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INTERNATIONAL STANDARD

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Optical amplifiers –
Part 2: Single channel applications – Performance specification template

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FOREWORD

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This redline version of the official IEC Standard allows the user to identify the changes made to the previous edition IEC 61291-2:2016. A vertical bar appears in the margin wherever a change has been made. Additions are in green text, deletions are in strikethrough red text.

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IEC 61291-2 has been prepared by subcommittee 86C: Fibre optic systems and active devices, of IEC technical committee 86: Fibre optics. It is an International Standard.

This fifth edition cancels and replaces the fourth edition published in 2016. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

a) the test methods for gain ripple in Table 2, Table 4 and Table 6 refer now to the IEC 61290-1 series;

b) the SOA definition (3.1.3) refers now to IEC 61931.

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

Draft	Report on voting
86C/1849/FDIS	86C/1858/RVD

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

A list of all parts in the IEC 61291 series, published under the general title *Optical amplifiers*, 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 webstore.iec.ch in the data related to the specific document. At this date, the document will be

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- withdrawn,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

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INTRODUCTION

This document is devoted to the subject of optical amplifiers. The technology of optical amplifiers is still rapidly evolving, hence amendments and new additions to this document can be expected. Each abbreviated term introduced in this document is generally explained in the text the first time it appears. However, for an easier understanding of the whole text, a list of all abbreviated terms used in this document is given in Clause 3.

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OPTICAL AMPLIFIERS –

Part 2: Single channel applications – Performance specification template

1 Scope

This part of IEC 61291 provides a performance specification template applicable to optical amplifiers (OAs) used in single channel applications. Multichannel applications are covered in IEC 61291-4.

The objective of this ~~performance specification~~ template is to provide a framework for the preparation of performance standards and/or product specifications ~~on~~ defining the performance of OA devices used in single channel applications. ~~In the performance standards or product specifications, other specifications such as ratings, operating conditions, tests and pass/fail criteria could be included in addition to the requirements based on this performance specification template.~~ In addition to the requirements specified in this template, a performance standard or product specification could include other parameters, such as ratings, operating conditions, tests, and pass/fail criteria.

For a particular application, product specification writers ~~may~~ could add specification parameters and/or groups of specification parameters ~~for particular applications~~ to this template, without removing the parameters specified in this document. ~~However, product specification writers should not remove specification parameters specified in this standard.~~

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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

~~IEC 61000 (all parts), *Electromagnetic compatibility (EMC)*~~

IEC 61000-6-1, *Electromagnetic compatibility (EMC) – Part 6-1: Generic standards – Immunity standard for residential, commercial and light-industrial environments*

IEC 61000-6-3, *Electromagnetic compatibility (EMC) – Part 6-3: Generic standards – Emission standard for equipment in residential environments*

IEC 61290-1 (all parts), *Optical amplifiers – Test methods – Part 1: Power and gain parameters*

IEC 61290-3 (all parts), *Optical amplifiers – Test methods – Part 3: Noise figure parameters*

IEC 61290-4-3, *Optical amplifiers – Test methods – Part 4-3: Power transient parameters – Single channel optical amplifiers in output power control*

IEC 61290-5 (all parts), *Optical amplifiers – Test methods – Part 5: Reflectance parameters*

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IEC 61290-6-1, *Optical fibre amplifiers – Basic specification – Part 6-1: Test methods for pump leakage parameters – Optical demultiplexer*

IEC 61290-11 (all parts), *Optical amplifiers – Test methods – Part 11: Polarization mode dispersion parameter*

IEC 61291-1, *Optical amplifiers – Part 1: Generic specification*

IEC 61291-5-2, *Optical amplifiers – Part 5-2: Qualification specifications – Reliability qualification for optical fibre amplifiers*

IEC TS 62538:2008, *Categorization of optical devices*

3 Terms, definitions and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 61291-1, IEC TS 62538 and the following apply.

NOTE Possible supplementary definitions specific to OAs for single channel applications can be given in product specifications.

