

INTERNATIONAL STANDARD



**Laser display devices –
Part 5-4: Optical measuring methods of colour speckle**



THIS PUBLICATION IS COPYRIGHT PROTECTED

Copyright © 2018 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
info@iec.ch
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

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 - webstore.iec.ch/advsearchform

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 It also gives information on projects, replaced and withdrawn publications.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

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

The world's leading online dictionary of electronic and electrical terms containing 21 000 terms and definitions in English and French, with equivalent terms in 16 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

IEC Glossary - std.iec.ch/glossary

67 000 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

If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: sales@iec.ch.

INTERNATIONAL STANDARD



**Laser display devices –
Part 5-4: Optical measuring methods of colour speckle**

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 31.260

ISBN 978-2-8322-5243-7

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, letter symbols and abbreviated terms.....	7
3.1 Fundamental terms	7
3.2 Terms related to colour speckle distribution	7
3.3 Terms related to spatial variation	8
3.4 Letter symbols	8
3.5 Abbreviated terms.....	9
4 Theory of colour speckle.....	9
4.1 General.....	9
4.2 Mechanism for generating colour speckle	9
5 Calculation methods of colour speckle	11
5.1 General.....	11
5.2 Measuring method of spectral behaviour of BGR light sources	12
5.3 Target chromaticity	12
5.4 Adjustment of BGR power ratio	14
5.5 Calculation method (a) using BGR speckle contrast C_{S-B} , C_{S-G} , C_{S-R}	15
5.5.1 General	15
5.5.2 Examples of measured distributions.....	16
5.6 Evaluation metrics	20
5.7 Calculation method (b) using the measured spatial distribution of BGR monochromatic speckles	21
5.7.1 General	21
5.7.2 Examples of measured distributions.....	21
5.7.3 Comparison between methods (a) and (b)	23
5.7.4 Elimination of the background effects	25
5.8 Error analysis based on data size	28
6 Direct measuring methods of colour speckle	32
6.1 General.....	32
6.2 Fundamental design of LMD for colour speckle measurement.....	33
6.3 Colour speckle measuring method using LMD with XYZ filters	34
6.4 Colour speckle measuring method using LMD with BGR filters.....	35
7 Measuring methods related to spatial variation	36
7.1 General.....	36
7.2 Angular colour speckle variation	36
7.3 Photometric speckle contrast uniformity/non-uniformity.....	37
7.4 Colour speckle variance/covariance non-uniformity.....	38
Annex A (informative) Complementary explanation of colour speckle	39
Annex B (informative) Examples of colour speckle distributions	40
B.1 Colour speckle distributions (one of the BGR: 90 %, the others: 1 %)	40
B.2 Colour speckle distributions (two of the BGR: 90 %, the other: 1 %)......	43
Annex C (informative) Calibration of XYZ errors	48
C.1 General.....	48
C.2 Formulation of XYZ mismatches	48

