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INTERNATIONAL STANDARD

Display lighting unit –
Part 2-3: Electro-optical measuring methods for LED frontlight unit

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DISPLAY LIGHTING UNIT –

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International Standard IEC 62595-2-3 has been prepared by IEC technical committee TC 110: Electronic display devices.

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

CDV	Report on voting
110/891/CDV	110/933A/RVC

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 parts in the IEC 62595 series, published under the general title *Display lighting unit*, can be found on the IEC website.

Future standards in this series will carry the new general title as cited above. Titles of existing standards in this series will be updated at the time of the next edition.

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- withdrawn,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.

DISPLAY LIGHTING UNIT –

Part 2-3: Electro-optical measuring methods for LED frontlight unit

1 Scope

This part of IEC 62595 specifies the standard measurement conditions and measuring methods for determining electrical, optical, and electro-optical properties of LED frontlight units (FLUs) for reflective displays.

NOTE: See 3.1.1 for a definition of reflective display.

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 61747-6-2, *Liquid crystal display devices – Part 6-2: Measuring methods for liquid crystal display modules – Reflective type*

IEC 62595-1-2, *Display lighting unit – Part 1-2: Terminology and letter symbols*

IEC 62595-2-1, *Display lighting unit – Part 2-1: Electro-optical measuring methods of LED backlight unit*

IEC 62679-3-3, *Electronic paper displays – Part 3-3: Optical measuring methods for displays with integrated lighting units*

3 Terms, definitions, abbreviated terms and letter symbols

For the purposes of this document, the terms, definitions, abbreviated terms and letter symbols given in IEC 62595-1-2 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 Terms and definitions

3.1.1
reflective display
display whose function is based on the light reflection of a reflective layer in its structure

EXAMPLE A reflective LCD, an electronic paper display, a micro electro-mechanical system (MEMS) and a micro electro-opto-mechanical system (MEOMS) display device. See IEC 62679-3-3.

3.1.2
normal state
normal-state FLU
state of an FLU in which the light emerges from its front surface that faces toward the reflective display

Note 1 to entry: For an example, see Annex A, Annex B, Figure A.1 and Figure B.1, [1] to [8][1].

3.1.3
inverted state
inverted-state FLU
FLU with an illuminating surface toward a viewer

Note 1 to entry: For an example, see Figure B.2.

3.1.4
optical trap
optical device that is used in FLU measurements for trapping or absorbing the emergent light from the opposite surface of the FLU under measurement device, whether the FLU is in a normal state or in inverted state

Note 1 to entry: For examples, see Figure 1.

3.1.5
optical absorbing sheet
optical absorbing plate
plane sheet or plate that is used beneath an FLU under measurement to absorb the emergent light

3.1.6
BRDF
bi-directional reflectance distribution function
variation of reflected luminance ($L_{vR}(\theta_r,\phi_{r;}\theta_i,\phi_i,\lambda_i)$) due to the change of non-polarized illumination ($E_v(\theta_i,\phi_i,\lambda_i)$) of an infinitesimal uniform area on an FLU

Note 1 to entry: See Annex C and Annex D. In case of an equal reflection factor of the FLU surface, the BRDF is a space invariant characteristic, and the eigen value of the FLU is expressed in solid angle (Ω) unit, i.e., in terms of steradian.

3.1.7
BTDF
bi-directional transmittance distribution function
variation of transmitted luminance ($L_{vT}(\theta_r,\phi_{r;}\theta_i,\phi_i,\lambda_i)$) due to non-polarized illuminating variation ($E_v(\theta_i,\phi_i,\lambda_i)$) of an infinitesimal area on an FLU

Note 1 to entry: See Annex C and Annex D. In case of an equal transmittance factor on each point of the FLU surface, the BTDF is a space invariant characteristic, and the eigen value of the BRDF of the FLU is expressed in solid angle (Ω) unit, i.e., in terms of steradian.

