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TECHNICAL REPORT

colour inside

Electronic displays –
Part 1-31: Generic – Practical information on the use of light measuring devices

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FOREWORD

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The text of this Technical Report is based on the following documents:

DTR	Report on voting
110/1258/DTR	110/1281A/RVDTR

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this Technical Report is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/standardsdev/publications.

A list of all parts in the IEC 62977 series, published under the general title *Electronic displays*, can be found on the IEC website.

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- withdrawn,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

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INTRODUCTION

Measurements of the optical characteristics of electronic displays are primarily affected by three factors: measuring procedures, displays (devices under test: DUTs), and light measuring devices (LMDs), for which there are many international standards supporting consistent and comparable measurements. Most of them, however, provide only limited information on LMDs, making it difficult to appropriately select and use the LMD for the measurement objective. The purpose of this document is to provide best practices and suggestions which are missing in the standards.

This document addresses how the major properties of a typical LMD affect the measurement results. It is often impractical and unnecessary to consider the influences of all properties of LMDs and all characteristics of DUTs as well as their interactions and influences on the measurement results. Therefore, the multiple interaction effects that exist are beyond the scope of this document. Due to the rapid innovation and abundance of LMDs, covering all types of LMDs is also outside the objectives of this document.

ELECTRONIC DISPLAYS –

Part 1-31: Generic – Practical information on the use of light measuring devices

1 Scope

This part of IEC 62977 provides practical information on light measuring devices (luminance meters, colorimeters, and spectroradiometers) with luminance measuring optics for the characterization of electronic displays.

2 Normative references

There are no normative references in this document.

3 Terms, definitions, and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at http://www.iso.org/obp
- IEC Electropedia: available at http://www.electropedia.org/

NOTE CIE Electronic international lighting vocabulary (e-ILV) is also available at http://cie.co.at/e-ilv.

3.1.1
repeatability
<of an LMD> closeness of agreement between indications or measured quantity values obtained by replicated measurements over a short period of time using a specific LMD under conditions specified by the LMD manufacturer

Note 1 to entry: Repeatability of an LMD is usually expressed numerically by statistical quantities, such as standard deviation, variance, or coefficient of variation (relative standard deviation) under the specified conditions of measurement.

Note 2 to entry: The influence on measurement repeatability caused by fluctuations of the measured light source and by the measurement procedure is assumed to be negligible when the manufacturer specifies the repeatability of an LMD. Manufacturers often specify the type of light source and measurement conditions used for determining the repeatability of an LMD.

Note 3 to entry: Measurement precision is the closeness of agreement between indications or measured quantity values obtained by replicate measurements on the same or similar objects under specified conditions. Measurement repeatability is measurement precision under a set of repeatability conditions of measurement that includes the same measurement procedures, same operators, same measuring system, same operating conditions, same location, and replicate measurements on the same or similar objects over a short period of time. Measurement reproducibility is measurement precision under a set of reproducibility conditions of measurement that includes different locations, operators, measuring systems, and replicate measurements on the same or similar objects [1], [2][1].

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1 Numbers in square brackets refer to the Bibliography.

3.1.2
accuracy
<of an LMD> difference between a measured quantity value and an accepted reference value when using a specific LMD under conditions specified by the LMD manufacturer

Note 1 to entry: This term is a quantity with a numerical value and is usually expressed as a range specification.

Note 2 to entry: The accepted reference value is a value that serves as an agreed-upon reference for comparison, and which is derived as:

a) a theoretical or established value, based on scientific principles;

b) an assigned or certified value, based on experimental work of some national or international organization;

c) a consensus or certified value, based on collaborative experimental work under the auspices of a scientific or engineering group;

d) (when a), b) and c) are not available) the expectation of the (measurable) quantity, i.e. the mean of a specified population of measurements [3].

Note 3 to entry: The influence on measurement accuracy caused by fluctuations of the measured light source and by the measurement procedure is assumed to be negligible when the manufacturer specifies the accuracy of an LMD. Manufacturers often specify the type of light source and other measurement conditions used for determining the accuracy of an LMD.

Note 4 to entry: Measurement accuracy is the closeness of agreement between a measured quantity value and the true quantity value of a measurand [1], [2]. The accuracy of measurement is not a quantity value while the accuracy of an LMD is a quantity value; thus, the term "accuracy" conventionally used for the specification of LMDs means something different than that used for measurement.

3.2 Abbreviated terms

CIE Commission Internationale de l'Éclairage (International Commission on Illumination)
CMF colour-matching function
DUT device under test
EOTF electro-optical transfer function
LCD liquid crystal display
LED light emitting diode
LMD light measuring device
ND neutral density
OLED organic light emitting diode
PWM pulse width modulation
RGB red, green, and blue
RGBW red, green, blue, and white
Vsync vertical synchronizing signal

4 General information on LMDs for photometry and colorimetry

4.1 General

Clause 4 describes the principles of photometry and colorimetry, configuration, calibration, and maintenance of LMDs, as well as setup conditions for measurement.

