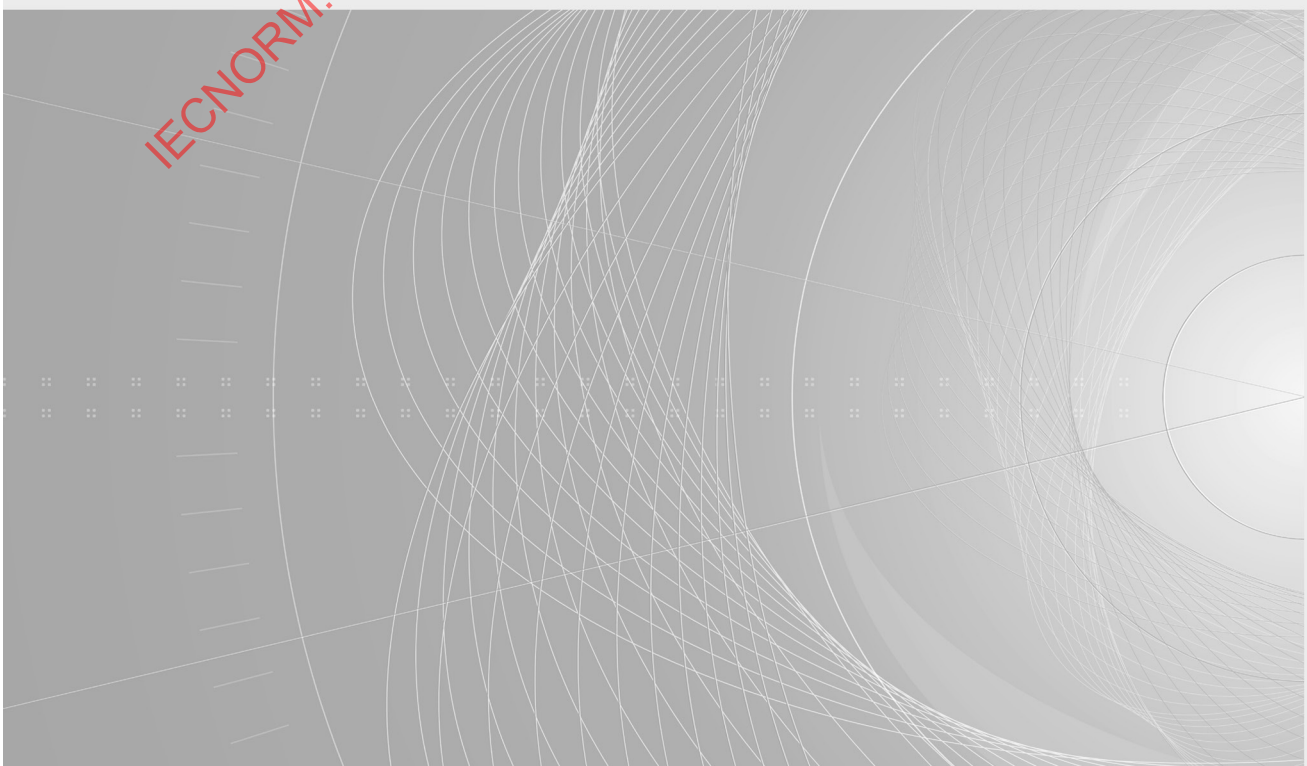
IEC 62977-2-11

Edition 1.0 2023-12

INTERNATIONAL STANDARD

colour inside

Electronic displays –
Part 2-11: Measurement of optical characteristics – Local luminance and uniformity



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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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ELECTRONIC DISPLAYS –

Part 2-11: Measurements of optical characteristics – Local luminance and uniformity

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

Draft	Report on voting
110/1566/FDIS	110/1591/RVD

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

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

A list of all parts in the IEC 62977 series, published under the general title *Electronic 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 webstore.iec.ch in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn, or
- revised.

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INTRODUCTION

Emissive displays are emerging as the most advanced displays featuring a high dynamic range from black to white luminance, as well as vivid colour for each pixel.

