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Date: 17 July 2020

Origin: International

Latest date for receipt of comments: 11 August 2020

Project No. 2019/02617

Responsible committee: EPL/47 Semiconductors

Interested committees:

Title: Draft BS IEC 62977-3-7 Ed.1.0 Electronic displays. Part 3-7: Evaluation of optical performances - Tone characteristics.

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This draft standard is based on national and international discussions. Your comments on this draft are invited and will assist in the preparation of the consequent standard.

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Template for comments and secretariat observations

Date: xx/xx/20xx	Document: ISO/DIS xxxx
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1	2	(3)	4	5	(6)	7
MB	Clause No./ Subclause No./Annex (e.g. 3.1)	Paragraph/Figure/ Table/Note	Type of comment	Commend (justification for change) by the MB	Proposed change by the MB	Secretariat observations on each comment submitted
	3.1	Definition 1	ed	Definition is ambiguous and needs clarifying.	Amend to read '...so that the mains connector to which no connection...'	
	6.4	Paragraph 2	te	The use of the UV photometer as an alternative cannot be supported as serious problems have been encountered in its use in the UK.	Delete reference to UV photometer.	



110/1218/CD

COMMITTEE DRAFT (CD)

PROJECT NUMBER:

IEC 62977-3-7 ED1

DATE OF CIRCULATION:

2020-07-17

CLOSING DATE FOR COMMENTS:

2020-09-11

SUPERSEDES DOCUMENTS:

110/1176/CD, 110/1185A/CC

IEC TC 110 : ELECTRONIC DISPLAYS

SECRETARIAT:

Japan

SECRETARY:

Mr Yoshi SHIBAHARA

OF INTEREST TO THE FOLLOWING COMMITTEES:

TC 100

PROPOSED HORIZONTAL STANDARD:



Other TC/SCs are requested to indicate their interest, if any, in this CD to the secretary.

FUNCTIONS CONCERNED:

☐ EMC

☐ ENVIRONMENT

☐ QUALITY ASSURANCE

☐ SAFETY

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TITLE:

Electronic displays – Part 3-7: Evaluation of optical performances - Tone characteristics

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

ELECTRONIC DISPLAYS –

Part 3-7: Evaluation of optical performance – Tone characteristics

FOREWORD

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

CDV	Report on voting
XX/XX/CDV	XX/XX/RVC

Full information on the voting for the approval of this International 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.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "<http://webstore.iec.ch>" in the data related to the specific document. At this date, the document will be

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

The National Committees are requested to note that for this publication the stability date is 2024.

THIS TEXT IS INCLUDED FOR THE INFORMATION OF THE NATIONAL COMMITTEES AND WILL BE DELETED AT THE PUBLICATION STAGE.

INTRODUCTION

Displays render the required gradation of an image through tone reproduction. Tone is the variation in luminance, ideally with constant hue *and* saturation, at (r, g, b) input $(n, 0, 0)$, $(0, n, 0)$, $(0, 0, n)$, and (n, n, n) , respectively, where $n: \{0, 1, \dots, N\}$, and N is the number of quantization levels. Similarly, colour saturation tone is defined as the luminance variation, ideally with constant hue, but with varying saturation of the input $(= 1 - \min(R, G, B) / \max(R, G, B))$, for input (N, n, n) , (n, N, n) , and (n, n, N) . Tone can also be defined for complementary colour (r, g, b) input $(0, n, n)$, $(n, 0, n)$, $(n, n, 0)$ and (n, N, N) , (N, n, N) , and (N, N, n) , respectively. This is conceptually shown in Figure 1 using the Hue Saturation Intensity (HSI) model. Note that this colour space is different from the device RGB colour space. Grey and RGB tone reproduction, and their additive relation are fundamental optical properties of displays since they affect the fidelity with which colour is rendered from the input code values.