3.1.8
BPDF
bi-directional polarization distribution function
variation of luminance with polarization of the reflected light ($L_{vP}(\theta_r,\phi_{r;}\theta_i,\phi_i,\lambda_i)$) due to a change of non-polarized illumination ($E_v(\theta_i,\phi_i,\lambda_i)$) of an infinitesimal uniform area on an FLU

Note 1 to entry: See Annex C, Annex D and Annex E. In case of an equal reflection factor on each point of the FLU surface, the BPDF is a space invariant characteristic, and the eigen value of the BTDF of the FLU is expressed in solid angle (Ω) unit, i.e., in terms of steradian.

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

3.1.9
OTF
optical transfer function
contrast of transmitted line pairs through an FLU versus line pairs periodicities and orientations

Note 1 to entry: See Annex F.

3.1.10
optical transfer function evaluation chart
OTF evaluation chart
printed charts of straight black and white line pairs with different widths (line pairs per millimeter) and periodicities for use beneath a normal-state FLU to measure and plot the observed light intensity versus line pairs per millimeter

Note 1 to entry: An example of the resolution test chart can be obtained based on ISO 12233 [9].

Note 2 to entry: See Annex F.

3.1.11
optical signal-to-noise ratio
optical SNR
ratio of the luminance of the illuminating directed light, $L_{\text{v,signal}}(x_i,y_i, \theta_j,\phi_j)$, toward the reflective display in a predefined direction in the spherical coordinate system, (θ, ϕ), and the luminance of noise, $L_{\text{v,noise}}(x_i,y_i,\theta_j,\phi_j)$, i.e. besides the directed illuminating light, expressed as

$$SNR = \frac{L_{\text{v,signal}}\left(x_i, y_i, \theta_j, \phi_j\right)}{L_{\text{v,noise}}\left(x_i, y_i, \theta_j, \phi_j\right)} \quad (1)$$

3.1.12
aliasing interference fringe
moiré pattern
periodic interference pattern that appears between the spatial distribution of the sub-micro or micro-optical structures on the front surface (non-illuminating surface) of a normal-state FLU and the spatial pixel structure of the reflective display

Note 1 to entry: See [1] to [8].

3.1.13
visual inspection
act of checking defects such as distraction of the transparency caused by flaws in the LGP/LGF of the non-lit FLU or scratches on either side of an FLU that can been seen under high white illumination by turning over in various directions

3.1.14
perceptual visual quality
cosmetic quality
image fidelity performance of the lit FLU when the images of the reflective display are viewed through the FLU

Note 1 to entry: It is also the performance of a normal-state FLU in an integration or in combination with a reflective display that indicates the no-distraction of a displayed image.

Note 2 to entry: See 7.15.

3.2 Abbreviated terms

ACU - angular colour uniformity

ALD - angular luminance distribution

BPDF - bi-directional polarization distribution function
BRDF - bi-directional reflectance distribution function
BTDF - bi-directional transmittance distribution function
CCD - charge coupled device
CMOS - complementary metal oxide semiconductor
DUT - device under test
FLU - frontlight unit
FOS - front-of-screen
LCD - liquid crystal display
LED - light emitting diode
lp - line pairs
LGF - light-guide film
LGP - light-guide plate
LMD - light measuring device
OTF - optical transfer function
SLG - stick-light guide

3.3 Letter symbols (quantity symbols / unit symbols)

The letter symbols for FLUs are shown in Table 1.