Various methods, which measure optical characteristics standardized in IEC TC 110, so far consider only a specified measurement area that covers more than 500 pixels. It is likely that optical performances reporting the spatially integrated data will have difficulty to represent the optical characteristics of each pixel.

For that to be possible, standardization related to the method of measuring luminance and uniformity from each pixel-to-pixel cluster within the specified local block which will cover at least 500 emission pixels regularly placed, will be identified.

This document assesses the consistent luminance and uniformity in the local block (for example, within a 4 % window box pattern and regularly scattered emission pixels) by comparing the changes in luminance variation and emissive ratio, where an emissive sequence of each pixel is controlled.

ELECTRONIC DISPLAYS –

Part 2-11: Measurements of optical characteristics – Local luminance and uniformity

1 Scope

This part of IEC 62977 specifies the local luminance and uniformity measurement methods of emissive displays. The light measuring device's (LMD) measurement field will cover more than 500 pixels of TVs, monitors or signage displays. The local luminance and uniformity measurement methods identify optical variations within the local block where over 500 emission pixels are regularly placed.

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 845: Lighting* (available at www.electropedia.org)

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

CIE 70-1987, *The Measurement of Absolute Luminous Intensity Distributions*

3 Terms, definitions, abbreviated terms, symbols and units

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60050-845, IEC 62341-1-2, and the following apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- IEC Electropedia: available at https://www.electropedia.org/
- ISO Online browsing platform: available at https://www.iso.org/obp

3.1.1
local block
area where at least 500 emission pixels are regularly arranged

3.1.2
local luminance
luminance not in the whole area but in a specified or designated local block, where regularly arranged pixels are gathered, of the emissive display panel

3.1.3
local luminance consistency
luminance variation range within the local block

3.1.4
local luminance uniformity
luminance variation among adjacent pixels in the local block of the emissive display panel

3.2 Abbreviated terms

APL average picture level
CCT correlated colour temperature
CIE Commission Internationale de l'Eclairage (International Commission on Illumination)
DUT device under test
iLMD imaging light measuring device
LMD light measuring device

3.3 Symbols and units

Table 1 describes the symbols and quantity units.

Table 1 – Letter symbols

No	Name of quantity	Symbol	Unit	Remark
01	Measuring distance between display and LMD	d	mm	Formula (1)
02	Measurement-field angle	a	degree	Formula (1)
03	Horizontal pixel pitch	p_h	mm	Formula (1)
04	Vertical pixel pitch	p_v	mm	Formula (1)
05	Number of pixels in the measured area	n	-	Formula (1)
06	Average of local luminance (L_i = i 1, 2, …, m)	L_{avg}	cd/m^2	Formula (2), Formula (3)
07	Luminance of arranged-pixels test pattern	L_i	cd/m^2	Formula (2)
08	Number of arranged-pixels test patterns	m	-	Formula (2)
09	Local luminance consistency	LLC	%	Formula (3)
10	Emissive ratio	P	%	Formula (3)
11	Luminance of reference (4 % white box)	L_{ref}	cd/m^2	Formula (3)
12	Luminance of 100 % black box	L_K	cd/m^2	Formula (3)
13	Local contrast of reference	CR_{Ref}	-	Formula (4)
14	Local contrast consistency	LCC	%	Formula (6)
15	Correct measurement distance between iLMD and display	D	mm	Formula (7)
16	Image luminance	L_{image}	cd/m^2	Formula (8)
17	Local luminance uniformity	LLU	%	Formula (9)
18	Minimum luminance of (L_i = i 1, 2, …, m)	L_{min}	cd/m^2	Formula (9)
19	Maximum luminance of (L_i = i 1, 2, …, m)	L_{max}	cd/m^2	Formula (9)
NOTE The pixel pitch is defined in ISO 9241-302:2008, 3.4.36 [9][1].				

