

INTERNATIONAL STANDARD



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

(<https://standards.iteh.ai>)

Document Preview

IEC 62341-6-1:2017

<https://standards.iteh.ai/standards/iec/55/iec/1b4-31cb-4cdd-ba9a-f4df5a585709/iec-62341-6-1-2017>



THIS PUBLICATION IS COPYRIGHT PROTECTED
Copyright © 2017 IEC, Geneva, Switzerland

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from either IEC or IEC's member National Committee in the country of the requester. If you have any questions about IEC copyright or have an enquiry about obtaining additional rights to this publication, please contact the address below or your local IEC member National Committee for further information.

IEC Central Office
3, rue de Varembe
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
Fax: +41 22 919 03 00
info@iec.ch
www.iec.ch

About the IEC

The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About IEC publications

The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigenda or an amendment might have been published.

IEC Catalogue - webstore.iec.ch/catalogue

The stand-alone application for consulting the entire bibliographical information on IEC International Standards, Technical Specifications, Technical Reports and other documents. Available for PC, Mac OS, Android Tablets and iPad.

IEC publications search - www.iec.ch/searchpub

The advanced search enables to find IEC publications by a variety of criteria (reference number, text, technical committee,...). It also gives information on projects, replaced and withdrawn publications.

IEC Just Published - webstore.iec.ch/justpublished

Stay up to date on all new IEC publications. Just Published details all new publications released. Available online and also once a month by email.

Electropedia - www.electropedia.org

The world's leading online dictionary of electronic and electrical terms containing 20 000 terms and definitions in English and French, with equivalent terms in 16 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

IEC Glossary - std.iec.ch/glossary

65 000 electrotechnical terminology entries in English and French extracted from the Terms and Definitions clause of IEC publications issued since 2002. Some entries have been collected from earlier publications of IEC TC 37, 77, 86 and CISPR.

IEC Customer Service Centre - webstore.iec.ch/csc

If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: csc@iec.ch.

IEC 62341-6-1:2017

<https://standards.iteh.ai/standards/iec/524e61b4-31eb-4cdd-ba9a-f4df5a585709/iec-62341-6-1-2017>

INTERNATIONAL STANDARD



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

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 31.260

ISBN 978-2-8322-3887-5

Warning! Make sure that you obtained this publication from an authorized distributor.

CONTENTS

FOREWORD	6
1 Scope	8
2 Normative references	8
3 Terms, definitions, and units abbreviated terms	8
3.1 Terms and definitions	8
3.2 Abbreviated terms	9
4 Structure of measuring equipment	9
5 Standard measuring conditions	9
5.1 Standard measuring environmental conditions for measurements	9
5.2 Standard measuring dark room conditions for measurements	9
5.3 Standard setup conditions	10
5.3.1 General	10
5.3.2 Adjustment of OLED display modules	10
5.3.3 Starting conditions of measurements	10
5.3.4 Conditions of Measuring equipment requirements	10
5.4 Standard locations of measurement field	13
5.5 Standard test patterns	13
6 Measuring methods for optical parameters	18
6.1 Primary luminance, colour, and its uniformity of full-colour high-resolution modules	18
6.1.1 Purpose	18
6.1.2 Measuring conditions	18
6.1.3 Measuring method for high-resolution full-colour modules	19
6.1.4 Maximum luminance of white and RGB primaries	20
6.1.5 Average colour of white and RGB primaries	20
6.1.6 Luminance uniformity of white and RGB primaries	21
6.1.7 Colour non-uniformity of white and RGB primaries	21
6.1.8 Colour additivity of white and RGB primaries	22
6.1.9 White correlated colour temperature	22
6.2 Primary luminance, colour, and uniformity of low-resolution modules	23
6.2.1 Purpose	23
6.2.2 Measuring conditions	23
6.2.3 Measuring method for low-resolution modules and segmented displays	23
6.3 Chromaticity, colour uniformity, colour gamut and white field correlated colour temperature	
6.3.1 Purpose	
6.3.2 Measuring conditions	
6.3.3 Measuring method	
6.3 Signal loading	23
6.3.1 Purpose	23
6.3.2 Measuring conditions	23
6.3.3 Measuring methods	23
6.4 Dark room contrast ratio	24
6.4.1 Purpose	24
6.4.2 Measuring conditions	24
6.4.3 Measuring method	29

