IEC 61747-30-4

Edition 1.0 2016-08

INTERNATIONAL STANDARD

colour inside

Liquid crystal display devices –
Part 30-4: Measuring methods for liquid crystal display modules –
Dynamic backlight units

IEC 61747-30-4:2016-08(en)

IEC Central Office
3, rue de Varembé
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 It also gives information on projects, replaced and withdrawn publications.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 15 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 61747-30-4

Edition 1.0 2016-08

INTERNATIONAL STANDARD

colour inside

Liquid crystal display devices –
Part 30-4: Measuring methods for liquid crystal display modules –
Dynamic backlight units

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 31.120

ISBN 978-2-8322-3608-6

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

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

LIQUID CRYSTAL DISPLAY DEVICES –

Part 30-4: Measuring methods for liquid crystal display modules – Dynamic backlight units

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.

International Standard IEC 61747-30-4 has been prepared by IEC technical committee 110: Electronic display devices.

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

FDIS	Report on voting
110/753/FDIS	110/769/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 61747 series, published under the general title *Liquid crystal display devices*, can be found on the IEC website.

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.

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.

LIQUID CRYSTAL DISPLAY DEVICES –

Part 30-4: Measuring methods for liquid crystal display modules – Dynamic backlight units

1 Scope

This part of IEC 61747 specifies the standard measurement conditions and measuring methods for determining the optical performance and power consumption of active matrix liquid crystal display modules with dynamic backlight units.

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 61747-1-2, *Liquid crystal display devices – Part 1-2: Generic – Terminology and letter symbols*

IEC 61747-30-1:2012, *Liquid crystal display devices – Part 30-1: Measuring methods for liquid crystal display modules – Transmissive type*

IEC 62087, *Methods of measurement for the power consumption of audio, video and related equipment*

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

3 Terms, definitionsand abbreviations

For the purposes of this document, the terms, definitions, symbols and units given in IEC 61747-1-2, as well as the following apply.

3.1 Terms and definitions

3.1.1
judder
motion-dependent temporal instability of a moving pattern

Note 1 to entry: Rather than smooth motion, there may be hesitations, inconsistencies, or other interruptions of the smooth motion of the moving content.

3.2 Abbreviations

APL	average picture level
CCD	charge coupled device
CIE	Commission Internationale de l'Eclairage (International Commission on Illumination)
CIELAB	CIE 1976 (L*a*b*) colour space
DUT	device under test
HVS	human visual system

LED light emitting diode
LMD light measuring device
PSF point spread function
RGB red, green, blue
SLSF spectral line spread function
TCSF temporal contrast sensitivity function

4 Standard measuring equipment

The system configuration and operating conditions of the measuring equipment shall comply with the structures specified in each item.

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

a) Luminance meter: the instrument's spectral responsivity shall comply with the relative luminance uncertainty of the measured luminance and shall not be greater than 4 % for luminance values over 10 cd/m^2 and not be greater than 10 % for luminance values 10 cd/m^2 and below.
b) Colourimeter: the detector’s spectral responsivity shall comply with the colour-matching functions for the CIE 1931 standard colourimetric observer with a chromaticity accuracy of 0,004 for x y. A correction factor can be used for the required accuracy by application of a standard source with a similar spectral distribution as the module to be measured.
c) Imaging colourimeter: the number of pixels within the measurement field of view of the colourimeter's detector shall not be less than 4 for each display subpixel and not be less than a 12-bit digital resolution. The spectral responsivity shall comply as colour-matching functions for the CIE 1931 standard colourimetric observer with a chromaticity accuracy of 0,004 for x y.
d) Fast-response photometer: the linearity shall be better than 0,5 % in a measured dynamic range. A –3 dB cut-off frequency shall be higher than1 kHz.

5 Measuring conditions

5.1 Standard measuring 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.

5.2 Power supply

The power supply for driving the DUT shall be adjusted to the rated voltage, ±0,5 %. The frequency of the power supply shall also provide the rated frequency, ±0,2 %.

5.3 Warm-up time

Measurements shall be carried out after sufficient warm-up. Sufficient warm-up 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 module show a variation in luminance of no more than 1 % per 5 min for at least 5 sampling points; the warm-up duration should be no less than 15 min.

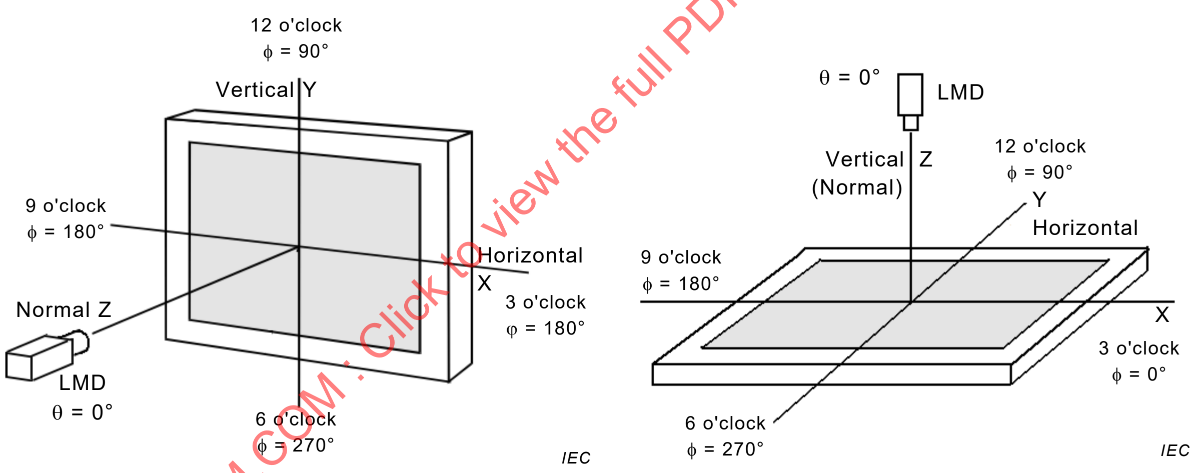
5.4 Standard measuring dark-room conditions

