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INTERNATIONAL STANDARD

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

**Afficheurs à diodes électroluminescentes organiques (OLED) –
Partie 6-3: Méthodes de mesure de la qualité des images**

IEC 62341-6-3:2012

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FOREWORD

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

FDIS	Report on voting
110/374/FDIS	110/399/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 stability 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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ORGANIC LIGHT EMITTING DIODE (OLED) DISPLAYS –

Part 6-3: Measuring methods of image quality

1 Scope

This part of IEC 62341 specifies the standard measurement conditions and measuring methods for determining image quality of organic light emitting diode (OLED) display panels and modules. More specifically, this standard focuses on five specific aspects of image quality, i.e., the viewing angle range, cross-talk, flicker, static image resolution, and moving image resolution.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 62341-1-2:2007, *Organic light emitting diode (OLED) displays – Part 1-2: Terminology and letter symbols*

CIE 015:2004, *Colorimetry, 3rd Edition*

ISO 11664-1/CIE S 014-1, *Colorimetry – Part 1: CIE standard colorimetric observers*

ISO 11664-5/CIE S 014-5, *Colorimetry – Part 5: CIE 1976 L*u*v* Colour space and u', v' uniform chromaticity scale diagram*

3 Terms, definitions, symbols, units and abbreviations

3.1 Terms, definitions, symbols and units

For the purposes of this document, the terms, definitions, symbols and units given in IEC 62341-1-2 apply.

3.2 Abbreviations

CCD	Charge coupled device
CIE	International Commission on Illumination (Commission Internationale de L'Éclairage)
CFF	Critrical flicker frequency
CIELAB	CIE 1976 (L*a*b*) colour space
DUT	Device under test
HVS	Human visual system
LED	Light emitting diode
LMD	Light measuring device
OLED	Organic light emitting diode
ppf	pixels per frame

PSF Point spread function

RGB Red, green, blue

SLSF Spectral line spread function

4 Standard measuring equipment and coordinate system

4.1 Light measuring devices

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

To ensure reliable measurements, the following requirements apply to the light measuring equipment, listed below:

a) Luminance meter [1][1]: the instrument's spectral responsivity shall comply with the CIE photopic luminous efficiency function with a CIE-f_1' value no greater than 3 % [2]; the relative luminance uncertainty of measured luminance (relative to CIE illuminant A source) shall not be greater than 4 % for luminance values over 10 cd/m^2 and not be greater than 10 % for luminance values 10 cd/m^2 and below.

b) Colorimeter: the detector's spectral responsivity shall comply with the colour matching functions for the CIE 1931 standard colorimetric observer (as defined in ISO 11664-1/CIE S 014-1) with a colorimetric accuracy of 0,002 for the CIE chromaticity coordinates x and y (relative to CIE illuminant A source). A correction factor can be used for required accuracy by application of a standard source with similar spectral distribution as the display to be measured.

c) Spectroradiometer: the wavelength range shall be at least from 380 nm to 780 nm, and the wavelength scale accuracy shall be less than 0,5 nm. The relative luminance uncertainty of measured luminance (relative to CIE illuminant A source) shall not be greater than 4 % for luminance values over 10 cd/m^2 and not be greater than 10 % for luminance values 10 cd/m^2 and below. Note that errors from spectral stray light within a spectroradiometer can be significant and shall be corrected. A simple matrix method may be used to correct the stray light errors, by which stray light errors can be reduced for one to two orders of magnitudes. Details of this correction method are discussed in [3].

d) Goniophotometric mechanism: the DUT or LMD can be driven rotating around a horizontal axis and vertical axis; angle accuracy shall be better than 0,5°.

e) Imaging colorimeter: number of pixels of the detector shall not be less than 4 for each display sub-pixel within the colorimeter's measurement field of view; more than 12 bit digital resolution; spectral responsivity complies with colour matching functions for the CIE 1931 standard colorimetric observer with colorimetric accuracy of 0,004 for the CIE coordinates x and y, and photopic vision response function with CIE-f_1' no greater than 3 %.

