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INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

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

Dispositifs d'affichage à cristaux liquides – Partie 30-1: Méthodes de mesure pour les modules d'affichage à cristaux liquides – Type transmissif

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LIQUID CRYSTAL DISPLAY DEVICES –

Part 30-1: Measuring methods for liquid crystal display modules – Transmissive type

FOREWORD

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International Standard IEC 61747-30-1 has been prepared by IEC technical committee 110: Electronic display devices.

This first edition cancels and replaces IEC 61747-6 published in 2004. This edition constitutes a technical revision.

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

a) the document structure was brought in line with 61747-6-2; and
b) various technical and editorial changes were made.

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

FDIS	Rapport de vote
110/364/FDIS	110/380/RVD

Full information on the voting for the approval on 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 the parts in the IEC 61747 series, under the general title *Liquid crystal display devices*, can be found on the IEC website.

Future standards in this series will carry the new general title as cited above. Titles of existing standards in this series will be updated at the time of the next edition.

This standard is to be read in conjunction with IEC 61747-1 (1998), to which it refers, which gives details of the quality assessment procedures, the inspection requirements, screening sequences, sampling requirements, and the test and measurement procedures required for the assessment of liquid crystal display modules.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC web site 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- withdrawn,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.

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.

INTRODUCTION

In order to achieve a useful and uniform description of the performance of liquid crystal display (LCD) devices, specifications for commonly accepted relevant parameters are put forward. These fall into the following categories:

a) general type specification (e.g. pixel resolution, diagonal, pixel layout);

b) optical specification (e.g. contrast ratio, response time, viewing-direction, crosstalk, etc.);

c) electrical specification (e.g. power consumption, electromagnetic compatibility);

d) mechanical specification (e.g. module geometry, weight);

e) specification of passed environmental endurance test;

f) specification of reliability and hazard / safety.

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

The purpose 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, it shall be assured that all equipment is suitably calibrated as is known to people skilled in the art and records of the calibration data and traceability are kept.

LIQUID CRYSTAL DISPLAY DEVICES –

Part 30-1: Measuring methods for liquid crystal display modules – Transmissive type

1 Scope

This part of IEC 61747 is restricted to transmissive liquid crystal display-modules using either segment, passive or active matrix and achromatic or colour type LCDs. Furthermore, the transmissive modes of transflective LCD modules with backlights ON are comprised in this document. An LCD module in combination with a touch-panel or a front-light-unit is excluded from the scope because measurements are frequently inaccurate. Touch-panels or front-light-units are removed before measurement. Throughout the main body of this standard, an integrated backlight is assumed to provide the illumination for the measurements. Deviations from this (e.g. segmented displays without integrated backlights) may usually be handled in the same way as display modules with integrated backlight, if an external backlight is provided. However, in the case where one of the two situations should be handled differently, this will be specifically stated.

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 60050 (all parts), *International Electrotechnical Vocabulary* (available at <http://www.electropedia.org>)

IEC 61747-1, *Liquid crystal and solid-state display devices – Part 1: Generic specification*

IEC 61747-6-2, *Liquid crystal display devices – Part 6-2: Measuring methods for liquid crystal display modules – Reflective type*

ISO 9241-307, *Ergonomics of human-system interaction – Part 307: Analysis and compliance test methods for electronic visual displays*

ISO 11664-2 (CIE S 014-2/E:2006), *Colorimetry – Part 2: CIE Standard illuminants*

CIE 15-2004, *Colorimetry*

3 Terms, definitions and abbreviations

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60050-845:1987 apply.

NOTE Several points of view with respect to the preferred terminology on "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 so

as 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 IEC 61747-6-2):

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 full-colour display has at least three user addressable primary colours with at least 6 bits per primary colour (≥ 260 000 colours).

3.2 Abbreviations

CFF critical flicker frequency

CR contrast ratio

CR_{PF} Plain Field Contrast Ratio

DUT device under test

FFT fast Fourier transform

GSI gray-scale inversion

HXT horizontal crosstalk

LCD liquid crystal display

LMD light measuring device

LNU long range non-uniformity

PWM pulse width modulation

UCS uniform colour space

VAR viewing angle range

VXT vertical crosstalk

XT crosstalk

4 Illumination and illumination geometry

4.1 General comments and remarks on the measurement of transmissive LCDs

Transmissive LCDs often make use of their own integrated source of backlight illumination to display visual information. It is difficult to achieve the required significance and reproducibility of the results of measurements because of the close coupling between the backlight illumination system, the LMD and DUT. In the cases where the backlight unit is not static, care shall be taken that the behaviour of the backlight is known, and measurements are taken making sure there is no interference between backlight temporal variations (e.g. by PWM signal or dynamic backlight), DUT addressing frequency and LMD sampling frequency. The luminance and colour of the backlight at the moment of measurement shall be specified and backlight operation shall be static and stable during the period of measurement.

The temporal drift in backlight luminance shall be less than 5 % of the stabilized value per hour and 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 backlight illumination system. Constant and correct temperature of the DUT should be verified.

