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INTERNATIONAL STANDARD

colour inside

Electronic displays –
Part 3-9: Evaluation of optical performance – Display sparkle contrast

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ELECTRONIC DISPLAYS –

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

Draft	Report on voting
110/1515/FDIS	110/1525/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.

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ELECTRONIC DISPLAYS –

Part 3-9: Evaluation of optical performance – Display sparkle contrast

1 Scope

This part of IEC 62977 specifies standard measurement conditions and methods for determining the sparkle contrast of direct-view displays which comprise display matrix elements to render real 2D images on a flat panel and an anti-glare layer. This document excludes measurement of sparkle, which is intentionally obtained by the specular reflection from reflecting flakes in coatings and paints.

2 Normative references

There are no normative references in this document.

3 Terms, definitions, abbreviated terms and letter symbols

For the purposes of this document, the following terms and definitions apply.

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

- IEC Electropedia: available at https://www.electropedia.org/
- ISO Online browsing platform: available at https://www.iso.org/obp

3.1 Terms and definitions

3.1.1
sparkle
visual phenomenon that becomes obvious as a random pattern extending across the display area formed by a distribution of tiny patches (granules, dots) with varying luminance and chromaticity (depending on the test pattern shown on the display) through the anti-glare layer of the display, resulting in a visually disturbing pattern that is distinctly changing with viewing direction

Note 1 to entry: In other fields, the term “sparkle” can refer to reflections from reflecting particles in effect coatings [1].

Note 2 to entry: Sparkle looks like “speckle” [2] in the field of laser displays (coherent or partially coherent light), however sparkle and speckle are different because the origins of both phenomena are quite different.

3.1.2
sparkle pattern
radiance distribution of sparkle

Note 1 to entry: The sparkle pattern can contain (1) periodic modulations caused by the display pixel matrix, (2) non-periodic effects caused by, for example, pixel defects, and (3) low-frequency radiance variations caused by non-uniformities of the backlight unit.

3.1.3
sparkle contrast
S_P
quotient of the standard deviation of the radiance variation of the sparkle pattern in the measurement field divided by its mean (average) value

3.1.4
anti-glare layer
AGL
scattering layer for the suppression of distinct (mirror) images of ambient light sources reflected by smooth polished (display) surfaces

3.1.5
image sampling ratio
ISR
ratio of the pitch of display matrix elements multiplied by the magnification of the imaging lens to the pitch of the elements of the detector array

Note 1 to entry: For the details, see Annex A.

Note 2 to entry: The display matrix element refers to a physical sub-pixel in the display products. In the display mock-up, it means a fundamental element partitioned by the black matrix.

3.2 Abbreviated terms

A/D analog/digital
AGL anti-glare layer
CCD charge coupled device
CMOS complementary metal oxide semiconductor
DUT device under test
ISR image sampling ratio
LMD light measuring device
MWA moving window averaging
MTF modulation transfer function
PPD pixel power deviation

3.3 Letter symbols

The letter symbols are shown in Table 1.

Table 1 – Letter symbols (quantity symbols and units)

Quantities	Symbols and units	
Fundamental frequency of the periodic modulation of the display matrix image	f_0	(lp/mm)
Measurement distance	L	(mm)
F-number (infinity)	$F\#$	(-)
Effective F-number	$F\#_E$	(-)
Focal length	f	(mm)
Image distance	Z_L	(mm)
Optical magnification	m	(-)
Image sampling ratio (ISR)	R_S	(-)
Diameter of the airy disk of the LMD lens as projected on the DUT	S	(µm)

Quantities	Symbols and units	
Pitch of the image of the display matrix elements	P_D	(µm)
Dominant wavelength of the primary colour of the display	λ	(µm)
Standard deviation of the radiance variation of the sparkle pattern	σ	(W/sr/m^2)
Mean radiance of the sparkle pattern	μ	(W/sr/m^2)
Sparkle contrast	S_P	(-)
Radiance matrix representing the image of the DUT	$L(x, y)$	(-)
Square convolution kernel	$K(s, t)$	(-)
Radiance matrix representing the filtered DUT image	$L^*(x, y)$	(-)
Variables used during convolution	s, t	(-)
Number of LMD pixels in the square kernel per side given by the square of the closest odd integer	k	(-)
Sum of all weights used in the convolution matrix	S_W	(-)
Standard deviation of the radiance variation of the sparkle pattern from the image 1 which is used for the difference image method	σ_1	(W/sr/m^2)
Standard deviation of the radiance variation of the sparkle pattern from the image 2 which is used for the difference image method	σ_2	(W/sr/m^2)
Standard deviation of the radiance variation of the difference image	σ_{diff}	(W/sr/m^2)
Average background radiance used for the PPD calculation	bg	(W/sr/m^2)
Average sample radiance within the pixel bin with coordinates i and j, which is used for the PPD calculation	T_{ij}	(W/sr/m^2)
Average normalized sample radiance within the pixel bin with coordinates i and j, which is used for the PPD calculation	nT_{ij}	(W/sr/m^2)
Average normalized sample radiance over all element bins contained within area A, which is used for the PPD calculation	$\overline{nT_{ij}}$	(W/sr/m^2)
Average reference radiance within the element bin with coordinates i and j, which is used for the PPD calculation	R_{ij}	(W/sr/m^2)
Horizontal dimension in units of elements of area A which is used for the PPD calculation	u	(-)
Vertical dimension in units of elements of area A which is used for the PPD calculation	v	(-)
Number of segments per side used for the elimination method of the low-frequency radiance variations from the sparkle pattern	P	(-)
Number of LMD pixels per side in the segment used for the elimination method of the low-frequency radiance variations from the sparkle pattern	Q	(-)

NOTE 1 L is a distance from the DUT to the principal point of the imaging lens along with the optical axis. The principal point of the imaging lens can be determined experimentally by the method in section 17.5 of [3][1].