The luminance contribution from the background illumination reflected off the test module in a direction perpendicular to the test module shall be less than 0,03 cd/m^2. If these conditions are not satisfied, then background subtraction is required and it shall be noted on the report. In addition, if the sensitivity of the LMD is inadequate to measure these low levels of luminance from the background illumination reflected off the test module, then the lower limit of the LMD shall be noted in the measurement report.

5.5 Standard set-up conditions

By default, the module shall be installed in the vertical position (Figure 1a)), but the horizontal alternative (Figure 1b)) is also allowed. When the latter alternative is used, it shall be noted in the measurement report.

Luminance, contrast and chromaticity of the white field and other relevant parameters of the modules have to be adjusted to nominal status in the detailed specification and they shall be noted in the measurement report. When there is no level specified, the maximum contrast and/or luminance level shall be used. These adjustments shall be held constant for all measurements, unless noted otherwise in the measurement report. Additional conditions are specified separately for each measuring method.



a) Primary set-up **b) Alternative set-up**

Figure 1 – DUT set-up conditions

5.6 Signal patterns

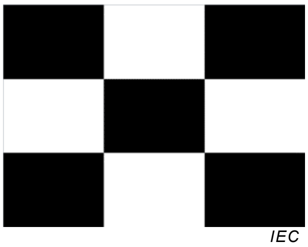
5.6.1 Full screen pattern

The pattern is applied with different grey levels or different colours on the full screen.

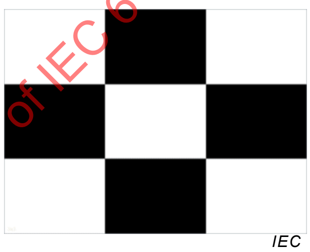
Figure 2 – Full screen pattern

5.6.2 Checkerboard patterns

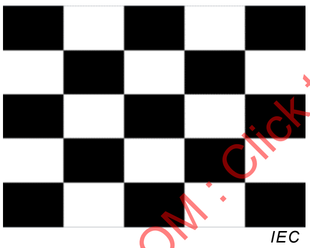
There are different columns and different rows (for example 3-by-3, 5-by-5) in checkerboard patterns. For a monochromatic display, apply a signal to make the white rectangle box emit at the highest grey level and the black rectangle box emit at the lowest grey level. For a colour display, apply a white signal level of 100 % on a white rectangle box and a black signal level of 0 % on a black rectangle box.



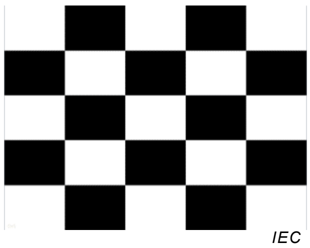
a)



b)



c)



d)

Figure 3 – Checkerboard patterns

Stray-light management should be used as indicated in the International Display Measurements Standard version 1.03:2012, Annex A, while using the checkboard patterns.

5.6.3 Increasing window patterns

Display a full screen black (0 % grey level) background and a white (100 % grey level) window with the specified dimension in the centre of the screen. The dimensions of the windows can be $n/10$ (n = 1 to 10) of the full screen area. A total of 10 patterns is valid for this kind of pattern as shown in Figure 4. The APL of the area is shown in Table 1.