6.5	Display colour gamut, colour gamut area, and colour gamut volume	29
6.5.1	Purpose	29
6.5.2	Measuring conditions	30
6.5.3	Measuring method	30
6.5.4	Display colour gamut	30
6.5.5	Display colour gamut area in CIE 1976 chromaticity diagram	30
6.5.6	Colour gamut volume	31
7	Measuring methods for power consumption	32
7.1	Purpose	32
7.2	Measuring conditions	32
7.3	Measuring method	33
7.3.1	Measuring the power consumption of the OLED display module	33
Annex A (normative)	Response time of passive matrix display panels	35
A.1	Purpose	35
A.2	Measuring conditions	35
A.3	Measuring method	35
Annex B (normative)	Luminance current efficiency	37
B.1	Purpose	37
B.2	Measuring conditions	37
B.3	Measuring method	37
Annex C (informative)	Veiling glare frustum	39
Annex D (informative)	Methods to obtain the correlated colour temperature (CCT) from chromaticity coordinates	40
D.1	Method 1: using McCamy's approximate formula	40
D.2	Method 2: using Javier Hernandez-Andres's approximate formula	40
D.3	Method 3: graphical determination of correlated colour temperature	41
Annex E (informative)	Measuring the performance of modern colour-managed displays and panels	43
E.1	Legacy displays	43
E.2	Modern displays	43
E.3	Results	45
E.4	Conclusion	48
Annex F (informative)	Simple window luminance and colour measurements	49
F.1	Background	49
F.2	Measuring conditions	49
F.3	Maximum full-screen luminance	49
F.4	4 % window luminance	49
F.5	Sampled luminance non-uniformity	50
F.6	4 % window centre colour	52
F.7	Sampled colour non-uniformity	52
Bibliography	53
Figure 1	– Layout diagram of measurement setup	10
Figure 2	– Standard measurement positions in the active area of the display	11
Figure 3	– Measurement points	11
Figure 3	– Test pattern scaling used to define the area size of the coloured rectangles in the active area of the display	12
Figure 4	– Example of the colour gamut	12

Figure 4 – Low APL loading series of red, green, blue, and white test patterns used for basic luminance, colour, and uniformity measurements..... 13

~~Figure 5 – Colour of blackbody source at various temperatures..... 14~~

Figure 5 – Medium (top) and high (bottom) APL loading versions of CTR pattern..... 14

Figure 6 – Standard low APL RGBCMY test pattern used for centre luminance and colour measurements..... 15

Figure 7 – Optional medium APL RGBCMY test pattern used for centre luminance and colour measurements..... 16

Figure 8 – Sequence for measuring luminance and colour at the nine standard display positions for all coloured tile patterns..... 17

Figure 9 – Colour of blackbody source at various temperatures as represented on the CIE 1931 chromaticity diagram..... 20

Figure 10 – Example representation of the same primary colours in the CIE 1931 (left) and CIE 1976 (right) chromaticity diagrams..... 24

Figure 11 – Example of the range of colours produced by a given display as represented by the CIELAB colour space..... 25

Figure 12 – Example of measurement setup of power consumption..... 27

Figure A.1 – Relationship between the driving signal and the optical response times..... 29

Figure B.1 – Example of a measurement configuration for measuring luminance current efficiency..... 31

Figure C.1 – Pattern for veiling glare frustum..... 32

Figure D.1 – CIE 1931 XYZ chromaticity diagram..... 34

Figure D.2 – Blackbody locus (Planckian locus) and isothermperature lines in CIE 1931 XYZ chromaticity diagram..... 35

Figure E.1 – Legacy model where the independent drive electronics provide a direct correlation between the input RGB signals and the display's colour primaries..... 36

Figure E.2 – Example of modern drive models utilizing multi-dimensional LUTs for RGB (top) and multi-primary (bottom) displays..... 37