1 Numbers in square brackets refer to the Bibliography.

4 Standard setup conditions

4.1 Light measuring devices

The requirements of light measuring devices are specified in the IEC 62977-2-1:2021, Clause 5, [1] and IEC 62341-6-1:2022, Clause 5 [2].

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

1) Luminance meter [3]: the instrument's spectral responsivity shall comply with the CIE photopic luminous efficiency function with a CIE-f_1, value no greater than 3 % (see CIE 70-1987); the relative luminance uncertainty of measured luminance (relative to the CIE Illuminant A source) shall not be greater than 4 % for luminance values over 0,1 cd/m^2 and not be greater than 10 % for luminance values 0,1 cd/m^2 and lower. If the luminance is lower than the LMD's lower limit of sensitivity it shall not be used for the measurement.
2) Colorimeter: the spectral responsivity shall comply with the colour matching functions for the CIE 1931 standard colorimetric observer with a colorimetric accuracy of ±0,002 for the CIE chromaticity coordinates x and y (relative to the CIE Illuminant A source) for luminance values over 1 cd/m^2. A correction factor can be used for the required accuracy by application of a standard source with similar spectral distribution as the display to be measured.
3) Spectroradiometer: the wavelength range shall be at least from 380 nm to 780 nm, and the wavelength scale accuracy shall be less than 1 nm. The relative luminance uncertainty of measured luminance (relative to the CIE Illuminant A source) shall not be greater than 4 % for luminance values over 0,1 cd/m^2 and not be greater than 10 % for luminance values 0,1 cd/m^2 and lower. A method can be used to correct the stray light error and improve the quality of colour measurements, which is specified in IEC 62341-6-1:2022, Clause 5 and Annex C.

   NOTE The errors from spectral stray light within a spectroradiometer can be significant when measuring spectra from narrow bandwidth primaries and will be corrected. Details of this correction method are discussed in [4].

   If the luminance is lower than the LMDs' lower limit of sensitivity it shall not be used for the measurement.
4) Imaging luminance meter: the number of pixels of the detector shall not be less than 4 for each display sub-pixel within the colorimeter's measurement-field area for setting good antialiasing properties [5] and shall have at least a 12-bit per frame digital resolution.

4.2 Measuring conditions

4.2.1 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.

4.2.2 Power supply

In order to stabilize the performances of the DUT, the power supply for driving the DUT shall be adjusted according to the specification of the DUT.

4.2.3 Warm-up time

Measurements shall be carried out after sufficient warm-up time. Warm-up time is defined as the time elapsed from when the supply source is switched on, and a 100 % grey 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 %/min and 5 %/h.

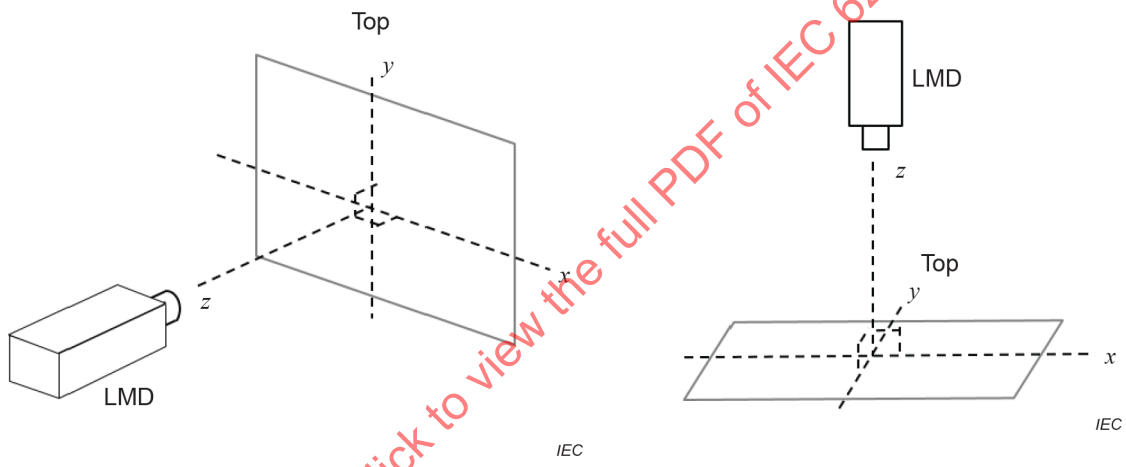
4.2.4 Standard measuring darkroom conditions

The luminance contribution from the background illumination reflected off the test display shall be < 0,01 cd / m^2. 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.

