BS EN 62149-3:2014

BSI Standards Publication

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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National foreword

This British Standard is the UK implementation of EN 62149-3:2014. It is identical to IEC 62149-3:2014. It supersedes BS EN 62149-3:2004 which is withdrawn.

The UK participation in its preparation was entrusted by Technical Committee GEL/86, Fibre optics, to Subcommittee GEL/86/3, Fibre optic systems and active devices.

A list of organizations represented on this committee can be obtained on request to its secretary.

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Composants et dispositifs actifs à fibres optiques - Normes de performances - Partie 3: Emetteurs à diodes laser à modulateur intégré pour des systèmes de transmission à fibres optiques de 2,5 Gbit/s à 40 Gbit/s
(CEI 62149-3:2014)

Aktive Lichtwellenleiterbauelemente und -geräte - Betriebsverhalten - Teil 3: Laserdiodensender mit integriertem Modulator für 2,5-Gbit/s- bis 40-Gbit/s-Lichtwellenleiter-Übertragungssysteme
(IEC 62149-3:2014)

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Foreword

The text of document 86C/1157/CDV, future edition 2 of IEC 62149-3, prepared by SC 86C "Fibre optic systems and active devices" of IEC/TC 86 "Fibre optics" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN 62149-3:2014.

The following dates are fixed:

• latest date by which the document has to be implemented at national level by publication of an identical national standard or by endorsement	(dop)	2015-03-30
• latest date by which the national standards conflicting with the document have to be withdrawn	(dow)	2017-06-30

This document supersedes EN 62149-3:2004.

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The text of the International Standard IEC 62149-3:2014 was approved by CENELEC as a European Standard without any modification.

In the official version, for Bibliography, the following notes have to be added for the standards indicated:

IEC 60068 Series	NOTE	Harmonized as EN 60068 Series.
IEC 60793 Series	NOTE	Harmonized as EN 60793 Series.
IEC 60825 Series	NOTE	Harmonized as EN 60825 Series.
IEC 60874 Series	NOTE	Harmonized as EN 60874 Series.
IEC 62572-2	NOTE	Harmonized as EN 62572-2.
IEC 62572-3	NOTE	Harmonized as EN 62572-3.
IEC 61280 Series	NOTE	Harmonized as EN 61280 Series.
IEC 62007-2	NOTE	Harmonized as EN 62007-2.

Annex ZA
(normative)

Normative references to international publications with their corresponding European publications

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.

NOTE 1 When an International Publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

NOTE 2 Up-to-date information on the latest versions of the European Standards listed in this annex is available here: www.cenelec.eu

Publication	Year	Title	EN/HD	Year
IEC 60068-2-1	-	Environmental testing -- Part 2-1: Tests - Test A: Cold	EN 60068-2-1	-
IEC 60068-2-2	-	Environmental testing -- Part 2-2: Tests - Test B: Dry heat	EN 60068-2-2	-
IEC 60068-2-6	-	Environmental testing -- Part 2-6: Tests - Test Fc: Vibration (sinusoidal)	EN 60068-2-6	-
IEC 60068-2-14	-	Environmental testing -- Part 2-14: Tests - Test N: Change of temperature	EN 60068-2-14	-
IEC 60068-2-27	-	Environmental testing -- Part 2-27: Tests - Test Ea and guidance: Shock	EN 60068-2-27	-
IEC 60068-2-78	-	Environmental testing -- Part 2-78: Tests - Test Cab: Damp heat, steady state	EN 60068-2-78	-
IEC 60749-7	-	Semiconductor devices - Mechanical and climatic test methods -- Part 7: Internal moisture content measurement and the analysis of other residual gases	EN 60749-7	-
IEC 60749-26	-	Semiconductor devices - Mechanical and climatic test methods -- Part 26: Electrostatic discharge (ESD) sensitivity testing - Human body model (HBM)	EN 60749-26	-
IEC 60825-1	-	Safety of laser products -- Part 1: Equipment classification and requirements	EN 60825-1	-
IEC 60950-1	-	Information technology equipment - Safety -- Part 1: General requirements	EN 60950-1	-
IEC 62007-1	-	Semiconductor optoelectronic devices for fibre optic system applications - Part 1: Specification template for essential ratings and characteristics	EN 62007-1	-
ITU-T G.694-1	-	Spectral grids for WDM applications: DWDM frequency grid	-	-
MIL-STD-883	-	Test methods and procedures for microelectronics	-	-

CONTENTS

INTRODUCTION

Fibre optic transmitters are used to convert electrical signals into optical signals. This part of IEC 62149 covers the performance standard for optical modulators monolithically integrated with laser diodes for 2,5 Gbit/s to 40 Gbit/s multi-channel optical telecommunication systems.