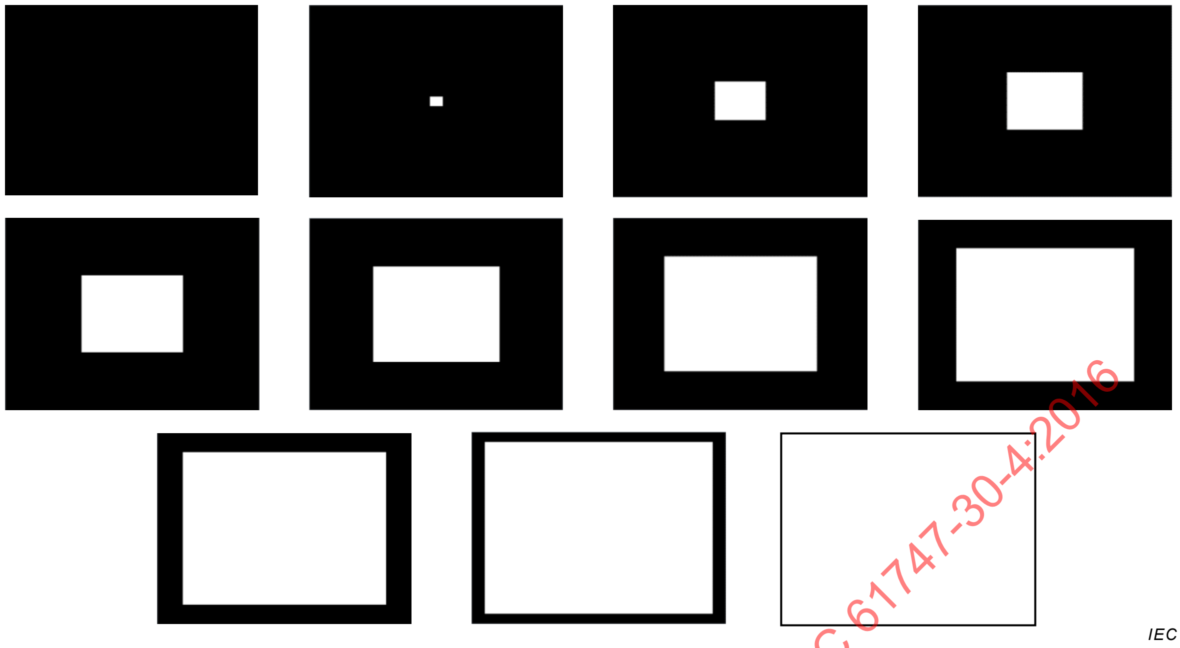


Figure 4 – Increasing window patterns

Table 1 – APL of increasing window patterns

STEP	All black	1	2	3	4	5	6	7	8	9	10
Horizontal	0	10 %	20 %	30 %	40 %	50 %	60 %	70 %	80 %	90 %	100 %
Vertical	0	10 %	20 %	30 %	40 %	50 %	60 %	70 %	80 %	90 %	100 %
Area (APL)	0,0 %	1,0 %	4,0 %	9,0 %	16,0 %	25,0 %	36,0 %	49,0 %	64,0 %	81,0 %	100,0 %

5.6.4 Line patterns

Line patterns are composed of horizontal or vertical lines with n white or black pixels, where n = 1 to 5 as in Figure 5.

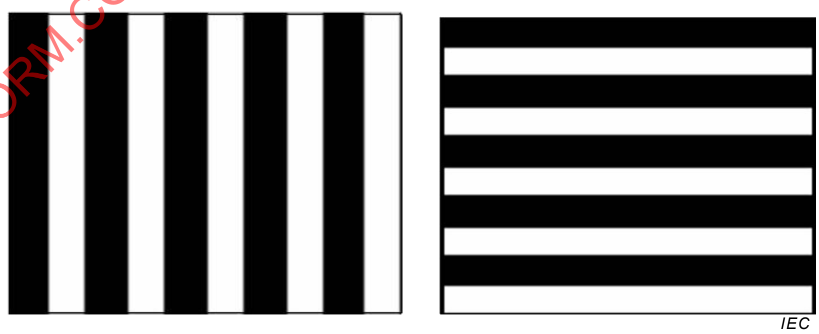
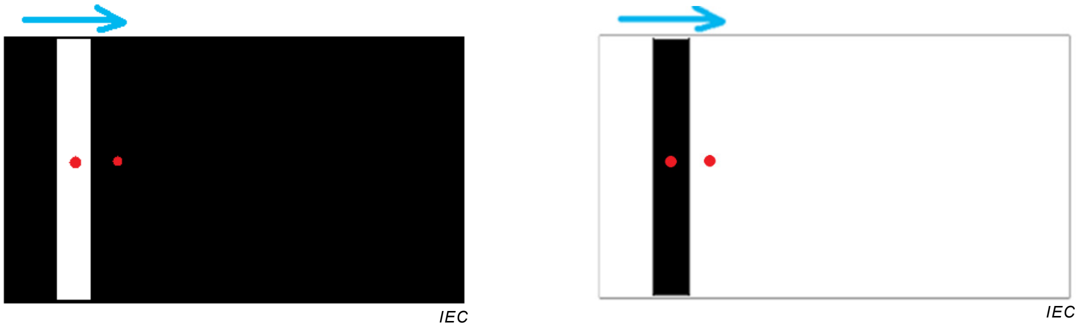


Figure 5 – Line patterns

5.6.5 Moving image

A vertical white (100 % grey level) bar is moving from the left to the right of the screen whose background is full screen black (0 % grey level) with a specified speed as in Figure 6 a).

A vertical black (0 % grey level) bar is moving from the left to the right of the screen whose background is full screen white (100 % grey level) with a specified speed as in Figure 6 b).



(a) **White pattern** (b) **Black pattern**

Figure 6 – Moving image

Stray-light management should be used as indicated in the International Display Measurements Standard version 1.03:2012, Annex A, while using the moving image patterns.

5.6.6 Video signal

Refer to IEC 62087.

6 Measuring methods

6.1 Optical performance

6.1.1 Luminance and uniformity

6.1.1.1 Purpose

The purpose of this method is to measure the luminance of the LCD module with active backlight control and its luminance uniformity.

6.1.1.2 Measuring conditions

The following measuring conditions shall be applied:

a) Apparatus: An LMD that can measure luminance, a power source, and driving signal equipment.

b) Standard measuring environmental conditions; dark-room conditions; standard set-up conditions.

6.1.1.3 Patterns

Set the pattern into a 3-by-3 and 5-by-5 checkerboard pattern as in Figure 3. There are two types for each pattern whose centre rectangles are black and white: a) and b) are for 3-by-3, c) and d) are for 5-by-5.

6.1.1.4 Measuring methods

6.1.1.4.1 Luminance

For luminance proceed as follows:

a) Set the DUT and the LMD under the standard measuring conditions.

b) Set the pattern as pattern a) or pattern b) in Figure 3.

c) Measure the luminance L_w and L_b on the position of the screen centre.

The luminance measurement for plain field pattern shall be as indicated in IEC 61747-30-1.

