.

5.3.4 Measuring equipment requirements

5.3.4.1 General conditions

Light measurements shall generally be made in terms of photometric or colorimetric units for a CIE 1931 standard colorimetric observer as defined in CIE S 014-1. Luminance can be measured by a photometer, and CIE tristimulus values (X, Y, Z) or CIE chromaticity coordinates by a colorimeter. A spectroradiometer can also obtain photometric and colorimetric values through a numerical conversion of the measured spectral radiance data (see for example [1][1]). A non-contact LMD, where the LMD is not in direct contact with the screen, shall be used without an illumination source. The following requirements are given for these instruments:

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

a) The LMD shall be a luminance meter, colorimeter, or a spectroradiometer. 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. For OLED primaries with a bandwidth ≤ 25 nm, the maximum bandwidth shall be ≤ 5 nm. The spectral bandwidth of the spectroradiometer shall be an integer multiple of the sampling interval. For example, a 5 nm sampling interval can be used for a 5 nm or 10 nm bandwidth.

   Ensure that the LMD has enough sensitivity and dynamic range to perform the required task. The measured LMD signal shall be at least ten times greater than the dark level (noise floor) of the LMD, and no greater than 85 % of the saturation level.

b) The LMD shall be focused on the image plane of the display and generally aligned perpendicularly to the display surface at the centre of the measurement field, unless stated otherwise.

c) The relative uncertainty and repeatability of all the measuring devices shall be maintained by following the instrument supplier's recommended calibration schedule.

d) The LMD integration time shall be an integer number of frame periods, synchronized to the frame rate, or the integration time shall be greater than one hundred frame periods.

e) If LMD measurements are taken for displays with impulse driving or duty driving, the high peak luminance of these displays can cause detector saturation errors. The accuracy of these measurements can be checked by attenuating the light with a neutral-density filter. If the change in signal amplitude of the detector is proportional to the transmittance of the neutral-density filter, then there are no detector saturation errors. This method is for measuring the maximum time-averaged full-screen luminance.

When using LMDs, stray light within the LMD (e.g. lens flare, veiling glare), and non-uniformities of sensitivity across detector area should be considered. Also, when measuring black regions, stray light from adjacent bright regions of the displays can introduce significant errors. The stray light can be significantly reduced by using a frustum (see Annex C).

In addition to LMDs that form an average value for the measured quantity over the measurement field under consideration (i.e. spot photometers, see Figure 1), there are imaging LMDs which give a value (or an array of values, e.g. R, G and B) for each individual area-element on the DUT. Such LMDs can replace a sequential mechanical scan of the surface of a display by an image of the entire active area of the DUT, and a subsequent evaluation of the data.

When imaging LMDs are used, a flat-field correction shall be applied to the LMD at the measuring distance.