If no built-in lightsource is used, the backlight luminance or backlight illuminance of the arrangement used for illumination of the DUT shall be constant within ± 1 %, and shall not exhibit short-term fluctuations (e.g. ripple, PWM, etc.).This should be realized by an equilibration period of 5 min to 10 min. Constant and correct temperature of the DUT should be verified.

4.2 Viewing-direction coordinate system

The viewing-direction is the direction under which the observer looks at the spot of interest on the DUT. During the measurement the light-measuring device is replacing the observer, looking from the same direction at a specified spot (i.e. measuring spot, measurement field)

on the DUT. The viewing-direction is conveniently defined by two angles: the angle of inclination θ (related to the surface normal of the DUT) and the angle of rotation ϕ (also called azimuth angle) as illustrated in Figure 1. The azimuth angle is related with the directions on a watch-dial as follows: ϕ = 0° is referred to as the 3 o'clock direction ("right"), ϕ = 90° as the 12 o'clock direction ("top"), ϕ = 180° as the 9 o'clock direction ("left") and ϕ = 270° as the 6 o'clock direction ("bottom").

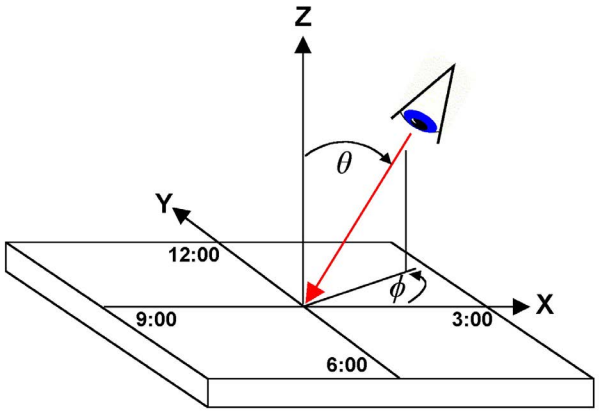

Figure 1 – Representation of the viewing-direction (equivalent to the direction of measurement) by the angle of inclination, θ and the angle of rotation (azimuth angle), ϕ in a polar coordinate system

4.3 Standard illumination geometries

Transmissive LCD modules often have built-in light sources. The built-in light source, the relative position between the built-in light source and the DUT, and the relative position between the DUT and the measurement equipment are restricted. Each system is positioned in a dark measuring room. The illuminance on the DUT not originating from the built-in light source shall be less than 1 lx and shall be less than the light level that significantly affects the measurement results.

Throughout this standard it is assumed the DUT is provided with its own, integrated backlight. However, if the DUT is not equipped with its own source of illumination (backlight), external illumination shall be provided in one of the following ways:

a) By means of an externally applied diffuse light source with specified (spatial and angular distribution of) luminance and spectrum, placed behind the DUT. This is used, for example, for measurements on direct view displays.

b) By means of a point lightsource (a geometrically small, homogeneous light source). lightsource, measurement spot and detector shall be aligned, and the focus of the detector shall be on the measurement spot on the DUT.

c) 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 spectral intensity distribution in the visible wavelength range. (This is mostly used for measurements on projection-display modules).

In all three cases, records of the lightsource (intensity distribution, temporal stability, opening angle, etc.) and its distance to the DUT shall be added to the detail specification. Use of light sources as close to illuminant D65 as possible is recommended

5 Standard measurement equipment and set-up

5.1 Light measuring devices (LMD)

The light measuring devices (LMDs) used for evaluation of the optical properties of transmissive LCDs shall be checked for the following criteria and specified accordingly:

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

5.2 Positioning and alignment

The LMD shall be positioned relative to the measurement field on the DUT in such a way as to be able to adjust the direction of measurement (viewing-direction) and to adjust the distance from the centre of the measuring spot to assure an angular aperture of smaller than 5°. Such adjustment can be realized with a mechanical system (often motorized) and alternatively with an appropriate optical system (conoscopic optics) as described in e.g. [2][1].

5.3 Standard measurement arrangements

5.3.1 LMD conditions

If the angular aperture of the LMD is not specified, it can be calculated using the distance of the LMD to the measurement field and the aperture of the LMD (acceptance area) (see Figure A.1).

When measuring matrix displays the LMD should be set to a circular or rectangular field of view that includes more than 500 pixels[2] on the display under normal observation (the standard measurement direction). The total angular aperture of detection by the LMD shall be less than 2°. This can be obtained by use of a measuring distance between the LMD and display area centre of 50 cm (recommended) and a diameter of the detector acceptance area of 4 cm. For low-resolution matrix displays, the number of pixels in the field of view may be lower than 500. Here, a minimum of 9 pixels is recommended. In case of measuring segment displays, the field of view should be set to a single segment, and not include any of its surroundings.

5.3.2 Effects of receiver inclination

When the measuring setup comprises an adjustable LMD for measurement and evaluation of variations with viewing-direction, it has to be taken into account that the LMD "sees" different parts of the DUT at different angles of inclination. An initially circular measuring spot (when the DUT is viewed or measured from normal, i.e., $\theta = 0°$) becomes elliptical when the LMD is inclined away from the normal direction ($\theta > 0°$), as shown in Figure 2. The short axis of the ellipse (here: vertical) remains constant with the plane of inclination being horizontal (e.g. $\phi = 0°$ or 180°).

