

INTERNATIONAL STANDARD

NORME INTERNATIONALE



Electronic displays – Part 3-5: Evaluation of optical performance – Colour capabilities

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

COMMISSION
ELECTROTECHNIQUE
INTERNATIONALE

ICS 31.120, 31.260

ISBN 978-2-8322-7551-1

**Warning! Make sure that you obtained this publication from an authorized distributor.
Attention! Veuillez vous assurer que vous avez obtenu cette publication via un distributeur agréé.**

CONTENTS

FOREWORD.....	5
INTRODUCTION.....	7
1 Scope.....	8
2 Normative references	8
3 Terms, definitions and abbreviated terms	9
3.1 Terms and definitions.....	9
3.2 Abbreviated terms.....	10
4 Standard measuring equipment	10
4.1 Video signal generator	10
4.2 Conditions of measuring equipment	10
4.3 Test equipment block diagram	10
5 Standard measuring conditions.....	12
5.1 Standard measuring environmental conditions	12
5.2 Standard measuring darkroom conditions	12
5.3 Standard setup conditions.....	13
5.4 Standard test pattern	13
6 Evaluation of colour and chromaticity capabilities	14
6.1 Chromaticity gamut and primary colour	14
6.1.1 Measured data for chromaticity gamut area	14
6.1.2 Absolute chromaticity gamut area	15
6.1.3 Chromaticity gamut intersection area.....	17
6.1.4 Chromaticity and colour difference for primary colour additivity by location on the screen	19
6.1.5 Measuring method of chromaticity and colour difference for primary colour additivity by location on the screen.....	20
6.2 Chromaticity gamut area by input level.....	21
6.2.1 Measured data.....	21
6.2.2 Measuring method	23
6.2.3 Evaluation of chromaticity gamut area by input level.....	23
6.3 Chromaticity gamut area by viewing direction	24
6.3.1 Measuring method	24
6.3.2 Evaluation of chromaticity gamut area by viewing direction.....	25
6.4 RGB primaries additivity of mixed colour.....	25
6.4.1 Overview and measured data	25
6.4.2 Measuring method	27
6.4.3 Evaluation of additive colour mixture by input variation from colour to white.....	28
6.5 Colour reference-based colour reproduction accuracy.....	30
6.5.1 Colour reference pattern.....	30
6.5.2 Measuring method	35
6.5.3 Evaluation of colour reproduction accuracy.....	36
6.5.4 Evaluation of chromaticity shift by viewing direction.....	37
6.6 Colour gamut volume by viewing direction	39
6.6.1 Purpose.....	39
6.6.2 Measuring method	39
6.6.3 Evaluation of colour gamut volume by viewing direction.....	40
6.7 Colour gamut intersection volume and gamut rings	41

6.7.1	Purpose of colour gamut intersection volume	41
6.7.2	Evaluation of colour gamut intersection volume	41
6.7.3	Evaluation using Gamut Rings	41
7	Reporting	41
7.1	Reporting information requirements	41
7.2	Measurement results requirements	42
Annex A (informative)	Alternative colour gamut volume evaluation	44
A.1	General	44
A.2	Measuring method for colour gamut volume at various viewing directions	44
A.3	Interpolation of colour coordinates	45
A.4	Alternative method for colour gamut intersection volume	48
A.5	Spreadsheets for colour gamut related evaluation	50
Annex B (normative)	Tool for colour gamut calculation and visualization	53
B.1	General	53
B.4	Graph selection	54
B.5	Graph layout	54
B.6	CIE 1976 $L^*a^*b^*$ and CIE 1931 xyY plots	55
B.7	CIE 1931 xy chromaticity diagram	56
B.8	Gamut rings	57
B.9	Exporting graphs	59
B.10	Support	60
Bibliography	61
Figure 1	– Measuring layout for a telescopic LMD	11
Figure 2	– Measuring layout for a close-up type LMD	11
Figure 3	– Setup for viewing directional measurements	12
Figure 4	– Standard multi-colour pattern for centre box measurement	14
Figure 5	– Example of chromaticity gamut area measurements	16
Figure 6	– Example of gamut area intersection in Recommendation ITU-R BT.709	18
Figure 7	– Example of absolute chromaticity gamut area dependence on input level normalized to the value at maximum input level (255)	24
Figure 8	– CIE $u'v'$ chromaticity diagram for Table 10	30
Figure 9	– CIE $u'v'$ chromaticity diagram for Table 15	37
Figure 10	– Average $\Delta u'v'$ graph for Table 16	38
Figure 11	– Average $\Delta u'v'$ graph for Table 17	39
Figure 12	– Example of colour gamut volume at the H and V directions	40
Figure 13	– Example of colour gamut volume at the azimuth directions	40
Figure A.1	– RGB input values for 602-point interpolation	45
Figure A.2	– Sub-gamut number for 602-point interpolation	46
Figure A.3	– Example of mapping of an outer point to the boundary of a standard gamut	50
Figure A.4	– User interface and graphics of colour gamut related calculation spreadsheets	52
Figure B.1	– User interface for reading measurement input data	54
Figure B.2	– Screenshot of the Gamut Rings Viewer tool with the mouse hovering on a file name showing a pop-up tip of the full path to the data file	55