6.1.1.4.2 Luminance uniformity

For luminance uniformity proceed as follows.

a) Set the patterns of (a and b) or (c and d) of Figure 3.

b) Measure the luminance L_{wn} (n = 1 to 9 or 1 to 25) at the centre of each white rectangle for each pattern.

c) Measure the luminance L_{bn} (n = 1 to 9 or 1 to 25) at the centre of each black rectangle for each pattern.

d) Get the maximum luminance L_{wmax}, L_{bmax} and the average luminance L_{wav}, L_{bav} from all points.

e) The luminance non-uniformity for white rectangular (LNU_w) and the luminance non-uniformity for black rectangular (LNU_b) are then calculated by the individual luminance L_n and the average luminance L_{av} according to:

$$LNU = \max\left|\frac{L_{av} - L_n}{L_{av}}\right| \quad LNU = \max\left|\frac{L_{av} - L_n}{L_{av}}\right| \qquad (1)$$

LNU = 0 indicates a perfectly uniform display for the selected number of measurement positions.

6.1.1.5 Report

Report L_w and L_b, L_n, LNU_W and LNU_B in the report. The pattern used shall be noted.

6.1.2 Chromaticity and uniformity

6.1.2.1 Purpose

The purpose of this method is to measure the chromaticity coordinates of the LCD module with active backlight control and its chromaticity uniformity.

6.1.2.2 Measuring conditions

The following measuring conditions shall apply:

1) Apparatus: an LMD that can measure the CIE 1931 chromaticity coordinates, a driving power source, and driving signal equipment.
2) Standard measuring environmental conditions; dark-room conditions; standard set-up conditions.

6.1.2.3 Patterns

Use the following three patterns:

1) Full screen patterns with red, green, blue, grey, with signal level at 100 %, 50 %, 10 %, 4 %. 3 %, as in the Figure 2 full screen pattern.
2) Checkerboard pattern b) in Figure 3.
3) Checkerboard pattern d) in Figure 3.

6.1.2.4 Measuring methods

6.1.2.4.1 Chromaticity

a) For monochrome displays:

Apply a signal to produce a full screen light at the highest grey level. Measure the CIE 1931 chromaticity coordinates (x, y) at the centre of the display.

b) For colour displays:

1) Apply a full screen white pattern or the checkboard pattern for the DUT.
2) Measure the CIE 1931 chromaticity coordinates (x_W, y_W) at the centre.
3) Turn on the red signal to ensure only the red light is emitting from the module.
4) Measure the chromaticity coordinates (x_R, y_R) of the red light at the centre.
5) Turn on the green signal to ensure only the green light is emitting from the module.
6) Measure the chromaticity coordinates (x_G, y_G) of the green light at the centre.
7) Turn on the blue signal to ensure only the blue light is emitting from the module.
8) Measure the chromaticity coordinates (x_B, y_B) of the blue light at the centre.
9) The colour gamut is represented by the triangle in the CIE 1931 chromaticity diagram formed by the colour points (x_R,y_R), (x_G, y_G), (x_B, y_B) as corner points.
10) The colour gamut area metric is defined as the percent colour space area enclosed by the colour gamut relative to the entire spectrum locus in the CIE 1976 UCS. For three primary displays, this is calculated as A % = 256, 1 | $(u'_R - u'_B)(v'_G - v'_B) - (u'_G - u'_B)(v'_R - v'_B)$|, where the subscripts R, G and B refer to the red, green, and blue primaries, respectively. For example, the colour gamut area metric for the 1953 NTSC primaries would be 38 %, using the x, y chromaticity red (0,67, 0,33), green (0,21, 0,71), and blue (0,14, 0,08).

6.1.2.4.2 Input signal level dependence on chromaticity

For input signal level dependence on chromaticity, apply a full screen red, green and blue of 50 %, 30 %, 10 % and 4 % signal levels and measure by following the above steps b) 2) to 8). Plot a colour space triangle as shown in Figure 7.

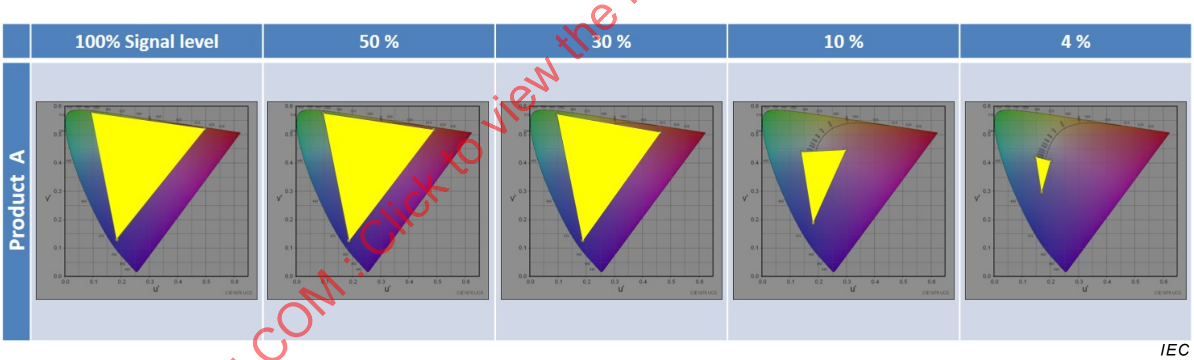


Figure 7 – Example of input signal level dependence on chromaticity

6.1.2.4.3 Chromaticity uniformity

Proceed as follows:

a) Measure the CIE 1931 chromaticity coordinates x_i and y_i (i= 1 to 9 or 1 to 25) in each white rectangle in pattern b) and pattern d) of Figure 3.

b) The CIE 1976 UCS chromaticity coordinates u'_i ,v'_i are obtained from the CIE 1931 chromaticity coordinates x, y (both specified in ISO 11664-1).

c) Use the CIE 1976 chromaticity coordinates u' , v' at each location to determine the colour difference between pairs of sampled colours using the following colour difference equation:

$$\Delta u'v' = \sqrt{\left(u'_i - u'_j\right)^2 + \left(v'_i - v'_j\right)^2} \quad (2)$$

For i, j = 1 to 9 or 1 to 25, and $i \neq j$. Colour non-uniformity is defined as the largest sampled colour difference $(\Delta u'v')_{max}$ between any two points.

