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INTERNATIONAL STANDARD

colour inside

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

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CONTENTS

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DISPLAY LIGHTING UNIT –

Part 2-1: Electro-optical measuring methods of LED backlight unit

FOREWORD

International Standard IEC 62595-2-1 has been prepared by IEC Technical Committee 110: Electronic display devices.

This first edition cancels and replaces the first edition of IEC 62595-2 published in 2012. This edition constitutes a technical revision.

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

a) changed the series title in order to cover frontlight unit;
b) added the detailed measurement procedures particularly for block-wise BLU;
c) deleted Annex A;
d) revised Figure 1 and Figure 2 and some editorial errors.

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

FDIS	Report on voting
110/731A/FDIS	110/743A/RVD

Full information on the voting for the approval of 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 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 publication will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

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- withdrawn,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

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

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DISPLAY LIGHTING UNIT –

Part 2-1: Electro-optical measuring methods of LED backlight unit

1 Scope

This part of IEC 62595 specifies the standard measurement conditions and measuring methods for determining the electrical and optical parameters of LED backlight units for liquid crystal displays.

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 61747-30-1, *Liquid crystal display devices – Part 30-1: Measuring methods for liquid crystal display modules – Transmissive type*

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

3 Terms, definitions and abbreviations

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 62595-1-2 apply.

3.2 Abbreviations

BLU backlight unit

FOV field of view

LMD light measuring device

LSF light spread function

4 General measurement conditions

4.1 Standard atmospheric conditions for LED BLU

Unless otherwise specified, all tests and measurements for LED BLU shall be carried out after sufficient warm-up time (see 4.3), under the standard environmental conditions, at a temperature of 25 °C ± 3 °C, a relative humidity of 25 % to 85 %, and an atmospheric pressure of 86 kPa to 106 kPa. When different environmental conditions are used, they shall be noted in the detail specification (see IEC 61747-30-1).

1 To be published.

4.2 Measuring setup

Figure 1 shows a typical setup of a BLU, luminance meter, power source, block controller, voltmeters and current meters for electro-optical measurements for LED BLU.