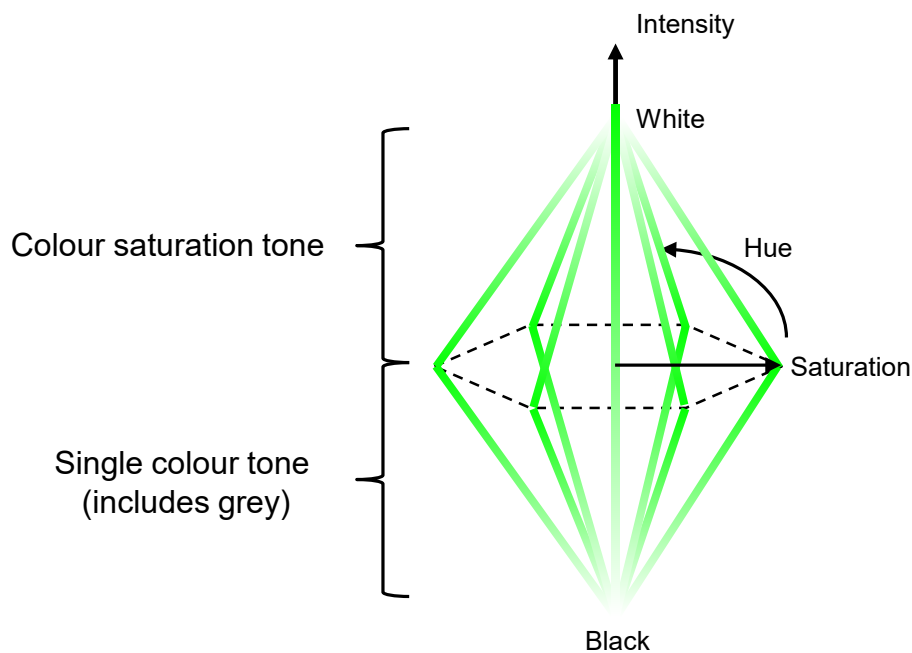


Figure 1 – Hue Saturation Intensity (HSI) colour space

In contemporary displays, nonlinear tone decoding is still being used for compatibility with historical cathode ray tube (CRT) displays as well as for the coding efficiency with the limited code words in digital video signal. Also, it linearizes the opto-electrical transfer function, the nonlinearity of which is beneficial for reduction of artefacts such as quantization noise, banding, contouring, and also for quantization efficiency.

Some displays exhibit variations in tone curves by viewing direction. The resulting impact omnidirectional image quality is more multifaceted compared to the viewing direction dependence of contrast, peak luminance, and colour of a limited number of patches.

This document describes methods for tone measurements and evaluation and points out the necessary precautions and diagnostics. The document is a reference for forthcoming standards to make the work of the involved experts more efficient and to avoid duplication of efforts.

ELECTRONIC DISPLAYS –

Part 3-7: Evaluation of optical performance – Tone characteristics

1 Scope

This part of IEC 62977 specifies the standard measurement and evaluation of optical performance for grey and colour tone reproduction of electronic displays under darkroom condition. This document describes measuring methods and evaluation of tone rendering of neutral grey, primary and secondary input colours. This document applies to displays which accept standard dynamic range (SDR) input signals.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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.

IEC 62341-6-3 Ed.2, *Organic Light Emitting Diode (OLED) Displays – Part 6-3: Measuring methods of image quality*

IEC 62977-2-1, *Electronic display devices – Part 2-1: Measurement of optical characteristics – Fundamental measurements (CDV)*

IEC TS 62977-3-1, *Electronic display devices – Part 3-1: Evaluation of optical performances – Colour difference based viewing direction dependence*

IEC 62977-3-5, *Electronic display devices – Part 3-5: Evaluation of optical performance – Colour capabilities (3CD)*

IEC 61966-4:2000, *Multimedia systems and equipment – Colour measurement and management – Part 4: Equipment using liquid crystal display panels*

IEC 61966-2-1:1999, *Multimedia systems and equipment- Colour measurement and management – Part 2-1: Colour management – Default RGB colour space - sRGB*

ISO 11664-1:2007, *Colorimetry – Part 1: CIE Standard Colorimetric Observers*

CIE 015, *Colorimetry*

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:

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

3.1.1

electro-optic transfer function (EOTF)

luminance variation of R , G , B , C , M , Y , and grey for (r, g, b) input $(n, 0, 0)$, $(0, n, 0)$, $(0, 0, n)$, $(0, n, n)$, $(n, 0, n)$, and $(n, n, 0)$, respectively, where $n \in \{0, 1, \dots, N\}$, and N is the number of quantization levels per primary colour

Note to entry CMY are optional

3.1.2 nonlinear encoding ^{[4], [7]}

signal transform expressed by a power function with a single exponent as an opto-electrical transfer function (OETF) ^[4]

Note 1 to entry It is used in image acquisition devices such as digital cameras for mapping scene luminance to digital code values prior to encoding, transmission, and/or compression

Note 2 to entry In conventional non-constant luminance systems, the nonlinear decoding is done in the RGB domain, whereas it is done in the YC_bC_r domain for constant luminance systems.

Note 3 to entry To save bit signal bit depth, the OETF of the image signal is sometimes a linear conversion of grey values near black.

3.1.3 nonlinear decoding

Same as EOTF

Note to entry Generally, the nonlinear decoding is the reciprocal of nonlinear encoding, but custom decoding is also available in many display products ("gamma" pre-sets).

3.1.4 display gamma

exponent of the power function fully defining the EOTF

Note to entry Generally, the display gamma value is calculated from an EOTF with the luminance of the black level subtracted (de-biasing). Gamma is only defined if the de-biased EOTF obeys a power law, the exponent of which is the gamma. The gamma value of an ideal display is the same for R, G, B, C, M, Y and grey tone.

3.1.5 colour saturation tone function

luminance variation of R , G , B , C , M , and Y for (r, g, b) input (N, n, n) , (n, N, n) , (n, n, N) , (n, N, N) , (N, n, N) , and (N, N, n) , respectively, where $n: \{0, 1, \dots, N\}$, and N is the number of quantization levels per primary colour

Note 1 to entry An ideal display renders constant colorimetric hue for the inputs.

