

Optical amplifiers —

Part 1: Generic specification

The European Standard EN 61291-1:2006 has the status of a British Standard

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National foreword

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A list of organizations represented on GEL/86/3 can be obtained on request to its secretary.

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CENELEC

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Foreword

The text of document 86C/705/FDIS, future edition 2 of IEC 61291-1, 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 was approved by CENELEC as EN 61291-1 on 2006-09-01.

This European Standard supersedes EN 61291-1:1998.

It includes the following significant changes: the applicability has been extended to all commercially available optical amplifiers, not just optical fiber amplifiers, and definitions for multichannel amplifiers are included.

The following dates were fixed:

- | | | |
|--|-------|------------|
| – latest date by which the EN has to be implemented at national level by publication of an identical national standard or by endorsement | (dop) | 2007-06-01 |
| – latest date by which the national standards conflicting with the EN have to be withdrawn | (dow) | 2009-09-01 |

Annex ZA has been added by CENELEC.

Endorsement notice

The text of the International Standard IEC 61291-1:2006 was approved by CENELEC as a European Standard without any modification.

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INTRODUCTION

This International Standard is devoted to the subject of optical amplifiers. The technology of optical amplifiers is still rapidly evolving, hence amendments and new editions to this standard can be expected.

OPTICAL AMPLIFIERS –

Part 1: Generic specification

1 Scope and object

This part of IEC 61291 applies to all commercially available optical amplifiers (OAs) and optically amplified assemblies. It applies to OAs using optically pumped fibres (OFAs based either on rare-earth doped fibres or on the Raman effect), semiconductors (SOAs), and waveguides (POWAs). The object of this standard is:

- to establish uniform requirements for transmission, operation, reliability and environmental properties of OAs;
- to provide assistance to the purchaser in the selection of consistently high-quality OA products for his particular applications.

Parameters specified for OAs are those characterizing the transmission, operation, reliability and environmental properties of the OA seen as a “black box” from a general point of view. In the sectional and detail specifications a subset of these parameters will be specified according to the type and application of the particular OA device or assembly.

2 Normative references

The following referenced documents are indispensable for the application 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 61290 (all parts): *Optical amplifiers – Test methods*

IEC 61290-1-1, *Optical fibre amplifiers – Basic specification – Part 1-1: Test methods for gain parameters – Optical spectrum analyzer*

IEC 61290-1-2, *Optical amplifiers – Test methods – Part 1-2: Power and gain parameters – Electrical spectrum analyzer method*

IEC 61290-1-3, *Optical amplifiers – Test methods – Part 1-3: Power and gain parameters – Optical power meter method*

IEC 61290-3-1, *Optical amplifiers – Test methods – Part 3-1: Noise figure parameters – Optical spectrum analyzer method*

IEC 61290-3-2, *Optical amplifiers – Part 3-2: Test methods for noise figure parameters – Electrical spectrum analyzer method*

IEC 61290-5-1, *Optical fibre amplifiers – Basic specification – Part 5-1: Test methods for reflectance parameters – Optical spectrum analyser*

IEC 61290-5-2, *Optical amplifiers – Test methods – Part 5-2: Reflectance parameters – Electrical spectrum analyser method*

IEC 61290-5-3, *Basic specification for optical amplifier test methods – Part 5-3: Test methods for reflectance parameters – Reflectance tolerance test method using electrical spectrum analyzer*

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

IEC 61290-7-1, *Optical fibre amplifiers – Basic specification – Part 7-1: Test methods for out-of-band insertion losses – Filtered optical power meter*

IEC 61290-10-1, *Optical amplifiers – Test methods – Part 10-1: Multichannel parameters – Pulse method using an optical switch and optical spectrum analyzer*

IEC 61290-10-2, *Optical amplifiers – Test methods – Part 10-2: Multichannel parameters – Pulse method using a gated optical spectrum analyzer*

IEC 61290-10-3, *Optical amplifiers – Test methods – Part 10-3: Multichannel parameters – Probe methods*

IEC 61290-11-1, *Optical amplifier test methods – Part 11-1: Polarization mode dispersion – Jones matrix eigenanalysis method (JME)*

IEC 61290-11-2, *Optical amplifiers – Test methods – Part 11-2: Polarization mode dispersion parameter – Poincaré sphere analysis method*

IEC 61291-2, *Optical fibre amplifiers – Part 2: Digital applications – Performance specification template*

IEC 61291-4, *Optical amplifiers – Part 4: Multichannel applications – Performance specification template*

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

IEC 61292-3, *Optical amplifiers – Part 3: Classification, characteristics and applications*

3 Terms, definitions and abbreviations

3.1 Overview

The definitions listed in this clause refer to the meaning of the terms used in the specifications of OAs. Only those parameters listed in the appropriate specification template, as in IEC 61291-2 and IEC 61291-4, are intended to be specified.