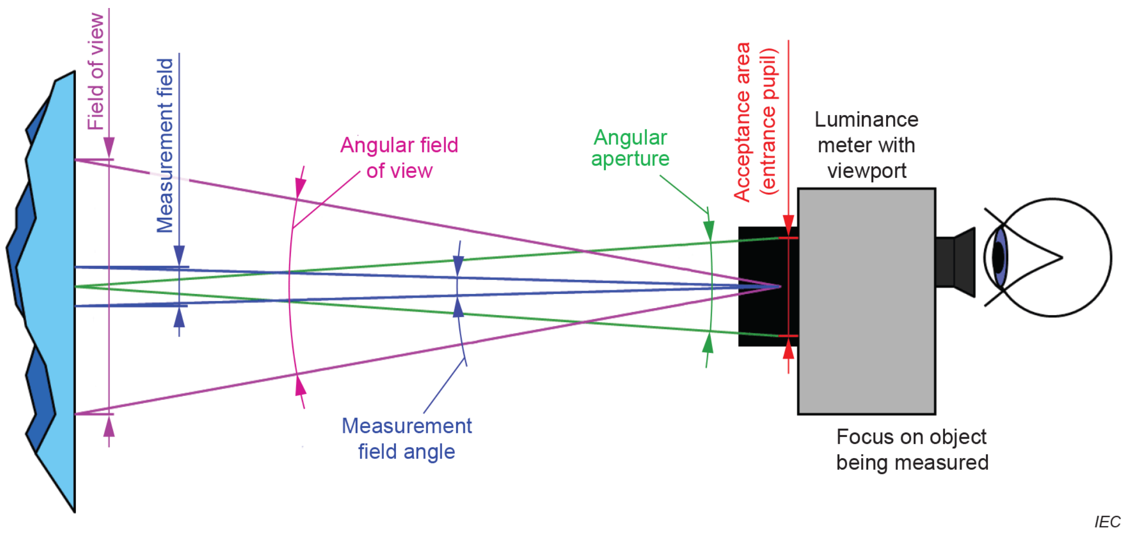

Figure 1 – Layout diagram of measurement setup

5.3.4.2 High pixel count matrix displays (≥ 320 pixels × 240 pixels)

The following applies for high pixel count matrix displays:

a) When measuring matrix displays, the light-measuring devices should be set to a measurement field that includes more than 500 pixels. For LMDs with a circular measurement field, this would be equivalent to a disk with a diameter greater than 25 display pixels. If smaller measurement areas are necessary, photometric and colorimetric equivalence to 500 pixels shall be confirmed and noted in the test report.

b) For small displays, the recommended measuring distance is between 20 cm to 50 cm. For larger displays, the measurement area shall contain at least 500 pixels. The measurement area contains at least 500 pixels. The measuring distance shall be noted in the report.

c) The angular aperture shall be less than or equal to 5°, and the measurement field angle shall be less than or equal to 2° (see Figure 1).

d) The display shall be operated at its design field frequency. When using separate driving signal equipment to operate a panel, the drive conditions shall be noted in the report.

5.3.4.3 Low pixel count matrix displays (< 320 pixels × 240 pixels) and segmented displays

The following applies for low pixel count matrix displays:

a) Low pixel count displays can contain fewer than 500 pixels. When the number of pixels in the measurement field is less than 500, it shall be noted in the report. The angular aperture shall be less than or equal to 5°, and the measurement field angle shall be less than or equal to 2°. The measuring conditions used shall be recorded.

b) For segment displays, the angular aperture shall be less than or equal to 5°, and the measurement field angle shall be less than or equal to 2°. All measurements shall be performed at the centre of a segment with the measurement field completely contained within the segment.

c) For small displays, the recommended measuring distance is between 20 cm to 50 cm. For larger displays, follow the manufacturer's recommended viewing distance. For larger displays, the measurement area shall contain at least 500 pixels. The measuring distance shall be noted in the report.

5.4 Standard locations of measurement field

Luminance, spectral distribution and/or tristimulus measurements may be taken at several specified positions on the display surface. The standard measurement locations are identified by positions P_1 to P_9 in the active area, as illustrated in Figure 2. The active screen area is divided into nine equal-sized boxes, with the measurement area centred within each box and identified by the corresponding numbering shown in Figure 2. Each box is 1/3 of the width (W) and height (H) of the active area. Centre screen measurements are taken at position P_5. The display or detector shall be translated in the horizontal and vertical directions to perform measurements at the desired display positions, with all measurements taken normal to the screen. Any deviation from the standard positions above shall be recorded.

