IEC 62906-5-7

Edition 1.0 2022-01

INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

Laser displays –
Part 5-7: Measuring methods of image quality affected by speckle for scanning laser displays

Affichages laser –
Partie 5-7: Méthodes de mesure de la qualité d'image affectée par la tacheture pour les affichages laser à balayage

IEC 62906-5-7:2022-01(en-fr)

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INTERNATIONAL
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LASER DISPLAYS –

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FOREWORD

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

Draft	Report on voting
110/1366/FDIS	110/1390/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.

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

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/standardsdev/publications.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under 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- withdrawn,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.

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INTRODUCTION

Beam-scanning laser displays have specific features which are quite different from full-frame (FF) laser displays using a spatial light modulator (SLM) and other electronic displays.

The image of the beam-scanning laser displays is usually projected on a planar or curved screen. Scanning laser displays that excite or pump full or patterned phosphor layers on a separate screen are excluded. The image pixels are virtually created by high-speed modulation of a scanning laser beam combining at least R, G, B primary colour beams, which is sometimes called "flying spot". Compared with displays with spatial light modulators, the image formed on the screen can have additional spatio-temporal blur and non-uniformities. Therefore, to measure the image quality projected on the screen, the dynamic scan mechanism even for still images is considered.

Furthermore, speckle greatly affects the image quality because a speckle pattern is created on the retina by interference of the coherent or partially coherent laser lights scattered on the screen. It is more difficult for the beam-scanning laser displays to reduce speckle effects than other laser displays. This is because some of the effective speckle-reducing techniques such as moving diffusers and angular compounding are not applicable to a laser beam. Therefore, the speckle more greatly affects the measurements of illuminance, chromaticity and resolution, that is, speckle effects are more dominant in that type of displays and therefore it is necessary to use light measuring equipment designed for measurements under the effect of speckle.

The speckle-affected image quality of scanning laser displays strongly depends on the optical quality of the laser beam, such as scanning speed, scanning angle, image-signal modulation, and speckle. The detail of the measuring methods of the laser beam emitted out of laser modules is specified in IEC 62595-2-4 [1][1].

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

LASER DISPLAYS –

Part 5-7: Measuring methods of image quality affected by speckle for scanning laser displays

1 Scope

This part of IEC 62906 specifies the standard measurement conditions and methods for determining the quality of images projected by a scanning laser display on a visible light fluorescence-free screen, when observed as being affected by speckle noise due to laser coherence.

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 60825-1, *Safety of laser products – Part 1: Equipment classification and requirements*

IEC 62471 (all parts), *Photobiological safety of lamps and lamp systems*

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

IEC 62906-5-4*, Laser display devices – Part 5-4: Optical measuring methods of colour speckle*

IEC 62906-5-6, *Laser displays – Part 5-6: Measuring methods for optical performance of projection screens*

3 Terms, definitions, abbreviated terms, and letter symbols

3.1 Terms and definitions

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

3.1.1
scanning laser display
laser display capable of projecting an image on a planar or curved screen by spatially scanning one or several laser beams

3.1.2
raster-scan laser display
laser display capable of projecting an image on a planar or curved screen by scanning one or several laser beams line-by-line

3.1.3
FF laser display
full-frame laser display
laser display capable of projecting an image on a screen via one or several spatial light modulators using one or several light sources including lasers

3.1.4
speckle-affected image quality
attributes of display image particularly affected by speckle, captured by human eyes, and described by spatially dependent optical properties, spatial contrast, spatial noise and its spatial distribution, each of which depends on input colours

3.1.5
speckle-affected image resolution
resolution of display image particularly affected by speckle, captured by human eyes, and described by spatially dependent optical properties, spatial contrast, spatial noise and its spatial distribution, each of which depends on input colours, measured separately for different directions

3.1.6
dynamic colour speckle
<of scanning laser display> colour speckle observed in the edge regions of an image pattern as the input signal levels of a scanning laser beam vary

3.1.7
laser multi-meter
light measuring device based on non-spectrometric methods using absorption filters with linear wavelength ramps capable of measuring centroid wavelength and optical power of laser light sources operating in single or multiple longitudinal mode, from which the tristimulus values XYZ are calculated to derive colorimetric and photometric quantities using the CIE colour-matching functions

Note 1 to entry: See [2].