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 optical modulators monolithically integrated with laser diodes for 2,5 Gbit/s to 40 Gbit/s multi-channel fibre optic transmission systems. This 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 as an initial design verification to prove any product's ability to satisfy the performance standard's requirements. This standard 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 complying with the performance standard, but should then be controlled by a quality assurance program.

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

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

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

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

IEC 60068-2-27, *Basic environmental testing procedures – Part 2: 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 62007-1, *Semiconductor optoelectronic devices for fibre optic system applications – Part 1: Specification template for essential ratings and characteristics*

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

MIL-STD-883, *U.S. Department of Defense – Test method standard – Microcircuits*

3 Terms, definitions and symbols

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.

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_{rmc} reverse modulation centre voltage

V_{rmpp} peak-to-peak modulation voltage

T_{sub} submount temperature

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_{sid}		260/10	°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}) = 0 V, unless otherwise stated		Symbol	Value		Unit
			Minimum	Maximum	
Laser and modulator diode					
Modulation speed		X	2,5	43,02	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) [a]		ER	8,2		dB
Peak emission wavelength at specified ϕ_e or I_{op} (under modulated conditions) [a, b]		λ_P	b	b	nm
Side-mode suppression ratio at specified ϕ_e or I_{op} (under modulated conditions) [a]		$SMSR$	30		dB
Switching times at specified ϕ_e or I_{op} (under modulated conditions)	Rise time [a]	t_r		600/X	ps
	Fall time [a]	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 conditions and specified fibre length [a]		Pe		2	dB
Monitor photodiode					
Dark current at ϕ_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		TE		0,5	dB
Thermal sensor					
Resistance at specified sensor current		R_s	9,5	10,5	kΩ
Thermister constant, B [a]		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 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 or I_{op}		V_p		2,5	V

[a] Definition and condition according to ITU-T G.957, PRBS $2^{23} - 1$, $V_{rm} = V_{rmc} \pm 1/2\ V_{rmpp}$.

[b] According to ITU-T Recommendation G.694.1.

[c] $B = \ln(R/R_0)/1/T\text{-}1/T_0)$ 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.

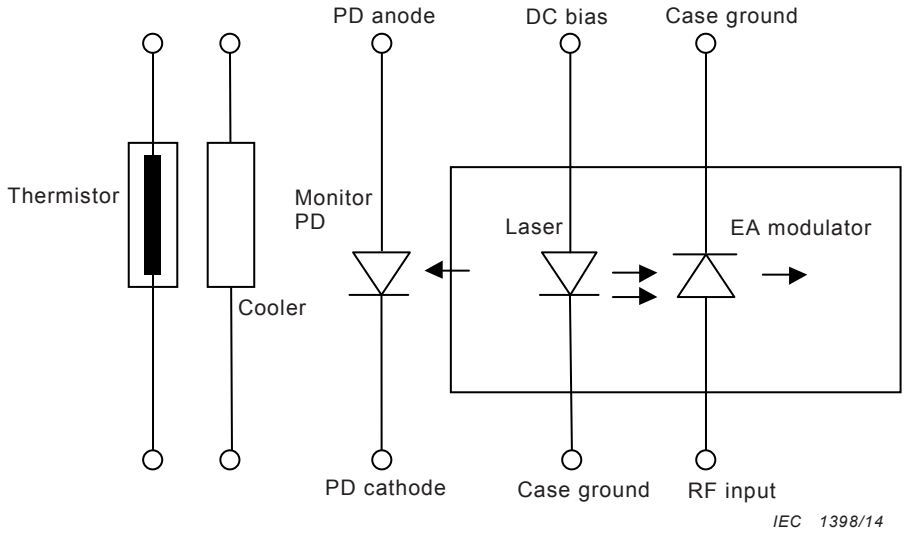

Figure 1 – Schematic diagram

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. Test conditions for all tests unless otherwise stated are 25 °C ± 2 °C

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, unless otherwise stated		Symbol	Value		Unit
			Minimum	Maximum	
Laser and modulator diode					
Modulation speed		X	2,5	43,02	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} or I_{op} (under modulated conditions) [a]		ER	8,2		dB
Peak emission wavelength at specified ϕ_e or I_{op} (under modulated conditions) [a, b]		λ_P	[b]	[b]	nm
Side-mode suppression ratio at specified ϕ_e or I_{op} (under modulated conditions) [a]		SMSR	30		dB
Switching times at specified ϕ_e or I_{op} (under modulated conditions)	Rise time [a]	t_r		600/X	ps
	Fall time [a]	t_f		600/X	ps
RF return loss at specified ϕ_e or I_{op} V_{rm} = 1/2V_{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 [a]		Pe		2	dB
Monitor photodiode					
Dark current at ϕ_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		TE		0,5	dB
Thermal sensor					
Resistance at specified sensor current		R_s	9,5	10,5	kΩ
Thermister B constant [c]		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 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 or I_{op}		V_p		2,5	V
Manufacturing lot shall be specified by each vendor.					