3.1.1
optical amplifier
OA
optical waveguide device containing a suitably pumped, active medium that is able to amplify an optical signal

[SOURCE: IEC TR 61931:1998, 2.7.75]

3.1.2
optical fibre amplifier
OFA
optical amplifier made of active optical fibre that is doped with rare-earth ions or that presents non-linear optical effects in order to obtain optical amplification

3.1.3
semiconductor optical amplifier
SOA
optical amplifier in which the active optical waveguide is formed by a semiconductor laser diode structure and will be electrically pumped

Note 1 to entry: The structure of these amplifiers is similar to that of Fabry-Perot laser diodes but with anti-reflection design elements at the end-face surfaces. The signal is amplified through the stimulated emission phenomenon in the gain medium.

[SOURCE: IEC TR 61931:1998, 2.7.77, modified – The note to entry has been added.]

3.1.4
optical element
unpackaged or partially packaged optical basic unit, typically non repairable and non-re-workable (at least by users)

Note 1 to entry: Examples of optical elements include laser chips or laser diodes, photodiodes, lenses, prisms, optical collimators, grating chips and filter chips.

[SOURCE: IEC TS 62538:2008, 2.2.1]

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3.1.5
optical component
packaged unit comprising at least one optical element, typically non repairable and non-re-workable (at least by users), suitably pigtailed or connectorized

Note 1 to entry: Examples of optical components include packaged lasers, photodiodes, optical splitters, couplers, attenuators, isolators, MEMS, and modulators.

[SOURCE: IEC TS 62538:2008, 2.2.2]

3.1.6
optical module
packaged integration of optical components and/or elements, accomplishing defined functionality, typically repairable and re-workable

Note 1 to entry: An optical module may comprise electronic components.

Note 2 to entry: An optical module is to be used as it is; users are not normally enabled to re-arrange inner components or add other components inside.

[SOURCE: IEC TS 62538:2008, 2.2.5]

3.1.7
OFA component
fibre-pigtailed optical component that consists of fibre based gain medium such as an erbium-doped fibre, one or more optical isolator(s), optical couplers for the wavelength-selector or the power monitor, a package, and fibres

Note 1 to entry: An OFA component may include an optical filter, such as a gain equalizing filter or ASE rejection filter, and possibly other components.

3.1.8
OFA module
fibre-pigtailed optical module that consists of an OFA component, pump laser component(s) with driving circuit, monitor photodiode component(s) with driving circuit, and a control circuit

3.1.9
SOA element
optical element of SOA that consists of a semiconductor chip

3.1.10
SOA component
fibre-pigtailed optical component that consists of an SOA element, lenses, optical isolator(s) (if necessary), a thermoelectric cooler (TEC), a thermistor, a package, and fibres

3.2 Abbreviated terms

EMC electromagnetic compatibility

OA optical amplifier

OFA optical fibre amplifier

SOA semiconductor optical amplifier

TEC thermoelectric cooler

4 Performance specification templates for power amplifiers

The following templates contain a minimum set of performance parameters to be included in the specifications for OFA components or modules (see Table 1) and SOA components (see Table 2) used as power amplifiers in single channel applications. The tables include specification criteria (in terms of the maximum values, minimum values or both) and references

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to the corresponding standards describing the test methods. Note that the list of the minimum parameters for SOAs (see Table 2) covers SOA components only, because most SOA products are currently ~~traded~~ commercialized in the form of ~~the component using~~ a package, such as a butterfly-type package, which contains only the SOA.