Figure E.3 – Example of APL loading behaviour for a WRGB (top) and RGB (bottom) OLED display..... 39

Figure E.4 – Low APL loading test pattern with small box size (1/9 the screen size dimensions)..... 40

Figure E.5 – APL loading profiles for several input colours measured at the centre of the test pattern using Figure E.4..... 41

Figure F.1 – ~~Luminance measuring pattern~~ Example of a simple 4 % white window pattern at the centre of the screen..... 43

~~Table 1 – Example of luminance non-uniformity..... 15~~

Table 1 – Standard digital-equivalent input signals for rendering the white, primary and secondary colours in test patterns..... 15

~~Table 2 – Example of chromaticity non-uniformity..... 18~~

Table 2 – Example of luminance measured of the same colour at the nine standard screen positions and the resulting luminance non-uniformity..... 18

Table 3 – Example of the same colour measured at the nine standard screen positions and the resulting chromaticity non-uniformity..... 18

Table 4 – Scaling the size of the colour boxes in the APL loading pattern relative to the screen dimensions..... 22

Table 5 – Example of a summary sheet for module power consumption measurements..... 27

Table D.1 – x_e , y_e , A_i and t_i for Formula (D.3) and Formula (D.4)..... 33

Table E.1 – Example of luminance data for an RGB and WRGB OLED display 38

Withdrawing

iTech Standards
(<https://standards.iteh.ai>)
Document Preview

<https://standards.iteh.ai/standards/iec/55/iec/1b4-31cb-4cdd-ba9a-f4df5a585709/iec-62341-6-1-2017>

INTERNATIONAL ELECTROTECHNICAL COMMISSION

ORGANIC LIGHT EMITTING DIODE (OLED) DISPLAYS –

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

FOREWORD

- 1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
- 2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
- 3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
- 4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
- 5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
- 6) All users should ensure that they have the latest edition of this publication.
- 7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
- 8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
- 9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

This redline version of the official IEC Standard allows the user to identify the changes made to the previous edition. A vertical bar appears in the margin wherever a change has been made. Additions are in green text, deletions are in strikethrough red text.

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

This second edition cancels and replaces the first edition published in 2009. This edition constitutes a technical revision.

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

- a) extends the applicability of the measuring methods to include OLED displays that have multi-primary or red, green, blue and white sub-pixels;
- b) adds a method to characterize how the luminance is affected by the amount of content on the screen;
- c) adds a method to determine the dark room colour gamut volume in the CIELAB colour space.

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

FDIS	Report on voting
110/816/FDIS	110/830/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 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 "<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.

A bilingual version of this publication may be issued at a later date.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

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~~. These methods are limited to flat displays measured in a dark room.

- ~~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 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*

CIE 15-2:1986 2004, *Colorimetry*, ~~(second 3rd edition)~~

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

3 Terms, definitions, and **units** abbreviated terms

3.1 Terms and definitions

For the purposes of this document, ~~most of the definitions and units used comply with~~ 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 <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

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.

3.2 Abbreviated terms

APL	average picture level
CCT	correlated colour temperature
CIE	Commission internationale de l'éclairage (International Commission on Illumination)
CIELAB	CIE 1976 ($L^*a^*b^*$) colour space
CMY	cyan, magenta, and yellow
DUT	device under test
LMD	light-measuring device
LUT	look-up table
PMOLED	passive matrix organic light-emitting diode
RGB	red, green, and blue
RGBCMY	red, green, blue, cyan, magenta, and yellow
sRGB	standard RGB colour space as defined in IEC 61966-2-1
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 for measurements**

Measurements shall be carried out under standard environmental conditions at a temperature of $25\text{ °C} \pm 3\text{ °C}$, at a relative humidity of 25 % to 85 %, and at an air 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 for measurements

~~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.~~

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. Any deviations from these conditions shall be ~~reported~~ recorded.