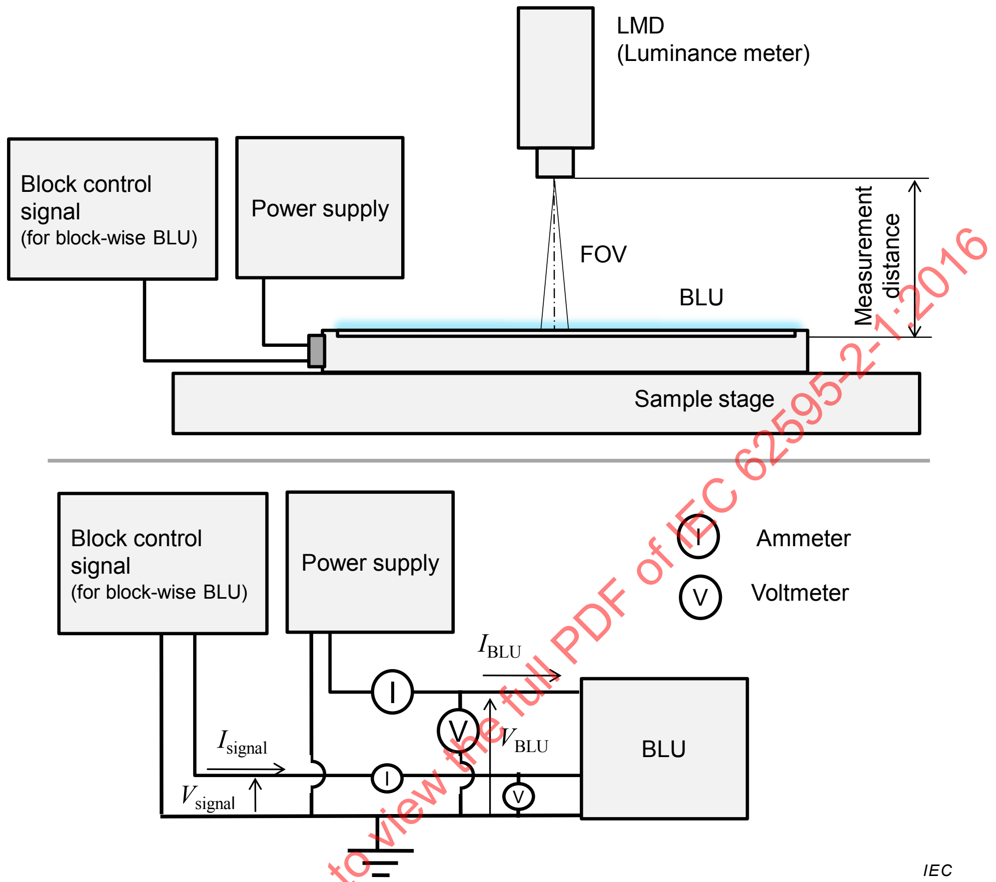

Figure 1 – Example of measuring setup for LED BLU

4.3 Warm-up time

The luminance of LED backlights is affected by the transient temperature behaviour of LED output as in Figure 2. It takes a certain time for LEDs until their junction temperature reaches the steady state. Luminance measurement shall be carried out and recorded until the fluctuations of luminance measured at an appropriate point (usually at the centre point) of the BLU become less than the range specified in IEC 61747-30-1 unless otherwise specified. The luminance measurement shall be carried out as in 5.2.2. All measuring conditions shall be kept constant during the measurements.

Chromaticity measurement shall be carried out in the same manner as in the above, unless otherwise specified. The chromaticity measurement shall be carried out as in 5.2.5.

The above measurements can be customized between the customer and the supplier, depending on various BLU sizes, applications, and so on.

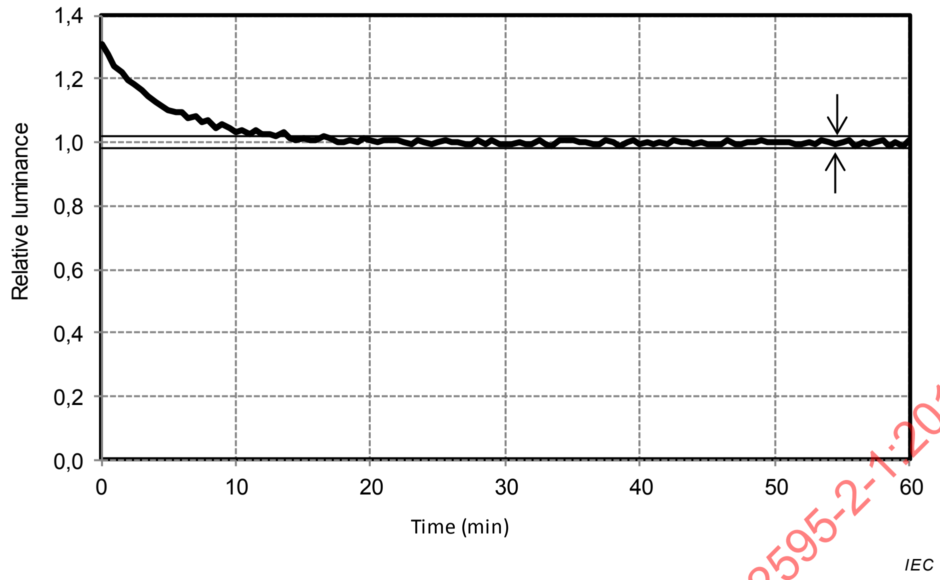

Figure 2 – Example of warm-up characteristic of BLU

5 Measurement methods

5.1 Electrical measurement methods

5.1.1 Conditions

The BLU shall be placed in the measurement arrangement and it shall be assured that all required conditions are fulfilled.

After applying the initial electrical driving conditions (i.e. analogue input voltage(s) or digital input signals) of the BLU and waiting during the warm-up time specified in 4.3 in order to reach the steady state, the measurement of the electrical quantities of interest shall be started.

