IEC 61747-6-2

Edition 1.0 2011-06

INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

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

Dispositifs d'affichage à cristaux liquides –
Partie 6-2: Méthodes de mesure pour les modules d'affichage à cristaux liquides – Type réflexible

IEC 61747-6-2:2011

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INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

COMMISSION
ELECTROTECHNIQUE
INTERNATIONALE

PRICE CODE
CODE PRIX XA

ICS 31.120

ISBN 978-2-88912-507-4

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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LIQUID CRYSTAL DISPLAY DEVICES –

Part 6-2: Measuring methods for liquid crystal display modules – Reflective type

FOREWORD

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International Standard IEC 61747-6-2 has been prepared by IEC technical committee 110: Flat panel display devices.

This standard should be read together with the generic specification to which it refers.

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

FDIS	Report on voting
110/281/FDIS	110/299/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.

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- withdrawn,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.

The contents of the corrigendum of January 2012 have been included in this copy.

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INTRODUCTION

In order to achieve a useful and uniform description of the performance of these 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, EMC);
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 above cases, 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.

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 must 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 6-2: Measuring methods for liquid crystal display modules – Reflective type

1 Scope

This part of IEC 61747 gives details of the quality assessment procedures, the 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 reflective liquid crystal display-modules using either segment, passive or active matrix and a-chromatic or colour type LCDs (see Note). Furthermore, the reflective modes of transflective LCD modules with backlights OFF and reflective LCD modules of front light type without its front-light-unit, are comprised in this standard. A reflective LCD module with combination of a touch-key-panel or a front-light-unit is out of the scope of this standard, because its measurements are frequently inaccurate. Its touch-key-panel or front-light-unit should be removed before it can be included in this scope.

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, (general-) physicists, colour-perception scientists, physical engineers and electrical engineers. In general, all LCDs demonstrate some sort of chromaticity (e.g. as 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 [19])

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 for 3 primaries), etc. A full-colour display has at least 6 bits per primary (≥ 260 thousand colours).

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.

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 11664-2:2007, *Colorimetry – Part 2: CIE standard illuminants*

CIE 15.2, *CIE Recommendations on Colorimetry*

CIE 17.4, *International Lighting Vocabulary*

CIE 38, *Radiometric and photometric characteristics of materials and their measurement*

CIE 1931, *CIE XYZ colour space*

CIE 1976, *CIE LAB colour space*

3 Illumination and illumination geometry

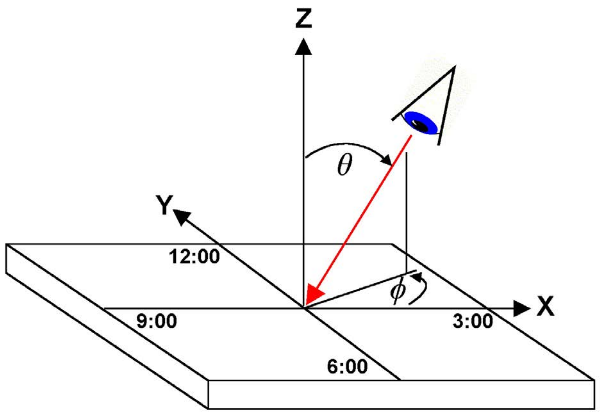
3.1 General comments and remarks on the measurement of reflective LCDs

Reflective LCDs make use of the ambient illumination to display visual information; often, they do not posses their own integrated source of illumination. It is difficult to achieve the required significance and reproducibility of the results of measurements because of the close coupling between the apparatus providing the illumination, the LMD (light measuring device) and the device under test (DUT). This dependence of results on the instrumentation implies that e.g. the contrast of reflective LCDs is not an intrinsic property of the device itself, but the contrast can only be evaluated under specific and well defined conditions for illumination and detection [3][1], [4], [5], [6], [7], [8] ..[.].

This part describes a selection of different geometries suitable for measuring and characterizing reflective LCDs as a function of the direction of observation (i.e. viewing-direction = direction of measurement), as examples. The range of geometries for illumination of the DUT and detection of the light reflected from the DUT shall not be limited to the examples presented here. A set of parameters provides detailed specification of the conditions that are used for measurement of the electro-optical characteristics as listed below.

3.2 Viewing-direction coordinate system

The viewing-direction is the direction under which the observer looks at the spot of interest on the display. During the measurement the light-measuring device replaces 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: refer to ϕ = 0 ° as the 3 o'clock direction ("right"), to ϕ = 90 ° as the 12 o'clock direction ("top"), ϕ = 180 ° as the 9 o'clock direction ("left") and to ϕ = 270 ° as the 6 o'clock direction ("bottom").



IEC 951/11

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

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1 Figures in square brackets refer to the bibliography.

3.3 Basic illumination geometries

Typical illumination geometries are (according to CIE 38):

- directional illumination

An illumination source where the incident rays are approximately parallel (max. deviation from optical axis < 5 °) is directed at the DUT, the direction of illumination is specified by θ and ϕ. The intensity across the cross-section of the beam shall be constant within 5 %. Any source of light sufficiently distant from the DUT provides a directional illumination (e.g. sun, moon). Figure 2 provides an example of directional illumination with a flat source disk (Lambertian emission) of radius r_s, distance to measuring spot d and measuring spot radius r_{ms}.

