IEC/PAS 61290-3-1

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PRE-STANDARD

Optical fibre amplifiers – Basic specification –

Part 3-1: Test methods for noise figure parameters – Optical spectrum analyzer

PUBLICLY AVAILABLE SPECIFICATION

INTERNATIONAL ELECTROTECHNICAL COMMISSION

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FOREWORD

A PAS is a technical specification not fulfilling the requirements for a standard, but made available to the public.

IEC-PAS 61290-3-1 has been processed by subcommittee 86C: Fibre optic systems and active devices, of IEC technical committee 86: Fibre optics.

The text of this PAS is based on the following document:	This PAS was approved for publication by the P-members of the committee concerned as indicated in the following document:
Draft PAS	**Report on voting**
86C/392/PAS	86C/401/RVD

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INTRODUCTION

This part of IEC 61290 is devoted to the subject of optical amplifiers. The technology of optical amplifiers is still rapidly evolving, hence amendments and new additions to this publication can be expected. Each abbreviation introduced in this part of IEC 61290 is generally explained in the text the first time it appears. However, for an easier understanding of the whole text, a list of all abbreviations used in this document is given in annex A.

Information concerning a patent involved in this part of IEC 61290, the holder of which accepted the IEC policy on patents, is given in annex B.

This document should be read in conjunction with IEC 61291-1: *Optical amplifiers – Part 1: Generic specification.*

OPTICAL FIBRE AMPLIFIERS – BASIC SPECIFICATION –

Part 3-1: Test methods for noise figure parameters – Optical spectrum analyzer

1 Scope and object

This part of IEC 61290 applies to commercially available optical fibre amplifiers (OFAs) using active fibres containing rare-earth dopants, or semiconductor optical amplifiers (SOWs) using laser gain media.

The object of this part of IEC 61290 is to establish uniform requirements for accurate and reliable measurements, by means of the optical spectrum analyzer test method, of the following OA parameters, as defined in clause 3 of the international standard IEC 61291-1:

a) signal-spontaneous noise figure

b) forward amplified spontaneous emission (ASE) power level

The methods described in this document apply to single-channel stimulus only.

Two alternatives for determining the signal-spontaneous beat noise are possible, namely the ASE direct interpolation technique (DI) and the polarization nulling with interpolation technique (PN). The accuracy of the DI technique will suffer when the slope of the OA spectral ASE curve has large wavelength dependence, as in the case of an OA with an internal narrowband ASE suppressing filter.

The accuracy of the DI technique degrades at high input power level due to the spontaneous emission from the laser source(s). Annex D provides guidance on the limits of this technique for high input power.

NOTE 1 – All numerical values followed by (‡) are intended to be currently under study.

NOTE 2 – General aspects of noise figure test methods are reported in the international standard IEC 61290-3

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 60793-1-1: *Optical fibres – Part 1-1: Generic specification – General*

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

IEC 60825-2: *Safety of laser products – Part 2: Safety of optical fibre communication systems*

IEC 60874-1: *Connectors for optical fibres and cables – Part 1: Generic specification*

IEC 61290-1-1: *Optical amplifier test methods – Basic specification – Test methods for gain parameters – Part 1-1: Optical spectrum analyser*

IEC 61290-3-1: *Optical fibre amplifiers – Basic specification – Part 1-1: Test methods for gain parameters – Optical spectrum analyser*

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

NOTE – A list of informative (not normative) references is given in annex C.

3 Apparatus

Two schemes of the measurement set-up (for DI and PN techniques, respectively), are given in figure 1.

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

a) *Narrowband optical source:*

The optical source shall be either at a fixed wavelength or wavelength tunable.

– *Fixed-wavelength optical source*:

This optical source shall generate light with a wavelength and optical power specified in the relevant detail specification. Unless otherwise specified, the optical source shall emit light with the full width at half maximum of the spectrum narrower than 1 nm (‡). Single-line lasers such as a distributed feedback (DFB) laser, a distributed Bragg reflector (DBR) laser, an external cavity laser (ECL) are applicable. Also applicable is a light emitting diode (LED) with a narrowband filter. The suppression ratio for the side modes for the single-line laser 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. Source-spontaneous emission and spectral broadening at the base of the lasing spectrum should be minimal for laser sources.