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1 Numbers in brackets refer to the Bibliography.

2 The official definition of pixel is used which may or may not include a multitude of constituent subpixels / dots (see the future IEC 61747-1-2).

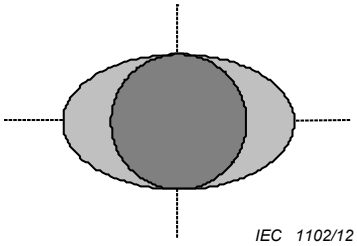


Figure 2 – Shape of measuring spot on DUT for two angles of LMD inclination

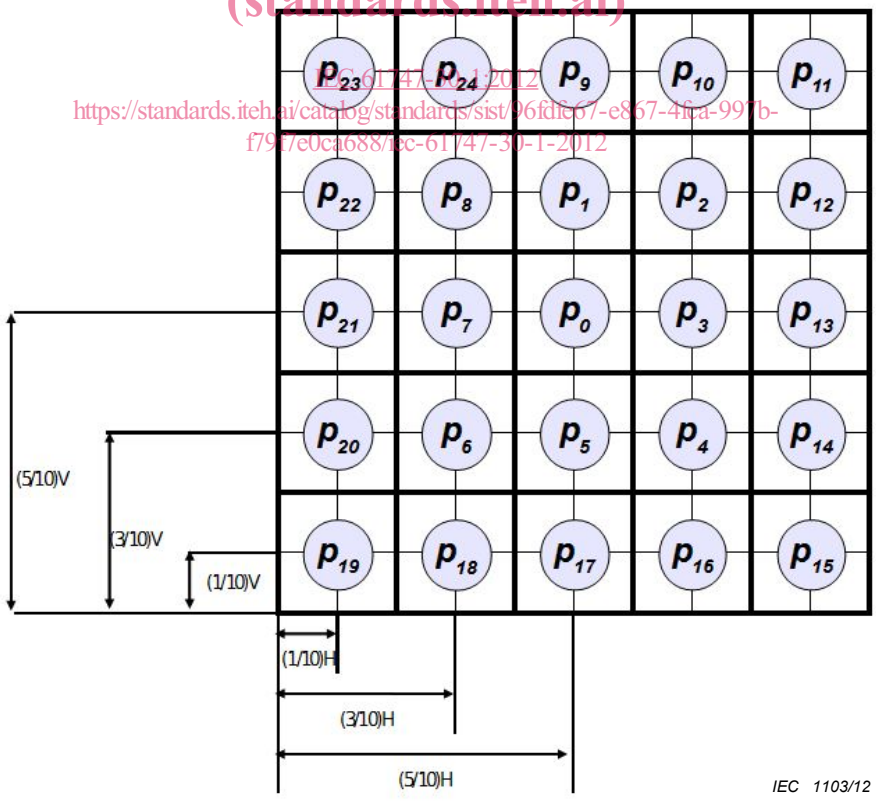
Two effects have to be considered when the LMD is adjustable. The increasing size of the measuring spot with angle of inclination shall not include:

- unwanted parts of the DUT (e.g. non-active parts of a display with segment-layout); or
- parts illuminated in a different way.

Both size and location of the measurement field have to be selected that these conditions are fulfilled and they have to be specified accordingly.

5.4 Standard locations of measurement field

5.4.1 Matrix displays



NOTE Height (V) and width (H) of each rectangle are 20 % of display height and width respectively.

Figure 3 – Standard measurement positions are at the centres of all rectangles p_0-p_{24}.

Luminance, spectral distribution and/or tristimulus measurements may be taken 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 H and V respectively (where H and V denote the dimensions 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 viewing direction (defined by angles θ and ϕ) shall not change.

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

5.4.2 Segment displays

Standard measurement positions are the same as those prescribed for matrix displays above. 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.

5.5 Standard DUT operating conditions

5.5.1 General

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 has to remain constant for all viewing-directions.

The module being tested shall be physically prepared for testing. It should be thermostatically controlled for stable operation of liquid crystal display devices during a specified period being less than one hour. If the control period is less than one hour, stable temperature shall be verified and reported for at least the centre of the DUT. Testing shall be conducted under nominal conditions of input voltage, current, etc. Any deviation from the standard device operation conditions shall be added to the detail specification.

5.5.2 Standard ambient conditions

5.5.2.1 Standard measuring environmental conditions

Measurements shall be carried out, after sufficient warm-up time for illumination sources and DUTs (see 6.12) under the standard environmental conditions, at a temperature of 25 °C ± 3 °C, at a relative humidity of 25 % to 85 %, and at an atmospheric pressure of 86 kPa to 106 kPa. When different environmental conditions are used, they shall be noted in the detail specification.

5.6 Standard measuring process

The standard measuring process comprises the following basic steps:

a) Preparation of the measurement equipment and set-up, of the DUT and of the ambient conditions to assure the specified standard values and stabilities. Whenever the actual conditions differ from the standard conditions, this shall be noted in the detail specification and the values actually used shall be specified in the detail specification.