The maximum deviation from the optical axis is depending on the diameter of both source and measuring spot. The maximum angle of deviation from the optical axis is given by the following Equation (1)

$$\text{atan}\ ([r_{ms} + r_s] \,/\, |d|) < 5\ ° \qquad (1)$$

- conical illumination

Illumination is provided out of an extended solid angle Ω_{SC} with the apex of this solid angle fixed to the centre of the measuring spot on the DUT. The variation of illuminance with direction inside this solid angle shall be specified. The recommended method for measuring this variation is given in Annex A. The cone of illumination itself is specified by the direction of the axis of the cone and the maximum inclination with respect to the axis (i.e. cone-angle).

- hemispherical illumination

Illumination is provided out of a wide solid angle Ω_{SH} with the apex of this solid angle fixed to the centre of the measuring spot on the DUT. In the true hemispherical case the solid angle Ω_{SH} extends to an angle of inclination of 90 °. For the purpose of this standard, the term hemispherical illumination shall be applicable when illumination is provided such that the illuminance does not drop below 50 % of the maximum value at an angle of inclination of 60 °. The variation of luminous intensity with direction inside the solid angle Ω_{SH} shall be specified. The recommended method for measuring this variation is given in Annex A.

Mixtures and modifications of the three basic illumination geometries are possible as long as the conditions are sufficiently specified.

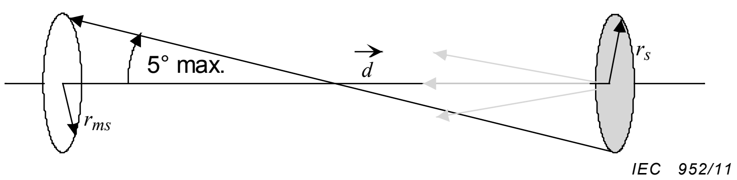

Figure 2 – Directional illumination with a flat source disk

3.4 Realization of illumination geometries

3.4.1 General

The three basic types of illumination can be realized in different ways as illustrated in this clause. Implementation results in the following four examples for geometries of illumination.

3.4.2 Directional illumination

Directional illumination can be realized with three different types of sources when the source dimensions are kept small enough compared to the distance between source and the measuring field on the sample. The following geometries are depicted in Figure 3:

- flat Lambertian source, e.g. the exit port of an integrating sphere (top),
- spherical isotropic source (e.g. incandescent bulb inside a diffusing glass-sphere) (middle),
- projection system with lenses or mirrors (bottom).

Condition: $\text{atan}\,([r_{ms} + r_s] / |d|) < 5\,°$ (2)

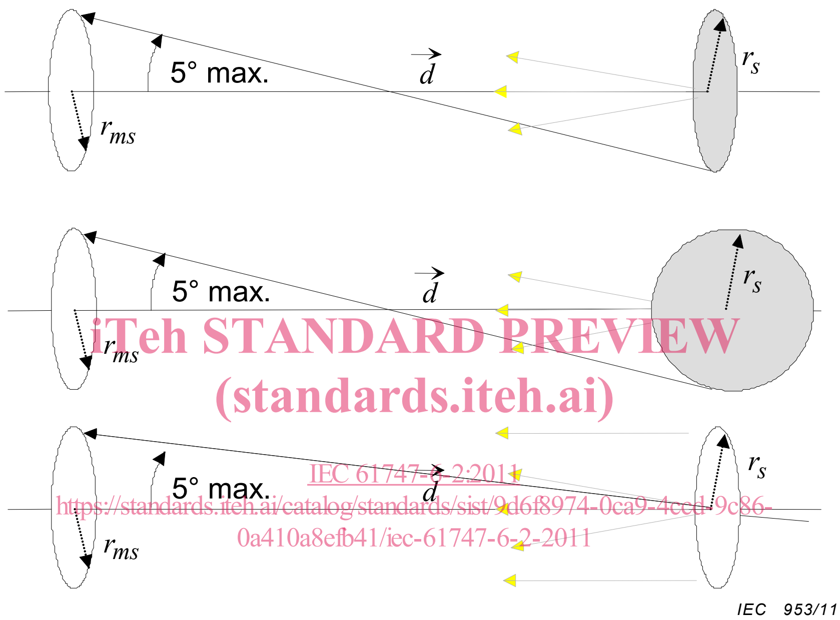

Figure 3 – Realization alternatives for directional illumination

3.4.3 Ring-light illumination

A ring-light illumination can be realized by application of :

- a ring-shaped fluorescent lamp (Figure 4a),
- fiber-optical ring-light,
- integrating sphere with a ring-shaped aperture (annulus) (Figure 4b),
- others.