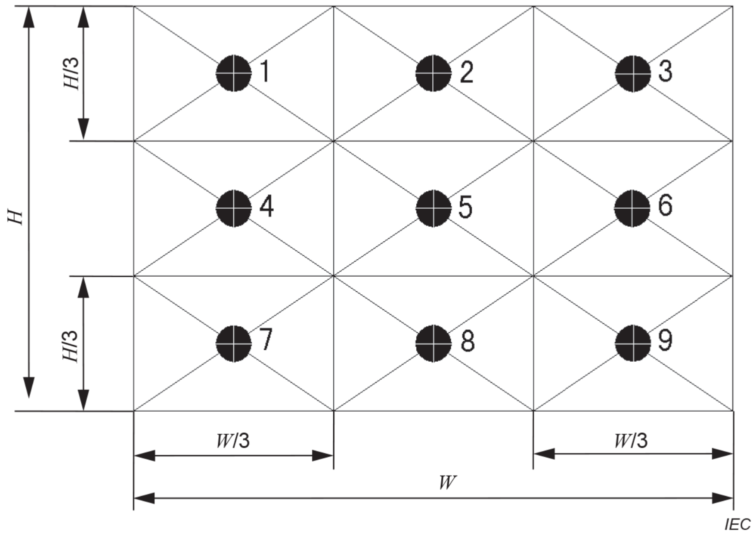

Figure 2 – Standard measurement positions in the display active area

5.5 Standard test patterns

The characterization of display luminance and colour can depend on the display test pattern. Therefore, several standard test patterns are given to help make the measurements more realistic to actual use cases (see Annex E). Additional test patterns may also be used (see Annex F). The standard test patterns use the scaling illustrated in Figure 3. The display is divided into a 3 × 3 array of rectangular areas, each of which has sides that are 1/3 of the dimension of the height and width of the screen active area. Each of these nine rectangular areas can then be further subdivided into smaller rectangles, as demonstrated in the upper left-hand corner of Figure 3 . The smallest subdivision would yield a rectangular box that has dimensions of 1/9 of those of the active area of each region of the 3 × 3 array.

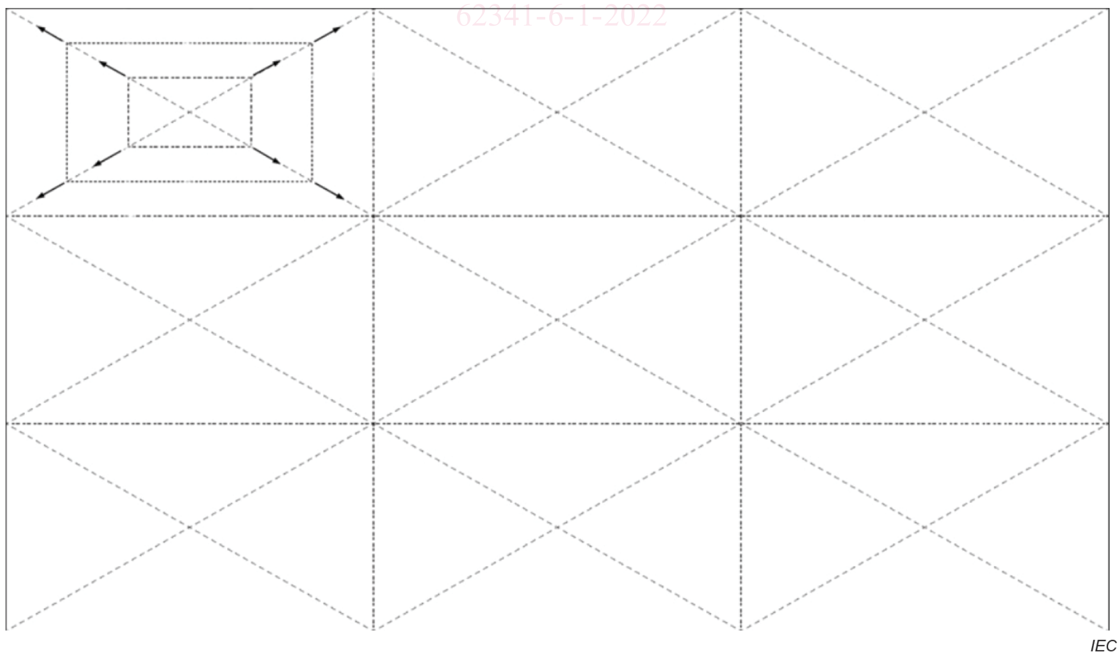

Figure 3 – Test pattern scaling used to define the area size of the coloured rectangles in the active area of the display

The standard test pattern for basic primary luminance and colour measurements shall use the low APL loading example of the colour tile test patterns illustrated in Figure 4. In this case, coloured rectangular boxes, with 1/9 of the dimensions of the active area, are centred on the nine standard active area locations on a black background. The red, green, and blue boxes are driven at the maximum input signal levels for the primary channels. For example, the red box is driven at the maximum input signal for the red channel, while the green and blue channels are at their minimum signal level. The white boxes are driven at their maximum red, green, and blue channel inputs. Each colour tile pattern is identified by the initials CT (colour tile) and the colour of the centre box. The patterns in Figure 4 are identified as CTR, CTG, CTW, and CTB starting at the upper left-hand pattern and moving clockwise.

