IEC 61290-1-3

Edition 3.0 2015-02

INTERNATIONAL STANDARD

NORME INTERNATIONALE

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

Amplificateurs optiques – Méthodes d'essai –
Partie 1-3: Paramètres de puissance et de gain – Méthode par appareil de mesure de la puissance optique

IEC 61290-1-3:2015-02(en-fr)

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Part 1-3: Power and gain parameters – Optical power meter method

FOREWORD

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International Standard IEC 61290-1-3 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 2005. This edition constitutes a technical revision.

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

a) Detail description of most parameters has been described in IEC 61290-1 and removed from this part;
b) Description of maximum output signal power and maximum total output power are added.

The text of this standard is based on the following documents:

CDV	Report on voting
86C/1255/CDV	86C/1292/RVC

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

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts in the IEC 61290 series, published under the general title *Optical amplifiers – Test methods*[1)] can be found on the IEC website.

This International Standard is to be used in conjunction with IEC-61290-1.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

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- withdrawn,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

1) The first editions of some of these parts were published under the general title *Optical fibre amplifiers – Basic specification* or *Optical amplifier test methods*.

OPTICAL AMPLIFIERS – TEST METHODS –

Part 1-3: Power and gain parameters – Optical power meter method

1 Scope

This part of IEC 61290-1 applies to all commercially available optical amplifiers (OA) and optically amplified subsystems. It applies to OA using optically pumped fibres (OFA based on either rare-earth doped fibres or on the Raman effect), semiconductors (SOA), and waveguides (POWA).

NOTE The applicability of the test methods described in the present standard to distributed Raman amplifiers is for further study.

The object of this part of IEC 61290-1 is to establish uniform requirements for accurate and reliable measurements, by means of the optical power meter test method, of the following OA parameters, as defined in IEC 61291-1:

a) nominal output signal power;

b) gain;

c) polarization-dependent gain;

d) maximum output signal power;

e) maximum total output power.

All numerical values followed by (‡) are suggested values for which the measurement is assured. Other values may be acceptable but should be verified.

This part of IEC 61290-1 applies to single-channel amplifiers. For multichannel amplifiers, the IEC 61290-10 series applies.

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

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

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

3 Terms, definitions and abbreviations

3.1 Terms and definitions

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

3.2 Abbreviations

ASE amplified spontaneous emission
DBR distributed Bragg reflector (laser diode)
DFB distributed feedback (laser diode)
ECL external cavity laser (diode)
FWHM full width at half maximum
LED light emitting diode
OA optical amplifier
OFA optical fibre amplifier
OSA optical spectrum analyzer
PDL polarization dependent loss
POWA planar optical waveguide amplifier
SOA semiconductor optical amplifier