Table 1 – Minimum relevant parameters for power amplifiers based on OFA components or modules using active fibre specified for single channel applications

	Parameters		Unit	Minimum values	Maximum values	IEC test method
Transmission characteristics	Input power range		dBm			IEC 61290-1 series
	Output power range[a]		dBm			IEC 61290-1 series
	Gain[a]		dB			IEC 61290-1 series
	Wavelength band		nm			IEC 61290-1 series
	Signal-spontaneous noise figure		dB	n/a		IEC 61290-3 series
	Polarization dependent gain		dB	n/a		IEC 61290-1 series
	Reverse amplified spontaneous emission power level		dBm	n/a		IEC 61290-3 series
	Input reflectance[b]		dB	n/a		IEC 61290-5 series
	Return loss[b]		dB		n/a	IEC 61290-3 series
	Maximum reflectance tolerable at input		dB	n/a		IEC 61290-5 series
	Maximum reflectance tolerable at output		dB	n/a		IEC 61290-5 series
	Pump leakage to input		dBm	n/a		IEC 61290-6-1
	Pump leakage to output		dBm	n/a		IEC 61290-6-1
	Maximum total output power		dBm	n/a		IEC 61290-1 series
Environmental and reliability parameters	Operating temperature		°C	See IEC 61291-5-2	See IEC 61291-5-2	
	Maximum operating relative humidity		%	n/a	See IEC 61291-5-2	
	Maximum operating vibration severity	Range of frequencies	Hz	See IEC 61291-5-2	See IEC 61291-5-2	
		Amplitude peak-to-peak	mm	n/a	See IEC 61291-5-2	
		Duration	s	n/a	See IEC 61291-5-2	
	Storage temperature		°C	See IEC 61291-5-2	See IEC 61291-5-2	
	Maximum storage relative humidity		%	n/a	See IEC 61291-5-2	
	Maximum shock severity, free drop	Drop height	mm	n/a	See IEC 61291-5-2	
	Failure rate		FIT	n/a	See IEC 61291-5-2	

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	Parameters	Unit	Minimum values	Maximum values	IEC test method

[a] Either output power range, gain, or both shall be stated.

[b] Either input reflectance or return loss shall be specified.

n/a: not applicable

Table 2 – Minimum relevant parameters for power amplifiers based on SOA components specified for single channel applications

	Parameters	Unit	Minimum values	Maximum values	IEC test method
Transmission characteristics[a]	Input power range	dBm			IEC 61290-1 series
	Output power range[b]	dBm			IEC 61290-1 series
	Gain[b]	dB	n/a		IEC 61290-1 series
	Saturation output power	dBm	n/a		IEC 61290-1 series
	Wavelength band	nm			IEC 61290-1 series
	Gain ripple[~~c~~]	dB	n/a		~~Under consideration~~ IEC 61290-1 series
	Signal-spontaneous noise figure	dB	n/a		IEC 61290-3 series
	Polarization dependent gain	dB	n/a		IEC 61290-1 series
	Forward amplified spontaneous emission power level	dBm	n/a		IEC 61290-3 series
	Reverse amplified spontaneous emission power level	dBm	n/a		IEC 61290-3 series
	Input reflectance	dB	n/a		IEC 61290-5 series
	Maximum reflectance tolerable at input	dB	n/a		IEC 61290-5 series
	Maximum reflectance tolerable at output	dB	n/a		IEC 61290-5 series
	Maximum total output power	dBm	n/a		IEC 61290-1 series
Environmental and reliability parameters[c]	Operating temperature	°C			
	Maximum operating relative humidity	%	n/a		
	Maximum operating vibration severity – Range of frequencies	Hz			
	Maximum operating vibration severity – Amplitude peak-to-peak	mm	n/a		
	Maximum operating vibration severity – Duration	s	n/a		
	Storage temperature	°C			
	Maximum storage relative humidity	%	n/a		

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	Parameters		Unit	Minimum values	Maximum values	IEC test method
	Maximum shock severity, free drop	Drop height	mm	n/a		
	Failure rate		FIT	n/a		
Operating condition[a,d]	Forward current		mA			
	Forward bias voltage		V			
	Gain peak wavelength		nm			
	TEC current		A			
	TEC voltage		V			
	Thermistor resistance		Ω			
	Thermistor constant					

[a] Detailed information about SOA characteristics for saturation output power, gain, gain ripple, signal-spontaneous noise figure, polarization dependent gain, maximum total output power, and operating conditions are described in IEC TR 61292-9.

[b] Either output power range, gain, or both shall be stated.

