SEMI D68-0512
TEST METHODS FOR OPTICAL PROPERTIES OF ELECTRONIC PAPER DISPLAYS

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1 Purpose

1.1 Electronic paper displays use reflective technology to create images and need no power to hold images because of their bistable nature. Since there are more and more applications of electronic paper displays on the market nowadays, such as e-Book readers, electronic shelf labels, and e-Signage, it is necessary to standardize the test methods for measuring optical properties of electronic paper displays.

2 Scope

2.1 This Standard is applicable to measurement for optical properties of electronic paper displays under diffuse or directional illumination.

NOTICE: SEMI Standards and Safety Guidelines do not purport to address all safety issues associated with their use. It is the responsibility of the users of the Documents to establish appropriate safety and health practices, and determine the applicability of regulatory or other limitations prior to use.

3 Limitations

3.1 This Standard is suitable for use with electrophoretic displays, cholesteric-LCDs, and MEMs-based interference displays, which are reflective and bistable electronic paper displays.

4 Referenced Standards and Documents

4.1 *CIE Standard*[1]

CIE 15:2004 3rd edition — Colorimetry

4.2 *IEC Standard*[2]

IEC 61747-6-2 — Measuring Methods for Liquid Crystal Display Modules – Reflective Type

4.3 *VESA Standard*[3]

VESA 2.0 — Flat Panel Display Measurements Standard

NOTICE: Unless otherwise indicated, all documents cited shall be the latest published versions.

5 Terminology

5.1 *Abbreviations and Acronyms*

5.1.1 *DUT* — display under test

5.1.2 *LMD* — light-measuring device

5.2 *Definitions*

5.2.1 *bistability* — ability to hold the image without applied power.

5.2.2 *contrast ratio* — ratio of the reflectance factor of the white state to that of the black state.

[1] International Commission on Illumination, http://www.cie.co.at

[2] International Electrotechnical Commission, 3 rue de Varembé, Case Postale 131, CH-1211 Geneva 20, Switzerland; Telephone: +41.22.919.02.11, Fax: +41.22.919.03.00, http://www.iec.ch

[3] Video Electronics Standards Association, http://www.vesa.org

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5.2.3 *ghosting* — an image sticking phenomenon of the previous image on the screen after the image is changed.

5.2.4 *lightness* — brightness exhibited by the electronic paper display relative to a perfect reflecting diffuser under the same illumination.

5.2.5 *lightness range* — lightness difference between the white state and the black state of a display.

5.2.6 *reflectance factor* — ratio of the reflected luminous flux from the electronic paper display to that from a perfect reflecting diffuser under the same measurement geometry.

5.2.7 *threshold-based viewing angle* — the angle at which the DUT displays lightness range larger than or equal to threshold value of lightness range.

6 Summary of Test Method

6.1 The test methods provide procedures for measuring the optical properties of electronic paper displays by using a spectrophotometer or colorimeter under diffuse or directional illumination. The key steps include:

6.1.1 Measuring the spectral reflectance factors of the reference white standard, black standard, and display under test (DUT) with a spectrophotometer.

6.1.2 Measuring the CIE tristimulus values of the reference white standard, black standard, and DUT with a colorimeter.

6.1.3 Measuring the ghosting index by measuring the spectral reflectance factors or the CIE tristimulus values of the four test points on the full-screen white.

6.1.4 Evaluating the angular optical performance either through measuring the lightness range at designated incidence angles, viewing angles, and azimuth angles or through measuring the threshold-based viewing angle.

6.1.5 Measuring the bistability by measuring the spectral reflectance factors or the CIE tristimulus values of DUT at two different time.

7 Environmental Conditions

- Temperature: 25 ± 3°C.
- Humidity: 25% to 85% RH.
- Illumination of surrounding: dark room ≤1 lx.
- No reflection or low reflection objects of surroundings.

7.1 When different environmental conditions are used, they shall be noted in the report.

8 Apparatus

8.1 *Light Source*

8.1.1 Use a tungsten halogen lamp (CIE standard illuminant A) as a light source. When different light sources are used, they shall be noted in the report.