4.2 Photometry and colorimetry for electronic displays

Photometry is the measurement of quantities referring to radiation as evaluated according to a given spectral luminous efficiency (see IEV 845-25-013). Colorimetry is the measurement of colour stimuli based on a set of conventions (see IEV 845-25-014). Details on the calculation formulae and specific conditions applied to electronic display measurement are shown in Annex A.

4.3 LMDs for luminance and chromaticity measurements

4.3.1 Configuration of LMDs

The configurations of three types of LMDs are described as follows:

1) Luminance meter

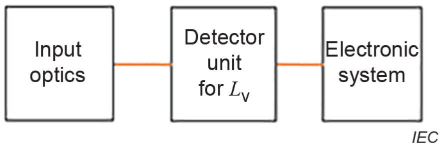
   A luminance meter is an instrument for measuring luminance (see IEV 845-25-021). A block diagram of the setup of a typical luminance meter is shown in Figure 1a): it consists of input optics, a detector unit for measuring the luminance, L_v, and an electronic system. An example of the configuration of the input optics and the detector unit is shown in Figure 2a), where a lens is used for the input optics. The input optics collects the light emitted from the DUT and converges it onto the detector. An optical compensation filter is arranged in front of the detector. The combination of the spectral characteristics of the filter, input optics, and detector approximates the spectral luminous efficiency function, $V(\lambda)$. A neutral density (ND) filter can be inserted into the optical path, for example when the LMD's dynamic range is insufficient and results in detector saturation. The detector receives the light and converts the optical signal to an electronic one, from which the electronic system calculates the luminance, L_v, as in [4], indicates it on an instrument display, and/or sends the result to an external system.

2) Colorimeter

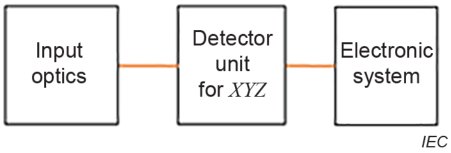
   A colorimeter is an instrument for measuring colorimetric quantities, such as the tristimulus values of a colour stimulus (see IEV 845-25-022). A block diagram of the most common setup for a colorimeter is shown in Figure 1b): it is conceptually similar to a luminance meter. A colorimeter has a detector unit for measuring the tristimulus values instead of one for the luminance. A colorimeter for both luminance and chromaticity measurements employs the same type of input optics as the luminance meter, as described in 4.3.1 1). An example of the configuration of the input optics and the detector unit is shown in Figure 2b), where the detector unit has three pairs of optical compensation filters and detectors. The input optics is connected to the detector unit by a three-branch optical fibre. The combined spectral characteristics of those components approximates the CIE colour-matching functions (CMFs). The electronic system calculates the tristimulus values, X, Y, and Z, where Y is practically identical to L_v (see Annex A).

3) Spectroradiometer

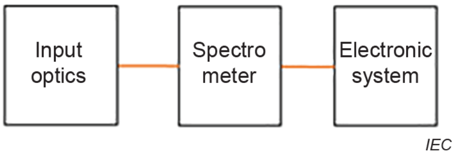
   A spectroradiometer is an instrument for measuring radiometric quantities in narrow wavelength intervals over a given spectral region (see IEV 845-25-007). A block diagram of the general setup of a spectroradiometer is shown in Figure 1c). A spectroradiometer for spectral radiance measurements, and luminance and chromaticity calculations therefrom, employs the same type of input optics as the luminance meter, as described in 4.3.1 1). An example of the configuration of the input optics and the spectrometer is shown in Figure 2c), where the input optics is connected to the spectrometer by an optical fibre. The example spectrometer consists of an input slit, a grating, for example a concave grating [5], and an array detector, where the output of the detector is related to the spectral radiance of the DUT. The obtained spectral radiance, $L_e(\lambda)$, is converted to the luminance, L_v, or tristimulus, values, X, Y, and Z, using $V(\lambda)$ or CMFs data, which are often stored in look-up tables [6], [7].



