

# INTERNATIONAL STANDARD



---

**Electronic paper displays –  
Part 3-3: Optical measuring methods for displays with integrated lighting units**





**THIS PUBLICATION IS COPYRIGHT PROTECTED**  
**Copyright © 2016 IEC, Geneva, Switzerland**

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from either IEC or IEC's member National Committee in the country of the requester. If you have any questions about IEC copyright or have an enquiry about obtaining additional rights to this publication, please contact the address below or your local IEC member National Committee for further information.

IEC Central Office  
3, rue de Varembe  
CH-1211 Geneva 20  
Switzerland

Tel.: +41 22 919 02 11  
Fax: +41 22 919 03 00  
[info@iec.ch](mailto:info@iec.ch)  
[www.iec.ch](http://www.iec.ch)

**About the IEC**

The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

**About IEC publications**

The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigenda or an amendment might have been published.

**IEC Catalogue - [webstore.iec.ch/catalogue](http://webstore.iec.ch/catalogue)**

The stand-alone application for consulting the entire bibliographical information on IEC International Standards, Technical Specifications, Technical Reports and other documents. Available for PC, Mac OS, Android Tablets and iPad.

**IEC publications search - [www.iec.ch/searchpub](http://www.iec.ch/searchpub)**

The advanced search enables to find IEC publications by a variety of criteria (reference number, text, technical committee,...). It also gives information on projects, replaced and withdrawn publications.

**IEC Just Published - [webstore.iec.ch/justpublished](http://webstore.iec.ch/justpublished)**

Stay up to date on all new IEC publications. Just Published details all new publications released. Available online and also once a month by email.

**Electropedia - [www.electropedia.org](http://www.electropedia.org)**

The world's leading online dictionary of electronic and electrical terms containing 20 000 terms and definitions in English and French, with equivalent terms in 15 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

**IEC Glossary - [std.iec.ch/glossary](http://std.iec.ch/glossary)**

65 000 electrotechnical terminology entries in English and French extracted from the Terms and Definitions clause of IEC publications issued since 2002. Some entries have been collected from earlier publications of IEC TC 37, 77, 86 and CISPR.

**IEC Customer Service Centre - [webstore.iec.ch/csc](http://webstore.iec.ch/csc)**

If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: [csc@iec.ch](mailto:csc@iec.ch).

# INTERNATIONAL STANDARD



---

**Electronic paper displays –  
Part 3-3: Optical measuring methods for displays with integrated lighting units**

INTERNATIONAL  
ELECTROTECHNICAL  
COMMISSION

---

ICS 31.120; 31.260

ISBN 978-2-8322-3616-1

**Warning! Make sure that you obtained this publication from an authorized distributor.**

## CONTENTS

FOREWORD.....	5
1 Scope.....	7
2 Normative references.....	7
3 Terms, definitions and abbreviated terms .....	7
3.1 Terms and definitions .....	7
3.2 Abbreviated terms .....	8
4 Standard measuring conditions .....	8
4.1 Standard environmental measuring conditions .....	8
4.2 Viewing direction coordinate system .....	8
4.3 Standard lighting conditions .....	9
4.3.1 General comments and remarks on the measurement of electronic paper displays .....	9
4.3.2 Dark room conditions .....	9
4.3.3 Standard indoor ambient illumination spectra.....	9
4.3.4 Standard illumination geometries.....	10
4.4 Adjustment of the EPD .....	11
4.5 Standard conditions of measuring equipment.....	11
4.6 Working standards and references.....	11
4.7 Standard locations of measurement field .....	11
4.7.1 Matrix displays.....	11
4.7.2 Segment displays.....	12
5 Optical measuring methods.....	12
5.1 Reflection measurements .....	12
5.1.1 General .....	12
5.1.2 Measuring conditions .....	12
5.1.3 Measuring the hemispherical diffuse reflectance .....	13
5.1.4 Measuring the reflectance factor for a directed light source .....	15
5.2 Display photometric uniformity in a dark room.....	16
5.2.1 Purpose .....	16
5.2.2 Measuring equipment.....	16
5.2.3 Measurement method.....	16
5.2.4 Definitions and evaluations.....	17
5.3 Dark room contrast ratio.....	17
5.3.1 Purpose .....	17
5.3.2 Measuring equipment.....	17
5.3.3 Measurement method.....	17
5.3.4 Definitions and evaluations.....	17
5.4 Contrast ratio under indoor illumination.....	18
5.4.1 Purpose .....	18
5.4.2 Measurement conditions .....	18
5.4.3 Measurement method.....	18
5.5 Cross-talk .....	19
5.5.1 Purpose .....	19
5.5.2 Measuring equipment.....	19
5.5.3 Greyscale matrix displays.....	19
5.5.4 Black and white (two-level) matrix displays .....	21