4 Apparatus

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

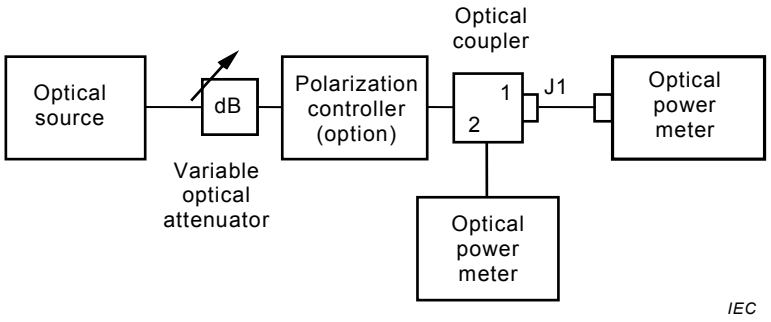

Figure 1a) Measurement of input signal power

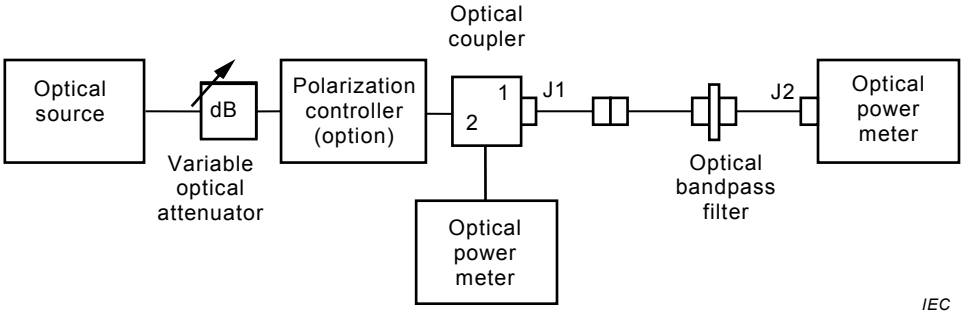

Figure 1b) Measurement of optical bandpass filter loss and jumper loss

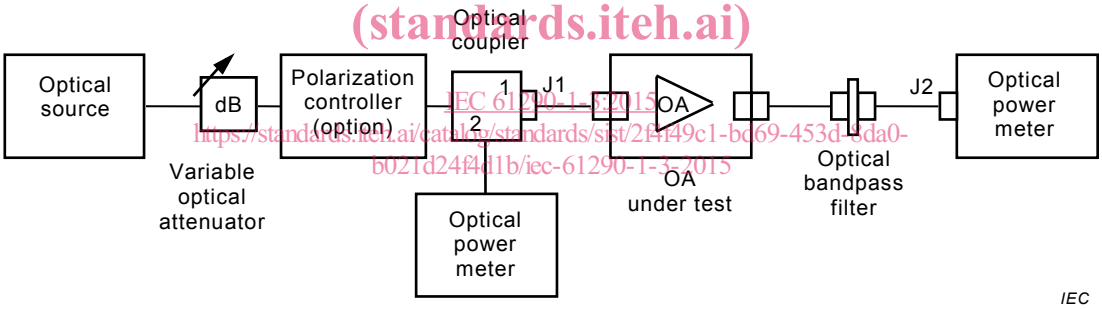

Figure 1c) Measurement of output signal power and gain

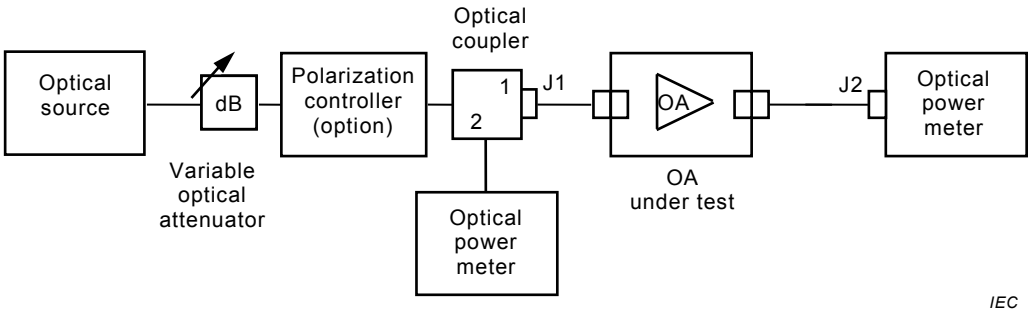

Figure 1d) Measurement of total output power

Figure 1 – Typical arrangement of optical power meter test apparatus for measurement

The test equipment listed below, with the required characteristics, is needed.

a) *optical source:* The optical source shall be either at fixed wavelength or wavelength-tuneable.

– *fixed-wavelength optical source:* This optical source shall generate a light with a wavelength and optical power specified in the relevant detail specification. Unless otherwise specified, the optical source shall emit a continuous wave with FWHM of the spectrum narrower than 1 nm (‡). A distributed feedback (DFB) laser, a distributed Bragg reflector (DBR) laser, an external cavity laser (ECL) diode, a light emitting diode (LED) with a narrow-band filter and a single line laser are applicable, for example.

  The suppression ratio for the side modes for the DFB laser, the DBR laser or the ECL shall be higher than 30 dB (‡). The output power fluctuation shall be less than 0,05 dB (‡), which may be better attainable with an optical isolator at the output port of the optical source. Spectral broadening at the foot of the lasing spectrum shall be minimal for laser sources, and the ratio of the source power to total spontaneous emission power of the laser shall be more than 30 dB.