~~[e] Measurement method should be defined in other documents.~~

[c] ~~There are no IEC publications regarding SOA reliability. There are two documents regarding reliability of fibre optic active components and devices. These are IEC TR 62572-2 and IEC 62572-3, which deal with laser modules.~~ There are no IEC publications specifying reliability parameters for SOAs. The reliability of laser modules is addressed in IEC TR 62572-2, and reliability parameters for laser modules are specified in IEC 62572-3.

[d] Operating conditions of a TEC and thermistor are commonly specified in IEC 62149-3, which ~~covers the~~ is a performance standard for ~~2,5 Gb/s~~ modulator-integrated laser diode ~~modules~~ transmitters for 40-Gbit/s fibre optic transmission systems.

5 Performance specification templates for pre-amplifiers

The following templates contain a minimum set of performance parameters to be included in the specifications for OFA components or modules (see Table 3) and SOA components (see Table 4) used as pre-amplifiers in single channel applications. The tables include specification criteria (in terms of the maximum values, minimum values, or both) and references to the corresponding standards describing the test methods. Note that the list of the minimum parameters for SOAs (see Table 4) covers SOA components only, because most SOA products are currently ~~traded~~ commercialized in the form of ~~the component using~~ a package, such as a butterfly-type package, which contains only the SOA.

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Table 3 – Minimum relevant parameters for pre-amplifiers based on OFA components or modules using active fibre specified for single channel applications

	Parameters	Unit	Minimum values	Maximum values	IEC test method
Transmission characteristics	Input power range	dBm			IEC 61290-1 series
	Output power range[a]	dBm			IEC 61290-1 series
	Gain[a]	dB			IEC 61290-1 series
	Wavelength band	nm			IEC 61290-1 series
	Available signal wavelength band	nm			IEC 61290-1 series
	Signal-spontaneous noise figure	dB	n/a		IEC 61290-3 series
	Polarization dependent gain	dB	n/a		IEC 61290-1 series
	Forward amplified spontaneous emission power level	dBm	n/a		IEC 61290-3 series
	Reverse amplified spontaneous emission power level	dBm	n/a		IEC 61290-3 series
	Input reflectance[b]	dB	n/a		IEC 61290-5 series
	Return loss[b]	dB		n/a	IEC 61290-3 series
	Maximum reflectance tolerable at input	dB	n/a		IEC 61290-5 series
	Maximum reflectance tolerable at output	dB	n/a		IEC 61290-5 series
	Pump leakage to input	dBm	n/a		IEC 61290-6-1
	Pump leakage to output	dBm	n/a		IEC 61290-6-1
	Maximum total output power	dBm	n/a		IEC 61290-1 series
Transient parameters[c]	Transient power response	dB	n/a		IEC 61290-4-3
	Transient power response time	s	n/a		IEC 61290-4-3
	Transient power overcompensation response	dB	n/a		IEC 61290-4-3
	Steady state power offset	dB	n/a		IEC 61290-4-3

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	Parameters		Unit	Minimum values	Maximum values	IEC test method
Environmental and reliability parameters	Operating temperature		°C	See IEC 61291 -5-2	See IEC 61291 -5-2	
	Maximum operating relative humidity		%	n/a	See IEC 61291 -5-2	
	Maximum operating vibration severity	Range of frequencies	Hz	See IEC 61291 -5-2	See IEC 61291 -5-2	
		Amplitude peak-to-peak	mm	n/a	See IEC 61291 -5-2	
		Duration	s	n/a	See IEC 61291 -5-2	
	Storage temperature		°C	See IEC 61291 -5-2	See IEC 61291 -5-2	
	Maximum storage relative humidity		%	n/a	See IEC 61291 -5-2	
	Maximum shock severity, free drop	Drop height	mm	n/a	See IEC 61291 -5-2	

[a] Either output power range, gain, or both shall be stated.

[b] Either input reflectance or return loss shall be specified.

[c] Transient parameters are applicable to OFA modules with output power control.

