

INTERNATIONAL STANDARD



Fibre optic active components and devices – Performance standards –
Part 3: Modulator-integrated laser diode transmitters for ~~2,5-Gbit/s to~~ 40-Gbit/s
fibre optic transmission systems

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INTERNATIONAL STANDARD



**Fibre optic active components and devices – Performance standards –
Part 3: Modulator-integrated laser diode transmitters for ~~2,5-Gbit/s to~~ 40-Gbit/s
fibre optic transmission systems**

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 33.180.20

ISBN 978-2-8322-8635-7

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

**FIBRE OPTIC ACTIVE COMPONENTS AND DEVICES –
PERFORMANCE STANDARDS –****Part 3: Modulator-integrated laser diode transmitters
for ~~2,5-Gbit/s~~ to 40-Gbit/s fibre optic transmission systems**

FOREWORD

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International Standard IEC 62149-3 has been prepared by subcommittee 86C: Fibre optic systems and active devices, of IEC technical committee 86: Fibre optics.

This third edition cancels and replaces the second edition published in 2014 and constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition: updates of the title, scope, normative references and performance test tables.

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

FDIS	Report on voting
86C/1666/FDIS	86C/1676/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 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 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- withdrawn,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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The contents of the corrigendum of February 2021 have been included in this copy.

INTRODUCTION

Fibre optic transmitters are used to convert electrical signals into optical signals. This document covers the performance standard for optical modulators monolithically integrated with laser diodes for ~~2,5 Gbit/s to 40 Gbit/s multi-channel~~ 40 Gbit/s optical telecommunication systems. This document is applicable for on-off keying format.

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FIBRE OPTIC ACTIVE COMPONENTS AND DEVICES – PERFORMANCE STANDARDS –

Part 3: Modulator-integrated laser diode transmitters for ~~2,5-Gbit/s to~~ 40-Gbit/s fibre optic transmission systems

1 Scope

This part of IEC 62149 covers the performance specification for electroabsorption (EA) type optical modulators monolithically integrated with laser diodes for ~~2,5-Gbit/s to 40-Gbit/s multi-channel~~ 40 Gbit/s fibre optic transmission systems. This ~~performance~~ document 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 as an initial design verification to prove any product's ability to satisfy this ~~performance~~ document's requirements. This document is ~~only~~ applicable for on-off keying format.

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

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 60068-2-1, *Environmental testing – Part 2-1: Tests – Tests A: Cold*

IEC 60068-2-2, ~~Basic~~ *Environmental testing procedures – Part 2-2: Tests – Tests B: Dry heat*

IEC 60068-2-6, *Environmental testing – Part 2-6: Tests – Test Fc: Vibration (sinusoidal)*

IEC 60068-2-14, ~~Basic~~ *Environmental testing procedures – Part 2-14: Tests – Test N: Change of temperature*

IEC 60068-2-27, ~~Basic~~ *Environmental testing procedures – Part 2-27: Tests – Test Ea and guidance: Shock*

IEC 60068-2-78, *Environmental testing – Part 2-78: Tests – Test Cab: Damp heat, steady state*

IEC 60749-7, *Semiconductor devices – Mechanical and climatic test methods – Part 7: Internal moisture content measurement and the analysis of other residual gases*

IEC 60749-26, *Semiconductor devices – Mechanical and climatic test methods – Part 26: Electrostatic discharge (ESD) sensitivity testing – Human body model (HBM)*

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 or cable retention*

IEC 62007-1, *Semiconductor optoelectronic devices for fibre optic system applications – Part 1: Specification template for essential ratings and characteristics*

IEC 62572-3, *Fibre optic active components and devices – Reliability standards – Part 3: Laser modules used for telecommunication*

ITU-T Recommendation G.694.1, *Spectral grids for WDM applications: DWDM frequency grid*

ITU-T Recommendation G.957, *Optical interfaces for equipments and systems relating to the synchronous digital hierarchy*

MIL-STD-883-1, *U.S. Department of Defense – Test method standard – Environmental test methods for microcircuits, Part 1: Test methods 1000-1999*

3 Terms, definitions and ~~symbols~~ abbreviated terms

3.1 Terms and definitions

~~For the purposes of this document, terminology concerning physical concepts, types of devices, general terms and definitions related to ratings and characteristics contained in IEC 62007-1 apply.~~

For the purposes of this document, the terms and definitions given in IEC 62007-1 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 <https://www.iso.org/obp>

~~3.2 Symbols~~

~~X modulation speed in Gbit/s~~

~~PD photodiode~~

~~T_{LD} laser sub-mount temperature~~

~~T_s shortening of symbol T_{sub}~~

~~V_{fm} forward modulation voltage~~

~~V_{rm} reverse modulation voltage~~

~~V_{rme} reverse modulation centre voltage~~

~~V_{rmpp} peak-to-peak modulation voltage~~

~~T_{sub} submount temperature~~

3.2 Abbreviated terms

DC direct current

EA electroabsorption

LD laser diode

LSL lower standard limit

PD photodiode

- PRBS pseudo-random bit sequence
- RF radio frequency
- RH relative humidity
- USL upper standard limit

4 Product parameters

4.1 Absolute limiting ratings

Absolute limiting (maximum and/or minimum) ratings given in Table 1 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 values of more than one parameter can be applied at any one time.

Table 1 – Absolute limiting ratings

Parameter	Symbol	Minimum	Maximum	Unit
Operating case temperature (at the bottom of the case)	T_{case}	0	+70	°C
Storage temperature	T_{stg}	-40	+85	°C
Soldering temperature (minimum distance to case specified)	T_{sld}		+260 (for 10 s)	°C/s
Laser diode				
Reverse voltage	$V_{R(LD)}$		2	V
Continuous forward current	$I_{F(LD)}$		200	mA
Continuous radiant power	ϕ_e		10	mW
Photodiode				
Reverse voltage	$V_{R(PD)}$		10	V
Forward current	$I_{F(PD)}$		1	mA
Modulator				
Reverse modulation voltage	V_{Rm}		5	V
Forward modulation voltage	V_{Fm}		1	V
Thermal electric cooler				
Cooler current under cooling and heating	I_P		1,5	A
Cooler voltage under cooling and heating	V_P		2,5	V

4.2 Operating environment

The operating environment is indicated in Table 2.

Table 2 – Operating environment

Parameter	Symbol	Value		Unit
		Minimum	Maximum	
Operating case temperature	T_{case}	0	+70	°C

4.3 Functional specification

Functional specification shall be within the limit specified in Table 4 at the operating conditions specified in Table 3.

Table 3 – Operating conditions for functional specification

Parameter	Symbol	Value		Unit
		Minimum	Maximum	
Laser operating current	I_{op}	50	200	mA
Laser operating temperature	T_{op}	15	35	°C
Reverse modulation centre voltage	V_{Rmc}	0,5	1,5	V
Peak to peak modulation voltage	V_{Rmpp}	2	3	V

NOTE Operating conditions are adjusted to match ITU-T Recommendation G.694.1 wavelength within the above specified limit.

Table 4 – Functional specification

Characteristics and conditions at $T_{LD} = T_{op}$, $I_{F(LD)} = I_{op}$ Reverse modulation voltage (V_{rm}) $V_{Rm} = 0$ V, unless otherwise stated	Symbol	Value		Unit
		Minimum	Maximum	
Laser and modulator diode				
Modulation speed	X	2,5	43,02 ^a	Gbit/s
Forward voltage at specified ϕ_e or I_{op}	$V_{F(LD)}$		2,2	V
Threshold current	$I_{(TH)}$		50	mA
Radiant power at specified I_{op}	ϕ_e	0,5		mW
Kink free radiant power	ϕ_e	0,6		mW
Extinction ratio at specified ϕ_e or I_{op} (under modulated conditions) ^b	ER r_{ER}	8,2		dB
Peak emission wavelength at specified ϕ_e or I_{op} (under modulated conditions) ^{b, c}	λ_P	c	c	nm
Side-mode suppression ratio at specified ϕ_e or I_{op} (under modulated conditions) ^b	$SMSR$ r_{SMSR}	30		dB
Switching times at specified ϕ_e or I_{op} (under modulated conditions)	Rise time ^b	t_r	600/ X	ps
	Fall time ^b	t_f	600/ X	ps
RF return loss at specified ϕ_e or I_{op} $V_{rm} = 1/2 V_{Rmpp}$, $f = X$ GHz, 50 Ω termination ^d	S_{11}	6,0		dB
Transmission penalty due to dispersion at specified ϕ_e or I_{op} , under modulated conditions and specified fibre length ^b	P_e		2	dB
Monitor photodiode				
Dark current at $\phi_e = 0$ and specified $V_{R(PD)}$	I_{DARK}		10	nA
Monitor current at specified ϕ_e or I_{op} and $V_{R(PD)}$	I_M	50	2 000	μ A
Tracking error between operating temperature range with reference at 25 °C at specified ϕ_e or I_{op} and $V_{R(PD)}$ specified	TE E_{tr}	-0,5	0,5	dB

Characteristics and conditions at $T_{LD} = T_{op}$, $I_{F(LD)} = I_{op}$ Reverse modulation voltage (V_{rm}) $V_{Rm} = 0$ V, unless otherwise stated	Symbol	Value		Unit
		Minimum	Maximum	
Thermal sensor				
Resistance at specified sensor current	R_s	9,5	10,5	k Ω
Thermistor B constant ^{a e}	B	3 300	3 950	K
Thermal electric cooler				
Cooler current at $\Delta T = T_{case(max)} - T_{LD}$ and $\Delta T = T_{LD} - T_{case(min)}$ at specified ϕ_e or I_{op}	I_p		1,5	A
Cooler voltage at $\Delta T = T_{case(max)} - T_{LD}$ and $\Delta T = T_{LD} - T_{case(min)}$ at specified ϕ_e or I_{op}	V_p		2,5	V
<p>a Upper limit in this document. Actual maximum modulation speed shall be designated by a system requirement.</p> <p>b Definition and condition according to ITU-T Recommendation G.957, PRBS 2²³ - 1, $V_{Rm} = V_{Rmc} \pm 1/2 V_{Rmpp}$.</p> <p>c According to ITU-T Recommendation G.694.1.</p> <p>d $V_{Rm} = 1/2 V_{Rmpp}$, 50 Ω termination, measurement frequency should be specified by system requirement.</p> <p>e $B = \ln(R/R_0)/(1/T - 1/T_0)$ where R is the resistance at ambient temperature T ($^{\circ}$K) and R_0 is the resistance at ambient temperature T_0 ($^{\circ}$K).</p>				

4.4 Diagrams

Figure 1 provides a representative example of a schematic diagram.

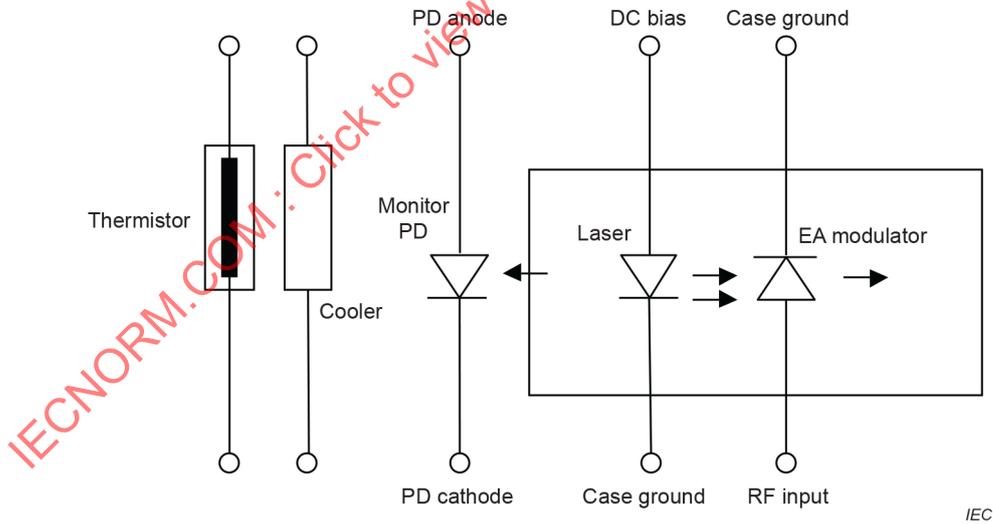


Figure 1 – Schematic diagram

5 Testing

5.1 General

Initial characterization and qualification shall be undertaken when a build standard has been completed and frozen. Qualification maintenance is carried using periodic testing programs. **Test Case** temperature conditions for all tests are 25 $^{\circ}$ C \pm 2 $^{\circ}$ C unless otherwise stated.

5.2 Characterization testing

Characterization shall be carried out on at least 20 transmitters, taken from at least three different manufacturing lots. The test conditions are detailed in Table 5.

Table 5 – Characterization tests

Characteristics and conditions at $T_{LD} = T_{op}$, $I_{F(LD)} = I_{op}$ Reverse modulation voltage (V_{rm}) = 0V_r $V_{Rm} = 0$ V, unless otherwise stated	Symbol	Value		Unit
		Minimum	Maximum	
Laser and modulator diode				
Modulation speed	X	2,5	43,02 ^a	Gbit/s
Forward voltage at specified ϕ_e or I_{op}	$V_{F(LD)}$		2,2	V
Threshold current	$I_{(TH)}$		50	mA
Radiant power at specified I_{op}	ϕ_e	0,5		mW
Kink free radiant power	ϕ_e	0,6		mW
Extinction ratio at specified I_{op} , ϕ_e or I_{op} (under modulated conditions) ^b	ER r_{ER}	8,2		dB
Peak emission wavelength at specified ϕ_e or I_{op} (under modulated conditions) ^{b, c}	λ_p	c	c	nm
Side-mode suppression ratio at specified ϕ_e or I_{op} (under modulated conditions) ^b	SMSR r_{SMSR}	30		dB
Switching times at specified ϕ_e or I_{op} (under modulated conditions)	Rise time ^b	t_r	600/ X	ps
	Fall time ^b	t_f	600/ X	ps
RF return loss at specified ϕ_e or I_{op} $V_{rm} = 1/2 V_{rmp}$, $f = X$ GHz, 50 Ω termination ^d	S_{11}	6,0		dB
Transmission penalty due to dispersion at specified ϕ_e or I_{op} , under modulated condition and specified fibre length ^b	P_e		2	dB
Monitor photodiode				
Dark current at $\phi_e = 0$ and specified $V_{R(PD)}$	I_{DARK}		10	nA
Monitor current at specified ϕ_e or I_{op} and $V_{R(PD)}$	I_M	50	2 000	μ A
Tracking error between operating temperature range with reference at 25 °C at specified ϕ_e or I_{op} and $V_{R(PD)}$ specified	TE E_{tr}	-0,5	0,5	dB
Thermal sensor				
Resistance at specified sensor current	R_s	9,5	10,5	k Ω
Thermistor B constant ^e	B	3 300	3 950	K
Thermal electric cooler				
Cooler current at $\Delta T = T_{case(max)} - T_{LD}$ and $\Delta T = T_{LD} - T_{case(min)}$ at specified ϕ_e or I_{op}	I_p		1,5	A
Cooler voltage at $\Delta T = T_{case(max)} - T_{LD}$ and $\Delta T = T_{LD} - T_{case(min)}$ at specified ϕ_e or I_{op}	V_p		2,5	V
Manufacturing lot shall be specified by each vendor.				

Characteristics and conditions at $T_{LD} = T_{op}$, $I_{F(LD)} = I_{op}$ Reverse modulation voltage (V_{rm}) = 0V, $V_{Rm} = 0 V$, unless otherwise stated	Symbol	Value		Unit
		Minimum	Maximum	
<p>a Upper limit in this document. Actual maximum modulation speed shall be designated by a system requirement.</p> <p>b Definition and conditions according to ITU-T Recommendation G.957, PRBS 2²³ - 1, $V_{Rm} = V_{Rmc} \pm \frac{1}{2} V_{Rmpp}$.</p> <p>c According to ITU-T Recommendation G.694.1.</p> <p>d $V_{Rm} = 1/2 V_{Rmpp}$, 50 Ω termination, measurement frequency should be specified by system requirement.</p> <p>e $B = \ln(R/R_0)/(1/T - 1/T_0)$ where R is the resistance at ambient temperature T ($^{\circ}K$) and R_0 is the resistance at ambient temperature T_0 ($^{\circ}K$).</p>				

5.3 Performance testing

Performance testing is undertaken when characterization testing is complete. See Table 6 for the performance test plan and Table 7 for recommended performance test failure criteria.

Table 6 – Performance test plan

Test		Reference	Conditions	Sample size
Endurance tests of module	High temperature storage	IEC 60068-2-2	Temperature: $T = T_{stg}$ max. Duration: > 2 000 h ^b	11
	Low temperature storage	IEC 60068-2-1	Temperature: $T = T_{stg}$ min. Duration: > 2 000 h ^b	11
	Temperature cycling	IEC 60068-2-14	Test Na Temperature: $T_A = T_{stg}$ min. $T_B = T_{stg}$ max. Number of cycles = 100 duration of exposure ^d	11
	Damp heat	IEC 60068-2-78	$T = 40$ $^{\circ}C$, RH = 95 %, 56 days	11
	Cyclic moisture resistance	MIL-STD-883H-1 Method 1004.7		11
Endurance test of laser diode on submount		IEC 60068-2-14 IEC 62572-3	Temperature: at least two test temperatures: ϕ_e specified, constant power $T_{sub1} = T_{sub}$ max. $T_{sub2} = (T_{sub1} - 20$ $^{\circ}C$ $T_{sub2} \leq (T_{sub1} - 20)$ $^{\circ}C$ or $T_{sub2} \leq (T_{sub1} - 10)$ $^{\circ}C$ if applicable Duration: > 5 000 h ^b	By agreement ^c By agreement ^c
Endurance test of photodiode in representative package		IEC 60068-2-14 IEC 62572-3	Temperature: at least two test temperatures: V_R or I_R specified $T_{sub1} = 125$ $^{\circ}C$ min. ^a $T_{sub2} = (T_{s1} - 30$ $^{\circ}C)$ $T_{sub2} \leq (T_{sub1} - 30)$ $^{\circ}C$ Duration: > 1 000 h	By agreement ^c By agreement ^c

Power cycle tests of the thermoelectric cooler		Number of cycles: 20 000 $T_{CASE} = T_{op\ max}$ $T_{sub} = T_{CASE\ to}$ $(T_{CASE} - \Delta T_{max})$	11
High temperature storage of the thermal sensor	MIL-STD-883H-1 Method 1008.2	$T = T_{stg\ max}$ of the sensor	25
Fibre pull	IEC 61300-2-4	5 s, 3 times, pull force ^e : 10 N for fibre cables 5,0 N for buffered fibres 2,0 N for primary coated fibres	11
Mechanical shock	IEC 60068-2-27	500 G 5 000 m/s ² , 1,0 ms 5 times/axis	11
Vibration	IEC 60068-2-6	20 G 200 m/s ² , 20 Hz to 2 000 Hz, 4 min/cycle, 4 cycles/axis	11
Thermal shock	IEC 60068-2-14	$\Delta T = 100\ ^\circ\text{C}$	11
ESD	IEC 60749-26	Human body model	11
Internal moisture	IEC 60749-7	$\leq 5\ 000 \times 10^{-6}$	11
<p>^a Or as limited by technology.</p> <p>^b Provided data about the distribution of wear-out lifetime is accumulated with significant accuracy. Provisional approval for product shipment shall be granted at 2 000 h. It is also recommended to continue the test until accurate extrapolation of lifetime is possible with an upper limit of 10 000 h. Duration up to 5 000 h may be needed for accurate lifetime prediction.</p> <p>^c The number shall be determined by discussion between the manufacturers and users concerned.</p> <p>^d Duration of exposure shall be specified in the relevant specification.</p> <p>^e Pull force shall be specified by the corresponding fibre/cable categories described in IEC 61300-2-4.</p>			

Table 7 – Recommended performance test failure criteria

Device	Parameter	Failure criterion	Measurement condition
Laser diode	Threshold current or operating current	$\geq 50\ %$ increase ^a or $\geq 10\ \text{mA}$ increase if $I_{(TH)}$ $< 20\ \text{mA}$	25 °C or life test temperature
	Slope efficiency	$\geq 10\ %$ change ^a	25 °C or life test temperature
	Forward voltage	$\geq 10\ %$ change ^a	25 °C or life test temperature
	Kinks in L/I curve	Kink-free within $1,2 \times P_{nom}$ (linearity change $\leq 10\ %$) linearity change $> 10\ %$ within $1,2 \times P_{nom}$ ^a	$T_{op\ min}$, 25 °C, $T_{op\ max}$
	Wavelength	See application	25 °C ^b
Photodiode	Dark current	$\geq\ \text{USL}$ or $\geq 10\ \text{nA}$ increase ^a	25 °C
Laser module	Laser threshold or operating current	$\geq 50\ %$ increase ^a or $\geq 10\ \text{mA}$ increase if $I_{(TH)}$ $< 20\ \text{mA}$	25 °C or life test temperature
	Fibre output power	$\geq 10\ %$ change ^a	Life test temperature I_M set to initial value
	Kinks in L/I curve	Kink-free within $1,2 \times P_{nom}$ (linearity change $\leq 10\ %$) linearity change $> 10\ %$ within $1,2 \times P_{nom}$ ^a	$T_{op\ min}$, 25 °C, $T_{op\ max}$
	Wavelength	See DS and application	See detail specification application

Device	Parameter	Failure criterion	Measurement condition
	Tracking ratio (I_M / P_{fibre})	< LSL, \geq USL	$T_{\text{op min}} - T_{\text{op max}}$ at rated power level
	Photodiode dark current	\geq USL or ≥ 10 nA increase ^a	25 °C
	Thermistor resistance	≥ 5 % change ^a	25 °C or life test temperature T_{sub}
	Peltier Thermal electric cooler current	$\geq \pm 10$ % change ^a	To maintain constant ΔT during test
	Peltier Thermal electric cooler voltage	$\geq \pm 10$ % change ^a	

^a Change of pre- and post- test values.

^b Or to be determined by agreement between the manufacturers and users concerned.

6 Environmental specifications

6.1 General safety

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

6.2 Laser safety

~~Transmitters shall be class 1 laser certified under any condition of operation. This includes single fault conditions, whether coupled into a fibre or out of an open bore.~~ Transmitters shall be ~~certified~~ verified 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.

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Bibliography

IEC 60068 (all parts), *Environmental testing*

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IEC TR 62572-2, *Fibre optic active components and devices – Reliability standards – Part 2: Laser module degradation*

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INTERNATIONAL STANDARD

NORME INTERNATIONALE

**Fibre optic active components and devices – Performance standards –
Part 3: Modulator-integrated laser diode transmitters for 40-Gbit/s fibre optic
transmission systems**

**Composants et dispositifs actifs fibroniques – Normes de performances –
Partie 3: Émetteurs à diodes laser à modulateur intégré pour systèmes de
transmission fibroniques 40 Gbit/s**

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

**FIBRE OPTIC ACTIVE COMPONENTS AND DEVICES –
PERFORMANCE STANDARDS –****Part 3: Modulator-integrated laser diode transmitters
for 40-Gbit/s fibre optic transmission systems**

FOREWORD

- 1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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International Standard IEC 62149-3 has been prepared by subcommittee 86C: Fibre optic systems and active devices, of IEC technical committee 86: Fibre optics.

This third edition cancels and replaces the second edition published in 2014 and constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition: updates of the title, scope, normative references and performance test tables.

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

FDIS	Report on voting
86C/1666/FDIS	86C/1676/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 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 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.

The contents of the corrigendum of February 2021 have been included in this copy.

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INTRODUCTION

Fibre optic transmitters are used to convert electrical signals into optical signals. This document covers the performance standard for optical modulators monolithically integrated with laser diodes for 40 Gbit/s optical telecommunication systems. This document is applicable for on-off keying format.

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FIBRE OPTIC ACTIVE COMPONENTS AND DEVICES – PERFORMANCE STANDARDS –

Part 3: Modulator-integrated laser diode transmitters for 40-Gbit/s fibre optic transmission systems

1 Scope

This part of IEC 62149 covers the performance specification for electroabsorption (EA) type optical modulators monolithically integrated with laser diodes for 40 Gbit/s fibre optic transmission systems. This document 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 as an initial design verification to prove any product's ability to satisfy this document's requirements. This document is applicable for on-off keying format.

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

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 60068-2-1, *Environmental testing – Part 2-1: Tests – Test A: Cold*

IEC 60068-2-2, *Environmental testing – Part 2-2: Tests – Test B: Dry heat*

IEC 60068-2-6, *Environmental testing – Part 2-6: Tests – Test Fc: Vibration (sinusoidal)*

IEC 60068-2-14, *Environmental testing – Part 2-14: Tests – Test N: Change of temperature*

IEC 60068-2-27, *Environmental testing – Part 2-27: Tests – Test Ea and guidance: Shock*

IEC 60068-2-78, *Environmental testing – Part 2-78: Tests – Test Cab: Damp heat, steady state*

IEC 60749-7, *Semiconductor devices – Mechanical and climatic test methods – Part 7: Internal moisture content measurement and the analysis of other residual gases*

IEC 60749-26, *Semiconductor devices – Mechanical and climatic test methods – Part 26: Electrostatic discharge (ESD) sensitivity testing – Human body model (HBM)*

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 or cable retention*

IEC 62007-1, *Semiconductor optoelectronic devices for fibre optic system applications – Part 1: Specification template for essential ratings and characteristics*

IEC 62572-3, *Fibre optic active components and devices – Reliability standards – Part 3: Laser modules used for telecommunication*

ITU-T Recommendation G.694.1, *Spectral grids for WDM applications: DWDM frequency grid*

ITU-T Recommendation G.957, *Optical interfaces for equipments and systems relating to the synchronous digital hierarchy*

MIL-STD-883-1, *U.S. Department of Defense – Test method standard – Environmental test methods for microcircuits, Part 1: Test methods 1000-1999*

3 Terms, definitions and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 62007-1 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 <https://www.iso.org/obp>

3.2 Abbreviated terms

DC	direct current
EA	electroabsorption
LD	laser diode
LSL	lower standard limit
PD	photodiode
PRBS	pseudo-random bit sequence
RF	radio frequency
RH	relative humidity
USL	upper standard limit

4 Product parameters

4.1 Absolute limiting ratings

Absolute limiting (maximum and/or minimum) ratings given in Table 1 imply that no catastrophic damage will occur if the product is subject to these ratings, 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 values of more than one parameter can be applied at any one time.

Table 1 – Absolute limiting ratings

Parameter	Symbol	Minimum	Maximum	Unit
Operating case temperature (at the bottom of the case)	T_{case}	0	+70	°C
Storage temperature	T_{stg}	-40	+85	°C
Soldering temperature (minimum distance to case specified)	T_{sld}		+260 (for 10 s)	°C
Laser diode				
Reverse voltage	$V_{R(LD)}$		2	V
Continuous forward current	$I_{F(LD)}$		200	mA
Continuous radiant power	ϕ_e		10	mW
Photodiode				
Reverse voltage	$V_{R(PD)}$		10	V
Forward current	$I_{F(PD)}$		1	mA
Modulator				
Reverse modulation voltage	V_{Rm}		5	V
Forward modulation voltage	V_{Fm}		1	V
Thermal electric cooler				
Cooler current under cooling and heating	I_P		1,5	A
Cooler voltage under cooling and heating	V_P		2,5	V

4.2 Operating environment

The operating environment is indicated in Table 2.

Table 2 – Operating environment

Parameter	Symbol	Value		Unit
		Minimum	Maximum	
Operating case temperature	T_{case}	0	+70	°C

4.3 Functional specification

Functional specification shall be within the limit specified in Table 4 at the operating conditions specified in Table 3.

Table 3 – Operating conditions for functional specification

Parameter	Symbol	Value		Unit
		Minimum	Maximum	
Laser operating current	I_{op}	50	200	mA
Laser operating temperature	T_{op}	15	35	°C
Reverse modulation centre voltage	V_{Rmc}	0,5	1,5	V
Peak to peak modulation voltage	V_{Rmpp}	2	3	V

NOTE Operating conditions are adjusted to match ITU-T Recommendation G.694.1 wavelength within the above specified limit.

Table 4 – Functional specification

Characteristics and conditions at $T_{LD} = T_{op}$, $I_{F(LD)} = I_{op}$ $V_{Rm} = 0$ V, unless otherwise stated		Symbol	Value		Unit
			Minimum	Maximum	
Laser and modulator diode					
Modulation speed		X		43,02 ^a	Gbit/s
Forward voltage at specified ϕ_e or I_{op}		$V_{F(LD)}$		2,2	V
Threshold current		$I_{(TH)}$		50	mA
Radiant power at specified I_{op}		ϕ_e	0,5		mW
Kink free radiant power		ϕ_e	0,6		mW
Extinction ratio at specified ϕ_e or I_{op} (under modulated conditions) ^b		r_{ER}	8,2		dB
Peak emission wavelength at specified ϕ_e or I_{op} (under modulated conditions) ^{b, c}		λ_P	c	c	nm
Side-mode suppression ratio at specified ϕ_e or I_{op} (under modulated conditions) ^b		r_{SMSR}	30		dB
Switching times at specified ϕ_e or I_{op} (under modulated conditions)		Rise time ^b	t_r	600/ X	ps
		Fall time ^b	t_f	600/ X	ps
RF return loss at specified ϕ_e or I_{op} ^d		S_{11}	6,0		dB
Transmission penalty due to dispersion at specified ϕ_e or I_{op} , under modulated conditions and specified fibre length ^b		P_e		2	dB
Monitor photodiode					
Dark current at $\phi_e = 0$ and specified $V_{R(PD)}$		I_{DARK}		10	nA
Monitor current at specified ϕ_e or I_{op} and $V_{R(PD)}$		I_M	50	2 000	µA
Tracking error between operating temperature range with reference at 25 °C at specified ϕ_e or I_{op} and $V_{R(PD)}$ specified		E_{tr}	-0,5	0,5	dB
Thermal sensor					
Resistance at specified sensor current		R_s	9,5	10,5	kΩ
Thermistor B constant ^e		B	3 300	3 950	K

Characteristics and conditions at $T_{LD} = T_{op}$, $I_{F(LD)} = I_{op}$ $V_{Rm} = 0$ V, unless otherwise stated	Symbol	Value		Unit
		Minimum	Maximum	
Thermal electric cooler				
Cooler current at $\Delta T = T_{case(max)} - T_{LD}$ and $\Delta T = T_{LD} - T_{case(min)}$ at specified ϕ_e or I_{op}	I_p		1,5	A
Cooler voltage at $\Delta T = T_{case(max)} - T_{LD}$ and $\Delta T = T_{LD} - T_{case(min)}$ at specified ϕ_e or I_{op}	V_p		2,5	V
a Upper limit in this document. Actual maximum modulation speed shall be designated by a system requirement. b Definition and condition according to ITU-T Recommendation G.957, PRBS 2 ²³ - 1, $V_{Rm} = V_{Rmc} \pm 1/2 V_{Rmpp}$. c According to ITU-T Recommendation G.694.1. d $V_{Rm} = 1/2 V_{Rmpp}$, 50 Ω termination, measurement frequency should be specified by system requirement. e $B = \ln(R/R_0)/(1/T - 1/T_0)$ where R is the resistance at ambient temperature T (K) and R_0 is the resistance at ambient temperature T_0 (K).				

4.4 Diagrams

Figure 1 provides a representative example of a schematic diagram.

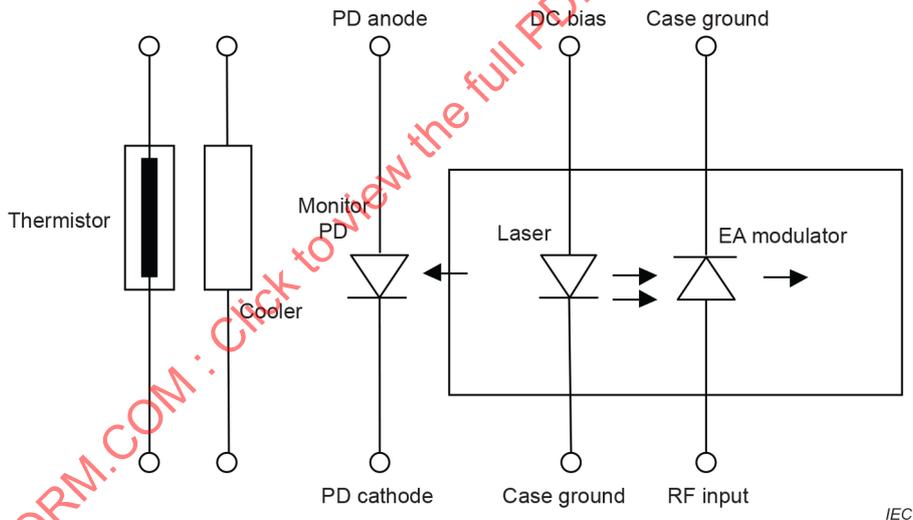


Figure 1 – Schematic diagram

5 Testing

5.1 General

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

5.2 Characterization testing

Characterization shall be carried out on at least 20 transmitters, taken from at least three different manufacturing lots. The test conditions are detailed in Table 5.

Table 5 – Characterization tests

Characteristics and conditions at $T_{LD} = T_{op}$, $I_{F(LD)} = I_{op}$ $V_{Rm} = 0$ V, unless otherwise stated	Symbol	Value		Unit
		Minimum	Maximum	
Laser and modulator diode				
Modulation speed	X		43,02 ^a	Gbit/s
Forward voltage at specified ϕ_e or I_{op}	$V_{F(LD)}$		2,2	V
Threshold current	$I_{(TH)}$		50	mA
Radiant power at specified I_{op}	ϕ_e	0,5		mW
Kink free radiant power	ϕ_e	0,6		mW
Extinction ratio at specified ϕ_e or I_{op} (under modulated conditions) ^b	r_{ER}	8,2		dB
Peak emission wavelength at specified ϕ_e or I_{op} (under modulated conditions) ^{b, c}	λ_p	c	c	nm
Side-mode suppression ratio at specified ϕ_e or I_{op} (under modulated conditions) ^b	r_{SMSR}	30		dB
Switching times at specified ϕ_e or I_{op} (under modulated conditions)	Rise time ^b	t_r	600/ X	ps
	Fall time ^b	t_f	600/ X	ps
RF return loss at specified ϕ_e or I_{op} ^d	S_{11}	6,0		dB
Transmission penalty due to dispersion at specified ϕ_e or I_{op} , under modulated condition and specified fibre length ^b	P_e		2	dB
Monitor photodiode				
Dark current at $\phi_e = 0$ and specified $V_{R(PD)}$	I_{DARK}		10	nA
Monitor current at specified ϕ_e or I_{op} and $V_{R(PD)}$	I_M	50	2 000	μ A
Tracking error between operating temperature range with reference at 25 °C at specified ϕ_e or I_{op} and $V_{R(PD)}$ specified	E_{tr}	-0,5	0,5	dB
Thermal sensor				
Resistance at specified sensor current	R_s	9,5	10,5	k Ω
Thermistor B constant ^e	B	3 300	3 950	K
Thermal electric cooler				
Cooler current at $\Delta T = T_{case(max)} - T_{LD}$ and $\Delta T = T_{LD} - T_{case(min)}$ at specified ϕ_e or I_{op}	I_p		1,5	A
Cooler voltage at $\Delta T = T_{case(max)} - T_{LD}$ and $\Delta T = T_{LD} - T_{case(min)}$ at specified ϕ_e or I_{op}	V_p		2,5	V
<p>^a Upper limit in this document. Actual maximum modulation speed shall be designated by a system requirement.</p> <p>^b Definition and conditions according to ITU-T Recommendation G.957, PRBS 2²³ - 1, $V_{Rm} = V_{Rmc} \pm \frac{1}{2} V_{Rmpp}$.</p> <p>^c According to ITU-T Recommendation G.694.1.</p> <p>^d $V_{Rm} = 1/2 V_{Rmpp}$, 50 Ω termination, measurement frequency should be specified by system requirement.</p> <p>^e $B = \ln(R/R_0)/(1/T - 1/T_0)$ where R is the resistance at ambient temperature T (K) and R_0 is the resistance at ambient temperature T_0 (K).</p>				

5.3 Performance testing

Performance testing is undertaken when characterization testing is complete. See Table 6 for the performance test plan and Table 7 for recommended performance test failure criteria.

Table 6 – Performance test plan

Test		Reference	Conditions	Sample size
Endurance tests of module	High temperature storage	IEC 60068-2-2	Temperature: $T = T_{stg \text{ max.}}$ Duration: > 2 000 h ^b	11
	Low temperature storage	IEC 60068-2-1	Temperature: $T = T_{stg \text{ min.}}$ Duration: > 2 000 h ^b	11
	Temperature cycling	IEC 60068-2-14	Test Na Temperature: $T_A = T_{stg \text{ min.}}$ $T_B = T_{stg \text{ max.}}$ Number of cycles = 100 duration of exposure ^d	11
	Damp heat	IEC 60068-2-78	$T = 40 \text{ °C}$, RH = 95 %, 56 days	11
	Cyclic moisture resistance	MIL-STD-883-1 Method 1004.7		11
Endurance test of laser diode on submount		IEC 62572-3	Temperature: at least two test temperatures: ϕ_e specified, constant power $T_{sub1} = T_{sub \text{ max.}}$ $T_{sub2} \leq (T_{sub1} - 20) \text{ °C}$ or $T_{sub2} \leq (T_{sub1} - 10) \text{ °C}$ if applicable Duration: > 5 000 h ^b	By agreement ^c By agreement ^c
Endurance test of photodiode in representative package		IEC 62572-3	Temperature: at least two test temperatures: V_R or I_R specified $T_{sub1} = 125 \text{ °C min.}^a$ $T_{sub2} \leq (T_{sub1} - 30 \text{ °C})$ Duration: > 1 000 h	By agreement ^c By agreement ^c
Power cycle tests of the thermoelectric cooler			Number of cycles: 20 000 $T_{CASE} = T_{op \text{ max}}$ $T_{sub} = T_{CASE \text{ to}}$ ($T_{CASE} - \Delta T_{max}$)	11
High temperature storage of the thermal sensor		MIL-STD-883-1 Method 1008.2	$T = T_{stg \text{ max}}$ of the sensor	25
Fibre pull		IEC 61300-2-4	5 s, 3 times, pull force ^e : 10 N for fibre cables 5,0 N for buffered fibres 2,0 N for primary coated fibres	11
Mechanical shock		IEC 60068-2-27	5 000 m/s ² , 1,0 ms 5 times/axis	11
Vibration		IEC 60068-2-6	200 m/s ² , 20 Hz to 2 000 Hz, 4 min/cycle, 4 cycles/axis	11
Thermal shock		IEC 60068-2-14	$\Delta T = 100 \text{ °C}$	11
ESD		IEC 60749-26	Human body model	11
Internal moisture		IEC 60749-7	$\leq 5\,000 \times 10^{-6}$	11

- ^a Or as limited by technology.
- ^b Provided data about the distribution of wear-out lifetime is accumulated with significant accuracy. Provisional approval for product shipment shall be granted at 2 000 h. It is also recommended to continue the test until accurate extrapolation of lifetime is possible with an upper limit of 10 000 h. Duration up to 5 000 h may be needed for accurate lifetime prediction.
- ^c The number shall be determined by discussion between the manufacturers and users concerned.
- ^d Duration of exposure shall be specified in the relevant specification.
- ^e Pull force shall be specified by the corresponding fibre/cable categories described in IEC 61300-2-4.

Table 7 – Recommended performance test failure criteria

Device	Parameter	Failure criterion	Measurement condition
Laser diode	Threshold current or operating current	$\geq 50\%$ increase ^a or ≥ 10 mA increase if $I_{(TH)} < 20$ mA	25 °C or life test temperature
	Slope efficiency	$\geq 10\%$ change ^a	25 °C or life test temperature
	Forward voltage	$\geq 10\%$ change ^a	25 °C or life test temperature
	Kinks in L/I curve	linearity change $> 10\%$ within $1,2 \times P_{nom}$ ^a	$T_{op\ min}$, 25 °C, $T_{op\ max}$
	Wavelength	See application	25 °C ^b
Photodiode	Dark current	\geq USL or ≥ 10 nA increase ^a	25 °C
Laser module	Laser threshold or operating current	$\geq 50\%$ increase ^a or ≥ 10 mA increase if $I_{(TH)} < 20$ mA	25 °C or life test temperature
	Fibre output power	$\geq 10\%$ change ^a	Life test temperature I_M set to initial value
	Kinks in L/I curve	linearity change $> 10\%$ within $1,2 \times P_{nom}$ ^a	$T_{op\ min}$, 25 °C, $T_{op\ max}$
	Wavelength	See application	See application
	Tracking ratio (I_M / P_{fibre})	$< LSL$, $\geq USL$	$T_{op\ min} - T_{op\ max}$ at rated power level
	Photodiode dark current	\geq USL or ≥ 10 nA increase ^a	25 °C
	Thermistor resistance	$\geq 5\%$ change ^a	25 °C or life test temperature T_{sub}
	Thermal electric cooler current	$\geq \pm 10\%$ change ^a	To maintain constant ΔT during test
Thermal electric cooler voltage	$\geq \pm 10\%$ change ^a		
^a Change of pre- and post- test values.			
^b Or to be determined by agreement between the manufacturers and users concerned.			

6 Environmental specifications

6.1 General safety

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

6.2 Laser safety

Transmitters shall be verified 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.

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IEC 60793 (all parts), *Optical fibres*

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IEC TR 62572-2, *Fibre optic active components and devices – Reliability standards – Part 2: Laser module degradation*

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COMMISSION ÉLECTROTECHNIQUE INTERNATIONALE

**COMPOSANTS ET DISPOSITIFS ACTIFS FIBRONIQUES –
NORMES DE PERFORMANCES –****Partie 3: Émetteurs à diodes laser à modulateur intégré
pour systèmes de transmission fibroniques 40 Gbit/s**

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La Norme internationale IEC 62149-3 a été établie par le sous-comité 86C: Systèmes et dispositifs actifs à fibres optiques, du comité d'études 86 de l'IEC: Fibres optiques.

Cette troisième édition annule et remplace la deuxième édition parue en 2014. Cette édition constitue une révision technique.

Cette édition inclut les modifications techniques majeures suivantes par rapport à l'édition précédente: mise à jour du titre, du domaine d'application, des références normatives et des tableaux des essais de performance.

Le texte de cette Norme internationale est issu des documents suivants:

FDIS	Rapport de vote
86C/1666/FDIS	86C/1676/RVD

Le rapport de vote indiqué dans le tableau ci-dessus donne toute information sur le vote ayant abouti à l'approbation de cette Norme internationale.

Ce document a été rédigé selon les Directives ISO/IEC, Partie 2.

Une liste de toutes les parties de la série IEC 62149, publiées sous le titre général *Composants et dispositifs actifs fibroniques – Normes de performances*, peut être consultée sur le site web de l'IEC

Le comité a décidé que le contenu de ce document ne sera pas modifié avant la date de stabilité indiquée sur le site web de l'IEC sous "<http://webstore.iec.ch>" dans les données relatives au document recherché. A cette date, le document sera

- reconduit,
- supprimé,
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- amendé.

Le contenu du corrigendum de février 2021 a été pris en considération dans cet exemplaire.

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INTRODUCTION

Les émetteurs fibroniques sont utilisés pour convertir les signaux électriques en signaux optiques. Le présent document couvre la norme de performance relative aux modulateurs optiques avec diodes laser intégrées de façon monolithique, destinés à des systèmes de télécommunications optiques 40 Gbit/s. Le présent document s'applique au format de codage binaire.

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COMPOSANTS ET DISPOSITIFS ACTIFS FIBRONIQUES – NORMES DE PERFORMANCES –

Partie 3: Émetteurs à diodes laser à modulateur intégré pour systèmes de transmission fibroniques 40 Gbit/s

1 Domaine d'application

La présente partie de l'IEC 62149 couvre les spécifications de performance concernant les modulateurs optiques à électro-absorption (EA) avec diodes laser intégrées de façon monolithique, destinés à des systèmes de transmission fibroniques 40 Gbit/s. Le présent document donne une définition des exigences de performances de produits, ainsi qu'une série d'ensembles d'essais et de mesures, avec des conditions, des sévérités et des critères d'acceptation/de rejet clairement définis. Les essais sont destinés à être réalisés à titre de vérification initiale de conception, pour prouver la capacité d'un quelconque produit à satisfaire aux exigences de la norme de performance. Le présent document s'applique au format de codage binaire.

Un produit qui a montré qu'il satisfaisait à toutes les exigences d'une norme de performance peut être déclaré comme conforme à la norme de performance, mais il sera ensuite contrôlé selon un programme d'assurance de la qualité.

2 Références normatives

Les documents suivants sont cités dans le texte de sorte qu'ils constituent, pour tout ou partie de leur contenu, des exigences du présent document. Pour les références datées, seule l'édition citée s'applique. Pour les références non datées, la dernière édition du document de référence s'applique (y compris les éventuels amendements).

IEC 60068-2-1, *Essais d'environnement – Partie 2-1: Essais – Essai A: Froid*

IEC 60068-2-2, *Essais d'environnement – Partie 2-2: Essais – Essai B: Chaleur sèche*

IEC 60068-2-6, *Essais d'environnement – Partie 2-6: Essais – Essai Fc: Vibrations (sinusoïdales)*

IEC 60068-2-14, *Essais d'environnement – Partie 2-14: Essais – Essai N: Variation de température*

IEC 60068-2-27, *Essais d'environnement – Partie 2-27: Essais – Essai Ea et guide: Chocs*

IEC 60068-2-78, *Essais d'environnement – Partie 2-78: Essais – Essai Cab: Chaleur humide, essai continu*

IEC 60749-7, *Dispositifs à semiconducteurs – Méthodes d'essais mécaniques et climatiques – Partie 7: Mesure de la teneur en humidité interne et analyse des autres gaz résiduels*

IEC 60749-26, *Dispositifs à semiconducteurs – Méthodes d'essais mécaniques et climatiques – Partie 26: Essai de sensibilité aux décharges électrostatiques (DES) – Modèle du corps humain (HBM)*

IEC 60825-1, *Sécurité des appareils à laser – Partie 1: Classification des matériels et exigences*

IEC 60950-1, *Matériels de traitement de l'information – Sécurité – Partie 1: Exigences générales*

IEC 61300-2-4, *Dispositifs d'interconnexion et composants passifs fibroniques – Procédures fondamentales d'essais et de mesures – Partie 2-4: Essais – Rétention de la fibre ou du câble*

IEC 62007-1, *Dispositifs optoélectroniques à semiconducteurs pour application dans les systèmes à fibres optiques – Partie 1: Modèle de spécification relatif aux valeurs et caractéristiques essentielles*

IEC 62572-3, *Composants et dispositifs actifs en fibres optiques – Normes de fiabilité – Partie 3: Modules laser utilisés pour les télécommunications*

Recommandation UIT-T G.694.1, *Grilles spectrales pour les applications de multiplexage par répartition en longueur d'onde: grille dense DWDM*

Recommandation UIT-T G.957, *Interfaces optiques pour les équipements et les systèmes relatifs à la hiérarchie numérique synchrone*

MIL-STD-883-1, *U.S. Department of Defense – Test method standard – Environmental test methods for microcircuits, Part 1: Test methods 1000-1999* (disponible en anglais seulement)

3 Termes, définitions et termes abrégés

3.1 Termes et définitions

Pour les besoins du présent document, les termes donnés dans l'IEC 62007-1, s'appliquent.

L'ISO et l'IEC tiennent à jour des bases de données terminologiques destinées à être utilisées en normalisation, consultables aux adresses suivantes:

- IEC Electropedia: disponible à l'adresse <http://www.electropedia.org/>
- ISO Online browsing platform: disponible à l'adresse <https://www.iso.org/obp>

3.2 Termes abrégés

c.c.	courant continu
EA	electro-absorption
LD	diode laser (laser diode)
LSL	limite inférieure normalisée (lower standard limit)
PD	photodiode
PRBS	séquence de bits pseudo-aléatoire (pseudo-random bit sequence)
RF	radiofréquence
HR	humidité relative
USL	limite supérieure normalisée (upper standard limit)

4 Paramètres du produit

4.1 Valeurs limites absolues

Les valeurs limites absolues (maximales et/ou minimales) données dans le Tableau 1 impliquent l'absence de dommage catastrophique si le produit est soumis à ces valeurs limites, à condition que chaque paramètre en limite soit considéré isolément et que tous les autres paramètres présentent des valeurs s'inscrivant dans les paramètres de performance conventionnels. Il convient de ne pas présumer que les valeurs limites de plusieurs paramètres peuvent être appliquées simultanément.

Tableau 1 – Valeurs limites absolues

Paramètre	Symbole	Valeur minimale	Valeur maximale	Unité
Température du boîtier en fonctionnement (au fond du boîtier)	T_{case}	0	+70	°C
Température de stockage	T_{stg}	-40	+85	°C
Température de soudage (distance minimale par rapport au boîtier spécifiée)	T_{sld}		+260 (pendant 10 s)	°C
Diode laser				
Tension en inverse	$V_{R(LD)}$		2	V
Courant continu en direct	$I_{F(LD)}$		200	mA
Puissance continue rayonnée	ϕ_e		10	mW
Photodiode				
Tension en inverse	$V_{R(PD)}$		10	V
Courant en direct	$I_{F(PD)}$		1	mA
Modulateur				
Tension de modulation en inverse	V_{Rm}		5	V
Tension de modulation en direct	V_{Fm}		1	V
Refroidisseur thermoélectrique				
Courant du refroidisseur en mode refroidissement et en mode chauffage	I_p		1,5	A
Tension du refroidisseur en mode refroidissement et en mode chauffage	V_p		2,5	V

4.2 Environnement de fonctionnement

L'environnement de fonctionnement est indiqué dans le Tableau 2.

Tableau 2 – Environnement de fonctionnement

Paramètre	Symbole	Valeur		Unité
		Valeur minimale	Valeur maximale	
Température du boîtier en fonctionnement	T_{case}	0	+70	°C