

Liquid crystal and solid-state display devices —

Part 6: Measuring methods for liquid crystal modules — Transmissive type

The European Standard EN 61747-6:2004 has the status of a
British Standard

ICS 31.120

National foreword

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The UK participation in its preparation was entrusted to Technical Committee EPL/47, Semiconductors, which has the responsibility to:

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Liquid crystal and solid-state display devices
Part 6: Measuring methods for liquid crystal modules –
Transmissive type
(IEC 61747-6:2004)

Dispositifs d'affichage à cristaux liquides
et à semiconducteurs
Partie 6: Méthodes de mesure
pour les modules à cristaux liquides -
Type transmissif
(CEI 61747-6:2004)

Flüssigkristall- und Halbleiter-Anzeige-
Bauelemente
Teil 6: Messverfahren
für Flüssigkristall-Module –
Transmissive Ausführung
(IEC 61747-6:2004)

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CENELEC

European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

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Foreword

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Annex ZA has been added by CENELEC.

Endorsement notice

The text of the International Standard IEC 61747-6:2004 was approved by CENELEC as a European Standard without any modification.

CONTENTS

1	Scope and object	4
2	Normative references.....	5
3	Chromaticity and pixel definitions	5
4	Standard measuring conditions	6
4.1	Standard measurement equipment and setup.....	6
4.2	Standard measurement positions	8
4.3	Standard device operation conditions	9
4.4	Standard ambient conditions	9
4.5	Standard measuring process	9
5	Measuring methods	10
5.1	Luminance and luminance uniformity	10
5.2	Warm-up characteristics	11
5.3	Response times (turn-on time, turn-off time, rise time and fall time)	12
5.4	Flicker (multiplexed displays)	15
5.5	Luminance contrast ratio.....	16
5.6	Peak viewing direction – Viewing angle range	18
5.7	Viewing angle range without gray-scale inversion	19
5.8	Specular reflectance from the active area surface	20
5.9	White chromaticity and its uniformity (matrix displays only).....	22
5.10	Reproduction of colour (matrix displays only)	23
5.11	Display resolution (high resolution matrix displays only)	24
5.12	Cross-talk	25
5.13	Power consumption	27
	Annex A (informative) Standard measuring conditions	30
	Annex B (informative) Measuring methods for liquid crystal display devices (segment type).....	31
	Annex ZA (normative) Normative references to international publications with their corresponding European publications	40
	Figure 1 – Measuring system and its configuration.....	6
	Figure 2 – Definition of polar coordinates θ , φ	7
	Figure 3 – Standard measurement positions at the centres of all rectangles p0-p24	8
	Figure 4 – Example of warm-up characteristic	12
	Figure 5 – Relationship between driving signal and optical response times	14
	Figure 6 – Frequency characteristics of the integrator (response of human visual system)	16
	Figure 7 – Example of power spectrum	16
	Figure 8 – Example of gray-scale inversion.....	20
	Figure 9 – Example of standard set-up for specular reflection measurements	21
	Figure 10 – Checker-flag pattern for current and power consumption measurements	27
	Figure 11 – Example of measuring block diagram for current and power consumption of a liquid crystal display device	28

LIQUID CRYSTAL AND SOLID-STATE DISPLAY DEVICES –

Part 6: Measuring methods for liquid crystal modules – Transmissive type

1 Scope and object

This part of IEC 61747 gives details of the quality assessment procedures, inspection requirements, screening sequences, sampling requirements and test and measurement procedures required for the assessment of liquid crystal display modules.

This standard is restricted to transmissive liquid crystal display (LCD) modules using either segment, passive or active matrix and achromatic or colour type LCDs (see Clause 3, chromaticity and pixel definitions) that are equipped with their own integrated source of illumination or without their own source of illumination.

For both rear projection-display systems and front projection-display systems, optical performance on the screen is not only determined by the panel performance as described in this standard, but also by the lighting system, such as the projection lens, screen, light filter, etc. Therefore, this standard is not applicable to such projection-display systems. (Nevertheless, for the determination of "on the screen" optical performance of rear projection-display systems, this standard may be used as a guideline).