4.3 Measuring direction setup condition

By default, the display shall be set in the vertical position (Figure 1 a)), but alternatively the horizontal position (Figure 1 b)) is also allowed.

Local luminance, uniformity and other relevant parameters of the displays have to be adjusted to nominal status in the detailed specification. Local luminance and uniformity shall be measured perpendicularly to the display surface.



a) Primary measuring direction

b) Alternative measuring direction

Figure 1 – DUT installation conditions

5 Test pattern

5.1 General

There are two test pattern categories for local luminance and uniformity. One is a reference pattern, and another category is emissive ratio-variable test patterns.

5.2 Reference pattern

A 4 % white box pattern is used as a reference pattern to measure local luminance and uniformity. The detailed information of the 4 % white box pattern is described in IEC 62977-2-1:2021, Figure 4 [1], and shown in Figure 2. As the luminance of some displays varies with changes in APL with a current driving circuit [7], it is essential to fix the luminance of pixel-by-pixel or pixel clusters whether or not some near-designated pixels in the pattern are turned off based on the intention.

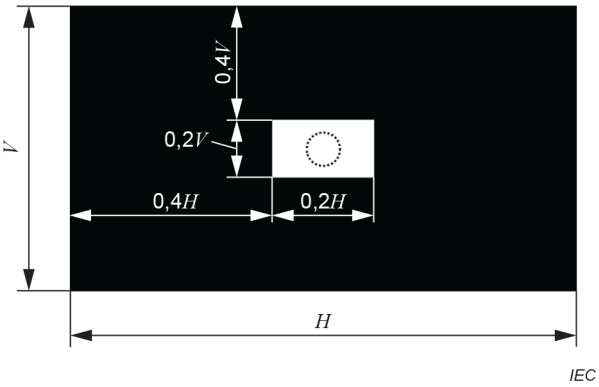


Figure 2 – Reference pattern (4 % white box pattern)

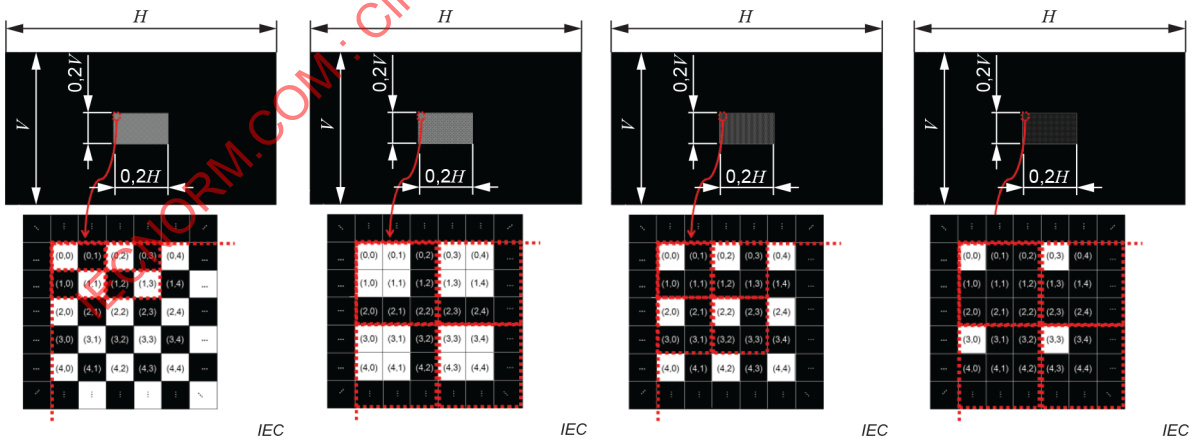
5.3 Emissive ratio-variable test patterns

5.3.1 Concept of test pattern

For local luminance and uniformity, the test patterns, which should vary the emissive area mainly based on the reference pattern (4 % white box), are considered. This refers to the extent to which the relationship between luminance variation and emissive ratio changes, under the measurement conditions. It enables easier determination of the luminance compensation technologies.