3.1.8
wavelength meter
light measuring device based on the principle of interference which is used for precise wavelength measurements of laser devices

3.1.9
Fourier transform spectrometer
light measuring device based on the principle of interference in which the length of a cavity is temporally scanned, calculating the spectrum by Fourier transforming the raw data recorded in the time domain

3.2 Abbreviated terms

DUT	device under test
LD	laser diode
LMD	light measuring device
MTF	modulation transfer function
ND	neutral density
NF	noise factor
RGB	red, green, blue
RMS	root mean square
SLM	spatial light modulator

SNR signal-to-noise ratio

W white colour

3.3 Letter symbols

The letter symbols are shown in Table 1.

Table 1 – Letter symbols (quantity symbols / unit symbols)

Distance from screen to DUT	D_1	m
Distance from screen to LMD (speckle, luminance)	D_2	m
Azimuth angle	ϕ	degree
Angle between the optical axis of DUT and LMD	$\Delta\theta$	degree
Cartesian coordinate on the screen or the virtual screen	x, y, z	-
Subscript denoting primary colours, R, G, B	Q	-
Optical output power	P	W
Optical output power of primary colours	P_{Q}	W
Irradiance	E_{e}	W/m^2
Irradiance of primary colours	$E_{\mathrm{e\text{-}Q}}$	W/m^2
Illuminance	E_{v}	lm/m^2
Illuminance of primary colours	$E_{\mathrm{v\text{-}Q}}$	lm/m^2
Radiance of primary colours	L_{Q}	W/sr/m^2
Wavelength	λ	nm
Wavelength of primary colours	λ_{Q}	nm
Centroid wavelength	λ_{c}	nm
Reference wavelength	λ_{r}	nm
Wavelength difference	δ	nm
CIE tristimulus values	X, Y, Z	-
CIE colour matching functions	$\bar{x}(\lambda),\ \bar{y}(\lambda),\ \bar{z}(\lambda),$	-
CIE 1931 coordinates	x, y	-
CIE 1976 coordinates	u', v'	-
Root mean square of illuminance	$E_{\mathrm{v\text{-}rms}}$	lm/m^2
Monochromatic speckle contrast of primary colours	$C_{\mathrm{s\text{-}Q}}$	-
Photometric speckle contrast	C_{ps}	-
Contrast modulation, grille-pattern luminance contrast for the conventional displays	C_{M}	-
Contrast modulation, grille-pattern contrast (average)	$C_{\mathrm{M\text{-}ave}}$	-
Contrast modulation, grille-pattern contrast (speckled)	$C_{\mathrm{M\text{-}speckle}}$	-
Illuminance along a line at local maximum or local minimum used in the calculation of $C_{\mathrm{M\text{-}speckle}}$	$E_{\mathrm{v\text{-}H}}, E_{\mathrm{v\text{-}L}}$	lm/m^2
Average illuminance along a line at local maximum or local minimum used in the calculation of $C_{\mathrm{M\text{-}speckle}}$	$\bar{E}_{\mathrm{v\text{-}H}}, \bar{E}_{\mathrm{v\text{-}L}}$	lm/m^2
Luminance along a line at local maximum or local minimum used in the calculation of C_{M}	$L_{\mathrm{H}}, L_{\mathrm{L}}$	lm
Nonuniformity	NU	%

Uniformity	U	%
Maximum or minimum illuminance of the thirteen windows for nonuniformity measurement	$E_{\text{v-max}}$ $E_{\text{v-min}}$	lm/m^2
CIE 1976 chromaticity difference	$\Delta u' v'$	-
Maximum of chromaticity difference of the thirteen windows for nonuniformity measurement	$(\Delta u' v')_{\text{max}}$	-

4 Standard measuring conditions

4.1 General

Unless stated otherwise, the following conditions shall be applied.

Measurements shall be performed according to the laser safety regulation in IEC 60825-1 for the products classified above Class 2M, and/or IEC 62471 (all parts) for RG2 and RG3.

4.2 Standard measuring environmental conditions

Measurements shall be carried out under the standard environmental conditions:

- temperature: 25 °C ± 3 °C
- relative humidity: 25 % to 85 %
- pressure: 86 kPa to 106 kPa

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

4.3 Standard measuring dark-room conditions

The background illuminance of the standard dark room shall be less than 0,01 lx.

NOTE The maximum illuminance depends on the direction of the LMD.

4.4 Standard DUT conditions

Measurements shall be started after the DUT achieves stability, keeping the same operating mode. The operating mode of the DUT shall be noted in the report. The stability shall be achieved when the output power of the DUT varies within ±3 % over the entire measurement timeframe.

