IEC 62341-6-1

Edition 1.0 2009-05

INTERNATIONAL STANDARD

NORME INTERNATIONALE

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

Afficheurs à diodes électroluminescentes organiques (OLED) – Partie 6-1: Méthodes de mesure des paramètres optiques et électro-optiques

IEC 62341-6-1:2009

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

COMMISSION ELECTROTECHNIQUE INTERNATIONALE

PRICE CODE
CODE PRIX

U

ICS 31.260

ISBN 978-2-88910-677-6

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The text of this standard is based on the following documents:

FDIS	Report on voting
110/170/FDIS	110/179/RVD

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

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

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 publication will remain unchanged until the maintenance result date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

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- withdrawn;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

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 measurement conditions and measuring methods for determining optical and electro-optical parameters of organic light emitting diode (OLED) display modules, and where specified, OLED display panels, in the following areas:

a) luminance and uniformity;

b) dark room contrast ratio;

c) chromaticity, colour uniformity, colour gamut and white field correlated colour temperature;

d) power consumption.

2 Normative references

The following referenced documents are indispensable for the application of this document. For undated references, the latest edition of the referenced document (including any amendments) applies.

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

CIE 15.2:1986, *Colorimetry (second edition)*

CIE S 014-1/E:2006, *Colorimetry – Part 1: CIE Standard Colorimetric Observers*

3 Terms, definitions and units

For the purposes of this part of IEC 62341, most of the definitions and units used comply with IEC 62341-1-2.

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 at a temperature of 25 ºC ± 3 ºC, at a relative humidity of 25 % to 85 %, and pressure of 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

With the OLED display turned off, the ambient illuminance at all points on the screen shall be less than 0,3 lx. When a higher ambient illuminance on the display is present, the background

luminance measured when the display is OFF shall be subtracted from subsequent luminance measurements of the display, and shall be reported.

5.3 Standard setup conditions

Standard setup conditions are given below. Any deviations from these conditions shall be reported.

5.3.1 Adjustment of OLED display modules

The luminance, contrast, correlated colour temperature of the white field, and other relevant parameters have to be adjusted to nominal values and they shall be reported in detail in the specifications of the measurement. For a full colour display, the chromaticity of the white field shall also be adjusted to match the product specification. When no levels are specified, the maximum contrast and/or luminance level shall be used and the settings reported. These adjustments 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.

5.3.2 Starting conditions of measurements

Warm-up time is defined as the time elapsed from the moment of switching on the supply voltage until repeated measurements of the display show a variation in luminance of less than 2 % per minute. Repeated measurements shall be taken for at least a period of 15 min after starting. The luminance variations shall also not exceed 5 % during the total measurement.

Measurements shall be started after the OLED displays and measuring instruments achieve stability. Sufficient warm-up time has to be allowed for the OLED displays to reach luminescence stability.

5.3.3 Conditions of measuring equipment

5.3.3.1 General conditions

The following general conditions apply.

a) The standard measurement setup is shown in Figure 1. The light measuring device (LMD) may be any of the following meters:

   1) a luminance meter with a spectral response approximating the spectral luminous efficiency function for photopic vision;

   2) a colorimetric meter with the spectral sensitivity as colour-matching functions for the CIE 1931 standard colorimetric observer (specified in CIE S 014-1);

   3) a spectroradiometer with a wavelength range from 380 nm to 780 nm;

   4) an imaging photometer or colourimeter with the spectral sensitivity as colour-matching functions for the CIE 1931 standard colorimetric observer.

   Care shall be taken to ensure that the device is capable of performing the required task.

b) The light measuring device shall be aligned perpendicular to the area to be measured on the image generating surface of the OLED display.

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

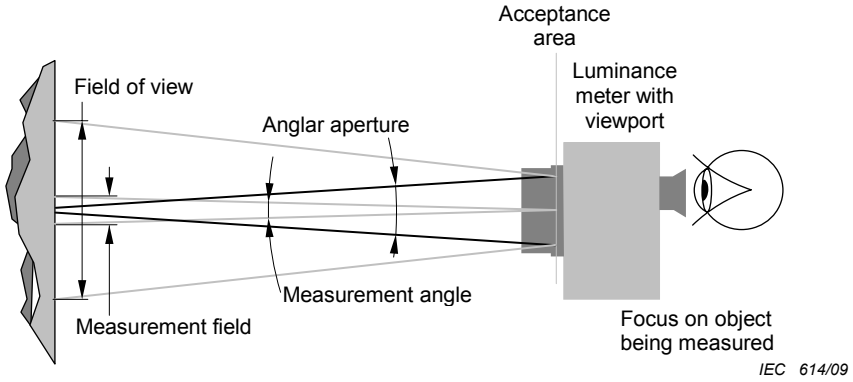

Figure 1 – Layout diagram of measurement setup

d) The LMD lens shall be focused on the light emitting plane of the display, and the LMD integration time shall be an integer number (≥10) of one frame period. Shorter integration times are acceptable if the detector is synchronized with the display frame rate.