5.1.2 Current

The measurement of input current should be performed under standard measuring conditions using the current meter shown in Figure 1.

5.1.3 Voltage

The measurement of input voltage should be performed under standard measuring conditions using the voltage meter shown in Figure 1.

5.1.4 Power consumption

The measurement of power consumption should be carried out under the standard measuring conditions in 4.1, using a power meter, or calculated by the measured values of voltage and currents in 5.1.2 and 5.1.3. For block-wise BLUs, the power consumption of the control signal shall be considered.

5.2 Optical measurement methods

5.2.1 Conditions

The LED BLU to be measured should be placed in the measurement arrangement and it shall be assured that all required conditions are fulfilled.

After applying the initial electrical driving conditions to the BLU and waiting during the warm-up time specified in 4.3 in order to reach the steady state, the measurement of the optical quantities of interest shall be started. The measurement of this standard should be carried out at various angles between the BLU and the LMD. A polar coordinate system (θ,ϕ), with the zenith denoted by θ and the azimuth denoted by ϕ should be considered (see Figure 3).

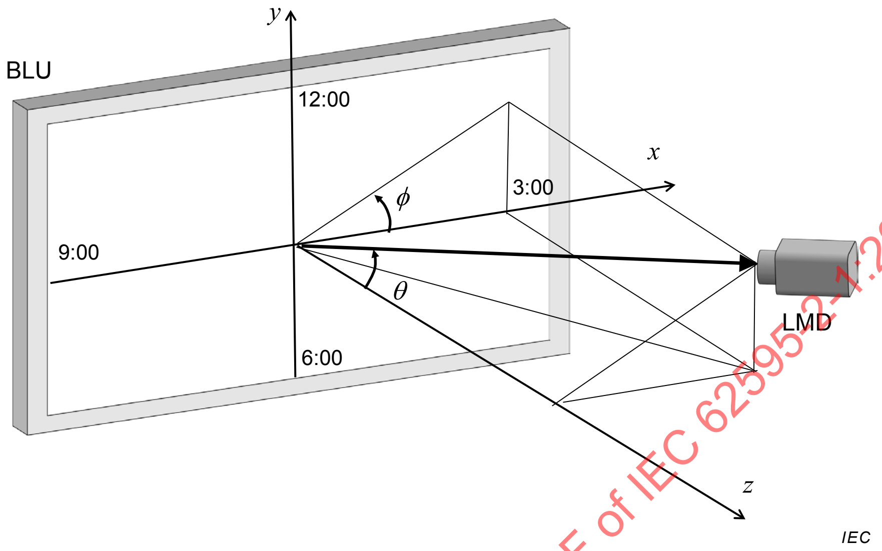

Figure 3 – Definition of zenith angle θ and azimuth angle ϕ

5.2.2 Luminance

The measurements should be carried out in the dark room under the standard measuring conditions and for the design viewing directions, as follows:

a) Position the BLU.

b) Adjust the LMD to the specified viewing direction, according to angles θ and ϕ.

c) Supply the value of the input signals to the BLU. Then measure the BLU at position p_i to obtain the luminance L_{vi} (θ,ϕ). (In case of i = 0, the position implies the centre of the active area of the BLU.)

The LMD should be carefully checked before measurements, considering the following elements:

- sensitivity of the measured quantity to the measuring light;
- errors caused by veiling glare and lens flare (i.e., stray light in an optical system);
- timing of data-acquisition, low-pass filtering and aliasing-effects;
- linearity of detection and data-conversion;
- measurement size and field of view (FOV).

To ensure luminance accuracy for the intended LED sources, a broad bandwidth LMD should be calibrated using a spectrometer with a bandwidth 5 nm or less.

The luminance of BLU should be measured by synchronizing the LMD with the BLU refresh rate, or integrating the measured luminance over a number of frames.

NOTE ISO/CIE 19476 [1] [2] is available for reference to the LMD evaluation procedures.

5.2.3 Luminance uniformity or non-uniformity

Luminance uniformity, U, or luminance non-uniformity, NU, is a calculated value of how well the luminance remains constant over the surface of the active area of the BLU, and it is closely related to luminance measurement itself.

