



BSI Standards Publication

## Electronic paper displays

---

Part 5-1: Legibility of EPD in spatial frequency

## National foreword

This Published Document is the UK implementation of IEC/TR 62679-5-1:2017.

The UK participation in its preparation was entrusted to Technical Committee EPL/47, Semiconductors.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

© The British Standards Institution 2017  
Published by BSI Standards Limited 2017

ISBN 978 0 580 89738 2

ICS 31.260; 31.120

**Compliance with a British Standard cannot confer immunity from legal obligations.**

This Published Document was published under the authority of the Standards Policy and Strategy Committee on 31 August 2017.

### Amendments/corrigenda issued since publication

Date	Text affected
------	---------------

---



# IEC TR 62679-5-1

Edition 1.0 2017-07

## TECHNICAL REPORT



---

**Electronic paper displays –  
Part 5-1: Legibility of EPD in spatial frequency**

INTERNATIONAL  
ELECTROTECHNICAL  
COMMISSION

---

ICS 31.120; 31.260

ISBN 9978-2-8322-4527-9

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

## CONTENTS

FOREWORD .....	3
INTRODUCTION .....	5
1 Scope .....	6
2 References .....	6
3 Terms, definitions and abbreviated terms .....	6
3.1 Terms and definitions .....	6
3.2 Abbreviated terms .....	7
4 Contrast sensitivity test chart (CSC) .....	7
5 Objective assessment .....	9
5.1 General .....	9
5.2 Conditions of objective assessment .....	10
5.3 Photometric characteristics for CSC .....	10
6 Subjective assessment .....	13
6.1 Conditions of subjective assessment .....	13
6.2 Result of sensory evaluation .....	14
7 Creating a legibility evaluation model .....	15
7.1 Multiple regression analysis .....	15
7.2 Results of multiple regression analysis .....	15
7.3 Demonstration experiment .....	16
7.4 Conclusion .....	16
Bibliography .....	18
Figure 1 – Layout of patches .....	8
Figure 2 – Example of patch of CSC .....	8
Figure 3 – Spatial frequency per unit viewing angle .....	9
Figure 4 – Measuring apparatus geometry .....	10
Figure 5 – Luminance distribution components .....	12
Figure 6 – Examination environment .....	14
Figure 7 – Result of sensory evaluation .....	15
Figure 8 – Experimental score versus prediction score ( $VL$ ) of EPD .....	16
Table 1 – Properties of five kinds of paper .....	9
Table 2 – EPDs for verification .....	16

## INTERNATIONAL ELECTROTECHNICAL COMMISSION

**ELECTRONIC PAPER DISPLAYS –****Part 5-1: Legibility of EPD in spatial frequency**

## 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.

The main task of IEC technical committees is to prepare International Standards. However, a technical committee may propose the publication of a technical report when it has collected data of a different kind from that which is normally published as an International Standard, for example "state of the art".

IEC TR 62679-5-1, which is a technical report, has been prepared by IEC technical committee 110: Electronic display devices.

The text of this technical report is based on the following documents:

Enquiry draft	Report on voting
110/836/DTR	110/864A/RVDTR

Full information on the voting for the approval of this technical report 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 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 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.**

## INTRODUCTION

A small device for an electronic paper display (EPD)[1]<sup>1</sup> was invented in 1997, and its first product as an electronic book was brought to the market in 2004. This product was the first electronic display which made human beings serious about reading letters and figures as well as those printed on a paper with ink. A definition of “electronic paper” was first given by N. K. Sheridan et al of PARC in 1998, as follows: Plane paper scatters light diffusely and efficiently, allowing for high contrast, high resolution images that can be viewed from broad angles without glare caused by specular reflection, in contrast, electronic display media can provide the extra benefits of reusability and easy integration into digital electronic systems. Electronic display media used in such a fashion can be called “electronic paper” [2]. For these reasons, the benchmark for estimation of EPD has always been printed paper.

The human action of reading is basically analysed through two subjective attributes, that is, legibility and readability. The legibility, as defined at 3.1.2, can be rated and analyzed by means of measuring optophysical or radiometric property of a certain pattern. This pattern is recognised by the retina as an aggregation of spatial frequencies. Legibility can be understood by analysing those kinds of spatial frequency. In 1967, the contrast sensitivity of the human eye for sinusoidal illuminance changes was measured as a function of spatial frequency [3]. As for readability, defined in 3.1.3, lot of human ergonomics tests and sophisticated statistical works are recommended with around a hundred human participants, to compare with printed paper, EPDs, and emissive displays, which will also require economical costs and expenditure of time. The readability of EPDs will be reported elsewhere.

IEC 62679 (all parts) specifies optical measuring methods for electronic paper displays (EPDs), but does not mention legibility and readability for EPDs, because there are no guidelines for measuring and estimating these elements in a practical fashion, especially under variation of optical environments.

This document offers permanent formulae to decide on the legibility level of EPD compared with paper, which will lead to specification of EPD with regard to the human action of reading. Legibility is one of the human actions of reading, which falls in the category of subjective assessments; on the other hand, the properties of EPDs fall in that of physical specifications, that is, objective assessments. The legibility in this document described by using a five-level rating system is revealed to show as a function of physical parameters.

In this document, legibility is suggested as having two essential parameters, that is, the spatial frequency, which can represent the complexity or size of a letter, font, or symbol, and the contrast, which shows brightness between a character and its background.

---

<sup>1</sup> Numbers in square brackets refer to the Bibliography.

## ELECTRONIC PAPER DISPLAYS –

### Part 5-1: Legibility of EPD in spatial frequency

#### 1 Scope

This part of IEC 62679, which is a technical report, specifies the legibility in terms of contrast, spatial frequency, and reflection of the screen as a function of the physical parameters of an EPD. This legibility evaluation model is introduced through both subjective and objective assessments. The scope of this document is restricted to EPDs using segment, passive, and active matrixes with monochromatic type displays.

#### 2 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 [16].

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

- IEC Electropedia: available at <http://www.electropedia.org/> [4]
- ISO Online browsing platform: available at <http://www.iso.org/obp>

##### 3.1.1

##### **contrast sensitivity test chart [5,6], CSC**

chart for measuring and quantifying visual sensitivity in terms of contrast sensitivity and spatial frequency response which contains a multiplicity of grating patches whose contrast, in term of luminance, varies sinusoidally for differing spatial frequencies

Note 1 to entry CSC is sometimes used for diagnosis in ophthalmology clinics.

##### 3.1.2

##### **legibility**

ability for unambiguous identification of single characters or symbols that may be presented in a non-contextual format

[SOURCE: ISO 9241-302:2008, 3.3.35] [7]

##### 3.1.3

##### **readability**

characteristics of a text presentation on a display that affect performance when groups of characters are to be easily discriminated, recognized and interpreted

[SOURCE: ISO 9241-302:2008, 3.3.38] [7]