6.1.2.5 Report

The measurement results of chromaticity coordinates (x, y) with different patterns, colour gamut area metric A % and uniformity $(\Delta u'v')_{max}$ shall be recorded. The largest colour difference can be narrowed down by plotting the (u', v') coordinates rather than calculating all (u', v') pairs. Report the largest chromaticity difference to no smaller uncertainty than ±0,001.

NOTE For the multiple-primary display, the above method for color gamut area metric is not suitable.

6.1.3 Window size dependence of luminance and chromaticity

6.1.3.1 Purpose

The purpose of this method is to measure the dynamic luminance stability and dynamic chromaticity stability of the LCD module with active backlight control.

6.1.3.2 Measuring conditions

The following measuring conditions apply:

1) Apparatus: An LMD that can measure luminance and chromaticity coordinates, a driving power source, and driving signal equipment.
2) Standard measuring environmental conditions; dark-room conditions; standard set-up conditions.

6.1.3.3 Patterns

Increasing window patterns with different dimensions of the central white windows as in Table 1 are used for this measurement.

6.1.3.4 Measuring methods

Proceed as follows:

1) Generate the increasing window patterns in the DUT.
2) Measure the luminance and chromaticity coordinates in the centre of the window.
3) Switch the different patterns, and record the results of luminance L_i and chromaticity coordinates (x_i, y_i) (where i is an index that represents the patterns with the different APL levels, i = 1 to 10).
4) Dynamic luminance stability η_L is obtained from the following equation:

$$\eta_L = \frac{L_{max} - L_{min}}{L_{ave}} \times 100\% \qquad (3)$$

5) Dynamic chromaticity stability η_x and η_y is obtained from the following equations:

$$\eta_x = \frac{x_{max} - x_{min}}{x_{ave}} \times 100\% \qquad (4)$$

$$\eta_y = \frac{y_{max} - y_{min}}{y_{ave}} \times 100\% \qquad (5)$$

6.1.3.5 Report

The dynamic luminance stability and chromaticity stability, as well as the dynamic curve of the luminance (see Figure 8) and dynamic curve of the chromaticity should be noted in the report.

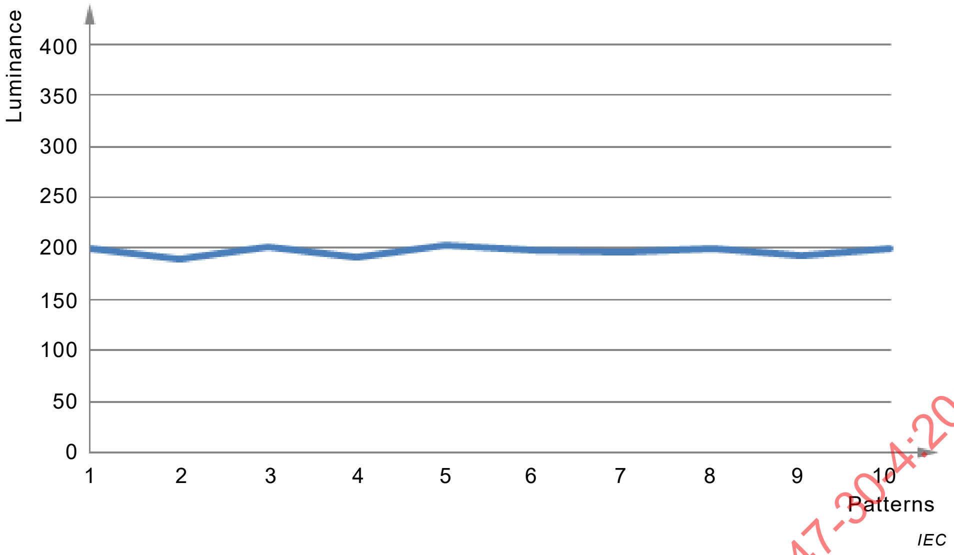


Figure 8 – Window size dependence on luminance and chromaticity

6.1.4 Contrast ratio

6.1.4.1 Purpose

The purpose of this method is to measure the luminance contrast ratio of the LCD module with active backlight control under specified window signals.

6.1.4.2 Measuring conditions

The following measuring conditions apply:

1) Apparatus: An LMD that can measure luminance, a driving power source, and driving signal equipment.
2) Standard measuring environmental conditions; dark-room conditions; standard set-up conditions.

6.1.4.3 Pattern

The checkerboard patterns in Figure 3 are used for this measurement.

6.1.4.4 Measuring method

Generate the checkerboard patterns a) and c) of Figure 3, and measure the luminance of the black rectangles to get $L_{\mathrm{b}i}$ (i = 1 to 5) and $L_{\mathrm{b}j}$ (j = 1 to 13) in each pattern. Then, generate the checkerboard patterns b) and d) of Figure 3, and measure the luminance of the white rectangles in the patterns to get $L_{\mathrm{w}i}$ (i = 1 to 5) and $L_{\mathrm{w}j}$ (j =1 to 13) in each pattern.