The luminance uniformity or non-uniformity measurement is sensitive to the testing positions. Typical layouts of measurement points over the BLU surface are shown in Figure 4 [2].

Luminance non-uniformity, NU, is usually calculated using the following equation:

$$NU = \frac{L_{\text{vM}} - L_{\text{va}}}{L_{\text{va}}}$$

One of the following four equations is also used widely in display industries.

$$U = \frac{L_{\text{vm}}}{L_{\text{vM}}}, \qquad U = \frac{L_{\text{vM}}}{L_{\text{vm}}}, \qquad NU = \frac{L_{\text{vM}} - L_{\text{vm}}}{L_{\text{vM}}}, \qquad NU = \frac{L_{\text{vM}} - L_{\text{vm}}}{L_{\text{va}}}$$

where

L_{vM} is the maximum luminance value of all measurement points in Figure 4;

L_{vm} is the minimum luminance; and

L_{va} is the average luminance calculated as:

$$L_{\text{va}} = \sum_{i=1}^{N} \frac{L_{\text{vi}}}{N}$$

where

N is the number of measurement points; and

L_{vi} is luminance of the i^{th} measurement point.

Typical measurement procedures of luminance uniformity U are as follows. At first, specified input current and voltage are supplied to the BLU to be measured. Secondly, luminance is measured at each point on the BLU on either five (positions p_0, p_{11}, p_{15}, p_{19}, and p_{23}) or nine (positions p_0, p_9, p_{11}, p_{13}, p_{15}, p_{17}, p_{19}, p_{21}, and p_{23}) points. This measurement is carried out usually at normal angle; however, other angles can also be considered for certain purposes.

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

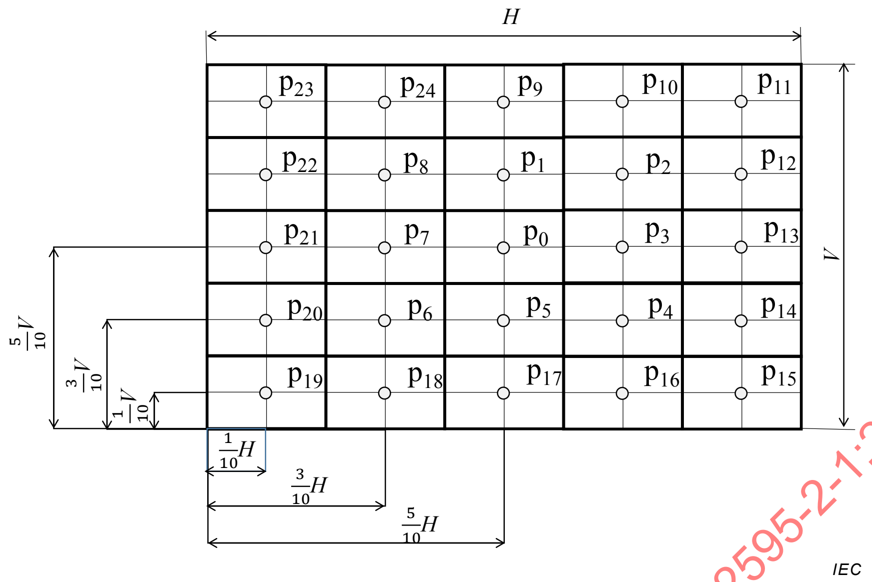

Figure 4 – Examples of measurement point layout

5.2.4 Spectral power distribution

A spectral power distribution of BLU, $S_{\mathrm{BLU}}(\lambda)$ is measured using a spectrometer or an equivalent optical instrument. The measuring procedures are in accordance with 5.2.2 and 5.2.3. To ensure luminance accuracy for the intended LED sources, a broad bandwidth LMD should be calibrated using a spectrometer with a bandwidth 5 nm or less.