[a] Definition and conditions according to ITU-T G.957, PRBS $2^{23} - 1$, $V_{rm} = V_{rmc} \pm ½\ V_{Rmpp}$.

[b] According to ITU-T Recommendation G.694.1.

[c] $B = \ln(R/R_0)/1/T\text{-}1/T_0)$ where R is the resistance at ambient temperature T (°K) and R_0 is the resistance at ambient temperature T_0 (°K).

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	Temperature: T_A = T_{stg} min. T_B = T_{stg} max. Number of cycles = 100	11
Damp heat	IEC 60068-2-78	T = 40 °C, RH = 95 %, 56 days	11
Cyclic moisture resistance	MIL-STD-883H Method 1004		11
Endurance test of laser diode on submount	IEC 60068-2-14	Temperature: at least two test temperatures: ϕ_e specified, constant power $T_{sub}1$ = T_{sub} max. $T_{sub}2$ = < ($T_{sub}1$ – 20 °C) Duration: >5 000 h [b]	 By agreement [c] By agreement [c]
Endurance test of photodiode in representative package	IEC 60068-2-14	Temperature: at least two test temperatures: V_R or I_R specified $T_{sub}1$ = 125 °C min. [a] $T_{sub}2$ = < (T_s1 – 30 °C) Duration: >1 000 h	 By agreement [c] By agreement [c]
Power cycle tests of the thermoelectric cooler		Number of cycles: 20 K T_{CASE} = $T_{op\ max}$ T_{sub} = T_{CASE} to (T_{CASE} – ΔT_{max})	11
High temperature storage of the thermal sensor	MIL-STD-883H Method 1008	T = $T_{stg\ max}$ of the sensor	25
Fibre pull		1 kg, 5 s, 3 times	11
Mechanical shock	IEC 60068-2-27	500 G, 1,0 ms 5 times/axis	11
Vibration	IEC 60068-2-6	20 G, 20 Hz – 2 000 Hz, 4 min/cycle, 4 cycles/axis	11
Thermal shock	IEC 60068-2-14	ΔT = 100 °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.

Table 7 – Recommended performance test failure criteria

Device	Parameter	Failure criterion	Measurement condition
Laser diode	Threshold current or operating current	50 % increase [a] or 10 mA increase if $I_{(TH)}$ <20 mA	25 °C or life test temperature
	Slope efficiency	10 % change [a]	25 °C or life test temperature
	Forward voltage	10 % change [a]	25 °C or life test temperature
	Kinks in L/I curve	Kink-free within 1,2 × P_{nom} (linearity change ≤ 10 %) [a]	$T_{op\ min}$, 25 °C, $T_{op\ max}$
	Wavelength	See application	25 °C [b]
Photodiode	Dark current	USL or 10-nA increase [a]	25 °C
Laser module	Laser threshold or operating current	50 % increase [a] or 10 mA increase if $I_{(TH)}$ <20 mA	25 °C or life test temperature
	Fibre output power	10 % change [a]	Life test temperature I_M set to initial value
	Kinks in L/I curve	Kink-free within 1,2 × P_{nom} (linearity change ≤10 %) [a]	$T_{op\ min}$, 25 °C, $T_{op\ max}$
	Wavelength	See DS and application	See detail specification
	Tracking ratio (I_M / P_{fibre})	<LSL ≥USL	$T_{op\ min}$ – $T_{op\ max}$ at rated power level
	Photodiode dark current	USL or 10 nA increase [a]	25 °C
	Thermistor resistance	5 % change [a]	25 °C or life test temperature T_{sub}
	Peltier cooler current	±10 % change [a]	To maintain constant ΔT during test
	Peltier cooler voltage	±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 standard 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 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.

Bibliography

IEC 60068 (all parts), *Environmental testing*

IEC 60793 (all parts), *Optical fibres*

IEC 60825 (all parts), *Safety of laser products*

IEC 60874 (all parts), *Fibre optic interconnecting devices and passive components – Connectors for optical fibres and cables*

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

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

IEC 61280 (all parts), *Fibre optic communication subsystem test procedures*

IEC 62007-2, *Semiconductor optoelectronic devices for fibre optic system applications – Part 2: Measuring methods*

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

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