– *Wavelength-tunable optical source*:

This optical source shall generate wavelength-tunable 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 light with the full width at half maximum of the spectrum narrower than 1 nm (‡). A single-line laser or an LED with a narrow bandpass optical filter is applicable for example. The suppression ratio of the side modes for the single-line laser 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. Source-spontaneous emission and spectral broadening at the base of the lasing spectrum should be minimal for the ECL.

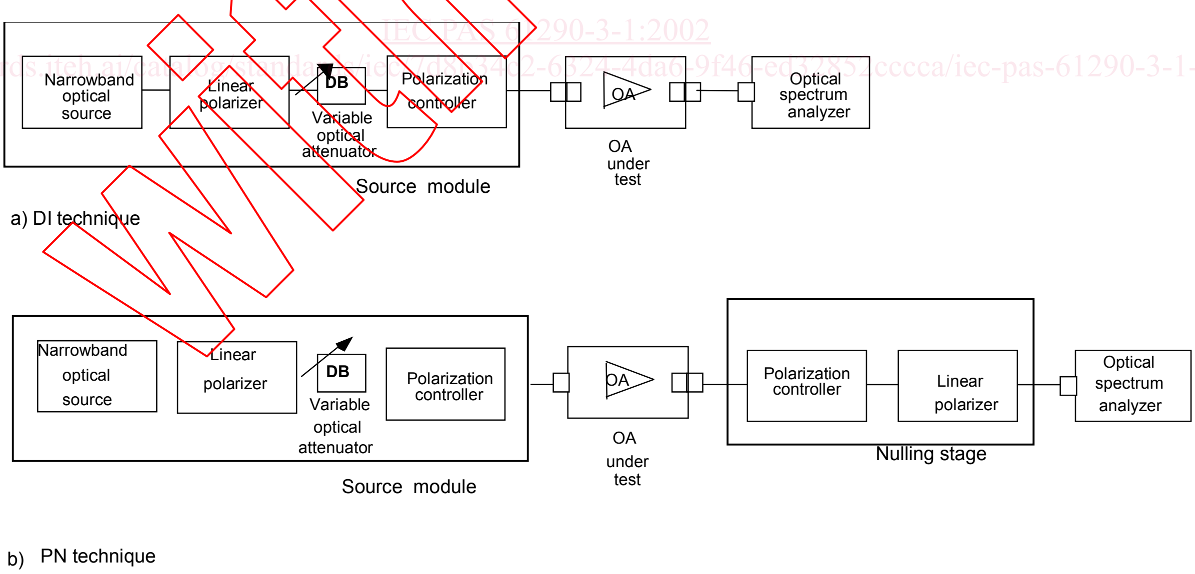

Figure 1 – Two typical arrangements of the optical spectrum analyzer test apparatus for noise figure parameter measurements

b) *Polarization controller:*

This device shall be able to convert any state of polarization of a signal to any other state of polarization. The polarization controller may consist of an all fibre polarization controller or a quarter-wave plate rotatable by a minimum of 90 degrees followed by a half wave plate rotatable by a minimum of 180 degrees. The reflectance of this device shall be smaller than –50 dB (‡) at each port. The insertion loss variation of this device shall be less than 0,2 dB (‡).

c) *Linear polarizer:*

This device should have a minimum extinction ration of 30 dB (‡), and reflectance smaller than –50 dB (‡) at each port. A rotatable polarizer is preferred to maximize the input signal power.

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 –50 dB (‡) at each port.

e) *Optical spectrum analyzer:*

The optical spectrum analyzer (OSA) shall have polarization sensitivity less than 0,1 dB (‡), stability better than 0,1 dB (‡), and wavelength accuracy better than 0,05 nm (‡). The linearity should be better than 0,2 dB (‡) over the device dynamic range. The reflectance from this device shall be smaller than –50 dB (‡) at its input port.

f) *Optical power meter:*

This device shall have a measurement accuracy better than 0,2 dB (‡), irrespective of the state of polarization, within the operational wavelength bandwidth of the OA and within the power range from –40 to +20 dBm (‡).

