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INTERNATIONAL STANDARD

colour inside

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

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FOREWORD

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

FDIS	Report on voting
110/661/FDIS	110/672/RVD

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 62906 series, published under the general title *Laser display devices*, can be found on the IEC website.

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- withdrawn,
- replaced by a revised edition, or
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LASER DISPLAY DEVICES –

Part 1-2: Vocabulary and letter symbols

1 Scope

This part of IEC 62906 gives the preferred terms, their definitions and symbols for laser display devices and relevant components with the object of using the same terminology when publications are prepared in different countries.

2 Terms, definitions, and abbreviations

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

2.1 Classification of terms

Terms for laser display devices and relevant components are classified as follows:

a) fundamental terms;

b) terms related to speckle;

c) terms related to display category;

d) terms related to optical devices;

e) terms related to light sources.

2.2 Fundamental terms

2.2.1
laser display device
LDD
display device using a laser or lasers, based on stimulated emission

2.2.2
hybrid laser display device
hybrid LDD
h-LDD
display device using both a laser or lasers and spontaneous emission-based light sources

2.3 Terms related to speckle

2.3.1
speckle
<laser display devices> irregularly aligned spatially-modulated image created by coherent or partially coherent lights as a result of interference on a sensor plane of the visual sensory system of the observer

Note 1 to entry: For a human observer, the sensor plane of the visual sensory system is the retina of the eye.

2.3.2
monochromatic speckle
speckle when the light source is monochromatic or quasi-monochromatic

2.3.3
colour speckle
speckle when the light source is multi-coloured

2.3.4
speckle pattern
illuminance distribution of speckle

2.3.5
speckle contrast ratio
speckle contrast
SCR
C_S
ratio of the illuminance standard deviation to the average of the speckle pattern in the measurement field

Note 1 to entry: See Clause A.3 for further information.

[SOURCE: J.W. GOODMAN, *Speckle Phenomena in Optics: Theory and Applications* (Roberts and Company Publishers, Colorado, 2006)]

2.3.6
signal to noise ratio
< speckle-oriented noise> inverse of the speckle contrast ratio

2.3.7
objective speckle
speckle observed by an optical sensory system without imaging optics

Note 1 to entry: See Clause A.1 for further information.

[SOURCE: M. KURASHIGE et al., *The evaluation of speckle contrast with variable speckle generator*, J. Soc. Info. Display 19/9, 631-638 (2011)]

2.3.8
subjective speckle
speckle observed by a visual sensory system with imaging optics

Note 1 to entry: See Clause A.2 for further information.

[SOURCE: M. KURASHIGE et al., *The evaluation of speckle contrast with variable speckle generator*, J. Soc. Info. Display 19/9, 631-638 (2011)]

2.3.9
projected speckle
subjective speckle arising from a projected interference pattern created by coherent or partially coherent light on a screen

Note 1 to entry: See Clause A.2 for further information.

[SOURCE: M. KURASHIGE et al., "*Classification of subjective speckle for evaluation of laser display"*, SID Symposium Digest 45, 419-422 (2014)]

2.3.10
screen speckle
subjective speckle arising from the scattering or diffusion of coherent or partially coherent light on a screen

Note 1 to entry: See A.2 for further information.

[SOURCE: M. KURASHIGE et al., "*Classification of subjective speckle for evaluation of laser display"*, SID Symposium Digest 45, 419-422 (2014)]

2.3.11
speckle grain size
spacing of interference fringes generated by coherent or partial coherent beams on a sensor plane of a visual sensory system

2.3.12
minimum objective speckle grain size
s_{obj}
minimum spacing of interference fringes which is determined by the interference of two coherent beams from the opposite edges of the illuminated area to the sensor plane

Note 1 to entry: See Clause A.1 for further information.

2.3.13
minimum subjective speckle grain size
s_{subj}
minimum spacing of interference fringes which is determined by the interference of two coherent beams from the opposite edges of the effective diameter of imaging optics to the sensor plane

Note 1 to entry: See Clause A.2 for further information.