5.3.2 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. The display shall be measured at its factory default settings. If other settings are used, they shall be noted in the test report. These adjustments 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

~~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 display and the 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 ~~to be allowed for the OLED displays to reach luminescence stability~~ been achieved when the luminance of the test feature to be measured varies by less than $\pm 3\%$ over the entire measurement method for a given display image.

5.3.4 ~~Conditions of~~ Measuring equipment requirements

5.3.4.1 General conditions

Light measurements shall generally be measured 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). Non-contact LMD, where the LMD is not in direct contact with the screen, shall be used without an illumination source. The following ~~general conditions apply~~ requirements are given for these instruments:

- 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;~~

¹ Numbers in square brackets refer to the Bibliography.

- ~~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.~~

The LMD shall be a luminance meter, a colorimeter, or a spectroradiometer. The spectroradiometer shall be capable of measuring spectral radiance over at least the 380 nm to 780 nm spectral range, with a maximum bandwidth of 10 nm for smooth broadband spectra. For OLED primaries with 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.

Care shall be taken to ensure that the ~~device is capable~~ 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 perpendicular to the ~~area to be measured on the image generating surface of the OLED display~~ 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 ~~lens shall be focused on the light emitting plane of the display~~ integration time shall be an integer number (~~≥ 10~~) of frame periods, synchronized to the frame rate, or the integration time shall be greater than one hundred frame periods. ~~Shorter integration times are acceptable if the detector is synchronized with the display frame rate.~~
- 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 the detector area should be considered.

In addition to LMDs that form an average value for the measured quantity over the measurement field under consideration (i.e. spot photometers, Figure 1), there are imaging LMDs which give a value for 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.

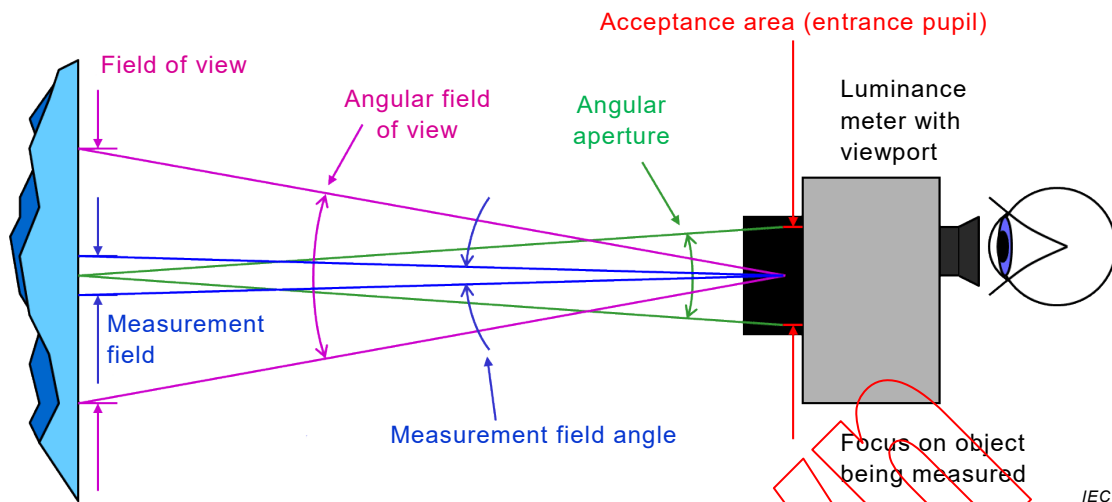


Figure 1 – Layout diagram of measurement setup

5.3.4.2 High pixel count matrix displays ($\geq 320 \times 240$ pixels)

The following applies for high pixel count matrix displays.

- a) When measuring matrix displays, the ~~measurement field shall~~ 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) ~~The standard measuring distance L_{50} 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.~~ 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 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). ~~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) 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 ($< 320 \times 240$ pixels) and segmented displays

The following applies for low pixel count matrix displays.

- a) Low pixel count displays may 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 measurement 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) ~~When the measurement conditions do not satisfy the requirement of $\leq 2^\circ$ for the measurement field angle, or the measurement field includes fewer than 500 pixels, the measured values for these parameters shall be reported.~~ 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.