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

The following high pixel count matrix applies.

a) When measuring matrix displays, the measurement field shall include more than 500 pixels.

b) The standard measuring distance l_{xo} is 2,5V (for $V \geq 20$ cm) or 50 cm (for $V < 20$ cm), where V is the height of the display active area or the shorter of the screen width and height dimensions. The measuring distance shall be reported.

c) The angular aperture shall be less than or equal to 5°, and measurement field angle shall be less than or equal to 2°. The measuring distance and the measurement field angle may be adjusted to achieve a measuring field greater than 500 pixels area if setting the above aperture angle is difficult.

d) Displays shall be operated at their design frame frequency. When using separate driving signal equipment to operate a panel, the drive conditions shall be reported.

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

The following low pixel count matrix applies.

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

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

c) When the measurement conditions do not satisfy the requirement of ≤2° for the measurement field angle, or the measurement field includes fewer than 500 pixels, the measured values for these parameters shall be reported.

6 Measuring methods for optical parameters

6.1 Luminance and its uniformity

6.1.1 Purpose

The purpose of this method is to measure the full screen display luminance and luminance uniformity of OLED display modules under test.

6.1.2 Measuring conditions

The following measuring conditions apply.

a) Apparatus: A light measuring device that can measure luminance, driving power source, and driving signal equipment.

b) Standard measuring environmental conditions; Darkroom conditions; Standard setup conditions.

6.1.3 Measuring methods

6.1.3.1 Maximum full screen luminance

For full screen luminance proceed as follows.

a) Set the OLED display and the LMD under the standard measuring conditions.

b) Set up the measurement following the layout diagram shown in Figure 1.

c) For a monochromatic display, apply a signal to make the full screen emit at the highest grey level. For a colour display, apply a white signal level of 100 % over the entire screen.

d) The measurement position is at the centre of the screen.

e) If luminance is measured 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.

f) For a segmented display, measure the luminance inside each unique colour segment closest to the centre at its maximum signal level. The segment location measured shall be reported.

6.1.3.2 4 % window luminance

This method shall measure the maximum time-averaged luminance of a small emitting region in the centre of the active area. The centre luminance of a 4 % window is the maximum window luminance.

a) Set the OLED display and the LMD under the standard measuring conditions.

b) Set up the measurement following the layout diagram shown in Figure 1.

c) Create a 4 % white window pattern on a black background in the centre of the active area, as shown in Figure 2. The 4 % window (100 %, white screen) has corresponding sides that are 1/5 the vertical and horizontal dimensions of the active area.

d) For a monochrome display, apply a signal at the highest grey level. For a colour display, apply a white signal level of 100 %.

e) Measure the time-averaged luminance at the centre of the active area (position P_0 in Figure 3).

f) If luminance is measured 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.

g) If luminance loading effects exist, reduce the area of the white window pattern and measure the luminance in the centre. If this luminance is larger than the 4 % window luminance, continue reducing the emitting area and take luminance measurements until the luminance no longer increases, or the measurement area becomes too small (≤500 pixels). The maximum window luminance is the stable maximum luminance value reached when reducing the emitting area. If no stable maximum luminance value can be obtained, then the luminance measured with the 4 % white window pattern shall be used as the maximum window luminance.