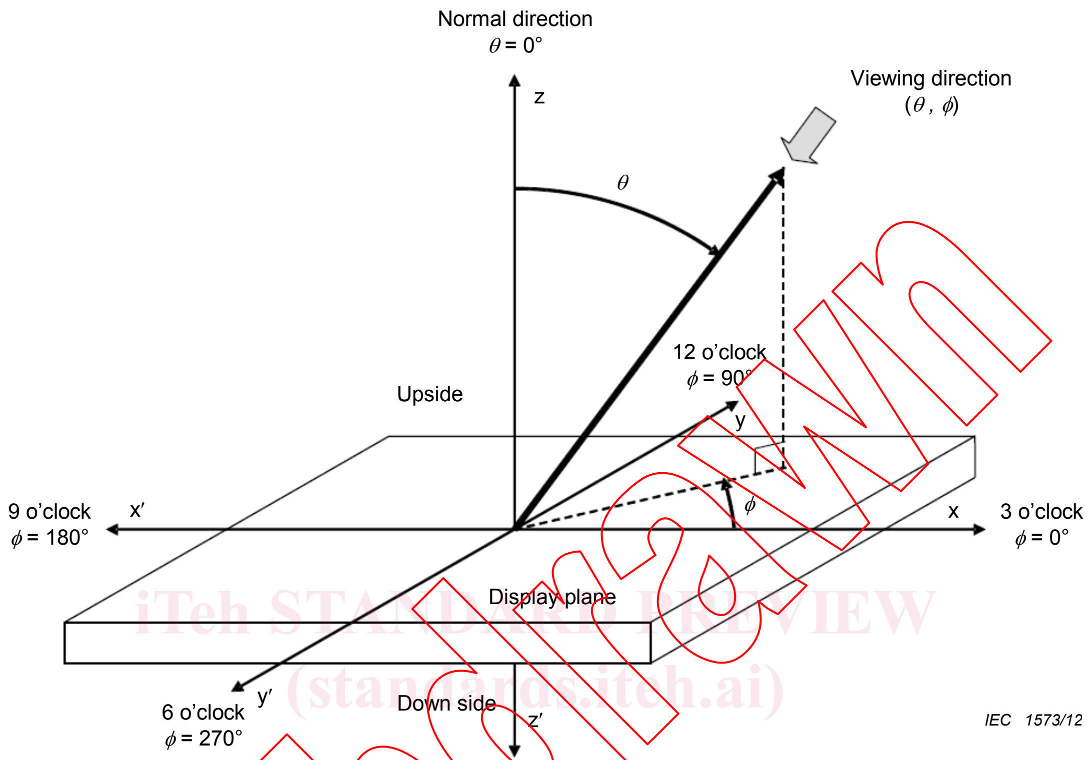
f) Fast-response photometer: the linearity shall be better than 0,5 % and frequency response higher than 1 kHz; and photopic vision response function with CIE-f_1' no greater than 5 %.

4.2 Viewing direction coordinate system

The viewing direction is the direction under which the observer looks at the spot of interest on the DUT (see also IEC 62341-1-2:2007, Figure A.2). During the measurement, the LMD is replacing the observer, looking from the same direction at a specified spot (i.e. measuring spot, measurement field) on the DUT. The viewing direction is conveniently defined by two angles: the angle of inclination θ (related to the surface normal of the DUT) and the angle of rotation ϕ (also called azimuth angle) as illustrated in Figure 1. The azimuth angle is related to

1 Numbers in square brackets refer to the bibliography.

the directions on a watch-dial as follows: ϕ = 0° is referred to as the 3 o'clock direction ("right"), ϕ = 90 ° as the 12 o'clock direction ("top"), ϕ = 180° as the 9 o'clock direction ("left") and ϕ = 270 ° as the 6 o'clock direction ("bottom").