Note 2 to entry When the luminance at maximum saturation is subtracted from the colour saturation tone function (bias correction), and the resulting function obeys a power law, its exponent is called colour saturation gamma.

3.1.6 display bit depth

Casual term for the number of quantization levels, assuming binary-encoded levels. It is the number of display bits or $\log_2$ [number of addressable shades] in the tone rendering

Note 1 to entry The actual number of renderable shades is often reduced when white balancing is done by gain control (see IEC 62977-3-5 (2CD) Annex B) ^{[4], [7]}.

Note 2 to entry Display colour depth is the sum of the bit depths of the rendered primary colours (RGB). Primary colours can have different bit depths, e.g. 5-, 6- and 5-bit RGB depth for 16-bit colour depth.

3.1.7 tone additivity function

Sum of the R, G, and B tones divided by the grey tone

Note to entry: An ideal display has unity additivity for all inputs.

3.2 Abbreviated terms

ABC automatic brightness control

ALS ambient light sensor

ALL average light level

APL average picture level, average pixel level

CIELAB CIE 1976 $L^*a^*b^*$ colour space

DUT device under test

EOTF electro-optical transfer function

HSI hue saturation intensity (device dependent colour space, also called HSL (lightness))

OETF opto-electrical transfer function

OOTF Opto-optical transfer function

RGBCMY red, green, blue, cyan, magenta, and yellow

SDR standard dynamic range

sRGB a standard RGB colour space as defined in IEC 61966-2-1 (same colorimetry as BT.709)

4 Standard measuring equipment

4.1 Video signal generator

A digital video signal generator or a computer with digital RGB outputs, each of which with at least 8 bits depth, shall be used. The signal bit depth supported by the DUT shall be reported according to Clause 7.

4.2 Measuring equipment and conditions

Refer to 5.3.4 in IEC 62977-2-1.

4.3 Test equipment setup

The setup of a non-close-up LMD is shown in Figure 2, where the vertical arrangement of the display is also possible. The optical axis of the LMD shall be centred on the screen and perpendicular to the plane of the display screen. The general requirements on the LMD, such as angular aperture, shall follow IEC 62977-2-1. Non-close-up LMDs are preferred but if there is straylight, it can be avoided by using a stray-light elimination tube (SLET) ^[1]. In the case of close-up type LMD, the measurement distance given by the LMD manufacturer should be satisfied as shown in Figure 3, where the vertical arrangement of the display is also possible. The close-up type LMD can be used also when avoiding the leakage illumination of the light to disable ABC in 5.3, or to save room space. A close-up LMD shall have input optics with a well-defined measurement field angle similar to that of non-close-up LMDs. If a hood is used, it shall be confirmed that light entering from oblique angles does not affect the measurement result by multiple reflections inside the hood. This can be confirmed by measuring the DUT in a dark room with and without hood and compare the results. The measuring layout for viewing directional measurement shall be applied by moving of LMD or rotation of display in horizontal viewing direction as shown in Figure 4 a) and b), where the vertical arrangement for vertical viewing direction is also possible. Or, the spherical coordinate system as shown in Figure 4 c) shall be applied (refer to 6.1 in IEC TS 62977-3-1, and 5.6 and 6.10 in IEC 62977-2-1). For the directional measurement, it shall be done with non-close-up measurement.

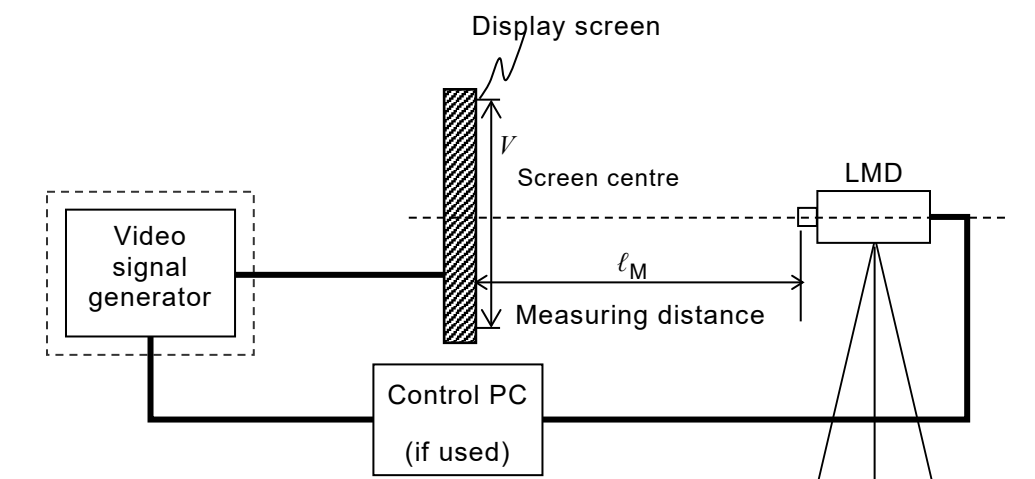


Figure 2 – Measurement setup for non-close-up measurement