5.6	Display colour, colour gamut, and colour gamut area .....	22
5.6.1	Purpose .....	22
5.6.2	Measuring equipment .....	22
5.6.3	Measurement method .....	22
5.6.4	Display colour gamut .....	22
5.6.5	Display colour gamut area .....	23
5.7	Display colorimetric uniformity in a dark room .....	25
5.7.1	Purpose .....	25
5.7.2	Measuring equipment .....	25
5.7.3	Measurement method .....	25
5.7.4	Definitions and evaluations .....	26
5.8	Display colour under indoor illumination .....	26
5.8.1	Purpose .....	26
5.8.2	Measurement conditions .....	26
5.8.3	Measurement method .....	27
5.8.4	Definitions and evaluations .....	27
5.9	Colour gamut volume under indoor illumination .....	28
5.9.1	Purpose .....	28
5.9.2	Measurement conditions .....	28
5.9.3	Measurement method .....	28
5.9.4	Definitions and evaluations .....	29
5.9.5	Recording .....	30
5.10	Viewing direction dependence in a dark room .....	30
5.10.1	Purpose .....	30
5.10.2	Measuring conditions .....	31
5.10.3	Measuring method .....	31
5.10.4	Definitions and evaluations .....	31
Annex A (informative)	Calculation method of daylight colour gamut volume .....	34
A.1	Purpose .....	34
A.2	Procedure for calculating the colour gamut volume .....	34
A.3	Surface subdivision method for CIELAB gamut volume calculation .....	36
A.3.1	Purpose .....	36
A.3.2	Assumptions .....	36
A.3.3	Algorithm .....	36
A.3.4	Software example .....	36
Bibliography	.....	41
Figure 1	– Representation of the coordinate system used to specify the viewing or measurement orientation .....	9
Figure 2	– Standard measurement positions .....	12
Figure 3	– Window pattern for cross-talk measurement .....	20
Figure 4	– Example representation of the same primary colours in the CIE 1931 (left) and CIE 1976 (right) chromaticity diagrams .....	22
Figure 5	– Example of evaluation results for the colour gamut area on the $a^*b^*$ plane of the CIELAB colour space .....	25
Figure 6	– An example of the range in colours produced by an sRGB display as represented by the CIELAB colour space .....	29
Figure 7	– Example of contrast ratio dependence on viewing direction .....	32

Figure A.1 – Analysis flow chart for calculating the colour gamut volume.....34

Figure A.2 – Graphical representation of the colour gamut volume for sRGB in the CIELAB colour space .....35

  

Table 1 – Eigenvalues  $M_1$  and  $M_2$  for CIE daylight Illuminant D50 ..... 14

Table 2 – Input signals for CIELAB and CIE UCS  $u'v'$  colour gamut area measurements .....24

Table 3 – Example data of in-plane colour non-uniformity .....26

Table 4 – Example of minimum colours required for gamut volume calculation of a 3-primary 8-bit display .....29

Table 5 – Measured tristimulus values for the minimum set of colours (see Table 4) required for gamut volume calculation under the specified indoor illumination conditions .....30

Table 6 – Calculated white point in the darkened room and indoor ambient condition .....30

Table 7 – Colour gamut volume in the CIELAB colour space .....30

Table 8 – Example format used for recording viewing direction performance .....33

Table A.1 – Tristimulus values of the sRGB primary colours .....35

Table A.2 – Example of sRGB colour set represented in the CIELAB colour space .....35

Table A.3 – Example of an sRGB colour gamut volume in the CIELAB colour space.....36

## INTERNATIONAL ELECTROTECHNICAL COMMISSION

**ELECTRONIC PAPER DISPLAYS –****Part 3-3: Optical measuring methods for displays  
with integrated lighting units**

## 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) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

International Standard 62679-3-3 has been prepared by IEC technical committee 110: Electronic display devices.

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

CDV	Report on voting
110/723/CDV	110/780/RVC

Full information on the voting for the approval of 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 parts in the IEC 62679 series, published under the general title *Electronic paper displays*, can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC website 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.

A bilingual version of this publication may be issued at a later date.

**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.**

## ELECTRONIC PAPER DISPLAYS –

### Part 3-3: Optical measuring methods for displays with integrated lighting units

#### 1 Scope

This part of IEC 62679 specifies the standard measurement conditions and measurement methods for determining the optical performance of electronic paper display (EPD) devices which have an operating integrated lighting unit (such as a front light). The scope of this document is restricted to EPDs using segmented or matrix structures with either monochromatic or colour type displays. The measurement methods are intended for EPDs operated in a reflective mode with the integrated lighting unit (ILU) turned on in a dark or indoor ambient lighting environment. Colour systems beyond three primaries are not covered in this document.

#### 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 for 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 62679-1-1, *Electronic paper displays – Part 1-1: Terminology*

IEC 62679-3-1:2014, *Electronic paper displays – Part 3-1: Optical measuring methods*

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

CIE 15, *Colorimetry*

#### 3 Terms, definitions and abbreviated terms

##### 3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 62679-1-1, IEC 60050-845, and the following 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

###### ILU

###### integrated lighting unit

light source integrated into an EPD device to provide supplementary illumination to compensate for the lack of adequate ambient illumination