Key

θ	incline angle from normal direction
ϕ	azimuth angle
3 o'clock	right edge of the screen as seen from the user
6 o'clock	bottom edge of the screen as seen from the user
9 o'clock	left edge of the screen as seen from the user
12 o'clock	top edge of the screen as seen from the user

Figure 1 – Representation of the viewing direction (equivalent to the direction of measurement) by the angle of inclination, θ, and the angle of rotation (azimuth angle), ϕ 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 °C ± 3 °C;
- 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 measurement report.

5.2 Power supply

The power supply for driving the DUT shall be adjusted to the rated voltage ± 0,5 %. In addition, the frequency of power supply shall provide the rated frequency ± 0,2 %.

5.3 Warm-up time

Measurements shall be carried out after sufficient warm-up. Warm-up time is defined as the time elapsed from when the supply source is switched on, and a 100 % gray level of input signal is applied to the DUT, until repeated measurements of the display show a variation in luminance of no more than 2 % per minute and 5 % per hour.

5.4 Standard measuring dark-room conditions

The luminance contribution from the background illumination reflected off the test display shall be < 0,01 cd/m^2 or less than 1/20 the display's black state luminance, whichever is lower. If these conditions are not satisfied, then background subtraction is required and it shall be noted in the measurement report. In addition, if the sensitivity of the LMD is inadequate to measure these low levels, then the lower limit of the LMD shall be noted in the measurement report.

5.5 Standard set-up conditions

By default, the display shall be installed in the vertical position (Figure 2a), but the horizontal alternative (Figure 2b) is also allowed. When the latter alternative is used, it shall be noted in the measurement report.

Luminance, contrast and chromaticity of the white field and other relevant parameters of the displays have to be adjusted to nominal status in the detailed specification and they shall be noted in the measurement report. When there is no level specified, the maximum contrast and/or luminance level shall be used. These adjustments shall be held constant for all measurements, unless noted otherwise in the measurement report. Additional conditions are specified separately for each measuring method.

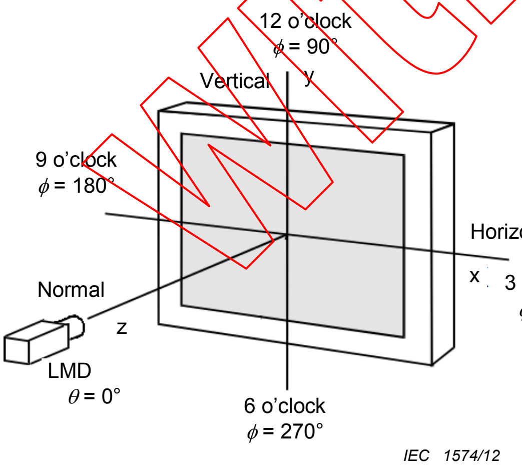


Figure 2a – Primary installation

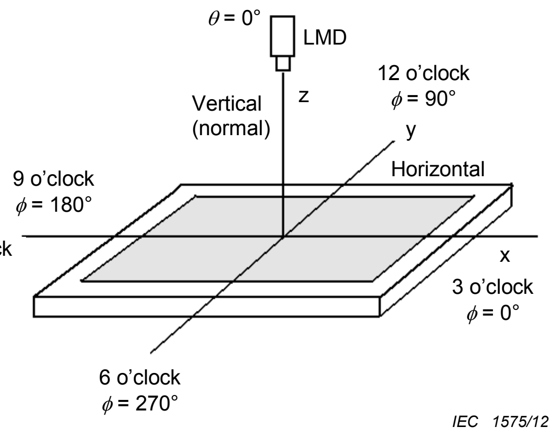


Figure 2b – Alternative installation

Figure 2 – DUT installation conditions

6 Measuring methods of image quality

6.1 Viewing angle range

6.1.1 Purpose

The purpose of this method is to measure the viewing angle range of an OLED display module in the horizontal ($\phi = 0^\circ$, $\phi = 180^\circ$) and vertical ($\phi = 90^\circ$, $\phi = 270^\circ$) viewing direction. Different evaluation criteria are described with which the viewing angle range can be determined. Several studies [4 – 8] have indicated that the contrast ratio (CR > 10:1) is, from a visual quality point of view, not very useful to determine the viewing angle range for matrix displays. When colour differences are included in a viewing angle metric, the correlation between the metric value and a visual assessment value is significantly increased [9]. A more recent study [10] revealed that a metric, combining viewing angle related luminance degradation and colour deviation can accurately predict the relative change in visual assessment value. This information is the basis for the determination of the image quality based viewing angle range, which has relevance from a visual quality point of view.