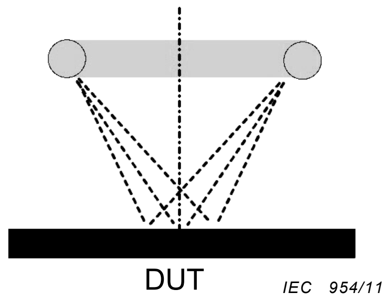

Figure 4a – Ring-shaped fluorescent lamp

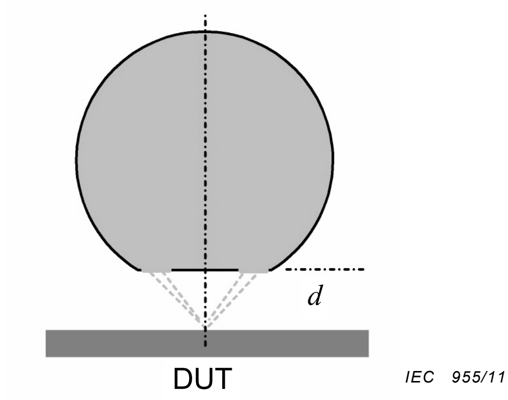

Figure 4b – Integrating sphere with annulus

NOTE Ring-light illumination is not intended to provide a diffuse illumination. It provides a directed illumination with rotatory symmetry around the normal of the display in the measurement spot.

Figure 4 – Examples of ring-light illumination

3.4.4 Conical illumination

Conical illumination can be realized with three different geometries:

- The exit port of an integrating sphere at some distance to the measuring spot produces a conical illumination with constant intensity from all directions of light incidence (Figure 5b).
- A hemispherical dome (reflective or transmissive section of a sphere) produces conical illumination (up to angles of inclination of e.g. 80 °) usually with variations of the illuminance versus direction of light incidence (Figure 5a).
- A flat Lambertian luminance source parallel to the DUT-surface produces an illumination of the measuring spot that drops with $\cos^4\theta$ (θ is the angle of inclination of the direction of light incidence).

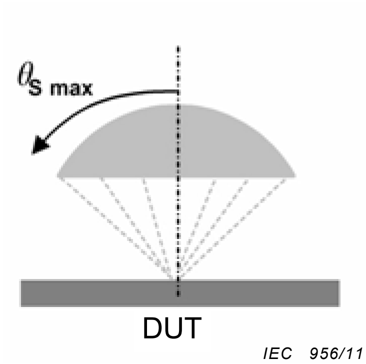

Figure 5a – Spherical dome

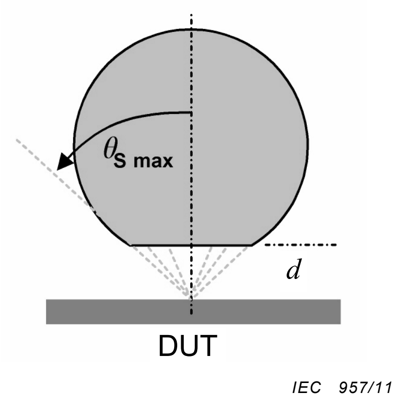

Figure 5b – Integrating sphere with large aperture

Figure 5 – Examples of conical illumination with a spherical dome (Figure 5a) and an integrating sphere with large aperture (Figure 5b)

3.4.5 Hemispherical illumination

Good approximation of ideal hemispherical illumination (i.e. constant illuminance from all directions up to 90 °) can only be provided by integrating spheres with a small exit port diameter compared to the diameter of the sphere. The exit port must be directly adjacent to the surface of the DUT in order to assure good hemispherical illumination (up to inclination angles of 90 °) (Figure 6a).

Other approximations of hemispherical illumination may be realized by:

- diffusing hemispheres with diffuse reflective coatings (Figure 6b),
- transmissive diffusing spheres and domes.

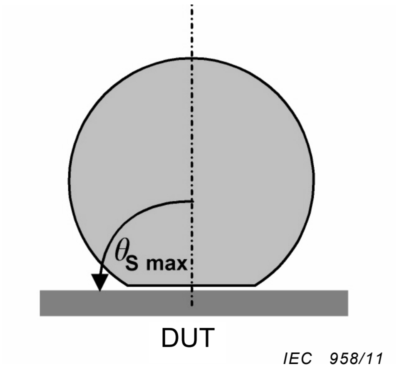

Figure 6a – Integrating sphere

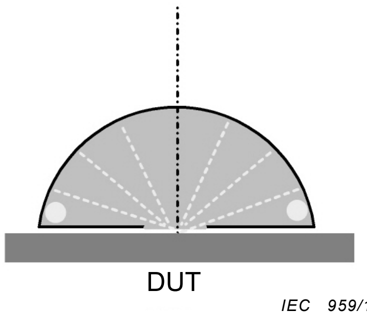

Figure 6b – Diffuse hemisphere

Figure 6 – Examples of hemispherical illumination

4 Standard measurement equipment and set-up

4.1 Light measuring devices (LMD)

The light measuring devices used for evaluation of the reflectance of reflective 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.

4.2 Positioning and alignment

The LMD has to be positioned with respect to the measurement field on the DUT in order 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. [9].

4.3 Standard measurement arrangements

4.3.1 General

The following standard measuring geometries are introduced:

a) directional illumination,
b) ring-light illumination,
c) conical illumination,
d) hemispherical illumination.