In order to achieve a useful and uniform description of the performance of the display devices covered in this standard, specifications for commonly accepted relevant parameters are provided and fall into the following categories:

- a) general type (e.g. pixel resolution, diagonal, pixel layout);
- b) optical (e.g. contrast ratio, response time, viewing direction, cross-talk, etc.);
- c) electrical (e.g. power consumption, EMC);
- d) mechanical (e.g. module geometry, weight);
- e) passed environmental endurance test;
- f) reliability and hazard/safety.

In most categories, the specification is self-explanatory. For some, however, notably in the area of optical and electrical performance, the specified value may depend on the measuring method.

The object of this standard is to indicate and list the procedure-dependent parameters and to prescribe the specific methods and conditions that are to be used for their uniform numerical determination.

It is assumed that all measurements are performed by personnel skilled in the general art of radiometric and electrical measurements as the purpose of this standard is not to give a detailed account of good practice in electrical and optical experimental physics. Furthermore, all equipment needs to be suitably calibrated by competent personnel, and records of the calibration data and traceability need to be kept.

2 Normative references

The following referenced documents are indispensable for the application 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.

ISO 13406-1:1999, *Ergonomic requirements for work with visual displays based on flat panels – Part 1: Introduction*

ISO 13406-2:2001, *Ergonomic requirements for work with visual displays based on flat panels – Part 2: Ergonomic requirements for flat panel displays*

3 Chromaticity and pixel definitions

Several points of view with respect to the preferred terminology concerning "monochrome", "achromatic", "chromatic", "colour", "full-colour", etc. can be encountered in the field amongst spectroscopists, physicists, colour-perception scientists, physical engineers and electrical engineers. In general, all LCDs demonstrate some sort of chromaticity (e.g. as a function of viewing angle, ambient temperature or externally addressable means). Pending detailed official description of the subject, the pre-fix pertaining to the chromaticity of the display will be used to describe the colour capability of the display that is externally (and electrically) addressable by the user. This leads us to the following definitions (see also ISO 13406-1, Chapter 3: Terminology):

- a) a monochrome display has no user-addressable chromaticity ("colours"). It may or may not be "black and white" or a-chromatic;
- b) a colour display has at least two user-addressable chromaticities ("colours"). A 64-colour display has 64 addressable colours (often made using 2 bits per primary), etc. A full-colour display has at least 6 bits per primary ($\geq 260\,000$ colours).

Within this document, the official definition of pixel is employed, which may or may not include a multitude of constituent dots.

4 Standard measuring conditions

4.1 Standard measurement equipment and setup

4.1.1 High resolution matrix displays ($\geq 320 \times 240$ pixels)

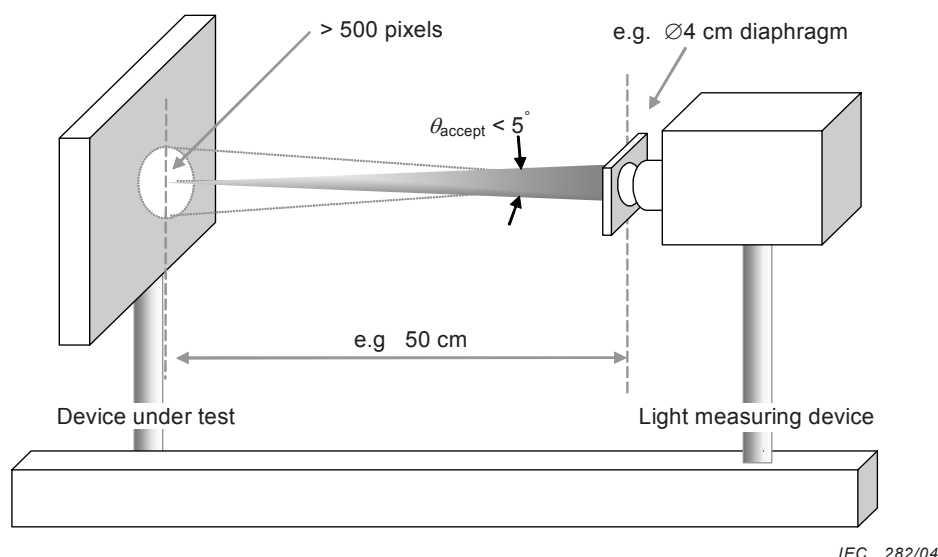
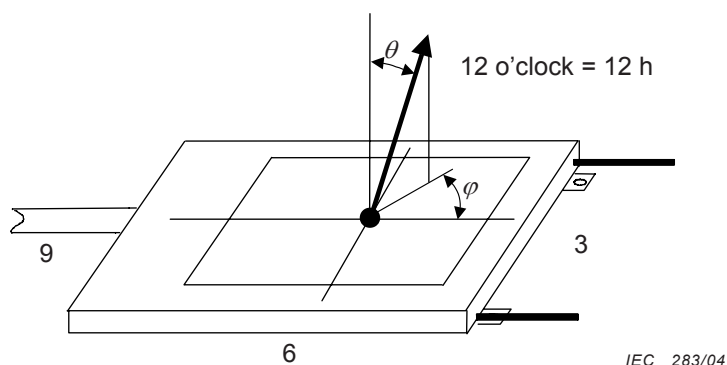