6.1.2 Measuring conditions

Standard measuring is implemented under standard dark-room and set-up conditions.

6.1.3 Set-up

a) Apparatus: an LMD to measure luminance and chromaticity of the DUT; driving power source; driving signal equipment; geometric mechanism illustrated in Figure 3.

b) Mount the display and LMD in a mechanical system that allows the display to be measured along its vertical and horizontal plane, which lie normal to the display surface. Figure 3 illustrates the geometry to be used in this measurement. The angle relative to the display normal in the horizontal plane, 3 o'clock and 9 o'clock direction, is expressed as θ_H, and the angle in the vertical plane, 6 o'clock and 12 o'clock direction, by θ_V. Either the display can be tilted to scan both planes, or the LMD can be moved within these planes. During the measuring procedure, the LMD shall be directed at the same field of measurement for all angles of inclination. In either case, the centre of the measurement field shall remain at the same location on the DUT surface for all angles of inclination. The angular positioning of the display in the goniophotometric system shall be accurate to ± 0,5°, and the measuring range shall be implemented from -90° to +90° both in vertical and horizontal plane.

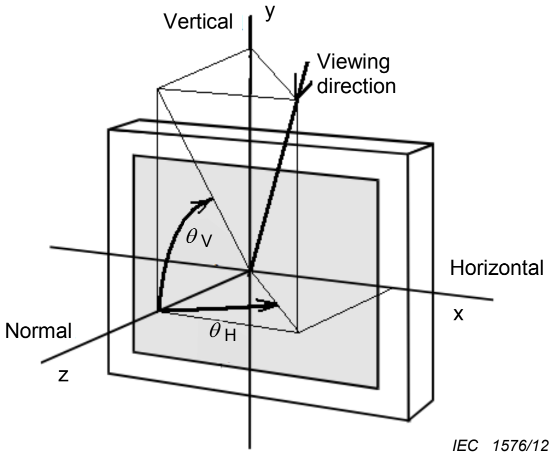


Figure 3a – Geometric structure of display to be measured

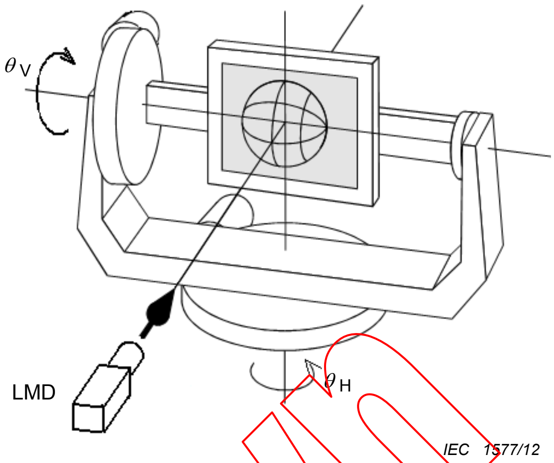


Figure 3b – Geometric system

Figure 3 – Geometry used for measuring viewing angle range

c) Input signal to the DUT:

1) To determine the luminance (*L*) and CIE 1976 (as defined in ISO 11664-5/CIE S 014-5) chromaticity coordinates (*u'*, *v'*) related viewing angle ranges, generate a full white screen with a 100 % signal level (R = G = B = 255 for an 8 bit input signal) on the display.