NOTE 2 Z_L is a distance from the principal point to the image point of the imaging lens along with the optical axis.

[1] Numbers in square brackets refer to the Bibliography.

4 Standard measurement conditions

4.1 Environmental conditions

Measurements shall be carried out under the standard environmental conditions:

– temperature: 25 °C ± 3 °C,
– relative humidity: 25 % to 85 % RH,
– atmospheric pressure: 86 kPa to 106 kPa.

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

4.2 Dark room conditions

The luminance contribution from ambient illumination reflected off the display shall be less than 1/20 of the lowest black level of the display. In the case of other dark room conditions, these shall be reported.

4.3 Warm-up time

The measurements shall be carried out after the DUT radiance and LMD are sufficiently stable. The radiance shall not vary by more than ±5 % over the entire measurement.

4.4 Measurement coordinate systems

The viewing direction is the direction under which the observer gazes at the point of interest on the device under test (DUT). During the measurement, the imaging light measurement device (LMD) simulates the observer, by aiming the LMD at the location of interest on the DUT from the viewing direction. The viewing direction is defined by two spherical angles: the angle of inclination θ (relative to the surface normal of the DUT) and the angle of rotation ϕ (also called azimuthal angle) as illustrated in Figure 1. Although the azimuthal angle is measured in the counter-clockwise direction, it is related to the directions on a clock face as follows: ϕ = 0° is the 3-o'clock direction ("right"), ϕ = 90° is the 12-o'clock direction ("top"), ϕ = 180° the 9-o'clock direction ("left") and ϕ = 270° the 6-o'clock direction ("bottom").

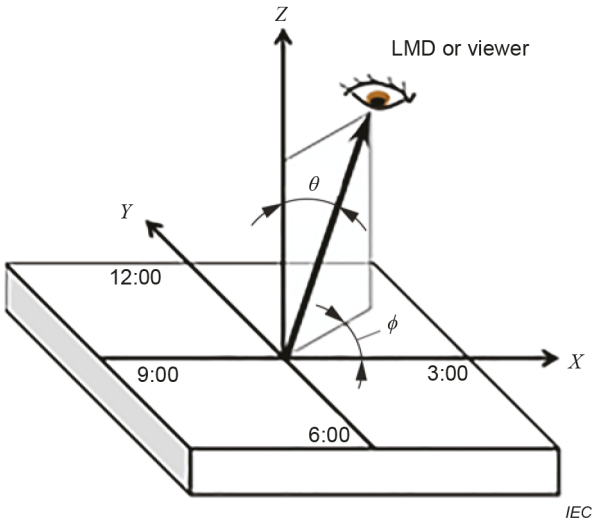

Figure 1 – Cartesian coordinate system and spherical coordinate system for the specification of the viewer's gazing (viewing) direction

4.5 Standard conditions for the measuring equipment

4.5.1 General

Measurement and evaluation of sparkle contrast can be performed during several stages of display manufacturing and use. Table 2 gives the explanation of the structure of this document, including the different measurements and their mutual relations. Combination of the display and the anti-glare layer (AGL) is the measurement subject of this document. The main body of this document only includes the typical measurement method which is commonly used for the measurements of sparkle contrast. For the cases when the image of the display matrix elements appears on the sparkle pattern, image filtering methods can be applied (see Annex B for examples of filtering methods). Annex F specifies a sparkle measurement technique that incorporates filtering after the images have been collected. Depending on the measurement conditions, the image of the display matrix elements, or moiré pattern (sampling artefact, see Annex A) can appear on the sparkle pattern. There are also cases where the image of the display matrix is not shown on the captured image because of the low modulation transfer function (MTF) condition of the imaging LMD (see Annex A).

During product development and optimization, the AGL (on a glass substrate or integrated into or applied to polymer films) is usually available as a separate component. In this case, there are two methods which can separate the random radiance variations that constitute sparkle from the low-frequency radiance variations caused by the non-uniformity of the backlight by using two different images. One is the difference image method in Annex E, the other is the pixel power deviation in Annex F. These methods are intended to investigate the performance of the AGL components under the fixed pitch of the display matrix elements. In the case where only the performance of the AGL components is investigated, a display mock-up can be used instead of intact displays. The details are introduced in Annex D.

NOTE The low-frequency radiance variations caused by the non-uniformity of the backlight can be removed by the methods in Annex G, when the DUT is an inseparable combination of the display and the AGL.

Table 2 – Distinguishing types of DUT, imaging conditions, number of involved images and methods for suppression of display matrix modulations

DUT	Imaging	Number and nature of images	suppression of display matrix modulation
Inseparable combination of display and AGL	Wide-band	Image number 1: sparkle pattern with display matrix modulation	Image filtering in spatial domain – MWA (B.2.1) Image filtering in frequency domain (B.2.2)
	Low-pass (Annex A)	Image number 1: sparkle pattern without display matrix modulation	No need for filtering applied to the image (Annex A).
Separate AGL + intact display Separate AGL + display mock-up (Annex D)	Wide-band	Image number 1: sparkle pattern with display matrix modulation	Image filtering in spatial domain – MWA (B.2.1) Image filtering in frequency domain (B.2.2)
		Image number 1: sparkle pattern with display matrix modulation Image number 2: sparkle pattern with display matrix modulation	Difference image method (Annex E) (with the methods in Annex B, if necessary)
		Image number 1: sparkle pattern with display matrix modulation Image number 2: display matrix image	PPD (Annex F)
	Low-pass (Annex A)	Image number 1: sparkle pattern without display matrix modulation	No need for filtering applied to the image (Annex A).

The configuration and the status of the components as agreed by the involved parties have to be specified in the measurement report.