Figure 1 – Measuring system and its configuration

Three different instruments may be applied to the measurements of the light transmitted and/or reflected by the device under test (DUT); a luminance meter, tristimulus photometer or a spectro-radiometer. The optical system is schematically shown in Figure 1 and shall allow for measurement of well-defined spot sizes (field of view) on the DUT. When measuring matrix displays, these meters should be set to a circular or rectangular field of view that includes more than 500 pixels on the display under normal observation (the standard measurement direction). The total acceptance angle of detection by these meters, θ_{accept} , shall be less than 5° (see Figure 1). This can be obtained, for example, by use of a measuring distance between the meters and display area centre of 50 cm (recommended) and a diameter of the detector pupil of 4 cm; see Figure 1. If measuring segment displays, the field of view should be set to a single segment, and not include any of its surroundings.

Viewing direction and angle range are given by polar coordinates θ and φ as defined in Figure 2. $\theta_\varphi = 0$ is referred to as the 3 o'clock direction (the "right"), $\theta_\varphi = 90$ as the 12 o'clock direction ("upward"), $\theta_\varphi = 180$ as the 9 o'clock direction ("left") and $\theta_\varphi = 270$ as the 6 o'clock direction ("bottom"). In the standard measurement direction, the photometer observes the DUT under vertical viewing angle ($\theta = 0^\circ$). While scanning θ and/or φ , the centre of the measuring spot on the DUT shall stay fixed.



12 o'clock pertains to "top" of the display area, 3 o'clock to "right" of the display area (as viewed under "normal" operating viewing conditions)

Figure 2 – Definition of polar coordinates θ , φ

Any condition (either measuring spot on the DUT, meter aperture angle, viewing angle, meter spectral sensitivity, resolution etc.) that is not compliant to the required condition described in this shall be recorded in the detail specifications.

If the DUT is not equipped with its own source of illumination, external illumination shall be done in either of two ways:

- by means of an externally applied diffuse light source with specified (spatial and angular distribution of) luminance and spectrum (this is, for example, used for measurements on direct view displays);
- by means of an externally applied directional light source with calibrated spatial uniformity of illumination at the plane of the DUT, full opening angle of illumination at the location of the measuring spot in the plane of the DUT of less than 30° , and (if needed) (calibrated) distribution of spectral irradiation in the visible region of radiation (mostly used for measurements on projection-display modules).

In both cases, records of the light source (intensity distribution, temporal stability, opening angle, etc.) and its distance to the device under test shall be added to the detail specification.

The temporal drift in luminance shall be less than 1 % of the stabilized value per minute. Care shall be taken that the temperature of the DUT has stabilized and is not affected by the illumination system. The temperature of the DUT shall be measured and specified.