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Table 4 – Minimum relevant parameters for pre-amplifiers based on SOA components specified for single channel applications

	Parameters		Unit	Minimum values	Maximum values	IEC test method
Transmission characteristics[a]	Input power range		dBm			IEC 61290-1 series
	Output power range[b]		dBm			IEC 61290-1 series
	Gain[b]		dB	n/a		IEC 61290-1 series
	Saturation output power		dBm	n/a		IEC 61290-1 series
	Wavelength band		nm			IEC 61290-1 series
	Gain ripple[c]		dB	n/a		~~Under consideration~~ IEC 61290-1 series
	Signal-spontaneous noise figure		dB	n/a		IEC 61290-3 series
	Polarization dependent gain		dB	n/a		IEC 61290-1 series
	Forward amplified spontaneous emission power level		dBm	n/a		IEC 61290-3 series
	Reverse amplified spontaneous emission power level		dBm	n/a		IEC 61290-3 series
	Input reflectance		dB	n/a		IEC 61290-5 series
	Maximum reflectance tolerable at input		dB	n/a		IEC 61290-5 series
	Maximum reflectance tolerable at output		dB	n/a		IEC 61290-5 series
	Maximum total output power		dBm	n/a		IEC 61290-1 series
Environmental and reliability parameters[c]	Operating temperature		°C			
	Maximum operating relative humidity		%	n/a		
	Maximum operating vibration severity	Range of frequencies	Hz			
		Amplitude peak-to-peak	mm	n/a		
		Duration	s	n/a		
	Storage temperature		°C			
	Maximum storage relative humidity		%	n/a		
	Maximum shock severity, free drop	Drop height	mm	n/a		
	Failure rate		FIT	n/a		

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	Parameters	Unit	Minimum values	Maximum values	IEC test method
Operating condition[a,d]	Forward current	mA			
	Forward bias voltage	V			
	Gain peak wavelength	nm			
	TEC current	A			
	TEC voltage	V			
	Thermistor resistance	Ω			
	Thermistor constant				

[a] Detailed information about SOA characteristics for saturation output power, gain, gain ripple, signal-spontaneous noise figure, polarization dependent gain, maximum total output power, and operating conditions are described in IEC TR 61292-9.

[b] Either output power range, gain, or both shall be stated.

~~[e] Measurement method should be defined in other documents.~~

[c] ~~There are no IEC publications regarding SOA reliability. There are two documents regarding The reliability of fibre optic active components and devices. These are IEC TR 62572-2 and IEC 62572-3, which deal with laser modules.~~ There are no IEC publications specifying reliability parameters for SOAs. The reliability of laser modules is addressed in IEC TR 62572-2, and reliability parameters for laser modules are specified in IEC 62572-3.

[d] Operating conditions of a TEC and thermistor are commonly specified in IEC 62149-3, which ~~covers the~~ is a performance standard for ~~2,5 Gb/s~~ modulator-integrated laser diode ~~modules~~ transmitters for 40-Gbit/s fibre optic transmission systems .

6 Performance specification templates for line amplifiers

The following templates contain a minimum set of performance parameters to be included in specifications for OFA components and modules (see Table 5) and SOA components (see Table 6) used as line amplifiers in single channel applications. These tables include specification criteria (in terms of the maximum values, minimum values or both) and references to the corresponding standards describing the test methods. Note that the list of the minimum parameters for SOAs (see Table 6) covers SOA components only, because most SOA products are currently ~~traded~~ commercialized in the form of ~~the component using~~ a package, such as a butterfly-type package, which contains only the SOA.