C.3 Calibration of the mismatched XYZ errors using the true BGR chromaticity values	50
Bibliography.....	51
Figure 1 – Two speckle measuring methods and their flow charts	12
Figure 2 – Target chromaticity and colour gamut.....	13
Figure 3 – $S_{B,G,R}(\lambda)$ with an FWHM of 2 nm.....	13
Figure 4 – Adjustment method of BGR power ratio.....	15
Figure 5 – Colour speckle distribution for $C_{S-B} = 100\%$, $C_{S-G} = 100\%$, $C_{S-R} = 100\%$	16
Figure 6 – Photometric speckle distribution for $C_{S-B} = 100\%$, $C_{S-G} = 100\%$, $C_{S-R} = 100\%$	17
Figure 7 – Colour speckle distribution for $C_{S-B} = 50\%$, $C_{S-G} = 50\%$, $C_{S-R} = 50\%$	18
Figure 8 – Photometric speckle distribution for $C_{S-B} = 50\%$, $C_{S-G} = 50\%$, $C_{S-R} = 50\%$	18
Figure 9 – Colour speckle distribution for $C_{S-B} = 10\%$, $C_{S-G} = 10\%$, $C_{S-R} = 10\%$	19
Figure 10 – Photometric speckle distribution for $C_{S-B} = 10\%$, $C_{S-G} = 10\%$, $C_{S-R} = 10\%$	20
Figure 11 – Colour speckle distribution for $C_{S-B} = 9,2\%$, $C_{S-G} = 9,7\%$, $C_{S-R} = 9,2\%$ obtained by method (b)	22
Figure 12 – Colour speckle distribution for $C_{S-B} = 9,2\%$, $C_{S-G} = 19,2\%$, $C_{S-R} = 23,2\%$ obtained by method (b)	23
Figure 13 – Colour speckle distribution for $C_{S-B} = 9,2\%$, $C_{S-G} = 9,7\%$, $C_{S-R} = 9,2\%$ obtained by method (a)	24
Figure 14 – Colour speckle distribution for $C_{S-B} = 9,2\%$, $C_{S-G} = 19,2\%$, $C_{S-R} = 23,2\%$ obtained by method (a)	24
Figure 15 – Raw data of BGR speckle distributions (upper row) and post-processed data (lower row) for BGR monochromatic speckles (left: B, centre: G, right: R)	26
Figure 16 – Colour speckle distribution directly using the raw data in Figure 15	26
Figure 17 – Colour speckle distribution for $C_{S-B} = 16,2\%$, $C_{S-G} = 17,4\%$, $C_{S-R} = 17,3\%$ obtained by indirect measuring method (a).....	27
Figure 18 – Calculated average chromaticity values of the colour speckle distribution with respect to data size for $C_{S-B} = C_{S-G} = C_{S-R} = 80\%$	28
Figure 19 – Calculated average values of the normalized speckle illuminance speckle distribution and the normalized monochromatic speckle intensity distribution with respect to data size for $C_{S-B} = C_{S-G} = C_{S-R} = 80\%$	29
Figure 20 – Calculated average chromaticity values of the colour speckle distribution with respect to data size for $C_{S-B} = C_{S-G} = C_{S-R} = 60\%$	29
Figure 21 – Calculated average values of the normalized speckle illuminance speckle distribution and the normalized monochromatic speckle intensity distribution with respect to data size for $C_{S-B} = C_{S-G} = C_{S-R} = 60\%$	30
Figure 22 – Calculated average chromaticity values of the colour speckle distribution with respect to data size for $C_{S-B} = C_{S-G} = C_{S-R} = 40\%$	30
Figure 23 – Calculated average values of the normalized speckle illuminance speckle distribution and the normalized monochromatic speckle intensity distribution with respect to data size for $C_{S-B} = C_{S-G} = C_{S-R} = 40\%$	31
Figure 24 – Calculated average chromaticity values of the colour speckle distribution with respect to data size for $C_{S-B} = C_{S-G} = C_{S-R} = 20\%$	31
Figure 25 – Calculated average values of the normalized speckle illuminance speckle distribution and the normalized monochromatic speckle intensity distribution with respect to data size for $C_{S-B} = C_{S-G} = C_{S-R} = 20\%$	32
Figure 26 – Example of LMDs using XYZ filters for colour speckle measurement	33