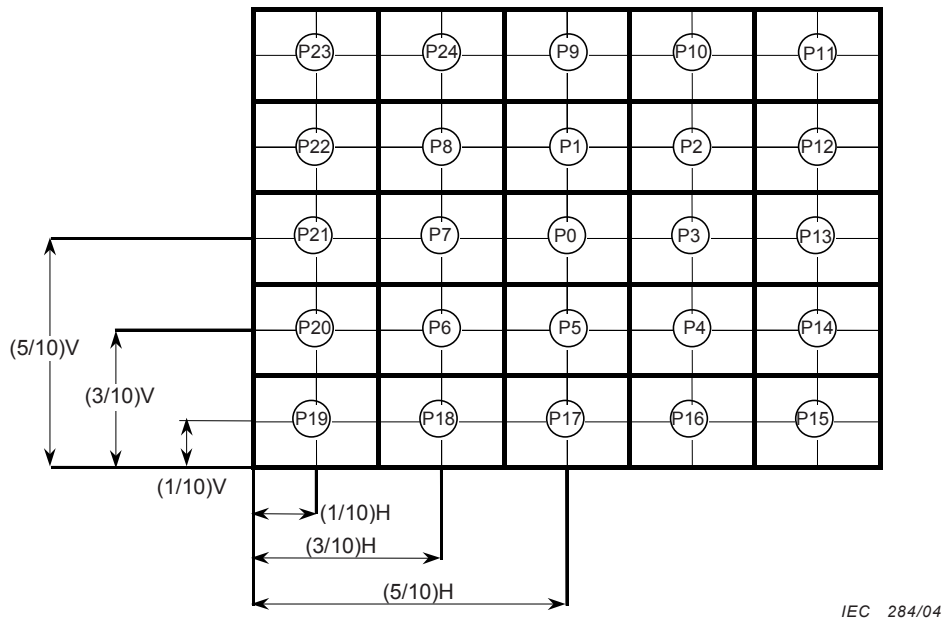
Any deviation from the above described standard measurement equipment or setup shall be added to the detail specification.

4.1.2 Low resolution (< 320 × 240 pixels) and segment display specific remarks

Default measurement conditions are the same as those prescribed for high-resolution matrix displays. However, for low resolution and segment displays the measurement field may contain fewer than 500 pixels. For matrix displays, a minimum of 9 is recommended. For measuring segment displays, the field of view should be set to a single segment, and not include any of its surroundings under any measurement angle.

4.2 Standard measurement positions

4.2.1 Matrix displays



NOTE Height and width of each rectangle is 20 % of display height and width respectively.

Figure 3 – Standard measurement positions at the centres of all rectangles p0-p24

Luminance, radiance distribution and/or tristimulus values may be measured at several specified positions on the DUT surface. To this end, the front view of the display is divided into 25 identical imaginary rectangles, according to Figure 3. Unless otherwise specified, measurements are carried out in the centre of each rectangle. Care shall be taken that the measuring spots on the display do not overlap. Positioning of the measuring spot on the thus prescribed positions in the *x* and *y* direction shall be to within 7 % of *X* and *Y* respectively (where *X* and *Y* denote the length of the active display area in the *x* and *y* direction, respectively).

While scanning the position of the measuring spot over the surface of the DUT, the polar angles shall stay fixed.

Any deviation from the above-described standard positions shall be added to the detail specification.

4.2.2 Segment displays

Standard measurement positions are the same as those prescribed for matrix displays in 4.2.1. However, for segment displays, all measurements shall be performed at the centre of a segment and the chosen segment should be as close as possible to the centre of the designated rectangle. Thus, when measurements on position *p_i* (*i* = 0 to 24) are requested, the geometrical centre of the segment closest to the centre of box *p_i* should be used for positioning of the detector.

Any deviation from the above described standard positions shall be added to the detail specification.

4.3 Standard device operation conditions

The module being tested shall be physically prepared for testing. It shall be warmed up for the stable operation of liquid crystal display devices at a specified period of less than 1 h. Testing shall be conducted under nominal conditions of input voltage, current, etc. The bias setting (if any) of the module shall be specified and set to those expected under typical use.

Any deviation from the standard device operation conditions shall be added to the detail specification.

4.4 Standard ambient conditions

4.4.1 Temperature, humidity and pressure conditions

The standard measuring ambient for the liquid crystal display devices is (25 ± 2) °C for temperature, (25 to 85) % for relative humidity and (86 to 106) kPa for pressure.