5.2.5 Chromaticity

CIE 1931 chromaticity coordinates (IEC 60050-845:1987, 845-03-28 [3] and ISO 11664-1 [4]), x, y, z on the BLU surface of the active area are obtained using the tristimulus values, X, Y, Z calculated from measured spectral power distribution $S(\lambda)$ given in 5.2.4 (see IEC 62595-1-2). The correlated colour temperature (CCT) can also be used.

NOTE Correlated colour temperature (CCT) is defined in IEC 60050-845:1987, 845-03-50. The calculation method from the measured chromaticity data is specified in CIE publication 15:2004 [5]. Robertson's [6] procedure is available for an actual computing program.

This measurement is carried out usually on on the axis normal to the surface of the BLU, however, other angles can also be considered for certain purposes.

5.2.6 Colour uniformity

Colour uniformity should be evaluated using CIE 1976 chromaticity (IEC 60050-845:1987, 845-03-53 [3] and ISO 11664-5 [7]) differences between the centre and the other points on the BLU surface, using the following equation:

$$\Delta u'v' = \mathrm{Max}\left[\left\{(u'_{\mathrm{i}} - u'_{\mathrm{centre}})^2 + (v'_{\mathrm{i}} - v'_{\mathrm{centre}})^2\right\}^{1/2}\right] \qquad i = 1,2,3,\ldots$$

Another equation used is as follows:

$$\Delta u'v' = \mathrm{Max}\left[\left\{(u'_{\mathrm{i}} - u'_{\mathrm{j}})^2 + (v'_{\mathrm{i}} - v'_{\mathrm{j}})^2\right\}^{1/2}\right] \qquad i,j = 1,2,3,\ldots$$

where

$u' = 4x / (-2x + 12y + 3)$;

$v' = 9y / (-2x + 12y + 3)$;

x, y, z are CIE 1931 chromaticity coordinates.

The same measurement points as shown in 5.2.3 should be used.

5.2.7 Angular luminance uniformity

Angular performance of the LED BLU directly affects the whole display performances. The luminance values at angles (0°, 0°), (θ, 0°), (θ, 90°), (θ, 180°) and (θ, 270°) in the polar coordinate system defined in 5.2.1 should be measured as in Figure 5. Measurement at additional angles should be carried out if necessary.

The measurements should be carried out at each point of the BLU shown in Figure 4.

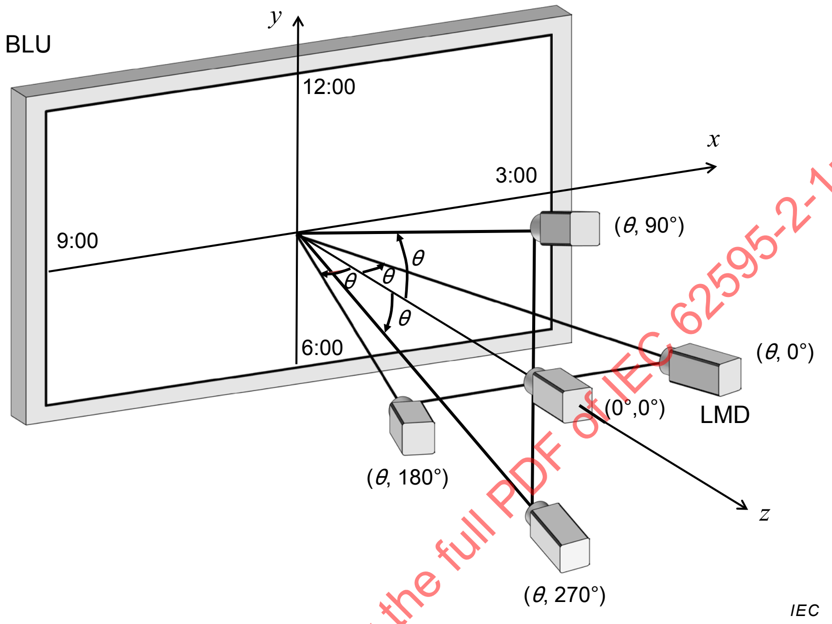

Figure 5 – Angular luminance uniformity measurement

5.2.8 Angular colour uniformity

The angular colour uniformity of the BLU affects the whole display angular performance. The angles can be selected in the same manner as the angular luminance uniformity given in 5.2.7. It should be in accordance with 5.2.6, to obtain the chromaticity differences between the normal angle and the other four angles.