2.4 Terms related to display category

2.4.1
raster-scanned projection
image projection (on a screen or a projection plane) by raster-scanning laser beams

2.4.2
full-frame projection
image projection (on a screen or a projection plane) by a 2D spatial light modulator

2.4.3
line-scanned projection
image projection (on a screen or a projection plane) by a combination of a 1D spatial light modulator and a 1D optical scanner

2.4.4
front projection
image projection (on a screen or a projection plane) from the same side as the observer

2.4.5
rear projection
image projection (on a screen or a projection plane) from the side opposite to that of the observer

2.4.6
retina direct projection
image projection directly on the retina

2.5 Terms related to optical devices

2.5.1
screen
projection screen
projection plane
plane on which an image is projected and observed as diffused light

2.5.2
liquid crystal on silicon
LCOS
spatial light modulator to create images, based on liquid crystal fabricated on a silicon wafer

2.5.3
digital mirror device
digital micromirror device
DMD
spatial light modulator to create images by switching a Micro Electro Mechanical Systems (MEMS) mirror array

2.6 Terms related to light sources

2.6.1
second harmonic generation laser
SHG laser
coherent or partially coherent light source of which photon energy is up-converted to twice that of the pump laser through the second harmonic generation process

3 Letter symbols (quantity symbols / unit symbols)

See Table 1.

Table 1 – Letter symbols

C_s	Speckle contrast ratio
s_{obj}	Minimum objective speckle grain size (m)
s_{subj}	Minimum subjective speckle grain size (m)

Annex A
(informative)

Categorization of speckle and speckle contrast ratio

A.1 Objective speckle

Objective speckle is recognized as a speckle pattern on a sensor plane without any imaging optics. Figure A.1 shows an optical configuration for explaining objective speckle and its sensing method. In this case, a sensor array is simply set at the sensor plane.

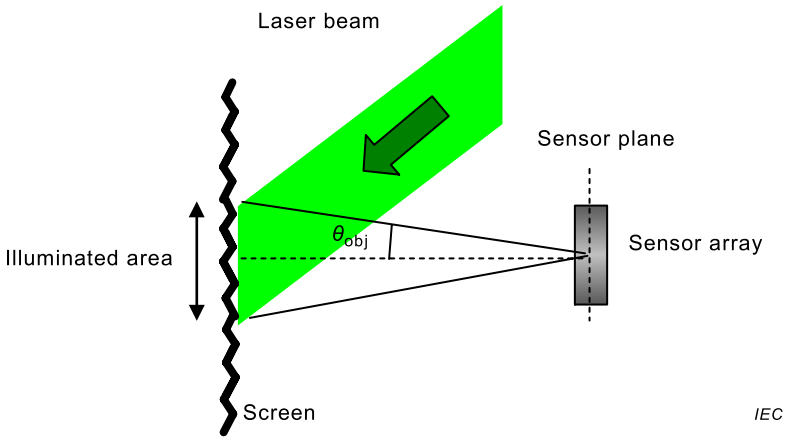

Figure A.1 – Optical configuration to observe objective speckle

The structure of objective speckle depends on the surface state of the screen, the illuminated area on the screen, and the distance between the screen and the sensor plane. Minimum objective speckle grain size s_{obj} is defined as the minimum spacing of interference fringes generated by interference of two coherent beams from the opposite edges of the illuminated area. Minimum objective speckle grain size, s_{obj} is obtained by the following equation.

$$s_{obj} = \frac{\lambda}{2\sin\theta_{obj}} \tag{A.1}$$

where

λ is the wavelength of the coherent beam;

θ_{obj} is the half-angle between two coherent beams from opposite edges of the illuminated area.

The size of the illuminated area and the distance between the sensor array and the screen should be carefully chosen to resolve the objective speckle structure sufficiently.

A.2 Subjective speckle

Subjective speckle is recognized as a speckle pattern on a sensor plane through imaging optics. An optical configuration for explaining the subjective speckle and its sensing method is shown in Figure A.2. In this case, a camera, implying an imaging system consisting of the sensor array and imaging lenses, is used as a sensing device. For simplicity, a single-lens system represents the imaging system in Figure A.2.