Figure B.3 – CIELAB plot of the same data as in Figure B.2 with the 3D rotation showing the axes toolbar 56

Figure B.4 – CIE xyY plot of the same data as in Figure B.2 56

Figure B.5 – CIE 1931 xy chromaticity diagram of the same data as in Figure B.2 57

Figure B.6 – Same plot as Figure B.2 in dark mode 57

Figure B.7 – Schematic of the gamut ring transform 58

Figure B.8 – Gamut rings in outline mode with the plot mode pop-up menu 59

Figure B.9 – Total gamut of the test display (grey areas indicate DUT colours that lie outside the reference gamut) 59

Table 1 – Application comparison with the related documents 7

Table 2 – RGB input values for the chromaticity gamut boundaries (8-bit example) 15

Table 3 – Example of chromaticity gamut area intersection 17

Table 4 – Cross-points of Table 3 18

Table 5 – Example of primary colour by location for each RGB input 20

Table 6 – Example of measured and additively calculated white by location 20

Table 7 – RGB input levels for determining the chromaticity gamut area dependence on the input level 22

Table 8 – Example of absolute and intersecting chromaticity gamut area dependence on the input level 23

Table 9 – RGB mixed colour inputs for colour to white 26

Table 10 – Example of evaluation for input variation from colour to white 28

Table 11 – Device characterization matrices for some standard chromaticities 31

Table 12 – RGB input code values for colour reference pattern in Recommendation ITU-R BT.709 32

Table 13 – RGB input code values for colour reference pattern in Recommendation ITU-R BT.2020 33

Table 14 – RGB input code values for colour reference pattern in DCI-P3 34

Table 15 – Example of evaluation for colour reference pattern 36

Table 16 – Example of average chromaticity difference $\Delta u'v'$ for colour reference pattern at the H and V directions 38

Table 17 – Example of average chromaticity difference $\Delta u'v'$ for colour reference pattern at the azimuthal directions 38

Table 18 – Letter symbols of the tristimulus values in 6.1, 6.4 and 6.5 42

Table A.1 – Example of sub-gamut assignment for RGB inputs 47

Table A.2 – Example of sub-gamut primary in Recommendation ITU-R BT.709 47

INTERNATIONAL ELECTROTECHNICAL COMMISSION

ELECTRONIC DISPLAYS –**Part 3-5: Evaluation of optical performance –
Colour capabilities****FOREWORD**

- 1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
- 2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
- 3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
- 4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
- 5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
- 6) All users should ensure that they have the latest edition of this publication.
- 7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
- 8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
- 9) IEC draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). IEC takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, IEC had not received notice of (a) patent(s), which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at <https://patents.iec.ch>. IEC shall not be held responsible for identifying any or all such patent rights.

IEC 62977-3-5 has been prepared by IEC technical committee 110: Electronic displays. It is an International Standard.

The text of this International Standard is based on the following documents:

Draft	Report on voting
110/1547/FDIS	110/1563/RVD

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 International Standard 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/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.

This document contains attached files in the form of Microsoft Excel spreadsheet and App installers. These files are intended to be used as a complement and do not form an integral part of the standard.

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

- reconfirmed,
- withdrawn, or
- revised.

IMPORTANT – The "colour inside" logo on the cover page of this document 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.

The content of the corrigendum 1 (2024-10) has been included in this copy.

INTRODUCTION

The standards in IEC TC 110 that have been mainly concerned with the measurement and evaluation of electronic displays refer to a set of methods and procedures that are similarly performed at the condition of the display system complying with the standard requirement.

