

# INTERNATIONAL STANDARD

## NORME INTERNATIONALE

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

**Amplificateurs optiques - Méthodes d'essai -  
Partie 1-2: Paramètres de puissance et de gain - Méthode de l'analyseur de  
spectre électrique**



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INTERNATIONAL ELECTROTECHNICAL COMMISSION

**Optical amplifiers - Test methods -  
Part 1-2: power and gain parameters -  
Electrical spectrum analyzer method**

FOREWORD

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IEC 61290-1-2 has been prepared by subcommittee 86C: Fibre optic systems, sensing and active devices, of IEC technical committee 86: Fibre optics. It is an International Standard.

This third edition cancels and replaces the second edition published in 2005. This edition constitutes a technical revision.

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

- a) addition of information on the applicability of this document to the scope;
- b) harmonization of the scope with the IEC 61290-1 series;
- c) addition of safety recommendations to Clause 4 and Clause 5;
- d) correction of an error in Clause 7, item e);

e) replacement of the term "wavelength measurement accuracy" with "wavelength accuracy".

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

Draft	Report on voting
86C/1973/CDV	86C/1991/RVC

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](http://www.iec.ch/members_experts/refdocs). The main document types developed by IEC are described in greater detail at [www.iec.ch/publications](http://www.iec.ch/publications).

A list of all parts in the IEC 61290 series, published under the general title *Optical amplifiers - Test methods*, 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](http://webstore.iec.ch) in the data related to the specific document. At this date, the document will be

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## 1 Scope

This part of IEC 61290 applies to all commercially available optical amplifiers (OAs) and optically amplified sub-systems. It applies to OAs using optically pumped fibres (OFAs based on either rare-earth doped fibres or on the Raman effect), semiconductors (SOAs), and planar optical waveguides (POWAs). This document does not apply to polarization-maintaining optical amplifiers.

This document defines uniform requirements for accurate and reliable measurements, by means of the electrical spectrum analyzer test method, of the following OA parameters, as defined in IEC 61291-1, Clause 3:

- a) nominal output signal power;
- b) gain;
- c) reverse gain;
- d) maximum gain;
- e) polarization-dependent gain.

In addition, this test method provides a means for measuring the following parameters:

- maximum gain wavelength;
- gain wavelength band.

This document specifically covers single-channel amplifiers. For multichannel amplifiers, the IEC 61290-10 series applies.

NOTE 1 The applicability of the test methods described in this document to distributed Raman amplifiers is for further study.

NOTE 2 A test method for polarization-maintaining optical amplifiers is for further study.

## 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 60793-1-40, *Optical fibres - Part 1-40: Measurement methods and test procedures - Attenuation*

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

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

### 3.1 Terms and definitions

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

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- IEC Electropedia: available at <https://www.electropedia.org/>
- ISO Online browsing platform: available at <https://www.iso.org/obp>

