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INTERNATIONAL STANDARD

colour inside

Display lighting unit –
Part 2-4: Electro-optical measuring methods of laser module

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FOREWORD

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International Standard IEC 62595-2-4 has been prepared by IEC technical committee 110: Electronic displays.

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

FDIS	Report on voting
110/1224/FDIS	110/1246/RVD

Full information on the voting for the approval of this International Standard 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 62595 series, published under the general title *Display lighting unit*, 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- withdrawn,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.

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INTRODUCTION

Laser modules, in general, have been used widely for various applications such as, optical communications, laser beam machining, bar-code reading, optical disc drives and so on. The laser module in this document is limited to display applications. It is a key light source for laser displays, laser backlight/front light units for liquid crystal displays (LCDs), holographic displays and so on. A typical laser module for display applications comprises multiple laser devices, electrical inputs and an optical output combining the outputs of the laser diodes (LDs). The laser device used in the laser module here is an edge-emitting laser diode (LD), a vertical cavity surface-emitting laser diode (VCSEL), or a photon up-conversion laser including second-harmonic generation (SHG).

The optical output is usually provided out of an optical component such as a pigtail fibre, a fibre with a connector, a waveguide, a light guide, or a lens unit for the convenience of users.

In advanced display applications, not only visible laser diodes but also near infrared (near IR) laser diodes are included in the module for sensor applications such as the LiDAR system (light detection and ranging, or laser image detection and ranging).

Therefore, the wavelength range for display applications covers all the visible wavelengths from 380 nm to 780 nm, including the laser diodes for pumping phosphors. That is, a violet laser diode emitting at 405 nm is included. Photometric and colorimetric measurements are the primary focus of this document. The near IR LD for a LiDAR system included in the module can be measured as a monochromatic light output using the light measuring device (LMD) covering the IR wavelength region. However, the measurements of IR lasers are out of the scope of this document.

It is important for the designing of the above display systems and devices to standardise the electro-optical measuring methods of the laser modules. Photometric and colorimetric measurements are particularly important for display applications because each LD has different electrical and optical performances, such as threshold currents, efficiency, spectrum, far field pattern (FFP) of the output laser beam, speckle-related behaviours and their temperature dependence.

Particularly for the colour speckle of the output laser beam, the measured speckle data are very useful to predict the visual quality of laser displays and to design speckle reducing devices.

DISPLAY LIGHTING UNIT –

Part 2-4: Electro-optical measuring methods of laser module

1 Scope

This part of IEC 62595 specifies the electro-optical measuring methods of laser modules with multiple laser devices and an optical output for various displays and display lighting applications which require photometric and colorimetric measurements, covering the wavelength range of 380 nm to 780 nm. The module has multiple laser devices such as edge-emitting laser diodes (LDs), vertical cavity surface-emitting laser diodes (VCSELs), or photon up-conversion laser devices including second-harmonic generation (SHG). The module has an optical output such as an optical fibre, waveguide, light guide, lens unit, or other optics, emitting a laser beam combining the output of the multiple laser devices.

NOTE See 3.1.1 for a definition of a laser device inside the laser module.

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 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*

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
laser device
<of display lighting unit> semiconductor-based or compactly assembled solid-state up-conversion laser

EXAMPLE Edge-emitting laser diode, vertical cavity surface-emitting laser diode, or photon up-conversion laser including second-harmonic generation (SHG), or third-harmonic generation (THG).

Note 1 to entry: See Annex A.

3.1.2
laser module
<of display lighting unit> display light source with an optical output combining the emitted lights of multiple laser devices

3.1.3
monochromatic laser module
<of display lighting unit> display light source with an optical output combining the emitted lights of multiple laser devices within the wavelength range of 10 nm

Note 1 to entry: See Figure B.1 in Annex B.

3.1.4
multi-colour laser module
<of display lighting unit> display light source with an optical output combining the emitted lights of multiple laser devices emitting at different monochromatic wavelengths

3.1.5
RGB laser module
<of display lighting unit> display light source with an optical output combining the emitted lights of red, green, blue monochromatic laser devices

Note 1 to entry: See Figure B.2 and Figure B.3 in Annex B.

3.1.6
laser display
display using a laser or lasers, based on stimulated emission

Note 1 to entry: This term is specified as "laser display device (LDD)" in IEC 62906-1-2. However, the term "laser display" covers more widely and appropriately than "laser display device".

3.1.7
fibre output power
<of laser module> optical output power of the optical fibre facet equipped with the laser module

3.1.8
wall-plug efficiency
WPE
<of laser module> power efficiency of the optical output power by the electrical input power of the laser module

3.1.9
threshold current
<of laser module> current input level of a laser module at which an optical output of the laser module, combining the emitted lights of multiple laser devices, starts laser oscillation

3.1.10
near field pattern
NFP
<of laser module> output power distribution on the output aperture of the laser module

3.1.11
far field pattern
FFP
monochromatic FFP
<of laser module> output power distribution measured on the plane at a distance which is significantly greater than W^2 / λ, where λ is the wavelength and W is the largest dimension in the output aperture

3.1.12
colorimetric far field pattern
colorimetric FFP
colour FFP
<of laser module> output chromaticity distribution measured on the plane at a distance which is significantly greater than W^2 / λ, where λ is the wavelength and W is the largest dimension in the output aperture

3.1.13
XYZ filters, pl.
set of optical filters which will produce an optical measuring device that approximately has the spectral responsivity of colour matching functions $\bar{x}, \bar{y}, \bar{z}$ in the CIE 1931 standard colorimetric system when used together with the intended lens, sensors, and other components

3.1.14
laser multi-meter
light measuring device for measuring centroid wavelengths and radiometric quantities of laser light sources with very narrow spectral linewidths using non-spectrometric methods, also deriving colorimetric and photometric quantities using the colour-matching functions

Note 1 to entry: See [1][1].

3.2 Abbreviated terms and letter symbols

3.2.1 Abbreviated terms

ACC	automatic current control
APC	automatic power control
BW	bandwidth
CW	continuous wave
DBR	distributed Bragg reflector
DUT	device under test
FFP	far field pattern
FWHM	full width at half maximum
IR	infrared
LCD	liquid crystal display
LD	laser diode
LiDAR	light detection and ranging (or laser image detection and ranging)
LMD	light-measuring device
MMF	multi-mode fibre
MTF	modulation transfer function
NA	numerical aperture
ND	neutral density
NFP	near field pattern
NRZ	non-return-to-zero
PCB	printed circuit board
PD	photodiode

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

PPG pulse pattern generator
PRBS pseudo-random binary (or bit) sequence
PWM pulse width modulation
QPM quasi-phase-matching
RGB red, green, blue
RMS root mean square
RT room temperature
SHG second harmonic generation
SLM spatial light modulator
SMF single-mode fibre
SHG second-harmonic generation
TE transverse electric
TEC Thermo-electric cooler
THG third harmonic generation
TM transverse magnetic
VCSEL vertical cavity surface-emitting laser diode
WPE wall-plug efficiency

3.2.2 Letter symbols

The letter symbols for a laser module are shown in Table 1.

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

Definition	Symbol	Unit
Electrical		
Current	I	A
Threshold current	I_{th}	A
Voltage	V	V
Input electrical power	IV, P_i	W

Definition	Symbol	Unit
Optical output		
Optical output power	P_o	W
Output of red power	P_R	W
Output of green power	P_G	W
Output of blue power	P_B	W
Wall-plug efficiency optical output (W) / electrical input (W)	P_o / P_i	-
Slope efficiency	η_s	W/A
Size of output aperture	W	nm
Wavelength	λ	nm
Centroid wavelength	λ_c	nm
Peak wavelength	λ_p	nm
Spectral power density	$S(\lambda)$	W/nm
CIE 1931 chromaticity	x, y	-
CIE 1976 chromaticity	u', v'	-
Rise/fall time of output waveform	t_r, t_f	s
Delay time of output waveform	t_d	s
Period of output waveform	T	s
Direct measurement setup		
Distance from DUT output to measurement plane along z	L	m
Azimuth angle	ϕ	degree
Zenith angle	θ	degree
Screen measurement setup (speckle measurement)		
Distance from DUT output to screen centre	L_s	m
Distance from LMD to screen centre	D_s	m
Angle between LMD and DUT	θ_s	degree
Speckle		
Speckle contrast	C_s	-
Speckle contrast for red colour	$C_{s\text{-}R}$	-
Speckle contrast for green colour	$C_{s\text{-}G}$	-
Speckle contrast for blue colour	$C_{s\text{-}B}$	-
Photometric speckle contrast	C_{ps}	-
u'-variance of CIE 1976 chromaticity distribution of colour speckle	$\sigma_{u'}$	-
v'-variance of CIE 1976 chromaticity distribution of colour speckle	$\sigma_{v'}$	-
Covariance of CIE 1976 chromaticity distribution of colour speckle	$\mu_{u'v}$	-