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Table 5 – Minimum relevant parameters for line amplifiers based on OFA components or modules using active fibre specified for single channel applications

	Parameters	Unit	Minimum values	Maximum values	IEC test method
Transmission characteristics	Input power range	dBm			IEC 61290-1 series
	Output power range[a]	dBm			IEC 61290-1 series
	Gain[a]	dB			IEC 61290-1 series
	Saturation output power	dBm	n/a		IEC 61290-1 series
	Wavelength band	nm			IEC 61290-1 series
	Signal-spontaneous noise figure	dB	n/a		IEC 61290-3 series
	Polarization dependent gain	dB	n/a		IEC 61290-1 series
	Forward amplified spontaneous emission power level	dBm	n/a		IEC 61290-3 series
	Reverse amplified spontaneous emission power level	dBm	n/a		IEC 61290-3 series
	Input reflectance	dB[b]	n/a		IEC 61290-5 series
	Return loss	dB[b]		n/a	IEC 61290-3 series
	Maximum reflectance tolerable at input	dB	n/a		IEC 61290-5 series
	Maximum reflectance tolerable at output	dB	n/a		IEC 61290-5 series
	Pump leakage to input	dBm	n/a		IEC 61290-6-1
	Pump leakage to output	dBm	n/a		IEC 61290-6-1
	Maximum total output power	dBm	n/a		IEC 61290-1 series
	Polarization mode dispersion	ps	n/a		IEC 61290-11 series
Transient parameters[c]	Transient power/gain response	dB	n/a		IEC 61290-4-3
	Transient power/gain response time	s	n/a		IEC 61290-4-3
	Transient power/gain overcompensation response	dB	n/a		IEC 61290-4-3
	Steady state power/gain offset	dB	n/a		IEC 61290-4-3

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	Parameters		Unit	Minimum values	Maximum values	IEC test method
Environmental and reliability parameters	Operating temperature		°C	See IEC 61291 -5-2	See IEC 61291 -5-2	
	Maximum operating relative humidity		%	n/a	See IEC 61291 -5-2	
	Maximum operating vibration severity	Range of frequencies	Hz	See IEC 61291 -5-2	See IEC 61291 -5-2	
		Amplitude peak-to-peak	mm	n/a	See IEC 61291 -5-2	
		Duration	s	n/a	See IEC 61291 -5-2	
	Storage temperature		°C	See IEC 61291 -5-2	See IEC 61291 -5-2	
	Maximum storage relative humidity		%	n/a	See IEC 61291 -5-2	
	Maximum shock severity, free drop	Drop height	mm	n/a	See IEC 61291 -5-2	

[a] Either output power range, gain, or both shall be stated.

[b] Either input reflectance or return loss shall be specified.

[c] Transient parameters are applicable to OFA modules with output power control.

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Table 6 – Minimum relevant parameters for line amplifiers based on SOA components specified for single channel applications

	Parameters		Unit	Minimum values	Maximum values	IEC test method
Transmission characteristics[a]	Input power range		dBm			IEC 61290-1 series
	Output power range[b]		dBm			IEC 61290-1 series
	Gain[b]		dB	n/a		IEC 61290-1 series
	Saturation output power		dBm	n/a		IEC 61290-1 series
	Wavelength band		nm			IEC 61290-1 series
	Gain ripple[c]		dB	n/a		~~Under consideration~~ IEC 61290-1 series
	Signal-spontaneous noise figure		dB	n/a		IEC 61290-3 series
	Polarization dependent gain		dB	n/a		IEC 61290-1 series
	Forward amplified spontaneous emission power level		dBm	n/a		IEC 61290-3 series
	Reverse amplified spontaneous emission power level		dBm	n/a		IEC 61290-3 series
	Input reflectance		dB	n/a		IEC 61290-5 series
	Maximum reflectance tolerable at input		dB	n/a		IEC 61290-5 series
	Maximum reflectance tolerable at output		dB	n/a		IEC 61290-5 series
	Maximum total output power		dBm	n/a		IEC 61290-1 series
	Polarization mode dispersion		ps	n/a		IEC 61290-11-1
Environmental and reliability parameters[c]	Operating temperature		°C			
	Maximum operating relative humidity		%	n/a		
	Maximum operating vibration severity	Range of frequencies	Hz			
		Amplitude peak-to-peak	mm	n/a		
		Duration	s	n/a		
	Storage temperature		°C			
	Maximum storage relative humidity		%	n/a		
	Maximum shock severity, free drop	Drop height	mm	n/a		
	Failure rate		FIT	n/a		

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