NOTE – The optical power meter is for calibration purposes.

g) *Broadband optical source:*

This device shall provide output broadband optical power over the operational wavelength bandwidth of the OA (for example, 1530 nm to 1565 nm). The output spectrum shall be flat with less than a 0,1 dB (‡) variation over the measurement bandwidth range (typically 10 nm). For example, the ASE generated by an OA with no signal applied could be used.

h) *Optical connectors:*

The connection loss repeatability shall be better than 0,1 dB (‡). The reflectance from this device shall be smaller than –50 dB (‡).

i) *Optical fibre jumpers:*

The mode field diameter of the optical fibre jumpers shall 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 –50 dB (‡), and the device length shall be short (<2m). The jumpers between the source and the device under test should remain undisturbed during the duration of the measurements in order to minimize state of polarization changes.

Subsequently, the combination of the narrowband optical source, the linear polarizer, the variable optical attenuator, and the input polarization controller shall be referred to as the *source module.* The polarization controller of the source module is optional and is required only when polarization dependent performances are to be measured.

The combination of the output polarization controller and the linear polarizer will be referred to as the *nulling stage*. The nulling stage is only required for the PN technique is employed and may be omitted for the DI technique.

4 Test sample

The OA under test 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 inaccuracy.

Care shall be taken in maintaining 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 used optical components, leading to measurement errors.

5 Procedure

This test method is based on the optical measurement of the following parameters:

– the ASE power level at the output of the OA under test,

– the optical bandwidth of the OSA.

Measurement of the ASE power level at the signal wavelength can be accomplished by either direct interpolation (DI) or by a polarization nulling technique incorporating interpolation (PN). The DI technique is faster and simpler to implement, however, it may be inaccurate due to distortions caused by the signal and its sidebands. The PN technique, on the other hand, will generally be slower but more accurate by virtue of minimizing the distortions. The principle of PN is based on the fact that ASE noise produced by an optical amplifier is randomly polarized, whereas the input signal has a definite state of polarization. By selecting a state of polarization orthogonal to that of the signal, the ASE noise can be measured without the associated signal distortion. Since the noise is randomly polarized, only half the ASE noise is observed with this method.

Both techniques aim to eliminate the unwanted source-spontaneous emission from the ASE measurement result. The DI technique requires a discrete measurement and correction for the source-spontaneous contribution to the ASE level. The PN technique directly filters the source-spontaneous contribution and reduces the amount of correction. Calibration of the optical bandwidth can be accomplished using the OSA. Procedures for both techniques (DI and PN) are provided.

5.1 Calibration

5.1.1 Calibration of optical bandwidth

The optical bandwidth, B_O, can be determined using the resolution bandwidth of the OSA. The calibration can be performed using one of the following two methods, based on the use of either a narrowband or a broadband optical source, respectively. Both calibration methods apply to either DI or PN measurement technique.

a) *Calibration using a narrowband optical source:*

The steps listed below shall be followed.

i) Connect the output of a tunable narrowband optical source (either the ECL or the DFB) directly to the OSA.

ii) Set the OSA centre wavelength to the signal wavelength to be calibrated, λ_s.

iii) Set the OSA span to zero.

iv) Set the OSA resolution bandwidth to the desired value, RBW.

v) Set the narrowband optical source wavelength to λ_i, such that: λ_s – RBW – δ = λ_i = λ_s + RBW + δ, choosing δ *large* enough to ensure the end wavelengths fall out of the OSA filter pass band.

vi) Record the OSA signal level, P(λ_i), in linear units.

vii) Repeat steps v) and vi), tuning the narrowband optical source wavelength through the wavelength range.

viii) Determine the optical bandwidth according to the following equation:

$$\Delta\lambda_{BW}(\lambda_s) = \int[P(\lambda_i) / P(\lambda_s)]\, d\lambda_i$$

The accuracy of this measurement is related to the tuning interval of the narrowband optical source ($\Delta\lambda_i$) and power flatness over the wavelength range. Tuning interval smaller than 0,1 nm is advisable. The optical power should not vary more than 0,4 dB over the wavelength range.

b) *Calibration using a broadband optical source:*

This method requires that the OSA have a rectangular shape bandwidth-limiting filter, when the resolution bandwidth is at the maximum value. The steps listed below shall be followed.