4.5 Standard LMD requirements

The LMD performance shall be as follows:

a) optical power meter
   - accuracy: ±5 %
   - spectral range: covering at least the R, G, B laser wavelengths

b) spectral irradiance meter
   - wavelength accuracy: ±0,3 nm
   - spectral range: covering at least the R, G, B laser wavelengths
   - spectral bandwidth: ≤ 5 nm

c) spectral radiance meter
   – wavelength accuracy: ±0,3 nm
   – spectral range: covering at least the R, G, B laser wavelengths
   – spectral bandwidth: ≤ 5 nm
d) filter-based illuminance meter
   – calibrated by the spectroradiometer

NOTE 1 It is used for the setup in Figure 1.

e) filter-based luminance meter
   – calibrated by the spectroradiometer

NOTE 2 It is used for the setup in Figure 2 or Figure 3.

f) filter-based colorimeter
   – calibrated by the spectroradiometer
g) wavelength meter
   – spectral range: covering at least the R, G, B laser wavelengths
   – wavelength accuracy: ±0,3 nm
h) laser multi-meter
   – calibrated by the spectroradiometer
   – wavelength range: covering the R, G, B laser wavelengths
   – wavelength accuracy: ±0,3 nm
i) spectroradiometer
   – spectral range: covering at least the R, G, B laser wavelengths
   – wavelength accuracy: ±0,3 nm
   – spectral bandwidth: ≤ 5 nm
   – spectral stray light inside: shall be corrected

NOTE 3 For calibrating array spectroradiometers, see [3], [4].

j) Fourier transform spectrometer
   – spectral range: covering at least the R, G, B laser wavelengths
   – wavelength accuracy: ±0,3 nm
   – spectral bandwidth: ≤ 1 nm
k) optical spectrum analyzer
   – wavelength range: covering at least the R, G, B laser wavelengths
   – wavelength accuracy: ±0,3 nm
   – spectral bandwidth: ≤ 0,1 nm

NOTE 4 The optical spectrum analyzer is used particularly for precisely analysing the spectral structure of the longitudinal modes of the laser devices.

l) speckle measurement equipment (speckle meter)
   – fundamental requirements shall be compliant with IEC 62906-5-2 and IEC 62906-5-4
   – wavelength range: covering at least the R, G, B laser wavelengths
   – synchronised with the frame refresh signal of the DUT to avoid the measurement errors due to an unfinished frame scan

NOTE 5 The R, G, B speckle patterns are obtained using calibrated R, G, B filters. When the XYZ filters are used, more careful calibration is done.

The LMDs shall have sufficient sensitivity and dynamic range to obtain accurate measurement results. That is, the LMD shall be capable of measuring accurately up to the absolute maximum rating of the DUT. However, a calibrated ND filter or other calibrated optics shall be used if the LMD is saturated by a too large optical output of the DUT.

When an LMD with a different performance is used, its specifications shall be noted in the report.

The optical filters used in the LMDs shall be calibrated appropriately.

The laser emission spectra are very narrow, and their chromaticity coordinates are almost on the wavelength locus of the chromaticity diagrams. Therefore, the chromaticity accuracy is sensitive to wavelength. The curvature of the wavelength locus at the laser wavelength greatly affects the chromaticity accuracy. The wavelength accuracy of ±0,3 nm specified in b), c), g), h), i), j) and k) above is a practical value mostly common to the conventional display measurements. To keep a specific value of chromaticity accuracy at a specific wavelength, the wavelength accuracy shall be evaluated [1]. Examples of the wavelength accuracy curves for various visible wavelengths are shown in Annex A.

4.6 Screen requirements

For the measurements using a full-size screen, a small screen or small screens, the screen materials shall be the Lambertian diffuse reflectance surface white standard. They shall be mechanically fixed in order to prevent blur or speckle reduction effect caused by unintentional movement. The screen shall have Lambertian diffusive reflectance values over 98 % and under 102 % at least for the RGB wavelengths. Otherwise, the screen specifications related to screen gain such as viewing angle characteristic, peak gain, half-gain angle, and so on shall be reported (see IEC 62906-5-6). The projection distance from the DUT to the screen, the projection direction, viewing mode, height, and tilted angle of the setup shall be also reported (see Figure 3).

NOTE The scattering properties and the spectral reflectance of the screen will affect the measurement results.

5 Standard measurement setup and coordinate system

5.1 Direct measurement setup

The fundamental properties of the DUT, such as R, G, B wavelengths/spectra, R, G, B irradiance, R, G, B illuminance, the illuminance and chromaticity of the RGB colours, and their non-uniformity, shall be accurately measured, unaffected by the screen and speckle behaviours, which means speckle and resolution shall not be measured directly. In this method, the above items can be measured by setting an LMD at one of the positions on a virtual screen where the screen measurements are supposed to be carried out. The LMD may be moved along the virtual screen from one position to another.

The setup, including the coordinate system for the direct measurements, is shown in Figure 1. The projection axis of the DUT is assumed to coincide with the z-axis normal to the centre of the projection area on the virtual screen (the origin of the x-y plane). If the projection axis is tilted against the virtual screen and the projection area is calibrated, the tilt angle β shall be added to Figure 1, as in IEC 62906-5-6. If the virtual screen is curved and the projection area is calibrated, the curvature shall be added to Figure 1. The LMD shall have an aperture larger than the incident beam diameter. Multiple LMDs may be prepared and set at every measurement position for simultaneous measurements as an alternative setup. In this case, all the LMDs shall be calibrated to minimize instrumental error.

5.2 Diffuse reflectance standard measurement

An alternative setup including the coordinate system for measuring R, G, B wavelengths/spectra, R, G, B radiance, monochromatic/colour speckle or their nonuniformity using a small diffuse reflectance white standard is shown in Figure 2. The small diffuse reflectance white standard specified in 4.6 shall be used and set firmly at one of the positions on the virtual screen. The small diffuse reflectance standard may be moved along the virtual screen from one position to another, or multiple small diffuse reflectance standards may be prepared and set at every position. The setup in Figure 2 may also be used instead of the full-screen measurement in Figure 3 if the full-size standard diffuse reflectance white screen is not available nor cost-effective.

The measured radiance values at the small diffuse reflectance shall be converted into irradiance. The radiance shall be measured normal to the diffuse reflectance standard. However, the DUT sometimes comes into the LMD field of view, or the LMD sometimes makes its shadow in the projection area because the DUT and the LMD are set on the same side. To avoid this problem, the angle of the LMD may be set slightly apart from the optical axis of the DUT, usually normal to the virtual screen. The angular difference between them is denoted by $\Delta\theta$ in Figure 2. It shall be kept small to have a negligibly small error in radiance measurement, or the measured radiance value shall be calibrated. The coherent or partially coherent light diffused on the reflectance standard causes speckle. Therefore, the reproducibility of the radiance measurement shall be confirmed. For speckle measurement, the size of the small diffuse reflectance or the area for measuring speckle contrast shall be optimized considering the captured 2D data size of the speckle measurement equipment or the number of measurement repetitions, as in the statistical error analysis in IEC 62906-5-4.

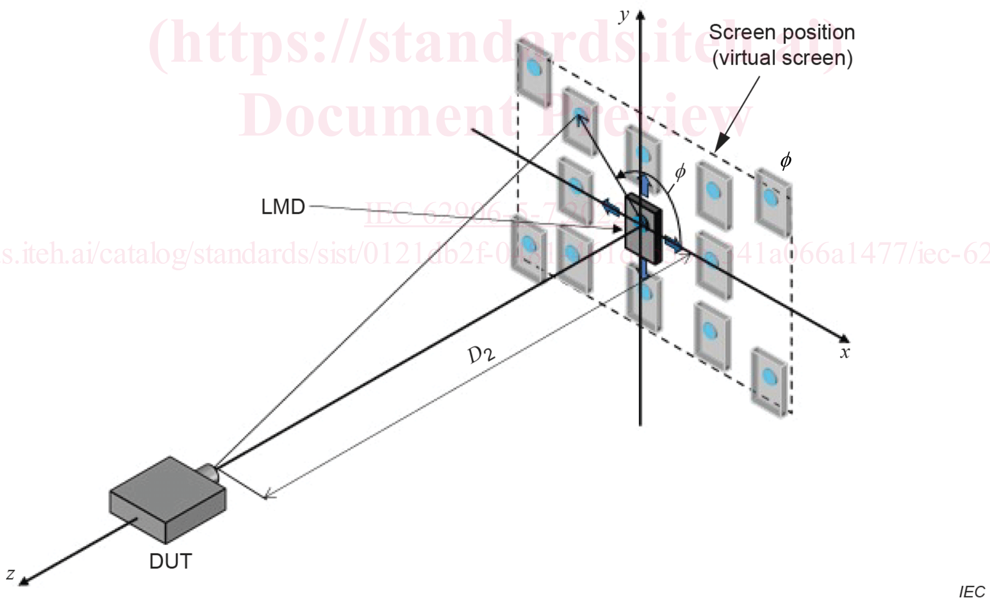

Figure 1 – Setup and coordinate system of direct illuminance measurements