The emissive ratio-variable test pattern is comprised of black and white dot patterns that are arranged at the designated area regularly within the reference pattern. Examples of the test pattern are shown in Figure 3. The emissive ratio can be calculated as the ratio of the number of white signal dots to the number of the 4 % boxes.

The white signal dots are arranged regularly as shown in Figure 3. The linear luminance degradation can be from 50 % (2 by 4 emissive) to 11,1 % (1 by 9 emissive).



a) 50 % emissive ratio pattern (2 by 4 emissive)

b) 44,4 % emissive ratio pattern (4 by 9 emissive)

c) 25 % emissive ratio pattern (1 by 4 emissive)

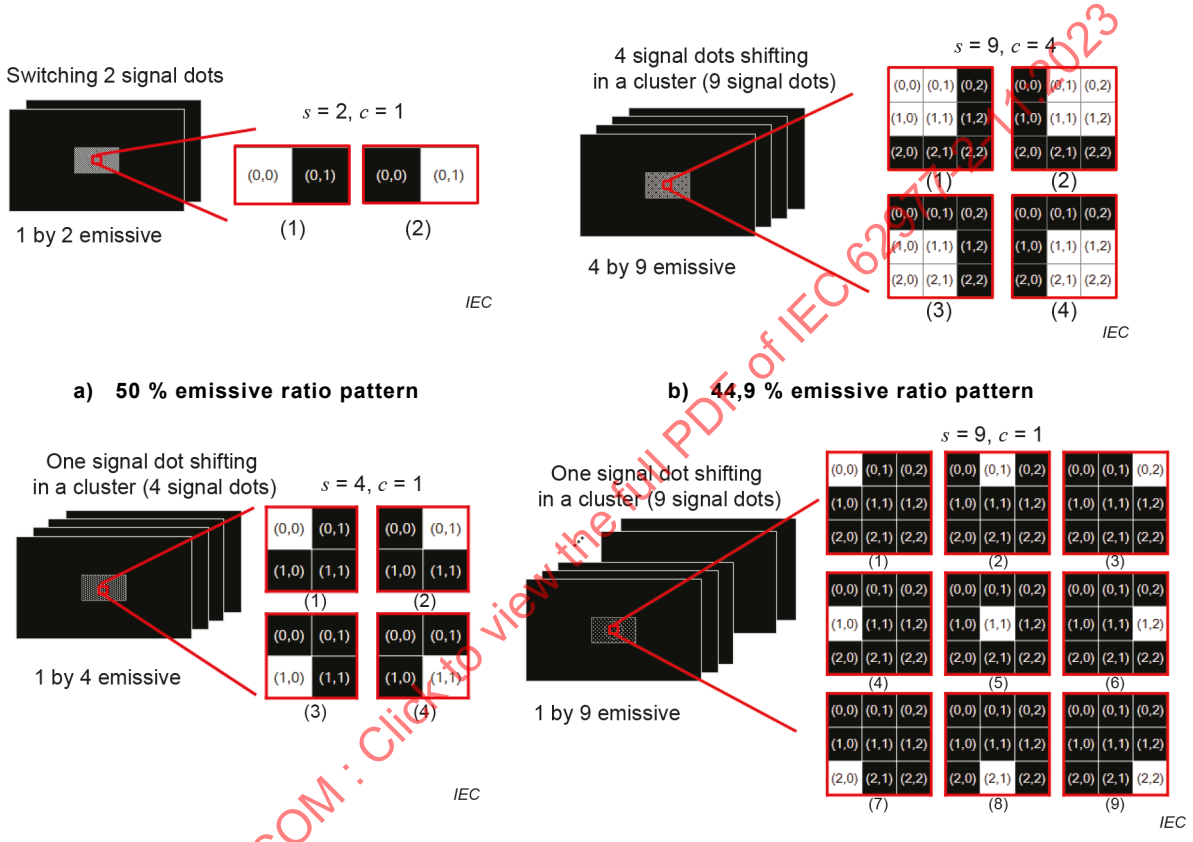
d) 11,1 % emissive ratio pattern (1 by 9 emissive)

NOTE Users of this document can add more patterns to improve the rationality of this measurement method.