4.4.2 Illumination conditions

Three possible ambient illumination variants are defined as follows:

- darkroom condition: illuminance of the measuring spot on the DUT below 1 lx; directionality unspecified;
- hemispherical diffused light condition: state of illumination of the measuring spot on the DUT where the illuminance is not quantified but Lambertian;
- room illumination condition: illuminance of the measuring spot on the DUT with an intensity between 300 lx and 1000 lx. The intensity of the incident light is equal in all directions (Lambertian illumination).

Records of the measured ambient illumination should be kept on the measuring data sheet. Any deviation from the standard ambient conditions shall be added to the detail specification.

4.5 Standard measuring process

Due to the physics of LCDs almost all optical properties of these devices vary with the direction of observation (i.e. viewing direction). Therefore, it should be understood that for the determination of several of the parameters below, good (mechanical) control and specification of the viewing direction is necessary. Also, the distance between the light measuring device and the measuring spot on the DUT shall remain constant for all viewing directions.

All light sources used for illumination of the DUT during the measurement shall be constant in intensity and spectrum, at least over the time-period of measurements that are related to each other in the evaluation (e.g. bright and dark state of a display for contrast evaluation). The luminance or illuminance of the arrangement used for illumination of the DUT shall be constant to within ± 1 % over a time period of minimum 15 min and shall not exhibit short-term fluctuations (e.g. ripple, PWM modulations, etc.).

The standard measuring process consists of the following steps:

- a) prepare the measurement equipment and set-up, device-under-test and ambient conditions to the specified (standard) values;
- b) make records of standard condition choices and of deviations from standard conditions;

- c) measure the necessary parameters in a darkroom;
- d) if an external light source is used, measure the following parameters of the light source in the plane of the DUT. At p0 (Figure 3), measure and specify
 - 1) spectrum of emission,
 - 2) luminance L ,
 - 3) temporal stability of the luminance $L(t)$,
 - 4) luminance distribution with viewing angle $L(\theta, \varphi)$.

When measuring window contrast ratio (5.5.3.2), chromaticity uniformity (5.9), display uniformity (5.1) or cross-talk (5.12), measure the spectrum of emission, luminance and luminance distribution with viewing angle also at the other relevant positions p1-p24 (Figure 3).

- e) add a drawing or photo of the exact geometry of arrangement between light source, DUT and light measuring device to the specification.

The illumination apparatus shall be specified in detail since corrections to the standard conditions are not possible.

5 Measuring methods

5.1 Luminance and luminance uniformity

5.1.1 Purpose

This method is applied to the measurements of luminance and its lateral uniformity (i.e. in the active area) of the liquid crystal display devices with a built-in backlight system.

5.1.2 Measuring equipment

The measuring instruments shall consist of a luminance meter, a driving power supply and a driving signal generator for liquid crystal display devices.

5.1.3 Measuring method

5.1.3.1 Maximum luminance

Measurements are performed in a darkroom under standard measuring conditions and design viewing direction.

Supply the signals to the device as it would be used under normal operating conditions, e.g. maximum contrast ratio, and specify these signals, then apply the data-input signal for maximum luminance.

5.1.3.1.1 Matrix displays

Measure the luminance L_0 at position p0 (the centre of the active area of the display).

5.1.3.1.2 Segment displays

Measurement shall be carried out at the centre of a segment, where the measurement spot is smaller than the segment.

5.1.3.2 Luminance non uniformity

Measurements are performed in a darkroom under standard measuring conditions. All 25 rectangles are addressed with 100 % data-input signal-level (WHITE). Measure the luminance L_i at the rectangles $i = 11, 15, 19, 23$ or $i = 9, 11, 13, 15, 17, 19, 21, 23$ and the centre position ($i = 0$). The luminance non uniformity (LNU) is calculated from the individual luminances L_i and the average luminance L_{av} according to

$$LNU = \left[\max \left(\left| \frac{L_{av} - L_i}{L_{av}} \right| \right) \right] \times 100\% \quad (1)$$

where $LNU = 0$ % indicates a perfectly uniform display.