The contrast ratio can be obtained from the following equation:

$$CR = \frac{\overline{L_{\mathrm{w}}}}{\overline{L_{\mathrm{b}}}} \qquad (6)$$

where,

$$\overline{L_{\mathrm{w}}} = \frac{1}{2} \times \left(\frac{1}{5} \sum_{i=1}^{5} L_{\mathrm{w}i} + \frac{1}{13} \sum_{j=1}^{13} L_{\mathrm{w}j} \right) \tag{7}$$

$$\overline{L_{\mathrm{b}}} = \frac{1}{2} \times \left(\frac{1}{5} \sum_{i=1}^{5} L_{\mathrm{b}i} + \frac{1}{13} \sum_{j=1}^{13} L_{\mathrm{b}j} \right) \tag{8}$$

6.1.4.5 Report

The luminance contrast ratio CR, the average luminance of the white rectangle $\overline{L_{\mathrm{w}}}$ and the black luminance of the black rectangle $\overline{L_{\mathrm{b}}}$ should be noted in the report.

The measurement of the plain field contrast ratio (CR_{PF}), dark-image contrast ratio on a light field (CR_{dol}) and light-image contrast ratio on a dark field (CR_{lod}) shall be as indicated in IEC 61747-30-1:2012, 6.2.4.2 and 6.2.4.3.

6.1.5 Flicker

6.1.5.1 Purpose

The purpose of this method is to measure the potential of an observable flicker from the LCD module with active backlight control.

6.1.5.2 Measuring conditions

The following measuring conditions apply:

1) Apparatus:
   a) An LMD with the following characteristics to record the luminance as a function of time:
      - CIE photonic vision spectral response,
      - capable of producing a linear response to rapid changes in luminance,
      - frequency response: greater than 1kHz,
      - field angle of measurement: less than 5°,
      - the LMD shall be dark field (zero) corrected.
   b) A signal generator.
   c) A frequency analyzer.
2) Standard measuring environmental conditions; dark-room illumination; standard set-up conditions.

6.1.5.3 Geometric arrangement

The following geometric arrangement appies:

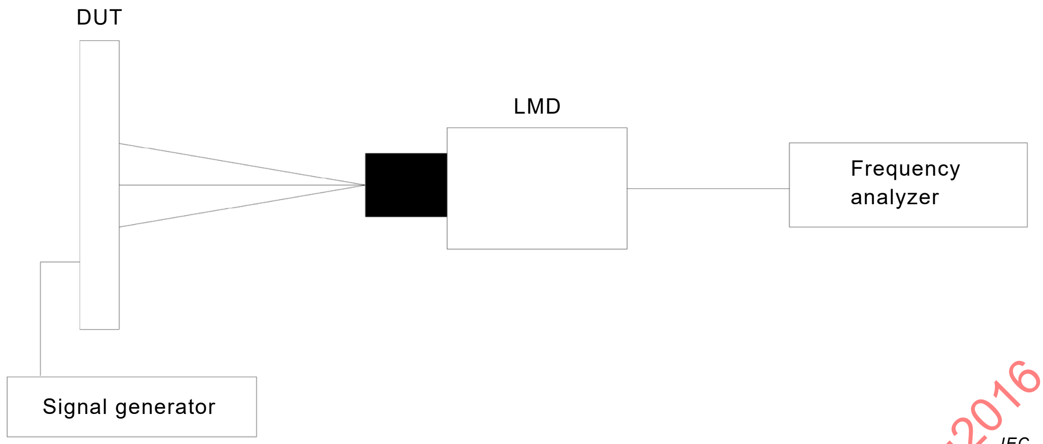


Figure 9 – Apparatus arrangement

1) The optical axis of the LMD is in accordance with the central normal line of the DUT.
2) Measurement region: larger than 500 pixels.
3) Measuring distance: twice the diagonal distance of the DUT. The minimum distance shall be 500 mm.

6.1.5.4 Pattern

The increasing window patterns of Table 1 are used for flicker measurement. Ten patterns should be displayed continuously and repeatedly with a specified interval. The interval shall be noted in the report.

6.1.5.5 Measuring methods

Proceed as follows:

1) Set the DUT under the standard measuring conditions.
2) Display the selected test pattern.
3) Measure the luminance as a function of time $L(t)$ in the centre of the screen with the LMD.

6.1.5.6 Evaluation method

Proceed as follows:

1) Perform a Fourier Transform with the array of data $L(t)$, to acquire the power spectrum $P(F)$.
2) Weigh the power spectrum $P(F)$ with the temporal contrast sensitivity function (TCSF) (see Figure 10 and Table 2), to obtain the perceptive power spectrum $P'(F)$.
3) Transform $P'(F)$ to the luminance as a function of time $L'(t)$ with the inverse Fourier Transform.

Table 2 – Temporal contrast sensitivity function

Frequency (Hz)	**Contrast sensitivity** (%)	**Frequency** (Hz)	**Contrast sensitivity** (%)
1,6	17,8	19,8	78,8
2,7	17,9	24	59,8
4	32,9	28	29,9
5,1	45,3	32	23
6,8	50,3	40	5,89
8,8	72,5	54	1,23
10,7	96,7	64	0,79
12,7	101,5	75	0,60
16,2	91,3		