5.2.9 Measurement methods of block-wise BLUs

5.2.9.1 General

A block-wise BLU is a segmented BLU which is divided two-dimensionally for synchronization with an LCD panel for the purpose of local dimming. Luminance of each block is optimally controlled by modulating LED arrays. The block segmentation is determined depending upon the whole display design.

Subclause 5.2.9 specifies the fundamental measuring methods for the block-wise BLU, assuming basically direct-lit BLUs. The block segmentation of the block-wise BLU and how to control the LED array for dimming the blocks shall be reported.

A similar measuring method to block segmentation in direct-lit BLUs in 5.2.9 can be applied to edge-lit BLUs.

NOTE Details of the measuring methods may be considered in the future.

5.2.9.2 Checkerboard pattern

Checkerboard pattern is used for measuring the block-wise BLU. An example of checkerboard test pattern is shown in Figure 6.

The stray light should be minimized using an appropriate method such as frustum (see ISO 9241-305 [8]).

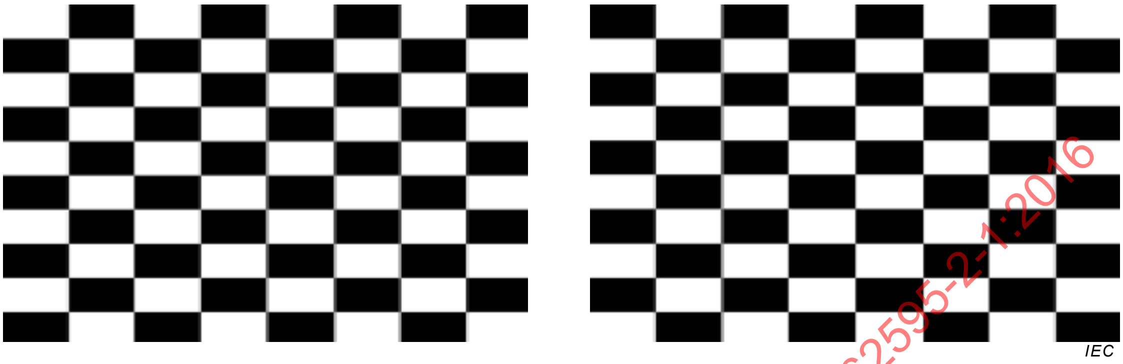

Figure 6 – Example of checkerboard pattern (8 segments × 10 segments) for block-wise BLU

5.2.9.3 Single block white pattern

Only a single block is turned ON to measure the light spread function, i.e. the optical leakage or optical noise in the neighbouring blocks in the block-wise BLU. An example of a single block white pattern (centre) is shown in Figure 7.

Figure 7 – Example of single block white pattern

5.2.9.4 Single block black pattern

Only a single block is turned OFF as a black pattern, which is used for measuring the light diffusion, the light leakage characteristic in a block and for evaluating the optical noise in a single block in the block-wise BLU. An example of a single block black pattern (centre) is shown in Figure 8.

The stray light should be minimized using an appropriate method such as frustum (see ISO 9241-305 [8]).

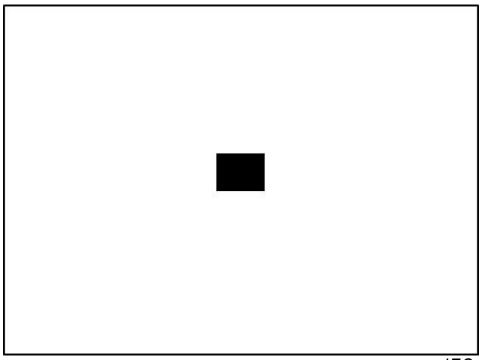

Figure 8 – Example of single block black pattern

5.2.9.5 Incoherent point spread function

When a single block turns on and the rest of the blocks turn off as in 5.2.9.3, the light spread function (LSF) is defined as a spatial luminance profile spreading outwards. An example of LSF is shown in Figure 9. Based on LSF, image signals of the LCD are controlled for optimizing image quality.