– *wavelength-tuneable optical source:* This optical source shall be able to generate a wavelength-tuneable light within the range specified in the relevant detail specification. Its optical power shall be specified in the relevant detail specification. Unless otherwise specified, the optical source shall emit a continuous wave with the full width at half maximum (FWHM) of the spectrum narrower than 1 nm (‡). An ECL or an LED with a narrow bandpass optical filter is applicable, for example. The suppression ratio of side modes for the ECL shall be higher than 30 dB (‡). The output power fluctuation shall be less than 0,05 dB, which may be better attainable with an optical isolator at the output port of the optical source. Spectral broadening at the foot of the lasing spectrum shall be minimal for laser sources and the ratio of the source power to total spontaneous emission power of the laser shall be more than 30 dB.

b) *optical power meter:* It shall have a measurement accuracy better than ±0,2 dB, irrespective of the state of polarization, within the operational wavelength bandwidth of the OA. A maximum optical input power shall be large enough [e.g. +20 dBm (‡)]. Sensitivity shall be high enough [e.g. –40 dBm (‡)]. A dynamic range exceeding the measured gain is required (e.g. 40 dB).

c) *optical isolator:* Optical isolators may be used to bracket the OA. The polarization-dependent loss (PDL) of the isolator shall be better than 0,2 dB (‡). Optical isolation shall be better than 40 dB (‡). The reflectance from this device shall be smaller than –40 dB (‡) at each port.

d) *variable optical attenuator:* The attenuation range and stability shall be over 40 dB (‡) and better than ± 0,1 dB (‡), respectively. The reflectance from this device shall be smaller than –40 dB (‡) at each port.

e) *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 may consist of a linear polarizer followed by an all-fibre-type polarization controller, or by a linear polarizer followed by a quarter-wave plate rotatable by minimum of 90 ° and a half wave plate rotatable by minimum of 180 °. The loss variation of the polarization controller shall be less than 0,2 dB (‡). The reflectance from this device shall be smaller than –40 dB (‡) at each port. The use of a polarization controller is considered optional, except for the measurement of polarization dependent gain, but may be necessary to achieve the desired accuracy for OA devices exhibiting significant polarization dependent gain.

f) *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 smaller than –40 dB (‡) at each port, and the length of the jumper shall be shorter than 2 m.

   Standard optical fibres defined in IEC 60793-2-50, B1 are recommended. However, other fiber type may be used as input/output fiber. In this case, the type of fibre will be considered.

g) *optical connectors:* The connection loss repeatability shall be better than ± 0,2 dB. The reflectance from this device shall be smaller than –40 dB (‡).

h) *optical bandpass filter:* The optical bandwidth (FWHM) of this device shall be less than 3 nm (‡). It shall be either wavelength-tuneable or an appropriate set of fixed bandpass filters. During measurement, the difference between the centre wavelength of this

bandwidth and the optical source centre wavelength shall be no more than 1,5 nm (‡). The PDL of the bandpass filter shall be less than 0,2 dB (‡). The reflectance from this device shall be smaller than –40 dB (‡).

NOTE 1 Optimization of optical band pass filter spectral width is discussed in Annex A.

i) *optical coupler:* The polarization dependence of the branching ratio of the coupler shall be less than 0,1 dB (‡).Any unconnected port of the coupler shall be properly terminated, in such a way as to decrease the reflectance below –40 dB (‡).

NOTE 2 The change of the state of polarization of the input light is typically negligible.

j) *wavelength meter:* It shall have a wavelength measurement accuracy better than 0,1 nm (‡). If the optical source is so calibrated that the accuracy of the wavelength is better than 0,1 nm (‡), the wavelength meter is not necessary.

5 Test sample

The OA shall operate at nominal operating conditions. If the OA is likely to cause laser oscillations due to unwanted reflections, use of optical isolators is recommended to bracket the OA under test. This will minimize the signal instability and the measurement uncertainty.

For all parameter measurements except polarization-dependent gain, care shall be taken to maintain the state of polarization of the input light during the measurement. Changes in the polarization state of the input light may result in input optical power changes because of the slight polarization dependency expected from all the optical components used, thus leading to measurement errors.

6 Procedure

a) *Nominal output signal power:* The nominal output signal power is given by the minimum output signal optical power, for an input signal optical power specified in the relevant detail specification, and under nominal operating conditions, given in the relevant detail specification. To find this minimum value, input and output signal power levels shall be continuously monitored for a given duration of time and in presence of changes in the state of polarization and other instabilities, as specified in the relevant detail specification. The measurement procedures described below shall be followed, with reference to Figure 1.

In order to minimize the amplified spontaneous emission (ASE) power contribution to the signal power output from the OA, several methods may be used. The optical bandpass filter method is given below.