NOTE 1 The numbered terms in this clause are indexed and cross-referenced in Annex A.

The list of parameter definitions of OAs, given in this clause, is divided into two parts: the first part, in 3.2, lists those parameters relevant for OA devices, namely power, pre-, line-, and distributed amplifiers; the second part, in 3.3 lists the parameters relevant for optically amplified, elementary assemblies, namely the optically amplified transmitter (OAT) and the optically amplified receiver (OAR).

In any case where the value of a parameter is given for a particular device, it will be necessary to specify certain appropriate operating conditions such as temperature, bias current, pump optical power, etc. In this clause, two different operating conditions are referred to: *nominal operating conditions*, which are those suggested by the manufacturer for normal use of the OA, and *limit operating conditions*, in which all the parameters adjustable by the user (e.g. temperature, gain, pump laser injection current, etc.) are at their maximum values, according to the *absolute maximum ratings* stated by the manufacturer.

The OA shall be considered as a “black box”, as shown in Figure 1. The OA device shall have two optical ports, namely an input and an output port (Figure 1a). The OAT and OAR are to be considered as an OA integrated on the transmitter side or on the receiver side, respectively. Both kinds of integration imply that the connection between the transmitter or the receiver and the OA is proprietary and not to be specified. Consequently, only the optical output port can be defined for the OAT (after the OA, as shown in Figure 1b) and only the optical input port can be defined for the OAR (before the OA, as shown in Figure 1c). The optical ports may consist of unterminated fibres or optical connectors. Electrical connections for power supply (not shown in Figure 1) are also necessary. Following this “black box” approach, the typical loss of one connection and the corresponding uncertainty will be included within the values of gain, noise figure and other parameters of the OA device.

NOTE 2 For distributed amplifiers, as described in Clause 4, this black-box configuration may be simulated for test purposes, for example by attaching a reference fibre to test a Raman pump unit.

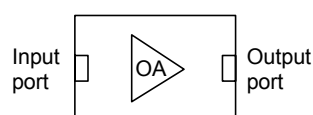


Figure 1a – OA device

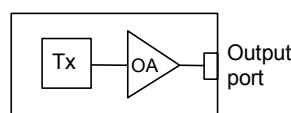
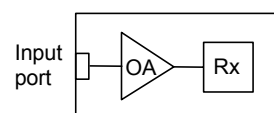


Figure 1b – OAT



IEC 1483/06

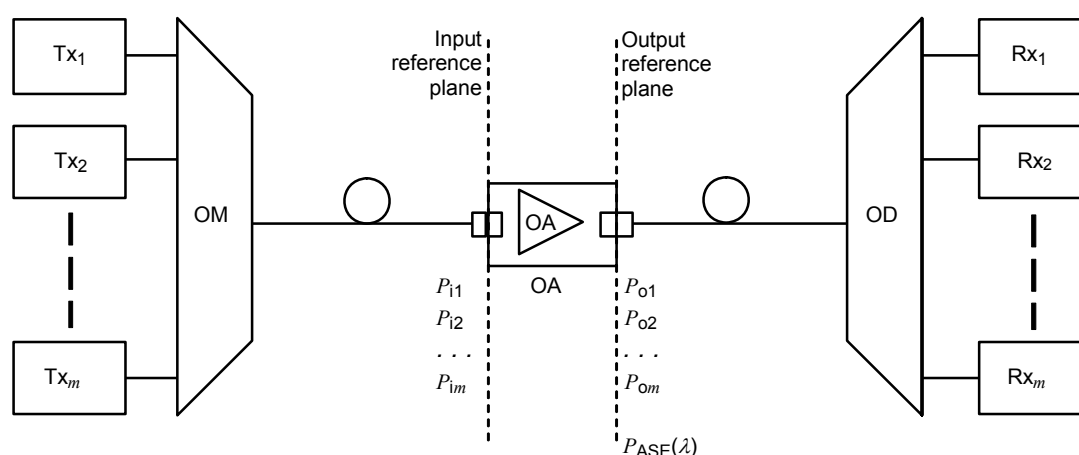
Figure 1c – OAR

Figure 1 – OA device and assemblies

The OA amplifies signals in a nominal *operating wavelength* region. In addition, other signals outside of the band of operating wavelength can in some applications, also cross the OA. The purpose of these *out-of-band* signals and their wavelength, or wavelength region, can be specified in the detail specifications.