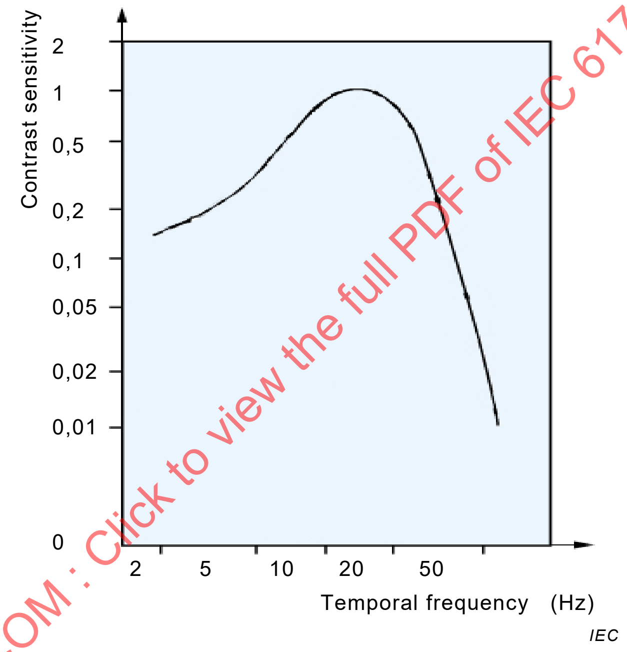


Figure 10 – Temporal contrast sensitivity function

Subsequently, calculate the flicker modulation amplitude (A_{FM}) as follows:

4) Determine the main flicker frequency f_m from the maximum of $P'(F)$.

5) Determine the flicker modulation amplitude A_{FM} in percent from $L'(t)$ as follows:

   a) Obtain the average luminance, L'_{ave}, the maximum luminance L'_{max}, and the minimum luminance L'_{min} of $L'(t)$ (see Figure 11).

   b) Calculate A_{FM} via

$$A_{FM} = \left(\frac{L'_{max} - L'_{min}}{L'_{ave}} \right) \times 100\% \quad (9)$$

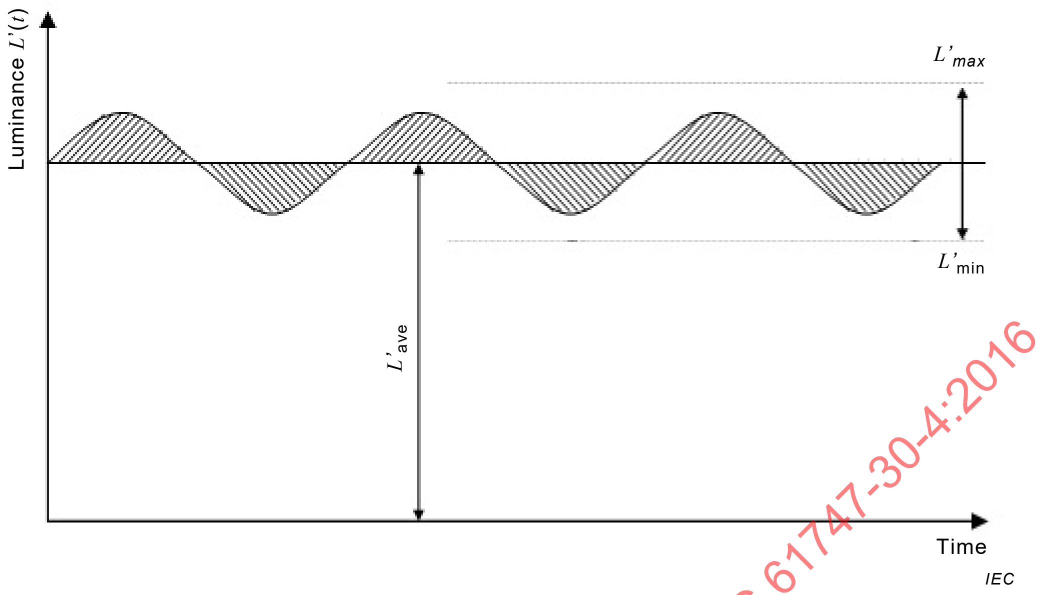


Figure 11 – Example of the luminance waveform by weighting TCSF

NOTE An example for flicker measurement is shown in Annex A.

6.1.5.7 Report

In the case that the flicker modulation amplitude has been calculated, the following information shall be noted in the measurement report:

- the test pattern that was used to produce the luminance variations,
- the temporal CSF that was used for filtering the recorded luminance,
- the minimum luminance (L'_{min}), maximum luminance (L'_{max}), and the average luminance (L'_{ave}) of the filtered temporal luminance [$L'(t)$] (see Figure 10),
- the flicker modulation amplitude (A_{FM}), and its main modulation frequency f_M.

6.1.6 Judder

6.1.6.1 Purpose

The purpose of this method is to measure the judder of the LCD module with active backlight control.

6.1.6.2 Measuring conditions

The following measuring conditions apply:

1) Apparatus: A driving power source, driving signal equipment, and an LMD with the following characteristics to record the luminance as a function of time:
   a) CIE photonic vision spectral response,
   b) capable of producing a linear response to rapid changes in luminance,
   c) frequency response: greater than 1kHz,
   d) field angle of view: less than 1/2 width of the pattern bar,
   e) the LMD shall be dark field (zero) corrected.
2) Standard measuring environmental conditions; dark-room conditions; standard set-up conditions.

6.1.6.3 Patterns

A vertical white pattern and a vertical black pattern shall be applied moving from the left to the right of the screen with a specified speed (Figure 6).

The speed of the moving image shall be selected from the following parameters: 1/15 screen/s, 1/10 screen/s, 1/5 screen/s, and 1/3 screen/s.

The unit for speed expressed here is the inverse of time (in seconds) in which the image passes over from one end to the opposite end of the screen. For example, 1/15 screen/s means one screen per 15 s.

The width of the vertical pattern bar shall be selected from the following suitable values: 1/20 screen, 1/15 screen, 1/10 screen, 1/5 screen.