### 3.2 Abbreviated terms

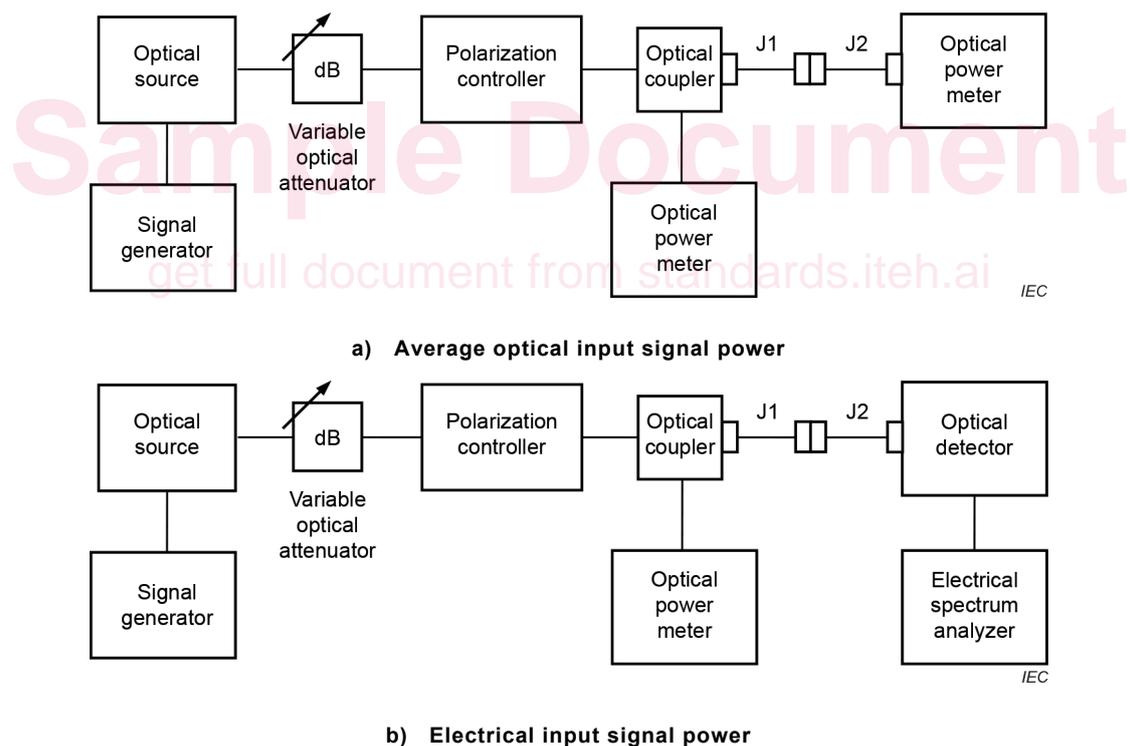
ASE	amplified spontaneous emission
DBR	distributed Bragg reflector (laser diode)
DFB	distributed feedback (laser diode)
ECL	external cavity laser (diode)
LED	light emitting diode
OA	optical amplifier
OFA	optical fibre amplifier
POWA	planar optical waveguide amplifier
SOA	semiconductor optical amplifier

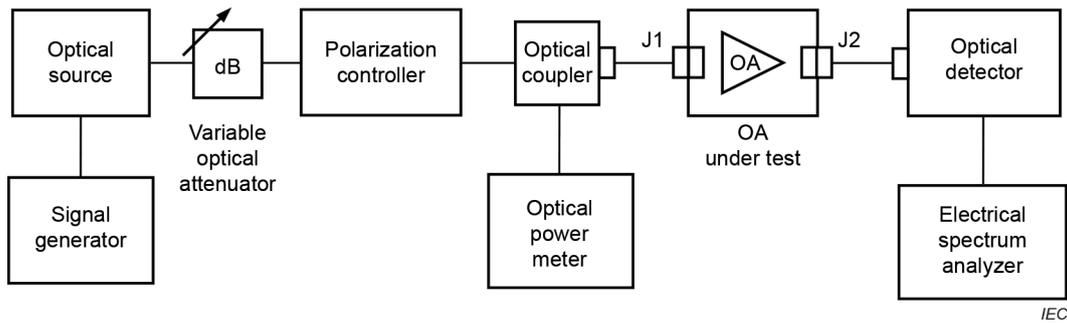
### 3.3 Symbols

(‡) indicates a suggested value for which a measurement is assured.

## 4 Apparatus

A diagram of the measurement set-up is given in Figure 1.





c) Electrical output signal power

**Key**

J1, J2 Optical connectors

**Figure 1 – Typical arrangement of the electrical spectrum analyzer test apparatus for measurement of average optical input signal power, electrical input signal power, and electrical output signal power**

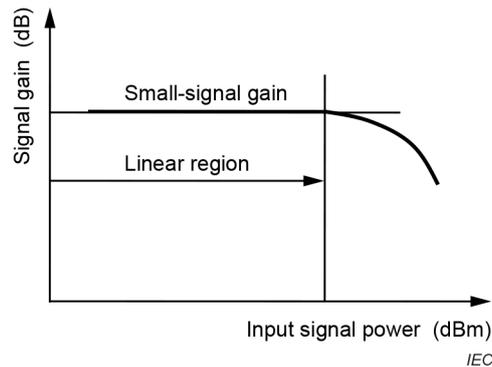
The test equipment items with their required characteristics listed in a) to k) in this clause shall be used.

a) *Optical source*: the optical source shall be either at a fixed wavelength or wavelength tuneable.