Figure 3 – Examples of emissive ratio test patterns

5.3.2 Concept of arranged signal dots of the test pattern

It is likely that the luminance variation among adjacent pixels will be very low owing to the compensation technologies applied. The method for shifting signal dots containing the same emissive ratio can handle the emissive signal dot position as shown in Figure 4. For example, Figure 4 a) is the 50 % emissive ratio pattern with two switching signal dots which are black and white. Figure 4 b) is the 44,9 % emissive ratio pattern. Four signal dots (2 by 2) are shifted within a red box which is 9 signal dots (3 by 3). The number of signal dots in a cluster (the red box) is indicated in Figure 4 as s whereas the number of white signal dots in the red box is indicated as c.



a) 50 % emissive ratio pattern

b) 44,9 % emissive ratio pattern

c) 25 % emissive ratio pattern

d) 11,1 % emissive ratio pattern

NOTE Users of this document can add more patterns to improve the rationality of this measurement method.

Figure 4 – Examples of test pattern with regularly arranged signal dots

6 Measurement methods

6.1 Local luminance consistency

6.1.1 Purpose

The purpose of this method is to measure the luminance consistency in the designated local block. The test patterns described in 5.3.1 and 5.3.2 are used.

6.1.2 Measuring conditions

The conditions described in 4.2 should be applied.

6.1.3 Setup

1) Apparatus: An LMD to measure the luminance of the DUT; a driving power source; a driving signal equipment.
2) Mount the display and the LMD in a mechanical system that allows the display to be measured along its vertical or horizontal plane. The LMD should be aligned perpendicularly to the display surface. The measuring distance between the display and LMD, d, can be adjusted in consideration of the number of pixels in measurement-field area.
3) Align the LMD perpendicularly to the display surface and position it at the centre of the display.

6.1.4 Test patterns for local luminance consistency

Test patterns for local luminance consistency are determined based on 5.3. Test patterns are composed as reference test patterns (Figure 2), types of emissive ratio-variable test patterns (Figure 3), arranged-pixels test patterns (Figure 4), and 100 % black box patterns.

6.1.5 Pixel numbers in the measurement field

The number of pixels, n, in the measurement field, according to a measuring distance and aperture degree of the LMD, can be calculated with Formula (1), which is for the non-contacted LMD.

$$n = \frac{\pi \times \left(\tan\left(\frac{a}{2}\right) \times d \right)^2}{p_h \times p_v} \tag{1}$$

where

α is the measurement-field angle;

d is the measurement distance (mm);

p_h is the horizontal pixel pitch (mm);

p_v is the vertical pixel pitch (mm).

NOTE The pixel pitch, defined in ISO 9241-302:2008, 3.4.36, is the separation between the centre of two adjacent pixels which is the same as the distance between identical points on two adjacent pixels. The horizontal pixel pitch, p_h (or vertical pixel pitch, p_v) can be calculated by dividing the actual display's horizontal (or vertical) dimensions by the number of horizontal pixels (or vertical pixels) [4].

6.1.6 Measurement field coverage of test pattern

It is essential to determine the measurement field coverage which should be larger than 500 / n, where n is the number of pixels described in 6.1.5. The calculation result would be suitable for less than 1 as the number of pixels covering the measurement field is more than 500 pixels.