The speed and width of the applied pattern should be noted in the report.

6.1.6.4 Measuring methods

Proceed as follows:

a) Set the DUT under the standard measuring conditions.
b) Generate the pattern specified as above in the DUT.
c) Measure the luminance $L_0(t)$ of the centre point P_0 of the pattern bar, and the luminance $L_1(t)$ of point P_1, whose distance to P_0 is the width of the pattern bar, on the right direction of P_0, with the LMD.
d) Record the average $L_0(t)$ and $L_1(t)$ in an integral frame cycle of the DUT, along the movement of the pattern bar.
e) Perform a Fourier Transform with the data $L_0(t)$ and $L_1(t)$, to acquire the power spectrum $P_0(F)$ and $P_1(F)$ respectively.
f) Weight the power spectrum $P_0(F)$ and $P_1(F)$ with the temporal contrast sensitivity function (TCSF) (see Figure 9), to obtain the perceptive power spectrum $P_0'(F)$ and $P_1'(F)$.
g) Transform $P_0'(F)$ and $P_1'(F)$ to the luminance as a function of time $L_0'(t)$ and $L_1'(t)$ with the inverse Fourier Transform.
h) Determine the judder number JN per screen from $L_0'(t)$ and $L_1'(t)$ as follows:
   1) Calculate of the average luminance L'_{0ave}, L'_{1ave} per screen, the maximum luminance $L_0'_{max}$, $L_1'_{max}$, and the minimum luminance $L_0'_{min}$, $L_1'_{min}$ from $L_0'(t)$ and $L_1'(t)$ in each judder pulse (see Figure 12).
   2) The criteria of the judder of the DUT are the following luminance variation, for the white pattern,

      $f_j = (L'_{0ave} - L_0'_{min})/(L'_{0ave} + L'_{1ave})$, or $(L_1'_{max} - L'_{1ave})/(L'_{0ave} + L'_{1ave})$

      and for the black pattern,

      $f_j = (L_0'_{max} - L'_{0ave})/(L'_{0ave} + L'_{1ave})$, or $(L'_{1ave} - L_1'_{min})/(L'_{0ave} + L'_{1ave})$
   3) Take a count of the judder if the luminance variation f_j is more than a specified criteria value.
   4) Repeat three times the above steps, and sum up the judder number JN averaged in three screens, including for white pattern and for black pattern.

6.1.6.5 Report

Report the judder number JN per screen, the speed and width of the applied pattern, and the specified criteria value.

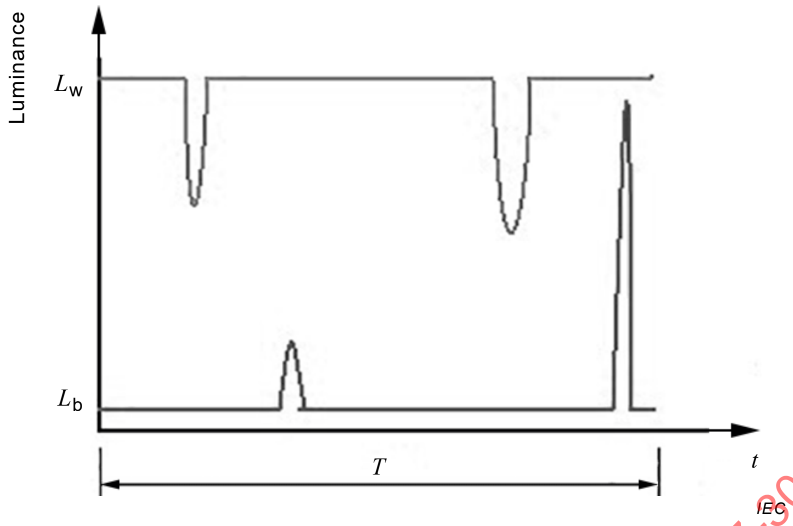


Figure 12 – Dynamic curve of the judder

6.2 Power consumption

6.2.1 Static power consumption

6.2.1.1 Purpose

The purpose of this method is to measure the power consumption of the LCD module with active backlight control with a specified static pattern.

6.2.1.2 Measuring conditions

The following measuring conditions apply:

a) Apparatus: An LMD that can measure luminance; a current meter; a voltage meter; a DC power source; an image signal generator.

b) Standard measuring environmental conditions; dark-room conditions; standard set-up conditions.

6.2.1.3 Pattern

A full white screen pattern and the checkboard patterns in Figure 3 are used for this measurement.

6.2.1.4 Measuring method

Proceed as follows:

a) Make all electrical connections needed operate the module under standard conditions.

b) Apply a full white screen or the checkboard patterns in Figure 3, driving the signal to the LCD module, and set all power supplies to the standard voltage specification value. The grey level value used shall be noted in the test report.

c) Measure the luminance in the centre of the display.

d) Record all relevant power, voltage and current readings of all meters.

e) The total module power may also be measured at other luminance levels and/or with a uniformly distributed pattern lighting a fraction of the total pixels. It could give significantly different results from the specified method depending on the efficiency versus luminance curve of the display. In this case, the luminance level and fraction shall be reported.

The rated luminance and the driving signal shall be specified in the report.

6.2.2 Dynamic power consumption

6.2.2.1 Purpose

The purpose of this method is to measure the average power consumption of the LCD module with active backlight control under a dynamic video signal.

6.2.2.2 Pattern

A video signal using a dynamic broadcast contents video signal as in IEC 62087.

6.2.2.3 Measuring method

Refer to the measuring method of IEC 62087.