- 1) *Fixed-wavelength optical source*: the optical source shall generate light with a wavelength and optical power specified in the relevant detail specification. The optical source shall emit modulated light with the full width at half maximum of the spectrum narrower than 1 nm ( $\pm$ ), unless otherwise specified in the relevant detail specification. A distributed feedback (DFB) laser, a distributed Bragg reflector (DBR) laser, an external cavity laser (ECL) diode, or a light-emitting diode (LED) with a narrow-band filter can be used as the optical source, for example. The suppression ratio of the side modes for the DFB laser, the DBR laser, and the ECL shall be higher than 30 dB ( $\pm$ ). The output power fluctuation shall be less than 0,05 dB ( $\pm$ ), which can require the insertion of an optical isolator at the output port of the optical source. Spectral broadening at the foot of the lasing spectrum should be minimal for laser sources.
- 2) *Wavelength-tuneable optical source*: this optical source shall be able to generate wavelength-tuneable light within the wavelength range specified in the relevant detail specification. Its optical power shall be specified in the relevant detail specification. The optical source shall emit modulated light with the full width at half maximum of the spectrum narrower than 1 nm ( $\pm$ ), unless otherwise specified in the relevant detail specification. An ECL or a LED with a narrow bandpass optical filter can be used as the optical source, for example. The suppression ratio of side modes for the ECL shall be higher than 30 dB ( $\pm$ ). The output power fluctuation shall be less than 0,05 dB, which can require the insertion of an optical isolator at the output port of the optical source. Spectral broadening at the foot of the lasing spectrum should be minimal for the ECL.

The use of a LED should be limited to small-signal gain measurements.

NOTE 1 The regime of small-signal gain is the range of input signal power sufficiently small so that the OA under test operates in the linear region. This regime can be found by plotting the signal gain  $G$  versus the averaged input optical signal power [see Formula (3)]. The linear region is the range of input optical signal powers where the gain is nearly independent of input optical signal power (see Figure 2). An averaged input optical signal power between  $-30$  dBm and  $-40$  dBm is generally well within this range. In the saturated region, the signal power is large enough to well suppress the ASE.



**Figure 2 – Typical variation of gain as a function of input signal power**

- b) *Optical power meter*: it shall have a measurement uncertainty less than 0,2 dB, irrespective of the state of polarization, within the operational wavelength bandwidth of the OA. The optical power meter shall have a dynamic range that exceeds the measured gain (e.g. 40 dB).
- c) *Electrical spectrum analyzer*: the spectral-power-measurement error shall be within  $\pm 0,5$  dB (optical). The linearity shall be within  $\pm 0,2$  dB (optical).
- d) *Optical isolator*: optical isolators may be used at the input and output ports of the OA. The polarization-dependent loss variation of the isolator shall be less than 0,2 dB ( $\pm$ ). Optical isolation shall be higher than 40 dB ( $\pm$ ). The reflectance from this device shall be less than -40 dB ( $\pm$ ) at each port.
- e) *Variable optical attenuator*: the attenuation range and stability shall be over 40 dB ( $\pm$ ) and within  $\pm 0,1$  dB ( $\pm$ ), respectively. The reflectance from this device shall be less than -40 dB ( $\pm$ ) at each port.
- f) *Polarization controller*: this device shall be able to provide as input signal light all possible states of polarization (e.g. linear, elliptical and circular). For example, the polarization controller can consist of a linear polarizer followed by an all-fibre-type polarization controller, or of a linear polarizer followed by a quarter-wave plate rotatable by minimum of  $90^\circ$  and a half-wave plate rotatable by minimum of  $180^\circ$ . The loss variation of the polarization controller shall be less than 0,2 dB ( $\pm$ ). The reflectance from this device shall be less than -40 dB ( $\pm$ ) at each port. The use of a polarization controller is considered optional, except for the measurement of polarization-dependent gain, but can be necessary to achieve the desired accuracy of other power and gain parameters for OA devices exhibiting significant polarization-dependent gain.
- g) *Optical fibre jumpers*: the mode field diameter of the optical fibre jumpers used should be as close as possible to that of fibres used as input and output ports of the OA. The reflectance from this device shall be less than -40 dB ( $\pm$ ) at each port, and the length of the jumper shall be shorter than 2 m.
- h) *Optical connectors* (J1 and J2 in Figure 1): the connection loss repeatability shall be within  $\pm 0,2$  dB.
- i) *Optical detector*: this device shall be highly polarization insensitive and have a linearity within  $\pm 0,2$  dB. To minimize the saturation effects due to high DC levels, the optical detector output shall be AC coupled. The maximum safe input power of the optical detector should be sufficiently large to ensure safe testing of the OA.

NOTE 2 The maximum safe input power to the optical detector can be effectively increased by adding an optical attenuator with very low polarization sensitivity in front of the optical detector and using it as an integral part of the optical detector.