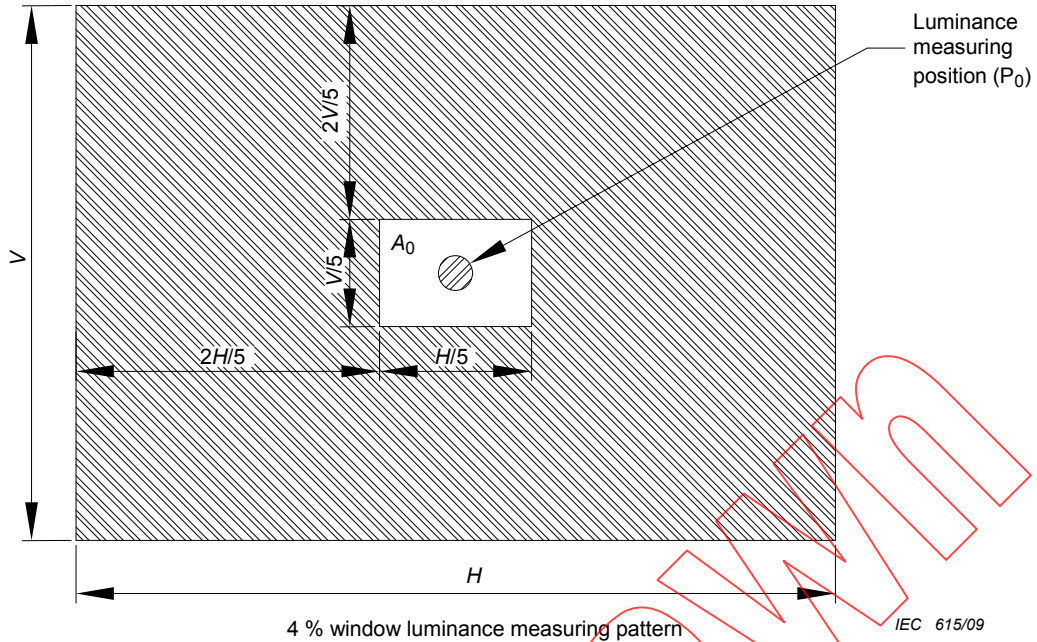

Figure 2 – Luminance measuring pattern

6.1.3.3 Sampled luminance non-uniformity

To achieve luminance non-uniformity, proceed as follows.

a) Set up the measurement following the layout diagram shown in Figure 1.

b) For a monochrome display, apply a signal to make the full screen emit at the highest grey level. For a colour display, apply a white signal level of 100 % over the entire screen.

c) Either 5 or 9 measurement points shall be used. For 5 points, use P_0 to P_4. For 9 points, use P_0 to P_8, see Figure 3.

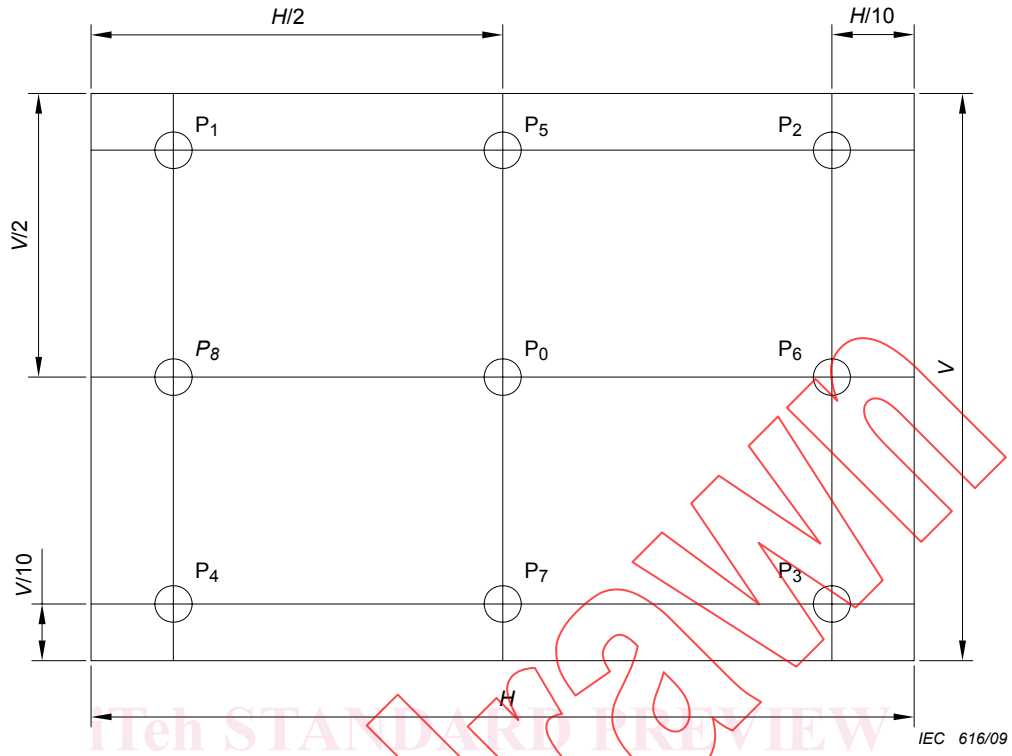

Figure 3 – Measurement points

The average luminance is:

$$L_{av} = \frac{1}{(n+1)} \sum_{i=0}^{n} L_i \qquad (1)$$

where

n = 4 or 8. L_i is the measured luminance at location P_i.

The luminance deviation at P_i is: $\Delta L_i = L_i - L_{av}$.