1) Set the optical source at the test wavelength specified in the relevant detail specification, measuring the input signal wavelength (e.g. with a wavelength meter).
2) Measure the branching ratio of the optical coupler through the signal power levels exiting the two output ports with an optical power meter.
3) Measure the loss L_{bj} of the optical bandpass filter and the optical fibre jumper between the OA and the optical power meter (see Figure 1(b)) by the insertion loss technique (see Method B in IEC 60793-1-40).
4) Activate the OA under test and evaluate the ASE power level passed through the optical filter, PASE, by measuring the optical output power from the OA, as shown in Figure 1(c), without input signal.

NOTE 1 In large-signal conditions, the measurement of the ASE power is sometimes omitted.

NOTE 2 For consideration of measurement uncertainty, refer to the last paragraph of Annex A, which concerns the optimization of the optical band pass filter spectral width.

5) Set the optical source and the variable optical attenuator in such a way as to provide, at the input port of the OA, the input optical signal power (P_{in}) specified in the relevant detail specification. Record the optical power (P_o) measured with an optical power meter at the other (second) output port of the optical coupler, as shown in Figure 1(a).

Instantly applying signal light into the active OA can cause the generation of an optical surge which may damage the optical components. The input signal shall have sufficiently small power to prevent the optical surge, when it is launched to the OA initially. The input power shall be gradually increased to the specified level.

6) Keep the optical signal power at the OA input constant (Pin) during the following measurements, by monitoring the second output port of the coupler and, if necessary, setting the variable optical attenuator in such a way that the optical power (P_o) exiting the second output port of the optical coupler remains constant.

7) Connect the fibre jumpers to the input and output port of the OA under test, as shown in Figure 1(c) and evaluate the optical output power (P_{out}) with input signal.

In the case using the polarization controller, the following procedure shall be adapted.

8) Set the polarization controller at a given state of polarization as specified in the relevant detail specification; activate the OA, and monitor, by means of the optical power meter, the optical signal power at the output of the OA, for the specified period of time, recording the minimum value.

9) Change the state of polarization of the input signal by means of the polarization controller, trying to measure maximum and minimum output optical signal powers with the optical power meter, and repeat procedure 8).

10) Repeat procedure 9) for the different states of polarization indicated in the relevant detail specification and, finally, take the absolute minimum and maximum output optical signal powers recorded in the various conditions: $P_{out-min}$ and $P_{out-max}$.

Optical connectors J1 and J2 shall not be removed during the measurement to avoid measurement errors due to reconnection.

The measurement error shall be reduced by eliminating the effect of the ASE simultaneously detected with the signal. This is better attainable by placing an optical bandpass filter having the narrower passband at the output of the OA under test, as it has been discussed in the main text. For large optical signal power levels, the optical bandpass filter may not be necessary to achieve an accurate measurement. The use of the optical bandpass filter is important, especially when the input signal to the OA is small. This is because the ASE power increases as the input signal decreases. However, if this kind of optical filter is already built in the OA, the external optical filter is not needed. The effectiveness of the optical band pass filter is further discussed in Annex A.

b) *Gain and polarization dependent gain:* As from procedures 1) to 7) in a), but this method permits determination of the gain through the measurements of the OA input signal power P_{in} and the OA output power P_{out}, taking into account the OA amplified spontaneous emission (ASE) power P_{ASE} at the signal wavelength.

11) Repeat procedures 5) to 7), with increasing input signal power gradually to the maximum input signal power given in the relevant detail specification. Maintain the pump power or pump current with the firstly set point. Polarization-dependent gain: as in a), but this parameter is determined through the measurements of the OA input signal power, P_{in}, the OA output power, $P_{out-min}$ and $P_{out-max}$, taking into account the OA amplified spontaneous emission (ASE) power, P_{ASE} at the signal wavelength, by repeating all procedures at different states of polarization as specified in the relevant detail specification.

The state of polarization of the input signal shall be changed after each measurement of P_{in}, P_{out} and P_{ASE} by means of the polarization controller, so that substantially all the states of polarization, in principle, are successively launched into the input port of the OA under test.

The polarization controller shall be operated as specified in the relevant detail specification. A possible way, when using a linear polarizer followed by a quarter-wave rotatable plate, is the following: the linear polarizer is adjusted so that the OA output power is maximized; the quarter-wave plate is then rotated by a minimum of 90 ° step-by-step. At each step, the half-wave plate is rotated by a minimum of 180 ° step-by-step.