When signals at multiple wavelengths are incident on the OA, as is the case in multichannel systems, suitable adjustment of the definitions of some existing relevant parameters is needed together with the introduction of definitions of new parameters relevant to this different application.

A typical configuration of an OA in a multichannel application is shown in Figure 2. At the transmitting side m signals, coming from m optical transmitters, $Tx_1, Tx_2, \dots, Tx_m$, each with a unique wavelength, $\lambda_1, \lambda_2, \dots, \lambda_m$, respectively, are combined by an optical multiplexer (OM). At the receiving side the m signals at $\lambda_1, \lambda_2, \dots, \lambda_m$, are separated with an optical demultiplexer (OD) and routed to separate optical receivers, $Rx_1, Rx_2, \dots, Rx_m$, respectively. To characterize the OA in this multichannel application, an input reference plane and an output reference plane are defined at the OA input and output ports, respectively, as shown in Figure 2.



IEC 1484/06

Figure 2 – Optical amplifier in a multichannel application

At the input reference plane, m input signals at the m wavelengths are considered, each with a unique power level, P_{i1} , P_{i2} , $\dots$, P_{im} , respectively. At the output reference plane, m output signals at the m wavelengths, resulting from the optical amplification of the corresponding m input signals, are considered, each with power level P_{o1} , P_{o2} , $\dots$, P_{om} , respectively. Moreover, the amplified spontaneous emission, ASE, with a noise power spectral density, $P_{ASE}(\lambda)$, is also to be considered at the OA output port.

Most definitions of relevant single-channel parameters can be suitably extended to multichannel applications. When this extension is straightforward, the word “channel” will be added to the pertinent parameter. In particular, the noise figure and the signal-spontaneous noise figure may be extended to multichannel applications, channel by channel, by considering the value of $P_{ASE}(\lambda)$ at each channel wavelength and the channel signal bandwidth. For each channel wavelength there will be a unique value of noise figure that will be a function of the input power level of all signals. In this case the parameters, channel noise figure and channel signal-spontaneous noise figure, are introduced. However some additional parameters also need to be defined. For each parameter, the particular multichannel configuration, including the full set of channel signal wavelengths and input powers, needs to be specified.

NOTE 1 Except where noted, the optical powers mentioned in the following are intended as average powers.

NOTE 2 The parameters defined below will in general depend also on temperature and polarization state of input channels. The temperature and state of polarization should be kept constant or controlled or be measured and reported together with the measured parameter.

NOTE 3 It should be noted that the measured optical powers are open beam powers: this can result in differences of about 0,18 dB in the measurement of absolute power levels.

NOTE 4 In the case of the distributed amplifier, all the parameters are related to a suitable reference fibre used to emulate the transmission fibre in conjunction with the pumping assembly.

For the purposes of this document, the following terms and definitions apply. These terms and conditions furthermore apply, in general, to optical amplifiers under the IEC 61290 and IEC 61291 series.

3.2 Terms and definitions – OA devices and distributed amplifiers

3.2.1

gain

in an OA which is externally connected to an input jumper fibre, the increase of signal optical power from the output end of the jumper fibre to the OA output port, expressed in dB

NOTE 1 The gain includes the connection loss between the input jumper fibre and the OA input port.

NOTE 2 It is assumed that the jumper fibres are of the same type as the fibres used as input and output port of the OA.

NOTE 3 Care should be taken to exclude the amplified spontaneous emission power from the signal optical powers.

3.2.2

small-signal gain

gain of the amplifier, when operated in linear regime, where it is essentially independent of the input signal optical power, at a given signal wavelength and pump optical power level

NOTE This property can be described at a discrete wavelength or as a function of wavelength.

3.2.3

reverse gain

gain measured using the input port of the OA as output port and vice versa

3.2.4

reverse small-signal gain

small-signal gain measured using the input port of the OA as output port and vice versa

3.2.5

maximum gain

highest gain that can be achieved when the OA is operated within the stated nominal operating conditions

3.2.6

maximum small-signal gain

highest small-signal gain that can be achieved when the OA is operated within the stated nominal operating conditions

3.2.7

maximum gain wavelength

wavelength at which the maximum gain occurs

3.2.8

maximum small-signal gain wavelength

wavelength at which the maximum small-signal gain occurs

3.2.9

wavelength variation

peak-to-peak variation of the gain over a given wavelength range

3.2.10

small-signal gain wavelength variation

peak-to-peak variation of the small-signal gain over a given wavelength range