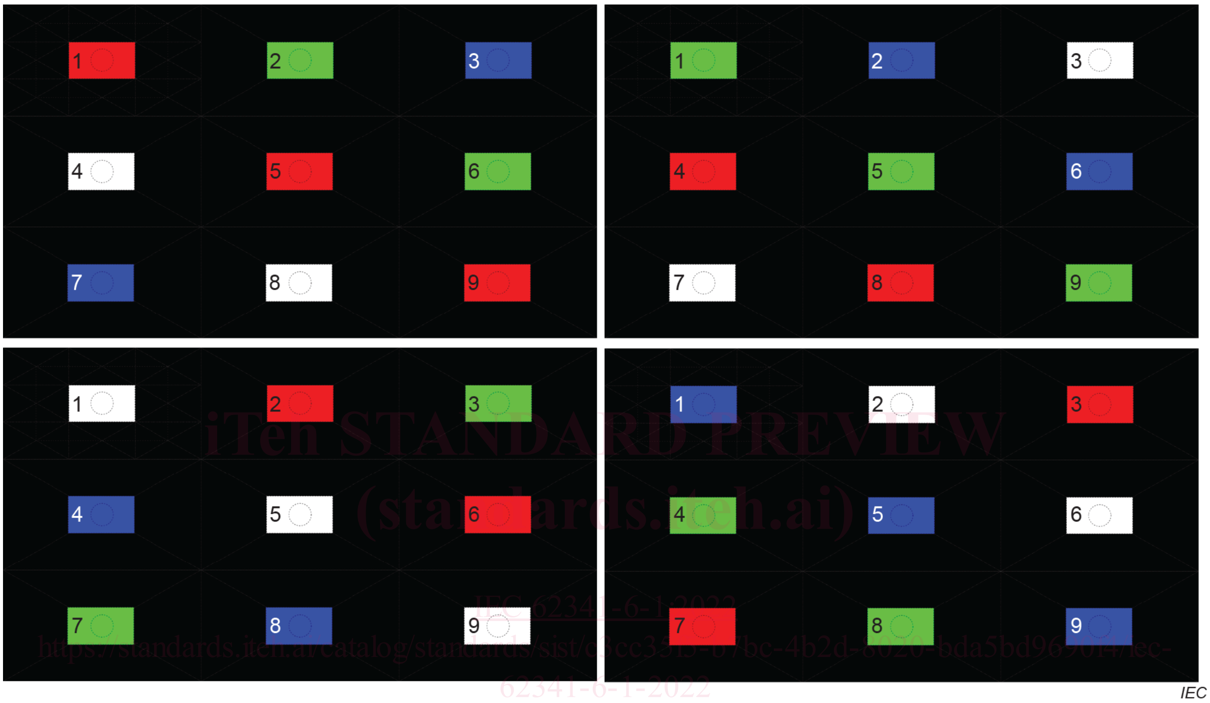

Figure 4 – Low APL loading series of red, green, blue, and white test patterns used for basic luminance, colour, and uniformity measurements

The area scaling of the coloured rectangles is adjusted to manipulate the APL loading on the display. The amount of APL loading is input-referred, assuming it is an RGB digital input. The percent APL is defined as:

$$\text{APL}(\%) = 100 \times \frac{\sum_{i=1}^{N} PL_i}{N} \tag{1}$$

where the summation is over all pixels in the active area, PL_i is the normalized signal pixel level of the i^{th} pixel relative to maximum white level, and N is the total number of pixels. A 100 % APL would be represented by all pixels in the active area at maximum white level. This would be implemented by setting the levels for the red, green, and blue input channels to their maximum values. A single primary colour (e.g. red) rendered on a full screen would have 1/3 of the APL of a full white screen. If it is assumed that the red, green, and blue areas correspond to 1/3 of the APL of the white areas, then the APL for each pattern in Figure 4 is (starting at the upper left-hand corner and going clockwise) 5,3 %, 5,3 %, 6,2 %, and 5,3 %. The average APL for the four patterns in Figure 4 is 5,6 %. An example calculation of the top left pattern in Figure 4 is given by: