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Laser display devices –
Part 5-3: Measuring methods of image quality for laser projection display

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INTERNATIONAL
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LASER DISPLAY DEVICES –

Part 5-3: Measuring methods of image quality for laser projection displays

FOREWORD

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

Draft	Report on voting
110/1269/FDIS	110/1285/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/standardsdev/publications.

A list of all parts in the IEC 62906 series, published under the general title *Laser display devices*, 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

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- withdrawn,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

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LASER DISPLAY DEVICES –

Part 5-3: Measuring methods of image quality for laser projection displays

1 Scope

This document specifies the standard measurement conditions and measuring methods for determining the parameters of image quality for full-frame laser projection displays integrating the projection devices and screens. The front and rear projection screens are included in this document. Other display devices, such as raster-scanned (flying spot) projection devices, are not included.

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 (IEV) – Part 845: Lighting*

IEC 60825-1, *Safety of laser products – Part 1: Equipment classification and requirements*

IEC TR 60825-8, *Safety of laser products – Part 8: Guidelines for the safe use of laser beams on humans*

IEC 62341-6-3:2017, *Organic light emitting diode (OLED) displays – Part 6-3: Measuring methods of image quality*

IEC 62471-5, *Photobiological safety of lamps and lamp systems – Part 5: Image projectors*

IEC 62906-1-2, *Laser display devices – Part 1-2: Vocabulary and letter symbols*

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

ISO/CIE 19476, *Characterization of the performance of illuminance meters and luminance meters*

CIE 63, *The spectroradiometric measurement of light sources*

3 Terms, definitions, and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60050-845, IEC 62906-1-2 and ISO/CIE 11664-1 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

3.2 Abbreviated terms

DUT Device under test

LDD Laser display device

LPD Laser projection display

LMD Light measuring device

4 Standard measuring conditions

4.1 General

Unless stated otherwise, the following conditions shall be applied. During the measurement, the protection of optical radiation safety shall be implemented according to IEC 60825-1 and IEC TR 60825-8 for the products with a classification over M2, and IEC 62471-5 for RG2 and RG3.

4.2 Environmental conditions

Measurements shall be carried out under the standard environmental conditions:

– temperature: 25 °C ± 3 °C,

– relative humidity: 25 % to 85 % RH,

– atmospheric pressure: 86 kPa to 106 kPa.

When different environmental conditions are used, they shall be noted in the measurement report.

4.3 Power supply

The power supply for driving the DUT shall be adjusted to the rated voltage ± 0,5 %, and the frequency shall be supplied at the rated frequency ± 0,2 %.

4.4 Warm-up time

The measurements should be carried out after the light output is sufficiently stable. It is defined as the time elapsed from when the supply source is switched on, and a full level of input signal is applied to the DUT, until the repeated measurements with the interval of one minute show a variation within ten minutes in luminance (or illuminance) of less than 3 %.

4.5 Dark ambient conditions

The LPDs are intended to be measured under the dark room conditions. Any background illuminance at the image plane shall be less than 1 % of the projector maximum illuminance when measured with a projector mask blocking the direct beam from the projector (for example refer to [1] in 15.1.4). The measurements should be conducted in a room with matte black surfaces having a photometric reflectance of less than 3 %.

4.6 Measuring equipment

The configurations and operating conditions of the measuring equipment shall comply with the requirements specified in each item. Unless stated otherwise, the measurement point shall be at the centre of the image area to be measured. The measurement area at the image plane shall be at least 1 cm in diameter and contain at least 10 pixels x 10 pixels. It shall be confirmed that this number of pixels is sufficient by shifting the LMD 20 % laterally and verifying that the luminance is less than 2 %. A large enough measurement area is needed to average out speckle-induced non-uniformity; in addition, the entrance pupil of the LMD shall be not less than 2 cm in diameter. To ensure accurate results for static measurements, the LMD integration time shall be a multiple n (n > = 1) of the frame time, or larger than 200 frame periods.

Filtered luminance meters and colorimeters are generally considered not to be accurate enough for laser projector measurements. Spectroradiometric instruments are preferred for these narrow bandwidth light sources. Filtered luminance meters and colorimeters shall only be used if they are corrected with a precision spectral radiance meter. However, it is noted that the correction factors shall be achieved for every given spectral distribution of the light from the screen (e.g. red, green, blue primaries, in addition to white and black).

To ensure repeatable measurements, the following requirements shall be applied.

1) Spot luminance meter: refer to ISO/CIE 19476. The spectral responsivity shall comply with the CIE photopic luminous efficiency function, and the general $V(\lambda)$ mismatch index f'_1 should be no greater than 6 %; the relative luminance uncertainty shall not be greater than 4 % for high luminance over 10 cd/m^2 and not be greater than 10 % for low luminance of 10 cd/m^2 and below.
2) Colorimetric luminance meter: the spectral responsivity shall comply with the colour-matching functions for the CIE 1931 standard colorimetric observer (see ISO/CIE 11664-1) with chromaticity accuracy of 0,004 for x, y.
3) 2D imaging luminance meter: the number of pixels of the imaging detector shall be 4 times of the image subpixel within the measurement field as given in following each item. When a large measurement field angle is applied, it shall be noted that the measured luminance might be different between the centre and edge field. The digitalization dynamic range shall not be smaller than 12 bit per sample, The spectral responsivity shall comply with the CIE photopic luminous efficiency function, and the general $V(\lambda)$ mismatch index f'_1 shall be not higher than 6 %.
4) Spectral radiance meter: The narrow spectral line widths of the laser projection displays usually require the use of a spectral radiance meter for accurate results of luminance and chromaticity. The requirements are as follows:
   - the wavelength accuracy shall be within ± 0,5 nm;
   - the wavelength measuring range shall be at least 380 nm to 780 nm;
   - the stray light shall be less than 10^{-3};
   - The sampling interval shall be set to $1/N$ (N is an integer) of the spectral bandwidth of the spectroradiometer referred to in CIE 63 to achieve uniform spectral sampling function for accurate results. For example, a 2,5 nm sampling interval can be used for a 2,5 nm or 5 nm bandwidth.

   It is recommended to use a spectroradiometer with a spectral bandwidth of not more than 5 nm.
5) Illuminance meter: It is used for checking ambient illuminance and shall refer to ISO/CIE 19476.

5 Installation and adjustment of the DUT

5.1 Placement of the projection device and screen

The laser projection device and screen to be tested shall be installed in the position as shown in the product specification.

The projection distance from the projection device to the screen, projection direction, viewing mode, height and tilted angle of the installation shall be reported.

5.2 Focusing and alignment of the LPD

1) The LDD mode shall be set to the factory settings or "standard".

   The LMD shall be placed in the front of the screen at the measuring distance, and with its optical axis perpendicular to the screen. These adjustments shall be held constant during the measurement. Otherwise it shall be noted in the measurement report.

2) Projection image placement: The image resolution and even luminance level of the projection image on the screen can be affected by the focus and zoom of the projector lens. The zoom and preferred image size will dictate an optimum state by applying an appropriate pattern provided by the manufacturer. A lens-shift projector shall be positioned at its optimum optical path as specified by the manufacturer. If the manufacturer does not define the optimum optical set-up, the lens shift shall be set either to the factory settings or in a way that centres the projected image along the geometrical axis of the projection lens. If the projector has a zoom lens, it shall be set to its widest angle. A manufacturer provided alignment pattern, or a pattern as shown in Figure 1, can be used to focus the projection image on the screen. The focus shall be adjusted until the centre features and the edge of the projected image on the image screen are the clearest. In Figure 1, W and H are the width and height of the image screen, respectively.

In Figure 2, an example of a DUT set-up is shown, the projector is set in front of the projecting screen. In Figure 2, L is the distance between the screen and the projector, and β is the angle between the optical and geometrical axes of the projector. Adjust the figure so that the geometrical axis is perpendicular to the screen.

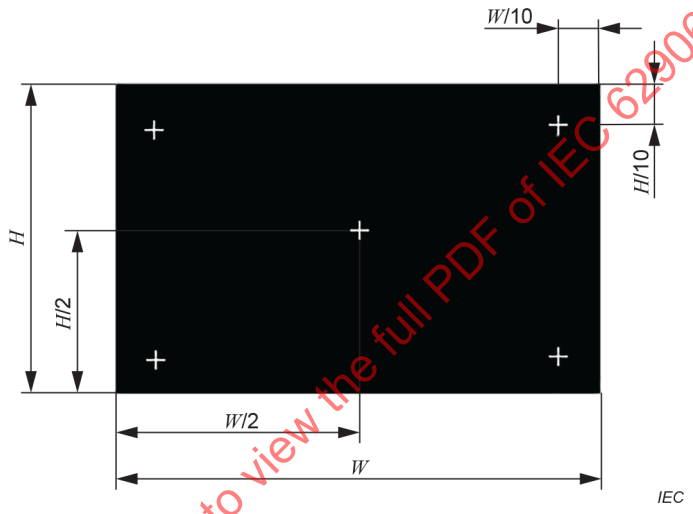


Figure 1 – Example of an image pattern with width W and height H

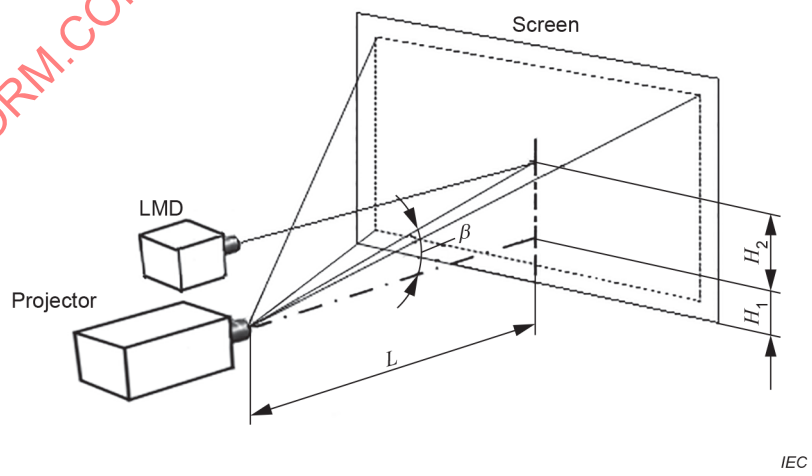


Figure 2 – Example of DUT setup

6 Test patterns

6.1 Full screen patterns

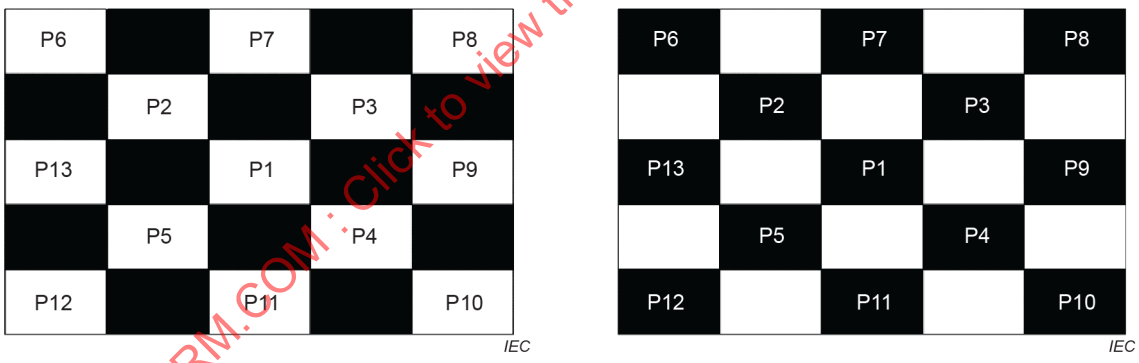
The full-screen patterns are either grey or a single colour (red, green, or blue) with 100 %, 50 %, 25 % and 10 % input signal levels (Figure 3).

Figure 3 – Full screen patterns

6.2 Checkerboard patterns

Checkerboard patterns have different columns and different rows by applying white signal levels of 10 %, 50 % and 100 % on a white rectangle box respectively, and a black signal level of 0 % on a black rectangle box. The 4-by-4 or 5-by-5 checkerboard patterns shall be applied, as specified by the manufacturer or supplier (an example of a 5-by-5 pattern is shown in Figure 4).

NOTE If the LMD is sensitive to the surrounding illumination or/and black wall reflection of the projector emission, a shield for avoiding effects from the background illumination is used.



a) With white centre and white corners

b) With black centre and black corners

Figure 4 – Examples of checkerboard patterns

7 Measuring methods

7.1 Luminance uniformity

7.1.1 Purpose

The purpose of this method is to determine the luminance uniformity of laser projection displays.

7.1.2 Measuring conditions

The following measuring conditions shall be applied:

a) Apparatus: an LMD which can be a spot luminance meter or a spectral radiance meter; a power source and a driving signal equipment.

b) Standard measuring environmental conditions; dark-room conditions; standard installation and adjustment of the DUT.

c) Measurement points: the point positions as shown in Figure 5.

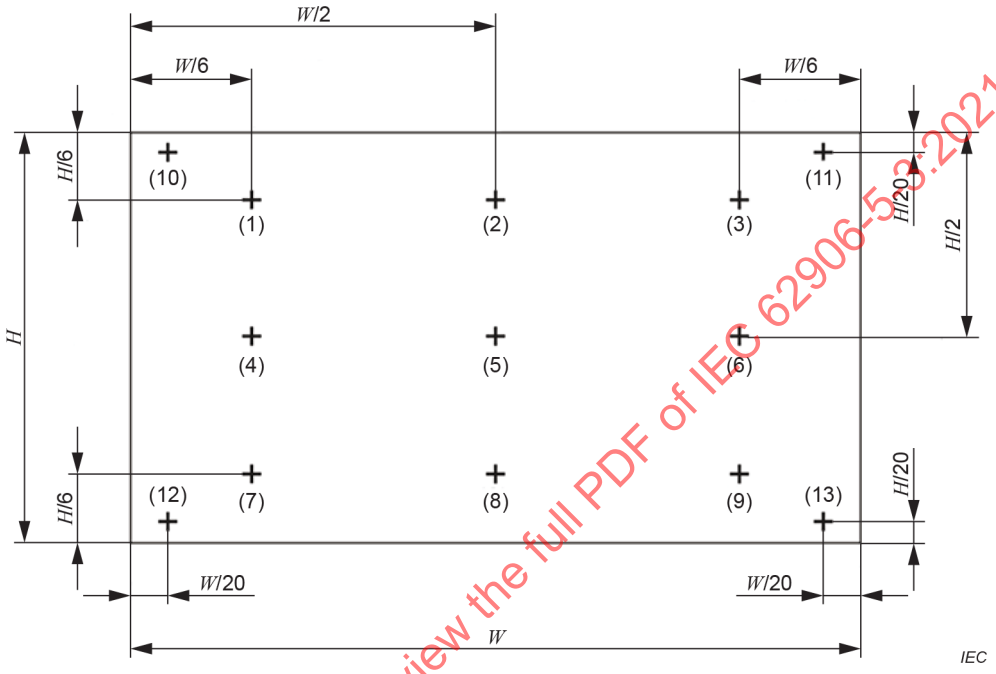


Figure 5 – Measurement points

7.1.3 Patterns

The full screen patterns shall be applied with 100 % grey levels as in Figure 3, and a 0 % grey level for the black screen.

7.1.4 Measuring method

For luminance uniformity, the measurement shall be as follows.

a) Measure the luminance at each of the common (P_1 to P_9) nine positions as shown in Figure 5. Alternatively, all thirteen positions (P_1 to P_{13}) may be measured.

b) Determine the maximum luminance L_{wmax} and minimum luminance L_{wmin} between all nine or thirteen positions, and the average luminance L_{wav} from the nine positions P_1 to P_9 only.

c) The percent deviation of the highest and lowest luminance values relative to the average, U_{high} and U_{low} respectively, shall be calculated as follows:

$$U_{high} = \left(\frac{L_{wmax} - L_{wav}}{L_{wav}} \right) \times 100 \ (\%) \qquad U_{low} = \left(\frac{L_{wmin} - L_{wav}}{L_{wav}} \right) \times 100 \ (\%) \tag{1}$$

d) The luminance uniformity shall be calculated as follows:

$$NU = \left(\frac{L_{max} - L_{min}}{L_{max}} \right) \times 100 \ (\%) \qquad U = 100 - NU \ (\%) \tag{2}$$

7.1.5 Report

The following information shall be noted in the report:

– the test patterns and measurement points on the screen.
– the luminance at each of all nine or thirteen positions.
– the average luminance, maximum luminance and minimum luminance.
– the luminance uniformity U, percent deviations U_{high} and U_{low}.

7.2 Contrast ratio uniformity

7.2.1 Purpose

The purpose of this method is to determine the contrast ratio uniformity of a laser projection display on the screen. By applying checkerboard patterns, an example of 5-by-5 checkerboard patterns with a white centre and black centre, respectively to measure the luminance at each rectangle position, the contrast ratio of each position shall be calculated. The contrast ratio uniformity is described by the maximum contrast ratio and the minimum contrast ratio on the screen.

7.2.2 Measuring conditions

The following measuring conditions shall be applied:

a) Apparatus: an LMD which can be a spot luminance meter or a spectral radiance meter; a power source and driving signal equipment.
b) Standard measuring environmental conditions; dark-room conditions; standard installation and adjustment of the DUT.

7.2.3 Patterns

The pattern shall be applied, for an example of 5-by-5 checkerboard patterns and the measurement points as shown in Figure 4. There are two types of test patterns whose centre rectangles are black and white.

7.2.4 Measuring method

1) Apply the checkerboard pattern whose centre rectangle is white.
2) Measure the luminance L_{CWi} (i = 1 to 13) at each centre of the white rectangles in the checkerboard screen, and the average white luminance L_{CWAV} from all thirteen white rectangles.
3) Apply the checkerboard pattern whose centre rectangle is black.
4) Measure the luminance L_{CBi} (i = 1 to 13) at each centre of the black rectangles in the checkerboard screen, and determine the average black luminance L_{CBAV} from all thirteen black rectangles.
5) The contrast ratio CR_{AV} is given as follows:

$$CR_{AV} = \frac{L_{CWAV}}{L_{CBAV}} \tag{3}$$

6) Calculate the contrast ratio CR_i (i = 1 to 13) for each measurement rectangle in the checkerboard screen as follows:

$$CR_i = \frac{L_{CWi}}{L_{CBi}} (i = 1 \text{ to } 13) \quad (4)$$

7) Determine the maximum contrast ratio CR_{MAX} and the minimum contrast ratio CR_{MIN} from all thirteen white rectangles.

7.2.5 Report

The following information shall be noted in the report:

– the test patterns and measurement position on the screen;
– the luminance at each centre of the rectangles with white and black;
– the contrast ratio for each measurement rectangle;
– the contrast ratio CR_{AV}, maximum contrast ratio CR_{MAX} and minimum contrast ratio CR_{MIN}.

NOTE The contrast ratio is expressed as a ratio in the format of "X:1".

7.3 Viewing direction

7.3.1 Purpose

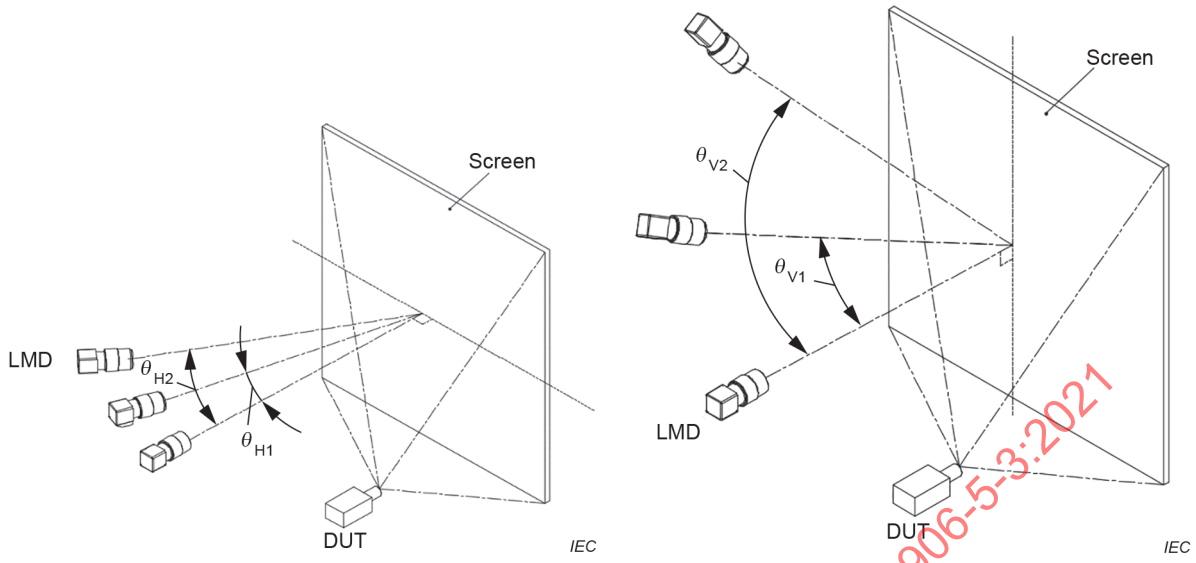
The purpose of this method is to measure the viewing direction range of laser projection displays.