This document is intended to describe colour and chromaticity capabilities at the system condition set to the required usage, together with suitable precautions and diagnostics, as a reference for R&D engineers, third party experts and reviewers to avoid miscommunication and duplication of efforts among them.

In this document, the methods are available for the verification or test purpose of the display product development or evaluation by the users. The aim of this document is to evaluate the available range of chromaticity and colour.

Introduction of the optical measurements of electronic displays (OPTs) is also related to a structure where each kind of optical measurement finds its unambiguous position for identification of similarities to other methods or for clarification of distinctions. This structural classification together with a general taxonomy is supposed to make the process of standards production easier, faster and thus more effective.

The basic application comparison with the related documents is summarized in Table 1. The display system means an integrated product with device hardware, firmware or application software, or both. The display system characteristics addressed in this part of IEC 62977 are normally evaluated at the R&D stage or product sample test purpose rather than for quality assurance in mass-production.

Table 1 – Application comparison with the related documents

	IEC 62977-2-1	IEC TS 62977-3-1	IEC 62977-3-5
Application	Display device module and display system	Display device module and display system	Display device module and display system
Purpose	Fundamental optical capabilities of displays with unbounded input signals	Viewing directional colour deviation of displays with unbounded input signals	Colour and chromaticity capabilities of displays with unbounded input signals
Usage	Mass-production and sample test	Sample test	Sample test
Colour and chromaticity dependence on viewing direction	Measures luminance and chromaticity variation with viewing direction	ΔE between the normal and a viewing direction based on relative deviation from the reference white at the viewing direction	Absolute chromaticity difference by $\Delta u'v'$ between the normal and a viewing direction
		ΔE calculated based on the reference white at each viewing direction	$\Delta u'v'$ not influenced by the white of each viewing direction
Chromaticity gamut area	The three primary colours (RGB) measured at the screen centre and parallel to the display normal	-	60 points connecting the RGB primaries Primary colour mixture by location Intersection and directional gamut area
Colour reproduction accuracy	-	-	Normal direction and viewing directional variation
Colour gamut volume	Total volume in normal direction	-	Directional volume Intersection volume

ELECTRONIC DISPLAYS –

Part 3-5: Evaluation of optical performance – Colour capabilities

1 Scope

This part of IEC 62977 specifies standard evaluation methods for determining the colour capabilities of electronic display modules and systems with respect to colour accuracy, colour gamut volume, and their intersection with a reference colour space. Also included is evaluation with respect to the chromaticity gamut area. These methods apply to emissive and transmissive direct view displays that render real 2D images on a flat panel or on a curved panel with a local radius of curvature larger than 1 500 mm. This document evaluates the optical characteristics of these displays under darkroom conditions. This document applies to the testing of display performance in response to standard analogue or digital input signals that are not absolute luminance encoded. The input signal is relative RGB without metadata information that codes for real luminance, colour space or colour coordinates. These methods are limited to input signals with typical opto-electronic transfer functions (OETFs) such as defined in IEC 61966-2-1, Recommendation ITU-R BT.601 [18]¹, Recommendation ITU-R BT.709, and Recommendation ITU-R BT.2020. The tests in this document are not suitable for use with HDR input signals.

NOTE A flat panel or flat panel display is a display with a planar surface that emits light from the surface. The display can consist of light valves modulating a backlight or be self-luminous. Emissive, transmissive, or reflective hybrid displays can be non-planar panel, non-planar panel displays, curved (design) panel, or curved (design) panel displays.

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

IEC 62977-2-1:2021, *Electronic displays – Part 2-1: Measurements of optical characteristics – Fundamental measurements*

IEC TS 62977-3-1:2019, *Electronic displays – Part 3-1: Evaluation of optical performances – Colour difference based viewing direction dependence*

IEC 61747-30-4, *Liquid crystal display devices – Part 30-4: Measuring methods for liquid crystal display modules – Dynamic backlight units*

IEC 62341-6-3:2017, *Organic light emitting diode (OLED) displays – Part 6-3: Measuring methods of image quality*

CIE 015:2018, *Colorimetry*

CIE 168:2005, *Criteria for the evaluation of extended-gamut colour encodings*

¹ Numbers in square brackets refer to the Bibliography.

Recommendation ITU-R BT.709, *Parameter values for the HDTV standards for production and international programme exchange*

Recommendation ITU-R BT.2020, *Parameter values for ultra-high definition television systems for production and international programme exchange*

SMPTE ST 431-1:2006, *D-Cinema Quality – Screen Luminance Level, Chromaticity and Uniformity*