2) To determine the contrast ratio (*CR*) related viewing angle range, generate a full white screen with a 100 % signal level (R = G = B = 255 for an 8 bit input signal) on the display to measure the maximum display luminance (L_{max}) and subsequently a full black screen with 0 % signal level (R = G = B = 0 for an 8 bit input signal) to measure the minimum luminance (L_{min}). The contrast ratio is defined by:

$$CR = \frac{L_{max}}{L_{min}} \quad (1)$$

3) To determine the image quality related viewing angle range, generate a full screen grey pattern with a 78,,4 % signal level (R=G=B=200 for an 8 bit input signal) on the display to measure the luminance (*L*) and the CIE 1976 chromaticity coordinates (*u*', *v*') [11].

d) Align the LMD perpendicular to the display surface (θ = 0, ϕ = 0), and position it to the centre of the display (position P_0 in Figure 4).

6.1.4 Measurement and evaluation

Proceed as follows:

a) Apply the required input signal(s) to the DUT.

b) Measure the centre luminance (L_0), chromaticity coordinates (u'_0, v'_0) and contrast ratio (CR_0) perpendicular to the display surface (θ = 0°, ϕ = 0°). The measurement area shall cover at least 500 pixels, or demonstrate equivalent results with fewer sampled pixels.

c) Take luminance ($L_{\theta,\phi}$), chromaticity coordinates ($u'_{\theta,\phi}$, $v'_{\theta,\phi}$) and contrast ratio ($CR_{\theta,\phi}$) measurements as the LMD steps through the various angles in the horizontal (ϕ = 0°, ϕ = 180°) and vertical (ϕ = 90°, ϕ = 270°) viewing planes.

d) Record the change in luminance and chromaticity coordinates from the perpendicular direction.

1) The luminance change is defined in terms of the luminance ratio:

$$LR_{\theta,\phi} = \frac{L_{\theta,\phi}}{L_0} \tag{2}$$

2) Colour shifts with viewing angle are to be determined relative to chromaticity coordinates measured at the display normal. The change in colour is defined by the colour difference equation using the CIE 1976 uniform colour space:

$$\Delta u'v'_{\theta,\phi} = \sqrt{(u'_0 - u'_{\theta,\phi})^2 + (v'_0 - v'_{\theta,\phi})^2} \tag{3}$$

e) Determine in each of the four viewing directions (ϕ = 0°, ϕ = 180°, ϕ = 90°, ϕ = 270°), the angles ($\theta\phi$ = 0°, $\theta\phi$ = 180°, $\theta\phi$ = 90°, $\theta\phi$ = 270°) at which the specified conditions are met:

1) For the luminance based viewing angle range, when the luminance ratio (*LR*), calculated with Equation (2), equals 50 % or any other agreed upon value, specified in the detail specification.

2) For the contrast ratio based viewing angle range, when the contrast ratio ($CR_{\theta,\phi}$), calculated with Equation (1), equals 100 or any other agreed upon value, specified in the detail specification.

3) For the colour based viewing angle range, when the colour difference ($\Delta u'v'$), calculated with Equation (3), equals 0,01 or any other agreed upon value, specified in the detail specification.

4) For the image quality based viewing angle range, in which both the change in luminance and the change in colour are considered, the condition specified in Equation (4) applies:

$$IQ = LR_{\theta,\phi} - 28 \times \Delta u'v' \geq 0{,}36 \tag{4}$$

where

$$LR_{\theta,\phi} = \frac{L_{\theta,\phi}}{L_0}$$

and

$$\Delta u'v' = \sqrt{(u'_0 - u'_{\theta,\phi})^2 + (v'_0 - v'_{\theta,\phi})^2}$$

NOTE Other measurement systems, such as conoscopic instruments, can also be used for the viewing angle range measurement, if equivalent results can be demonstrated.

6.1.5 Reporting

The horizontal and vertical viewing angles ranges shall be calculated according to Equation (5) on horizontal viewing angle range and Equation (6) on vertical viewing angle range.

$$\theta_{\mathrm{VAR,H}} = \theta_{\phi = 0^\circ} + \theta_{\phi = 180^\circ} \tag{5}$$

$$\theta_{\mathrm{VAR,V}} = \theta_{\phi = 90^\circ} + \theta_{\phi = 270^\circ} \tag{6}$$

The horizontal and vertical viewing angle ranges shall be noted in the measurement report, together with the used criteria, e.g. *LR* ≥ 0,50, *CR* > 100, $\Delta u'v'$ ≤ 0,01, or image quality based.

