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INTERNATIONAL STANDARD

NORME INTERNATIONALE

Fibre optic active components and devices – Performance standards – Part 7: 1 310-nm discrete vertical cavity surface emitting laser devices

Composants et dispositifs actifs à fibres optiques – Norme de performance – Partie 7: Dispositifs discrets à laser 1 310 nm émettant en surface

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

FIBRE OPTIC ACTIVE COMPONENTS AND DEVICES – PERFORMANCE STANDARDS –

Part 7: 1 310-nm discrete vertical cavity surface emitting laser devices

FOREWORD

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International Standard IEC 62149-7 has been prepared by subcommittee 86C: Fibre optic systems and active devices, of IEC technical committee 86: Fibre optics.

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

CDV	Report on voting
86C/1021/CDV	86C/1047/RVC

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 the parts in the IEC 62149 series, published under the general title *Fibre optic active components and devices – Performance standards*, can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

INTRODUCTION

Fibre optic laser devices are used to convert electrical signals into optical signals. This part of IEC 62149 covers the performance specification for 1 310 nm discrete vertical cavity surface emitting laser devices in fibre optic telecommunication and optical data transmission applications.

FIBRE OPTIC ACTIVE COMPONENTS AND DEVICES – PERFORMANCE STANDARDS –

Part 7: 1 310-nm discrete vertical cavity surface emitting laser devices

1 Scope

This part of IEC 62149 covers the performance specification for 1 310-nm discrete vertical cavity surface emitting laser (VCSEL) devices of transverse single-mode and multimode types used for the fibre optic telecommunication and optical data transmission application in a form of the VCSEL chips mounted on a substrate with wire bonding to their chips' anode and cathode terminals without any fibre pigtails. The performance standard contains a definition of the product performance requirements together with a series of sets of tests and measurements with clearly defined conditions, severities, and pass/fail criteria. The tests are intended to be run on a "one-off" basis to prove any product's ability to satisfy the performance standard's requirements.

A product that has been shown to meet all the requirements of a performance standard can be declared as complying with the performance standard, but should then be controlled by a quality assurance/quality conformance program.

Depending on the signalling speed and application areas, subcategorized specifications of the 1 310-nm discrete VCSEL are defined as shown in Table 1.

Table 1 – Subcategorized specifications of the 1 310-nm discrete VCSEL

	1,0625 GBd	1,25 GBd	2,125 GBd	3,125 GBd	4,25 GBd	8,5 GBd	10 GBd[a]	16 GBd	25,78125 GBd
Fibre Channel	FC1GB		FC2GB		FC4GB	FC8GB		FC16GB[b]	
Ethernet		E1A1a E1A1b E1B		E3A1a E3A1b E10BLX4			E10BLR E10BLW E40BLR4		E25B[c]
NOTE Bd is baud rate; A1a is 50 μm core multimode fibre; A1b is 62, 5 μm core multimode fibre; B is single-mode fibre; LR is 10 G LAN; LW is 10 G WAN; LR4 is 40 G WDM. (Refer to IEC 60793-2, IEEE 802.3-2002, INCITS 450-2009, INCITS/Project 2118-D/Rev1.00-2008.09.25, IEEE 802.3-2005, and IEEE P802.3ba-2009.)									
[a] Nominal signal rate of 10 G Ethernet is 10,312 5 GBd for E10BLR and E40BLR4 and 9,953 28 GBd for E10BLW. [b, c] VCSEL specifications for signalling rates of 16 GBd, 25,781 25 GBd and above are left for future works.									

Each subcategorized specification is also defined by separate details depending on the device types, such as specifications for a VCSEL device without a monitor photodiode (Case a) and for a VCSEL device with a monitor photodiode (Case b).

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60749 (all parts), *Semiconductor devise – Mechanical and climate test methods*

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

IEC 60950-1, *Information technology equipment – Safety – Part 1: General requirements*

IEC 61300-2-4, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 2-4: Tests – Fibre/cable retention*

IEC 61300-2-19, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 2-19: Tests – Damp heat (steady state)*

IEC 61300-2-48, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 2-48: Tests – Temperature-humidity cycling*

IEC 62148-15, *Fibre optic active components and devices – Package and interface standards – Part 15: Discrete vertical cavity surface emitting laser packages*

IEC Guide 107: 1998, *Electromagnetic compatibility – Guide to the drafting of electromagnetic compatibility publications*

3 Terms, definitions, symbols and abbreviated terms

NOTE Terminology concerning the physical concepts, the types of devices, the general terms, and that related to ratings and characteristics of semiconductor devices can be found in IEC 60747-5-1. In addition, the definition for the essential ratings and characteristics of the semiconductor optoelectronic devices for fibre optic system applications can be found in IEC 62007-1.

3.1 Terms and definitions

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

NOTE The following terms are defined for the specific characteristics of vertical cavity surface emitting laser devices.

3.1.1
modulation speed
digital modulation speed with an optimum modulation amplitude between the operating current and threshold current level

3.1.2
multimode
cross-section transverse mode of the laser beam profile with mode number greater than one

Note 1 to entry: This means that the intensity profile has more than one spot, compared to the single-mode which corresponds to the cross-section transverse mode of the laser beam profile with mode number of one having the intensity profile of one circular spot.

3.1.3
laser wavelength
peak central laser wavelength of the vertical cavity surface emitting laser device when it is operated at the normal operating conditions which is specified in the sectional specification of the VCSEL

3.1.4
submount
substrate upon which a laser is mounted for assembly into the further packaging

3.1.5
transverse mode
cross-sectional profile of the optical beam intensity at the laser output of the VCSEL

Note 1 to entry: Depending on the mode status between multimode and single-mode, the package type of the VCSEL devices is also defined.

3.1.6
VCSEL device with a monitor photodiode
VCSEL packaged device with a monitor photodiode

3.1.7
VCSEL device without a monitor photodiode
VCSEL packaged device without a monitor photodiode

3.2 Symbols and abbreviated terms

λ_p	peak laser wavelength
I_{th}	threshold current
V_{th}	threshold voltage
I_{op}	operating current
V_f	forward voltage at operating current
R_s	series resistance
η	slope efficiency
P_o	continuous laser output power (at connector output or pigtailed fibre output for packaged types)
$\Delta\lambda_T/\Delta T$	wavelength change over temperature
θ	beam divergence at 1/e² intensity
t_r/t_f	rise and fall time from 20 % to 80 % of the peak intensity
C	capacitance of the VCSEL chip
$\Delta\lambda$	spectral width, RMS (at static condition) for multimode VCSELS, -20 dB for single-mode VCSELs
RIN	relative intensity noise
$\Delta R_S/\Delta T$	series resistance temperature coefficient

4 Product parameters

4.1 Absolute limiting ratings

Absolute limiting (maximum and/or minimum) ratings imply that no catastrophic damage will occur if the product is subject to these ratings for short periods, provided each limiting parameter is in isolation and all other parameters have values within the normal performance parameters. It should not be assumed that limiting value of more than one parameter can be applied at any one time. The absolute maximum ratings of the subcategorized types, E1, E3, E10, E40 BLR4, FC1GB, FC2GB, FC4GB and FC8GB for signalling speeds are listed in Annexes A through D, depending on the transverse mode of the VCSELs between multimode and single-mode and on the monitor photodiode packaged together or unpackaged.

4.2 Operating environment

The operating environment of all the subcategorized types of the 1 310 nm VCSEL is specified in Table 2.

Table 2 – Operating environment

Parameter	Symbol	Value		Unit
		Minimum	Maximum	
Operating temperature	T_{op}	-40	+85	°C

4.3 Functional specification

Functional specifications of all the subcategorized types, E1, E3, E10, E40BLR4, FC1GB, FC2GB, FC4GB, and FC8GB, for signalling speeds and application areas are listed in Annexes A through D depending on the transverse mode of the VCSELs between multimode and single-mode and on the monitor photodiode packaged together or unpackaged.

4.4 Diagrams

Diagrams of all the VCSEL device types are included in Annexes A through D.

5 Testing

5.1 General

Initial characterisation and qualification shall be undertaken when a build standard has been completed and frozen. Qualification maintenance is carried using periodic testing programs. Test conditions for all tests unless otherwise stated are 25 °C ± 2 °C.

5.2 Characterization testing

Characterisation shall be carried out on at least 20 products taken from at least three different manufacturing lots. The characteristics and conditions of laser diode are tested at the operating temperature and the operating current to satisfy the functional specifications defined in 4.3.

5.3 Performance testing

Performance testing is undertaken when characterization testing is complete. The performance test plan and recommended performance test failure criteria are specified in Annexes A through D, depending on the device types.

6 Environmental specifications

6.1 General safety

All products meeting this standard shall conform to IEC 60950-1.

6.2 Laser safety

Fibre optic transmitter and transceiver using the laser diode specified in this document shall be class 3R laser certified under any condition of operation. This includes single fault conditions whether coupled into a fibre or out of an open bore. Fibre optic transmitter and transceiver using the laser diode specified in this document shall be certified to be in conformance with IEC 60825-1.

Laser safety standards and regulations require that the manufacturer of a laser product provide information about the product's laser, safety features, labelling, use, maintenance and service. This documentation shall explicitly define requirements and usage restrictions on the host system necessary to meet these safety certifications.

6.3 Electromagnetic compatibility (EMC) requirements

Products defined in this specification shall comply with suitable requirements for electromagnetic compatibility (in terms of both, emission and immunity), depending on particular usage/environment in which they are intended to be installed or integrated. Guidance to the drafting of such EMC requirements is provided in IEC Guide 107. Guidance for electrostatic discharge (ESD) is still under study.

Annex A
(normative)

Specifications for multimode 1 310-nm VCSEL device without a monitor photodiode (Case a)

A.1 Absolute limiting ratings

Absolute limiting (maximum and/or minimum) ratings imply that no catastrophic damage will occur if the product is subject to these ratings for short periods, provided each limiting parameter is in isolation and all other parameters have values within the normal performance parameters. It should not be assumed that a limiting value of more than one parameter can be applied at any one time. Absolute limiting ratings are shown in Table A.1.

Table A.1 – Absolute limiting ratings

Parameter	Symbol	Value		Unit
		Minimum	Maximum	
Storage temperature	T_{stg}	–40	+85	°C
Soldering condition	T_{sol}		260 °C, 10 s	
Laser diode				
Reverse bias voltage	V_{RB}		5	V
Continuous forward current	I_{FLD}		15	mA

A.2 Operating environment

The requirements of 4.2 shall be met.

A.3 Functional specification

Tables A.2 and A.3 contain the operating conditions for functional specifications and the functional specifications of multimode 1 310-nm VCSEL devices of signalling speeds of 1,25 GBd and 3,125 GBd without a monitor photodiode at the operating conditions.

Table A.2 – Operating conditions for functional specification

Parameter	Symbol	Value		Unit	Note
		Minimum	Maximum		
Operating forward current	I_{op}		12	mA	
Operating forward bias voltage	V_f		2,5	V	

Table A.3 – Functional specification

Parameter	Symbol	Value		Unit	Note
		Minimum	Maximum		
Laser diode					
Laser wavelength (for single channel uses)	λ_p	1 270	1 355	nm	CW, E1A1a, E1A1b
Laser wavelength (for four WDM channel uses)	λ_{p_C0}	1 269,0	1 282,4	nm	CW, E3A1a, E3A1b
	λ_{p_C1}	1 293,5	1 306,9	nm	CW, E3A1a, E3A1b
	λ_{p_C2}	1 318,0	1 331,4	nm	CW, E3A1a, E3A1b
	λ_{p_C3}	1 342,5	1 355,9	nm	CW, E3A1a, E3A1b
Spectral width, RMS (for single channel uses)	$\Delta\lambda$		4	nm	CW
Spectral width, RMS (for four WDM channel uses)	$\Delta\lambda$		0,62	nm	CW. E3A1a, E3A1b
Threshold current	I_{th}	0,5	5,0	mA	T_0=20 °C
Threshold voltage	V_{th}	1,1	2,0	V	
Slope efficiency (at I_{op} in a TO package)	η	0,05	0,3	mW/mA	
Slope efficiency (at I_{op} in a TOSA or pigtailed package)	η	0,03	0,2	mW/mA	
Continuous laser output power (at I_{op} in a TO package)	P_O	-7	5	dBm	E1A1a E1A1b
		-7	5	dBm	E3A1a, E3A1b
Continuous laser output power (at I_{op} in a TOSA or pigtailed package)	P_O	-11,5	-3,5	dBm	E1A1a, E1A1b
			-0,5	dBm	E3A1a, E3A1b
Wavelength change over temperature	$\Delta\lambda/\Delta T$		0,2	nm/°C	
Rise and fall time (20 % – 80 %)	t_r/t_f		260/260	ps	E1A1a, E1A1b
			120/120	ps	E3A1a, E3A1b
Capacitance (VCSEL chip)	C		5	pF	E1A1a, E1A1b V_{rev} = 0 V, 1 MHz
			2	pF	E3A1a, E3A1b V_{rev} = 0 V, 1 MHz
Relative intensity noise	RIN		-120	dB/Hz	[a]
Series resistance temperature coefficient	$\Delta R_S/\Delta T$		-4 000	ppm/°C	[b]

[a] For 1 GHz bandwidth and optical power specified (typically a negative value)

[b] Series resistance of laser diodes decreases as temperature increases and thus its thermal dependent parameter is typically a negative value.