The result of measurement shall be recorded as shown in Table 1.

The luminance non-uniformity of the display is characterized as the maximum $\Delta L_i / L_{av} \times 100$ %.

Table 1 – Example of luminance non-uniformity

Measuring point	Luminance L_i cd/m^2	$(\Delta L_i/L_{av}) \times 100$ % %
P_0	210	+1,9
P_1	205	–0,5
P_2	208	+1,0
P_3	199	–3,4
P_4	195	–5,3
P_5	211	+2,4
P_6	215	+4,4
P_7	204	–1,0
P_8	207	+0,5
L_{max}: 215 cd/m^2; L_{min}: 195 cd/m^2; Average luminance: 206 cd/m^2		

The type of driving signal shall be specified. Report the number of samples used, L_{max}, L_{min}, and the luminance non-uniformity. Report the non-uniformity in percent to no more than three significant figures.

6.2 Dark room contrast ratio

6.2.1 Purpose

The purpose of this method is to measure the dark-room contrast ratio (DRCR) of the OLED display under test.

6.2.2 Measuring conditions

The following measuring conditions apply.

a) Apparatus: A light measuring device that can measure luminance; a driving power source, and driving signal equipment.

b) Standard measuring environmental conditions; Dark-room condition; Standard setup conditions.

6.2.3 Measuring method

6.2.3.1 Measuring method of full screen dark-room contrast ratio

For full screen dark room contrast ratio, proceed as follows.

a) Measuring luminance of a full white screen

Apply a test input signal displaying the maximum full screen luminance (100 %, white screen) on the OLED display with the driving signal equipment. Measure the luminance L_{DRfmax} at the centre of the screen.

b) Measuring luminance of a full black screen

Apply a test input signal displaying the minimum luminance (0 %, black screen) on the full screen to the OLED display from the driving signal equipment. Measure the luminance L_{DRfmin} at the centre of the screen.

c) Procedure to determine the dark-room contrast ratio

The full screen dark-room contrast ratio $DRCR_f$ is given as follows:

$$DRCR_f = \frac{L_{DRf\,max}}{L_{DRf\,min}} \quad (2)$$

6.2.3.2 Measuring method of 4 % window dark-room contrast ratio

For 4 % window dark room contrast ratio, proceed as follows.

a) Measurement of 4 % window luminance

Apply a test input signal to the OLED display module that generates a 4 % white window (A_0) centred on a black background. The 4 % window (100 %, white screen) has corresponding sides that are 1/5 the vertical and horizontal dimensions of the active area (see Figure 2). Measure the luminance at the centre of the 4 % white window ($L_{BR0,04}$).

b) Measurement of minimum luminance

Apply a test input signal displaying the minimum full screen luminance (0 %, black screen) on the OLED display with the driving signal equipment. Measure the luminance L_{DRmin} at the centre of the screen.

c) Procedure to determine the dark-room contrast ratio

The 4 % window dark-room contrast ratio $DRCR_w$ is given as follows:

$$DRCR_w = \frac{L_{DR0,04}}{L_{DR\,min}} \tag{3}$$

6.3 Chromaticity, colour uniformity, colour gamut and white field correlated colour temperature

6.3.1 Purpose

The purpose of this method is to measure the CIE 1931 chromaticity coordinates (x, y) or CIE 1976 UCS (Uniform Colour Space) chromaticity coordinates (u', v'), colour gamut, the colour uniformity and the white field correlated colour temperature (CCT) of an OLED display under test.

6.3.2 Measuring conditions

The following measuring conditions apply.

a) Apparatus: A light measuring device that can measure the chromaticity of the emitted light, driving power source, and driving signal equipment.

b) Standard measuring environmental conditions; Darkroom condition; Standard setup conditions.

6.3.3 Measuring method

6.3.3.1 Centre chromaticity, colour gamut and colour gamut area metric

Proceed as follows.

a) For segmented displays measure the CIE 1931 chromaticity coordinates (x, y) inside each uniquely addressable colour segment closest to the display centre at its maximum signal level. The segment locations measured shall be reported.

b) For monochrome displays:

Apply a signal to produce a full screen light at the highest grey level. Measure the CIE 1931 chromaticity coordinates (x, y) at the centre of the display (P_0), as shown in Figure 3.

c) For colour displays:

1) Apply a full screen white signal at a 100 % grey level.
2) Measure the CIE 1931 chromaticity coordinates W(x, y) at the centre.
3) Turn on the red signal to ensure only the red light is emitting from the module.
4) Measure the chromaticity coordinates R(x, y) of the red light at the centre.
5) Turn on the green signal to ensure only the green light is emitting from the module.