For example, n is 2 500 pixels, which is five times more than 500 pixels, where a 2° measurement-field angle, 500 mm measurement distance and 0,315 mm horizontal and vertical pixel pitch are applied. Therefore, a 50 % (Figure 3 a)), 44,9 % (Figure 3 b)), or 25 % emissive ratio test pattern (Figure 3 c)) can be used to measure the luminance constancy, as the measurement-field can cover more than 500 pixels.

6.1.7 Measurement procedure

1) Apply a reference test pattern, which is the specified 4 % white box pattern as shown in Figure 2. A 100 % signal level (R = G = B = 255 for an 8-bit input signal) should be applied.
2) Measure the luminance of the centre of the reference test pattern, L_{ref}, perpendicularly to the display surface.

3) Render a 100 % black box pattern. A 0 % signal level (R = G = B = 0 for an 8-bit input signal) should be applied.

4) Measure the luminance of the centre of the 100 % black box pattern, L_k, perpendicularly to the display surface.

5) Apply one of the emissive ratio test patterns which was determined in 6.1.6. It is an initial test pattern for shifting.

   For example, as the measurement field coverage, m_c, is 20 %, the emissive ratio, P, can be 25 %, 44,9 % and 50 %.

6) Measure the luminance L_i (i = 1, 2, ..., m; m is the number of test patterns in Figure 4 for shifting).

   For example, as a 25 % emissive ratio is the minimum value (over 20 %), test patterns in Figure 4 c) are applied to measure the luminance from L_1 to L_4.

7) Calculate the average luminance of the arranged-pixels test patterns by using Formula (2)

$$L_{avg} = \sum_{i=1}^{m} L_i / m \tag{2}$$

where

L_i is the measured luminance of the arranged-pixels' test patterns.

8) Calculate the local luminance consistency, LLC (%), by using Formula (3)

$$LLC = \frac{L_{avg} - L_K}{(L_{ref} - L_K) \times P} \times 100 \tag{3}$$

where

L_{avg} is the luminance average;

L_K is the black luminance;

L_{ref} is the luminance of the reference test pattern (4 % white box pattern, see Figure 2);

P is the emissive ratio (see Figure 3).

9) Table 2 shows examples of measurement results for local luminance consistency. The data in Table 2 is an example of measurement data of a 25 % emissive ratio with one pixel shifting in a cluster (4 pixels).

Table 2 – Example of measurement results for local luminance consistency

Reporting – Sample data		
Local luminance and local luminance consistency		
Test patterns	Emissive ratio, P	Measured luminance
Reference pattern (L_{ref})	100 %	800
Test pattern #1 (L_1)	25 %	150
Test pattern #2 (L_2)		130
Test pattern #3 (L_3)		100
Test pattern #4 (L_4)		120
100 % black box pattern (L_K)	-	0,000 5
Number of pixels in the measurement area for reference pattern (n)		4 076
Sum of arranged-pixels luminance ($\sum_{i=1}^{4} L_i$)		500
Average luminance (L_{avg})		125
LLC (%)		62,5

6.2 Local contrast consistency

6.2.1 Purpose

The purpose of local contrast is to measure the black and white which are displayed simultaneously on the same frame. The aim of measurement of local contrast consistency is to consider consistency in the local block with test patterns in which regularly arranged pixels shift. The method outlined in IEC TS 62341-6-5:2019, Clause 6, should be referred to.

NOTE The local contrast, meaning in this document a non-global contrast, can be defined as the contrast ratio between pixel to pixel in the local block of the DUT, which describes how much the contrast ratio does not change in local pixels.

6.2.2 Measuring conditions

The conditions described in 4.2 should be applied.

6.2.3 Setup

1) Apparatus: An LMD to measure the luminance of the DUT; a driving power source; a driving signal equipment.
2) Mount the display and LMD in a mechanical system that allows the display to be measured along its vertical or horizontal planes. The LMD should be aligned perpendicularly to the display surface. The measuring distance between the display and LMD, d, can be adjusted in consideration of the number of pixels in the measurement-field area.
3) Align the LMD perpendicularly to the display surface (θ = 0, ϕ = 0), and position it in the centre of the display.