Table 1 – Letter symbols (quantity symbols / unit symbols)

Arbitrary luminance of a point (x_i, y_i) on an FLU	L_{vi}	(cd/m^2)
Maximum luminance on an FLU	L_{vM}	(cd/m^2)
Minimum luminance on an FLU	L_{vm}	(cd/m^2)
Average luminance on an FLU	L_{va}	(cd/m^2)
Centre luminance on FLU	L_{vc}	(cd/m^2)
Spatial luminance uniformity	U	(%)
Spatial luminance non-uniformity	NU	(%)
Angular luminance in an arbitrary direction	$L_v\ (x,\ y;\ \theta,\phi)$	(cd/m^2)
Solid angle	Ω	(sr)
Colour uniformity (chromaticity difference)	$\Delta u'v'$	
Spectral power distribution of a display lighting unit	$S_{FLU}(\lambda)$	
Angular luminance distribution of transmitted light at an arbitrary point (x_i,y_i)	$L_{vT}(x_i,y_i,\theta,\phi)$	(cd/m^2)
Angular luminance distribution of reflected light at an arbitrary point (x_i,y_i)	$L_{vR}(x_i,y_i,\theta,\phi)$	(cd/m^2)
Angular luminance distribution of a polarized light at an arbitrary point (x_i,y_i)	$L_{vP}(x_i,y_i,\theta,\phi)$	(cd/m^2)
Angular colour uniformity	$\Delta u'v'(\theta,\phi;x_i,y_i,)$	
BRDF	$L_{vR}(\theta_r,\phi_r;\theta_i,\phi_i,\lambda_i)\ /\ E_v(\theta_i,\phi_i,\lambda_i)$	(1/sr)
BTDF	$L_{vT}(\theta_r,\phi_r;\theta_i,\phi_i,\lambda_i)\ /\ E_v(\theta_i,\phi_i,\lambda_i)$	(1/sr)
BPDF	$L_{vP}(\theta_r,\phi_r;\theta_i,\phi_i,\lambda_i)\ /\ E_v(\theta_i,\phi_i,\lambda_i)$	(1/sr)
OTF	C_R	

4 Measuring devices

4.1 General

The following measuring devices shall be used in this document. The LMD shall be calibrated with the appropriate photometric or spectrometric standards.

4.2 Light measuring device (LMD)

4.2.1 Luminance meter

The luminance meter (a spot meter or an imaging meter) shall be equivalent to the human eye. The equipment shall be calibrated with the luminance standards, and should be carefully checked before measurement, considering the following elements:

– sensitivity of the measured quantity to measuring light;

– errors caused by veiling glare and lens flare (i.e., stray light in optical system);

– timing of data-acquisition, low-pass filtering and aliasing interference fringe effects;

– linearity of detection and data-conversion.

NOTE: ISO/CIE 19476 [10] is available asreference for the LMD evaluation procedures.

4.2.2 Spectroradiometer (spectral radiance-meter)

The wavelength range shall be at least 380 nm to 780 nm and the spectral bandwidth shall be 5 nm or less. The wavelength accuracy shall be 0,3 nm or less. The equipment shall be calibrated with the with the spectrometric standards. The performance should be carefully checked before measurement, considering the same elements as in 4.2.1.

4.2.3 Conoscopic system

The conoscopic system is the angular optical distribution measurement system with Fourier optics. The photometric values, such as luminance, which are obtained by the equipment without any photometric standard calibration shall not be used. The relative values, such as an angular optical distribution and colour uniformity, shall be applied.

4.2.4 Image sensor

The image sensor is constructed from a one-dimensional CCD (CMOS) line sensor or a two-dimensional CCD (CMOS). The image sensor shall be applied for measuring the OTF property of the DUT. The spatial resolution of the image sensor shall be at least twice as high as that of the DUT.

NOTE Sampling frequency or resolution is double or more that of the chart under measurement to prevent the aliasing interference fringe phenomenon or any countermeasure from eliminating aliasing interference fringe in the measurement.

4.3 Other devices

4.3.1 Sample stage

The orthogonal three axes stage should be used to adjust the measurement points of the DUT. The biaxial goniometer should be used to adjust the measurement direction (the zenith angle and azimuth angle) of the DUT. The positioning accuracy of these devices shall be enough to make the specified repeatability.

NOTE See Figure 2 and Figure 3.