8.2 *Light-Measuring Device (LMD)*

8.2.1 For a spectral reflection measurement, a spectrophotometer is used as an LMD and its wavelength intervals, $\Delta\lambda$ shall not be greater than 10 nm over the wavelength range from 380 nm to 780 nm.

8.2.2 For a filter photometric reflection measurement, a colorimeter (filter photometer) is used as an LMD.

8.3 *Reflection Standards*

8.3.1 For the spectral reflection measurement, one reference white standard and one reference black standard of calibrated spectral reflectance factor $R_{WS}(\lambda)$ and $R_{BS}(\lambda)$ respectively for the same measurement geometry as in the test configuration shall be used.

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8.3.2 For the filter photometric reflection measurement, one reference white standard and one reference black standard of calibrated CIE tristimulus values (X_{WS}, Y_{WS}, Z_{WS}) and (X_{BS}, Y_{BS}, Z_{BS}) respectively for the same measurement geometry as in the test configuration shall be used.

9 Measurement Geometry

9.1 *Diffuse Illumination*

9.1.1 *Hemispherical Illumination*

9.1.1.1 Use a light source with an integrating sphere, as a uniform diffuse light source, to illuminate DUT. Place the LMD at the measurement port with an inclination angle of θ_D (recommend 8°) off the normal to the center of the DUT (see Figure 1). The measurement area covers no less than 500 pixels and measurement field angle is 2° or less. For the specular reflection excluded measurement, open the cover of the specular port during the test. For the specular reflection included measurement, close the cover of the specular port during the test.

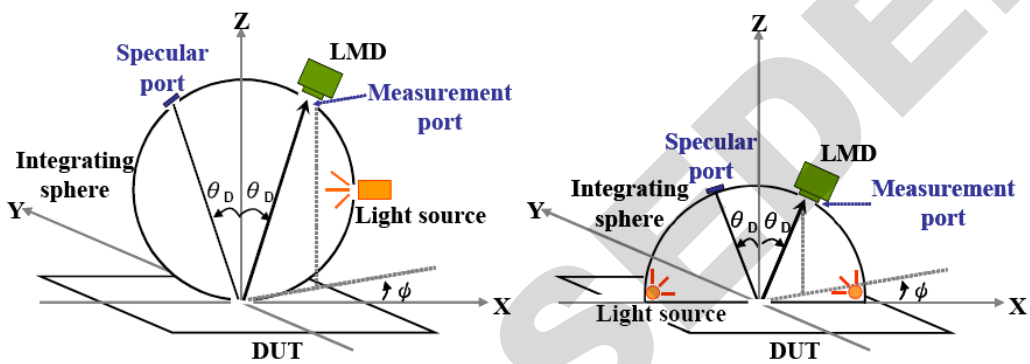

Figure 1
Hemispherical Illumination Measurement Geometry

9.2 *Directional Illumination*

9.2.1 *Ring-Light Illumination*

9.2.1.1 Use a ring-light source to provide uniform directional illumination on the DUT over all azimuth angles at an inclination angle of θ_S (recommend 45°). Place the LMD normal to the center of the DUT (see Figure 2). The measurement area covers no less than 500 pixels and measurement field angle is 2° or less.

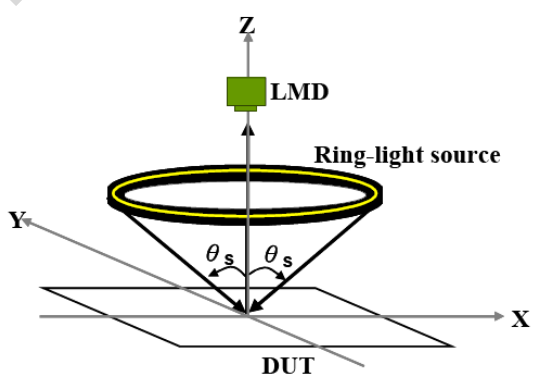

Figure 2
Ring-light Illumination Measurement Geometry

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