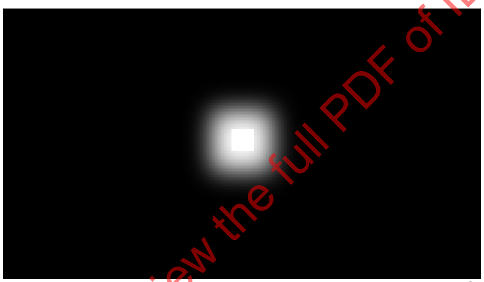

Figure 9 – Example of incoherent point spread function

In order to measure the LSF, a single ON-block white pattern as in Figure 7 shall be applied. Although LSF is a continuous function, the measurement of the distribution profile of this function shall be carried out at predetermined positions. The values between the positions should be interpolated.

The procedures for the measurement are as follows:

a) Select the block under test.
b) Determine the position and number of measuring points.
c) Measure the luminance of each position as shown in 5.2.2 (luminance measuring method).
d) Interpolate between the positions if necessary.

The results of each procedure shall be reported.

The position and number of measurement points can be determined by manufacturers. Measurement point size and field of view (FOV), which are determined by an aperture size of the LMD and measurement distance from BLU to LMD, shall be carefully selected and reported.

The measurement point size should be same or smaller than the distance between measurement points, to avoid overlap. The FOV of the LMD should be sufficiently smaller than the angle which is formed by the minimum block of BLU. All the measurement conditions are given in 5.2.2 (luminance measuring methods).

5.2.9.6 Evaluation of optical noise

Optical noise is the amount of light leaking from ON-blocks to adjacent blocks.

An appropriate block-wise checkerboard pattern shall be used to measure the optical noise, for example the pattern shown in Figure 6.

The procedures for the measurement are as follows:

a) Select the block under test.
b) Determine the position of the measuring points in the OFF-block (usually at the centre of the block).
c) Measure the luminance of each measuring points as shown in 5.2.2 (luminance measuring method).

If only one size black block does not give much information, a series of smaller blocks with stray light compensation should be considered.

The results of each procedure shall be reported.

The position of measurement points can be determined by manufacturers. The measurement point size and field of view (FOV), which are determined by the aperture size of the LMD and the measurement distance from the BLU to the LMD, shall be carefully selected and reported.

The measurement point size should be same as or smaller than the distance between measurement points, to avoid overlap. The FOV of the LMD should be sufficiently smaller than the angle which is formed by the minimum block of the BLU and the measurement distance. All the measurement conditions are shown in 5.2.2 (luminance measuring method).

5.2.9.7 Optical noise evaluation in a single block

Optical noise using a single block test pattern as shown in Figure 8 is defined as the amount of light leaking from all the remaining ON-blocks to a single OFF-block. It shall be measured as follows:

a) Select the block under test.
b) Determine the position of the measuring points in the OFF-block (usually at the centre of the block).
c) Measure the luminance of each measuring points as shown in 5.2.2 (luminance measuring method).

The results of each procedure shall be reported.

The position of measurement points can be determined by manufacturers. Measurement point size and field of view (FOV), which are determined by the aperture size of the LMD and the measurement distance from the BLU to the LMD, shall be carefully selected and reported.

The measurement point size should be same as or smaller than the distance between measurement points, to avoid overlap. The FOV of the LMD should be sufficiently smaller than the angle which is formed by the minimum block of the BLU and the measurement distance. All the measurement conditions are shown in 5.2.2 (luminance measuring methods).

Other test patterns should be used if necessary.

5.2.9.8 Optical signal-to-noise ratio in a block-wise BLU

Optical signal-to-noise (S/N) is the ratio of luminance caused by an optical leakage from an adjacent block to the luminance of the block itself (signal). It shall be measured as follows: