

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**

IEC 62149-3:2020

<https://standards.iteh.ai/standards/iec/5932d14e-8bc8-40c2-908a-e2bfbe8ba135/iec-62149-3-2020>



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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**

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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- withdrawn,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}		P_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	kΩ
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 (°K) and R_0 is the resistance at ambient temperature T_0 (°K).</p>				

4.4 Diagrams

Figure 1 provides a representative example of a schematic diagram.

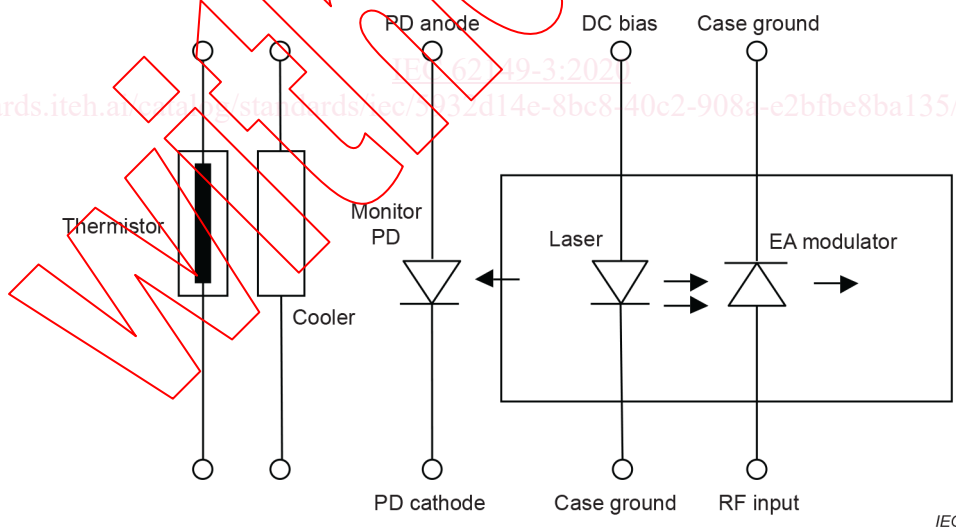


Figure 1 – Schematic diagram

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 °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 $T_{LD} = T_{op}$, $I_{F(LD)} = I_{op}$ 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} $V_{rm} = 1/2 V_{rmpp}$, $f = X$ GHz, 50 Ω termination	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	