6.2 Cross-talk

6.2.1 Purpose

The purpose of this method is to measure the cross coupling of electrical signals between elements (cross-talk) of an OLED display module.

6.2.2 Measuring conditions

The following measuring conditions apply:

a) Apparatus: an LMD that can measure luminance, a driving power source, and driving signal equipment.

b) Standard measuring environmental conditions; dark-room condition; standard set-up conditions.

c) The LMD shall be aligned perpendicularly to position P_0 in Figure 4 to measure the luminance.

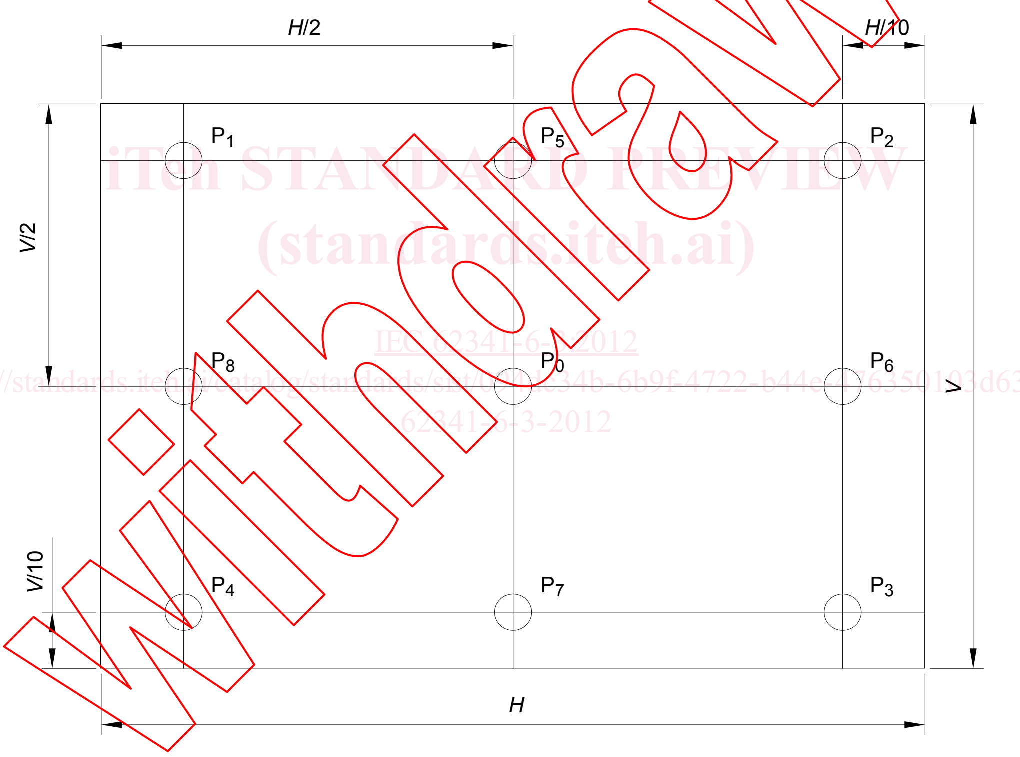


Figure 4 – Standard measurement positions, indicated by P_0 - P_8, located relative to the height (*V*) and display width (*H*) of active area

6.2.3 Measurement and evaluation

Proceed as follows:

a) Measure the maximum white level window luminance, $L_{w,max}$, at the centre of the active area (position P_0 in Figure 4).

Input signal is a 4 % white window pattern, with 100 % signal level, on a black background, 0 % signal level, in the centre of the active area, as shown in Figure 5. The 4 % window has corresponding sides that are 1/5 the vertical and horizontal dimensions of the active area. For a monochrome display, apply a signal at the highest grey level. For a colour display, apply a white signal level of 100 %.