Figure 27 – Example of LMDs using BGR filters for colour speckle measurement	34
Figure 28 – Example of measurement geometries for colour speckle using an LMD with XYZ filters.....	35
Figure 29 – Example of measurement geometries for colour speckle using an LMD with BGR filters	36
Figure 30 – Representation of the viewing direction, or direction of measurement, defined by the angle of inclination θ , and the angle of rotation (azimuth angle φ) in a polar coordinate system	37
Figure A.1 – Photograph of colour speckle	39
Figure B.1 – Colour speckle distribution for $C_{S-B} = 90\%$, $C_{S-G} = 1\%$, $C_{S-R} = 1\%$	40
Figure B.2 – Photometric speckle distribution for $C_{S-B} = 90\%$, $C_{S-G} = 1\%$, $C_{S-R} = 1\%$	41
Figure B.3 – Colour speckle distribution for $C_{S-B} = 1\%$, $C_{S-G} = 90\%$, $C_{S-R} = 1\%$	42
Figure B.4 – Photometric speckle distribution for $C_{S-B} = 1\%$, $C_{S-G} = 90\%$, $C_{S-R} = 1\%$	42
Figure B.5 – Colour speckle distribution for $C_{S-B} = 1\%$, $C_{S-G} = 1\%$, $C_{S-R} = 90\%$	43
Figure B.6 – Photometric speckle distribution for $C_{S-B} = 1\%$, $C_{S-G} = 1\%$, $C_{S-R} = 90\%$	43
Figure B.7 – Colour speckle distribution for $C_{S-B} = 90\%$, $C_{S-G} = 1\%$, $C_{S-R} = 90\%$	44
Figure B.8 – Photometric speckle distribution for $C_{S-B} = 90\%$, $C_{S-G} = 1\%$, $C_{S-R} = 90\%$	45
Figure B.9 – Colour speckle distribution for $C_{S-B} = 1\%$, $C_{S-G} = 90\%$, $C_{S-R} = 90\%$	45
Figure B.10 – Photometric speckle distribution for $C_{S-B} = 1\%$, $C_{S-G} = 90\%$, $C_{S-R} = 90\%$	46
Figure B.11 – Colour speckle distribution for $C_{S-B} = 90\%$, $C_{S-G} = 90\%$, $C_{S-R} = 1\%$	46
Figure B.12 – Photometric speckle distribution for $C_{S-B} = 90\%$, $C_{S-G} = 90\%$, $C_{S-R} = 1\%$	47
Figure C.1 – Deviated values (marker points) and ideal colour matching functions	49
Figure C.2 – Correct plot by spectral measurements and plot with XYZ errors	49
Table 1 – Values of measurement metrics for the calculated examples	21
Table 2 – Values of measurement metrics for the examples in Figure 11 to Figure 14.....	25
Table 3 – Values of measurement indices for the examples in Figure 16 and Figure 17	27
Table C.1 – Mismatch coefficients.....	49

INTERNATIONAL ELECTROTECHNICAL COMMISSION

LASER DISPLAY DEVICES –

Part 5-4: Optical measuring methods of colour speckle

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 IEC 62906-5-4 has been prepared by IEC technical committee TC 110: Electronic display devices.

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

FDIS	Report on voting
110/926/FDIS	110/938/RVD

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 document has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts in the IEC 62906 series, published under the general title *Laser display devices*, can be found on the IEC website.

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.

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.

LASER DISPLAY DEVICES –

Part 5-4: Optical measuring methods of colour speckle

1 Scope

This part of IEC 62906 specifies the fundamental colour speckle distribution in CIE colour systems and the measuring methods of the colour speckle of laser display devices (LDDs).

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 62906-1-2, *Laser display devices – Part 1-2: Vocabulary and letter symbols*

IEC 62906-5-2:2016, *Laser display devices – Part 5-2: Optical measuring methods of speckle contrast*

CIE publication 15:2004, *Colorimetry*

3 Terms, definitions, letter symbols and abbreviated terms

For the purposes of this document, the following terms and definitions given in IEC 62906-1-2 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 Fundamental terms

3.1.1

colour speckle distribution

colour distribution in a specified colour space of the speckle patterns which are generated by colour mixing of monochromatic screen speckles

3.1.2

photometric speckle distribution

distribution of photometric variables such as illuminance, luminance or luminous flux of a colour speckle pattern which are generated by colour mixing of monochromatic screen speckles

3.2 Terms related to colour speckle distribution

3.2.1

colour speckle variance

variance for either of the chromaticity coordinates of colour speckle distribution data, used as one of the metrics of colour speckle distribution