NOTE In the case of back projection, IEC 62341-6-3 can be referred to.

7.3.2 Measuring conditions

The following measuring conditions shall be applied.

a) Apparatus: an LMD that can be a spot luminance meter or a spectral radiance meter, a power source, and a driving signal equipment, as well as a goniometric mechanism to move the LMD around the projection plane;
b) Standard measuring environmental conditions; dark-room conditions.
c) Standard set-up condition as in Figure 6.



a) Measurement on the horizontal direction

b) Measurement on the vertical direction

Figure 6 – Set-up for viewing direction measurement

7.3.3 Patterns

The pattern shall be applied with 100 % grey levels for full white and black screens.

7.3.4 Measuring method

1) Align the LMD perpendicularly to the LPD surface, and focus on the centre of the screen.
2) Measure the centre luminance, and the contrast ratio perpendicular to the projection plane ($\theta_V = \theta_H = 0°$). The measurement area shall cover at least 500 pixels.
3) Measure the luminance values and determine the luminance contrast ratio as the LMD steps through the various angles in the horizontal or/and vertical directions at the specified angle ranges in the product specification.
4) Calculate the variation of the contrast ratio from the perpendicular direction to determine the viewing direction.
5) Report the angle ranges of the viewing direction in the horizontal or/and vertical directions based on the contrast ratio limits which may be specified by the manufacturer, for example 10:1.

7.4 Chromaticity uniformity

7.4.1 Purpose

The purpose of this method is to measure the chromaticity uniformity of laser projection displays on the screen.

7.4.2 Measuring conditions

The following measuring conditions shall be applied:

a) Apparatus: an LMD which can be a colorimetric luminance meter or a spectral radiance meter, a power source and driving signal equipment.
b) Standard measuring environmental conditions; dark-room conditions; standard installation and adjustment of the DUT.

7.4.3 Patterns

The pattern shall be applied with 100% grey levels for full screen white, red, green, and blue as in Figure 3.

7.4.4 Measuring method

For chromaticity uniformity, the measurement shall be as follows.

a) Apply the test patterns for full screen white, red, green, and blue colours, respectively, on the screen.

b) For each colour, measure the chromaticity u', v' in the CIE 1976 UCS chromaticity system at the centre of each of the common (P_1 to P_9) nine rectangles as shown in Figure 5.

c) Calculate the arithmetic average chromaticity value (u'_0 and v'_0) of the nine measurements for each colour.

d) Measure the u', v' chromaticity at the four corners (P_{10} to P_{13}) as shown in Figure 5 for each colour.

e) Calculate the chromaticity deviation $\Delta u'v'$ of the thirteen measurements from the average value for each colour as follows.

$$\Delta u'v' = \left[\left(u' - u'_0 \right)^2 + \left(v' - v'_0 \right)^2 \right]^{1/2} \quad (5)$$

f) Determine the maximum chromaticity deviation in u' and v' for each colour.

7.4.5 Report

The following information shall be noted in the report:

– the test patterns;

– the average chromaticity value (u'_0, v'_0) for each colour;

– the maximum chromaticity deviation $\Delta u'v'$ for each colour.

7.5 Image resolution

7.5.1 Purpose

The purpose of this method is to measure static image resolution of the LPD on the screen.

NOTE 1 An alternative method for determining effective resolution can be found in section 7.7 in [1], if necessary.

NOTE 2 The method for determining moving image resolution is found in IEC 62341-6-3:2012, 6.5, if necessary.

7.5.2 Measuring conditions

The following measuring conditions shall be applied:

a) Apparatus: an LMD which can be a spot luminance meter, a spectral radiance meter or 2D imaging luminance meter; driving power source; and a driving signal equipment;

b) The measurement direction of the LMD to determine the luminance profile shall be perpendicular to the parallel lines being measured. The integrating time of the LMD signal shall be long enough so that the standard deviation of the measured luminance is no greater than 2 % of the average value.

c) For a 2D imaging luminance meter, the number of pixels of the detector shall be enough. It is recommended at least five pixels from the detector fall within each pixel line at the crossed direction;