6.2.4 Measurement method of local contrast consistency

1) Apply the reference test pattern, which is the specified 4 % white box as shown in Figure 2. The 100 % signal level (R = G = B = 255 for an 8-bit input signal) should be applied.
2) Measure each luminance from P_1 to P_9 perpendicularly to the display surface as shown in Figure 5. The measurement points shall cover at least 500 pixels or demonstrate equivalent results with fewer sampled pixels. A mask or stray-light-elimination tube can be required to prevent veiling glare in the detector when measuring the black level.

3) Calculate the local contrast for the reference pattern, CR_{ref}, using Formula (4):

$$CR_{ref} = \frac{8 \times L_5}{L_{K,1} + L_{K,2} + L_{K,3} + L_{K,4} + L_{K,6} + L_{K,7} + L_{K,8} + L_{K,9}} \quad (4)$$

where

L_5 is the white luminance of the centre point, P_5;

$L_{K,i}$ (i = 1,2,3,4,6,7,8,9) is the black luminance of the points, from P_1 to P_9, except P_5.

4) Apply one of the emissive ratios which is determined in 6.1.6. It is an initial test pattern for shifting.

5) Measure the luminance and calculate the local contrast of the test pattern.

6) Apply the arranged-pixel test patterns which are matched with the emissive ratio test pattern in 4) and repeat step 5).

7) Calculate the average contrast of the arranged-pixels test patterns by using Formula (5):

$$CR_{avg} = \left(\sum_{i=1}^{m} CR_i\right) / m \quad (5)$$

where

m is the number of test patterns in Figure 4 for shifting;

CR_i is the local contrast for the reference pattern with the i^{th} test pattern.

8) Calculate the local contrast consistency, LCC (%), by using Formula (6)

$$LCC = \frac{CR_{avg}}{CR_{ref} \times P} \times 100 \quad (6)$$

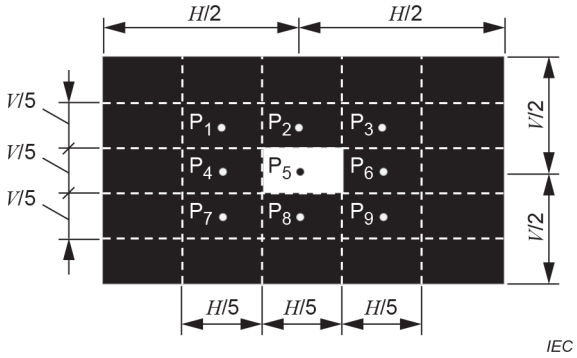
where

CR_{avg} is the contrast average;

CR_{ref} is the contrast of the reference test pattern (4 % white box pattern, see Figure 2);

P is the emissive ratio (see Figure 3).

9) Report the result in Table 3.



NOTE The white dotted lines and 9 points are imaginary; they are used to explain the measurement points. There is only a 4 % white box pattern with black background.

Figure 5 – Guided measurement points

Table 3 – Example of measurement results for local contrast consistency

Reporting – Sample data		
Local contrast consistency		
Test patterns	Emissive ratio, P	Measured local contrast
Reference pattern (L_{ref})	100 %	1 500 000
Test pattern #1 (L_1)	25 %	300 000
Test pattern #2 (L_2)		350 000
Test pattern #3 (L_3)		380 000
Test pattern #4 (L_4)		350 000
The number of pixels in the measurement area for reference pattern (n)		4 076
Sum of arranged-pixels luminance $\left(\sum_{i=1}^{4} CR_i\right)$		1 380 000
Average contrast (CR_{avg})		345 000
LCC (%)		92 %

6.3 Local luminance uniformity

6.3.1 Purpose

The purpose for measuring local luminance uniformity is to consider the luminance variations within the local block. It is an approach to measure the uniformity based on imaging luminance measurement for the average luminance, the local uniformity and the overall uniformity [8].

6.3.2 Measuring conditions

The conditions described in 4.2 should be applied.