The minimum speckle structure depends on localized surface structure of the screen and the angular aperture of imaging lens. Therefore, minimum subjective speckle grain size s_{subj} is

defined as the minimum spacing of interference fringes which is determined by interference of two coherent beams from the opposite edges of the angular aperture. Minimum subjective speckle grain size, s_{subj} is obtained by the following equation.

$$s_{subj} = \frac{\lambda}{2\sin\theta_{subj}} \tag{A.2}$$

where

λ is the wavelength of the coherent beam;

θ_{subj} is the half-angle between two coherent beams from opposite edges of the effective diameter of the imaging lens at image space.

Unlike in the case of objective speckle, minimum subjective speckle grain size is not dependent on the illuminated area on the screen or the distance from the screen, but on angular aperture of the image space. Therefore, the aperture size, focal length of imaging lens and pixel size of the sensor array should be carefully chosen to resolve the structure of subjective speckle clearly.

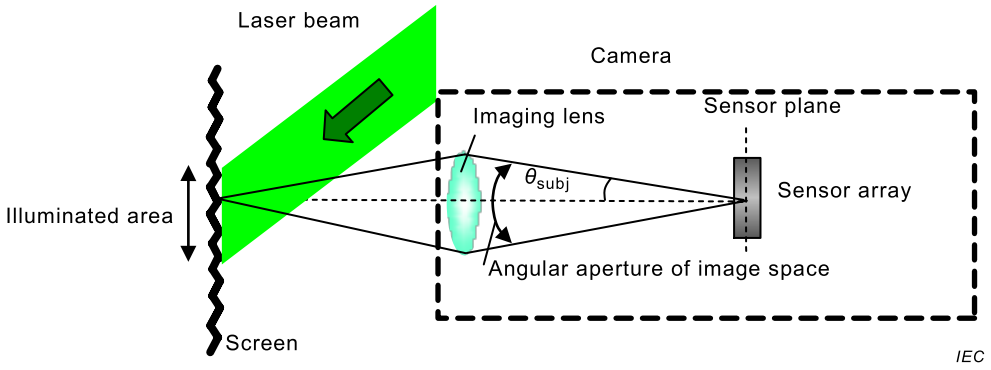

Figure A.2 – Optical configuration to observe subjective speckle

Subjective speckle is classified into two types according to its generation mechanism. Figure A.3 shows a classification map of speckle.

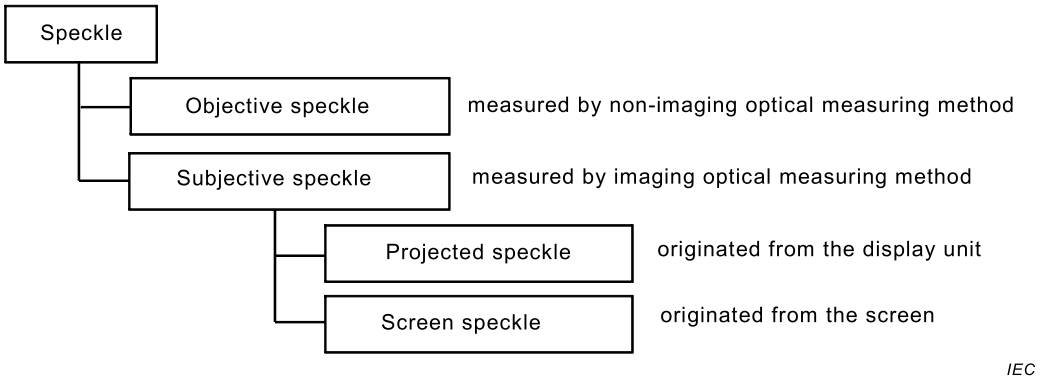

Figure A.3 – Classification map of speckle

A.3 Speckle contrast ratio

As a measurement parameter of speckle, speckle contrast ratio C_s is introduced and defined as:

$$C_S = \frac{\sigma}{\bar{I}} \tag{A.3}$$

where

σ is the standard deviation of the speckle pattern;

$\bar{I}$ is the average of the speckle pattern.

Speckle contrast ratio C_S is in general calculated using the illuminance distribution of the captured image, and applicable only to monochromatic speckle.

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[4] M. KURASHIGE et al., *Classification of subjective speckle for evaluation of laser display*, SID Symposium Digest 45, 419-422 (2014)

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