a) **Luminance meter**

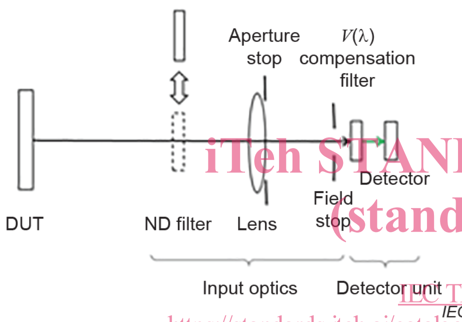


b) **Colorimeter**

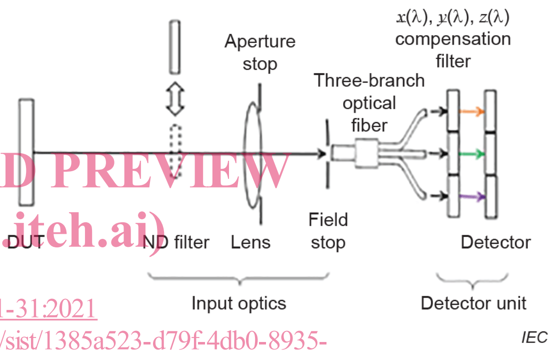


c) **Spectroradiometer**

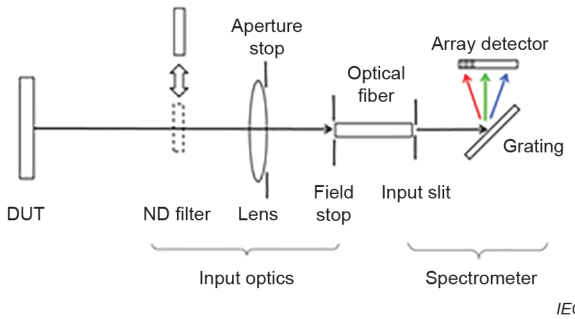
Figure 1 – Block diagrams of three types of LMDs



a) **Luminance meter**



b) **Colorimeter**



c) **Spectroradiometer with spectrometer using grating and array detector**

Figure 2 – Example of configurations for the input optics and detector

4.3.2 Input optics of LMDs

An LMD has an input optics system which collects the light emitted or reflected from a DUT. There are various types of imaging as well as non-imaging input optics, for example fixed-focus lens, variable-focus lens, and optical fibre. For luminance measurements, imaging optics is often used. Figure 3 shows an example of the input optics with an imaging lens, an aperture stop (aperture), a field stop, and a detector behind the field stop, together with the DUT and detector. Related optical properties are described in the following sentences. The aperture stop is an opening that defines the area over which the average optical emission is measured (see IEV 845-25-086). The entrance pupil is a virtual image of the aperture stop as viewed from the object space, and its position and size depend on the measurement distance. The angular aperture is the angle subtended by the entrance pupil. The field stop which is positioned on the image plane limits the measurement field of the DUT. The measurement field angle is the angle subtended by the measurement field at the entrance pupil.

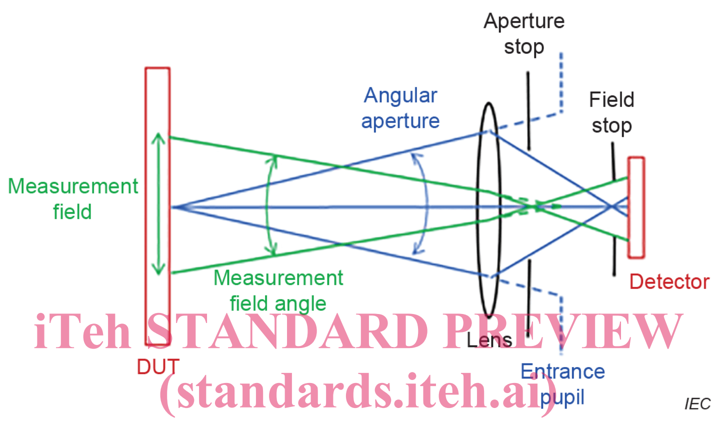


Figure 3 – Example of input optics for the luminance meters

4.3.3 Electronic system of LMDs

An LMD has an electronic system for processing the electronic signal from the detector [8] in order to deliver the measured values. Among the various types of systems, Figure 4 shows a typical one consisting of an analogue circuit amplifying the signal from the detector, an A/D converter converting the amplified signal into a digital signal, a data processor converting the digital signal to the measurement value, and a system controller controlling the whole system including the memory, display, and interface of the external devices.

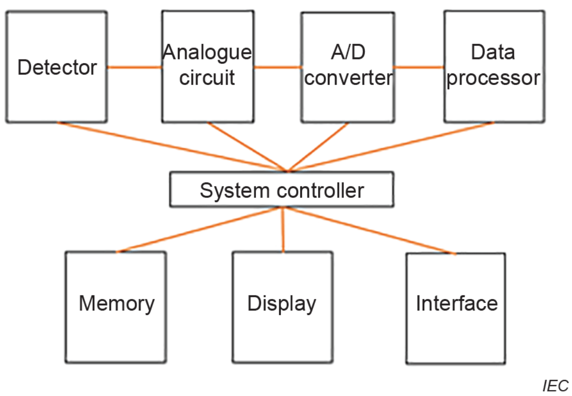


Figure 4 – Block diagram of a typical electronic system