5.1.4 Specified conditions

Records of the measurement shall be made in order to describe deviations from the standard measurement conditions and shall include the following information:

- driving signals (waveforms, voltage and frequency);
- measuring points.

5.2 Warm-up characteristics

5.2.1 Purpose

This method is applied to the measurements of turn-on luminance transient characteristics for the transmissive type liquid crystal display devices with built-in backlight system (these effects are mostly due to warm-up).

5.2.2 Measuring equipment

The measuring instruments shall consist of a luminance meter, a driving power supply and a driving signal generator for liquid crystal display devices.

5.2.3 Measuring method

5.2.3.1 Matrix displays

The measurement shall be performed under dark-room and standard measurement conditions, unless otherwise specified.

The device under test (DUT) shall be supplied with all voltages and input data required to obtain the maximum transmittance of the LCD. The measurement of the luminance as a function of time shall be carried out at position p0 and the luminance is recorded versus time until the observed fluctuations of luminance become less than 1 % of the mean value. This mean value shall be obtained by taking at least 10 measurements over a period of typically 15 min. The mean luminance level after having settled to the stable state is called the "luminance value after stabilization, L_{stab} ". All measuring conditions shall be kept stable over the time period of recording the luminance.

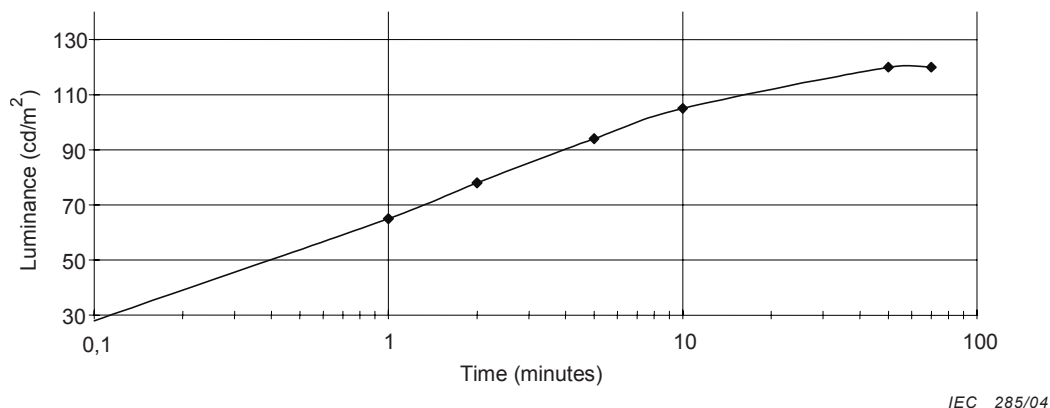


Figure 4 – Example of warm-up characteristic

Values of characteristics can be derived from the recorded luminance versus time values by computation of, say, t_{90} (time period required for the luminance to reach 90 % of L_{stab}).

When the time dependent luminance data are required for other positions, measure the luminance at these positions.

5.2.3.2 Segment displays

The same requirements as for matrix displays are applicable.

5.2.4 Specified conditions

Records of the measurement shall be made in order to describe deviations from the standard measurement conditions and shall include the following information:

- driving signals (waveforms, voltage and frequency);
- timing of data acquisition (sampling frequency and integration period).

5.3 Response times (turn-on time, turn-off time, rise time and fall time)

5.3.1 Purpose

The purpose of this test is to determine the time needed to change from light to dark (dark to light) by application of the driving voltage.

By convention, the response of LCDs to an increase in driving voltage is called "turn-on" whereas the relaxation following a decrease of the driving voltage is called "turn-off". While this definition is straightforward in the case of segment and low resolution LCDs, it is significantly more complicated in the case of high resolution matrix LCD screens, due to the complex data-processing included in such a display.¹

¹ As a consequence, ISO 13406-2 uses the term "image formation time" (sum of turn-on and turn-off) with the distinction of positive and negative contrast polarity (the turn-on process in the case of positive contrast polarity is then the switching from "bright" to "dark" as required to generate an image on the bright background).