SLOVENSKI STANDARD
SIST EN 61290-3:2002

01-september-2002

Optical fibre amplifiers - Basic specification - Part 3: Test methods for noise figure parameters (IEC 61290-3:2000)

Optical fibre amplifiers - Basic specification -- Part 3: Test methods for noise figure parameters

Lichtwellenleiter-Verstärker - Grundspezifikation -- Teil 3: Prüfverfahren für Rauschzahlparameter

Amplificateurs à fibres optiques - Spécification de base -- Partie 3: Méthodes d'essai des paramètres du facteur de bruit

Ta slovenski standard je istoveten z: **EN 61290-3:2000**

ICS:

33.180.30	Optiļ ni ojaļ evalniki	Optic amplifiers

SIST EN 61290-3:2002 **en**

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 61290-3

August 2000

ICS 33.180.30

English version

Optical fibre amplifiers - Basic specification
Part 3: Test methods for noise figure parameters
(IEC 61290-3:2000)

Amplificateurs à fibres optiques -
Spécification de base
Partie 3: Méthodes d'essai des
paramètres du facteur de bruit
(CEI 61290-3:2000)

Lichtwellenleiter-Verstärker -
Grundspezifikation
Teil 3: Prüfverfahren für
Rauschzahlparameter
(IEC 61290-3:2000)

This European Standard was approved by CENELEC on 2000-06-01. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CENELEC member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the Central Secretariat has the same status as the official versions.

CENELEC members are the national electrotechnical committees of Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.

CENELEC

European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

Central Secretariat: rue de Stassart 35, B - 1050 Brussels

Ref. No. EN 61290-3:2000 E

Foreword

The text of document 86C/271/FDIS, future edition 1 of 61290-3, 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 61290-3 on 2000-06-01.

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) 2001-03-01

- latest date by which the national standards conflicting with the EN have to be withdrawn (dow) 2003-06-01

This European Standard is to be read in conjunction with EN 61291-1:1998.

Annexes designated "normative" are part of the body of the standard.
Annexes designated "informative" are given for information only.
In this standard, annex ZA is normative and annex A is informative.
Annex ZA has been added by CENELEC.

Endorsement notice

The text of the International Standard IEC 61290-3:2000 was approved by CENELEC as a European Standard without any modification.

CONTENTS

INTRODUCTION

As far as can be determined, this is the first International Standard on this subject. The technology of optical fibre amplifiers is quite new and still emerging, hence amendments to and new editions of this standard can be expected.

Each abbreviation introduced in this standard is explained in the text at least the first time it appears. However, for an easier understanding of the whole text, a list of all abbreviations used in this standard is given in annex A.

OPTICAL FIBRE AMPLIFIERS – BASIC SPECIFICATION –

Part 3: Test methods for noise figure parameters

1 Scope and object

This International Standard applies to optical fibre amplifiers (OFAs) using active fibres, containing rare-earth dopants, presently commercially available.

The object of this standard is to provide the general background for OFA noise figure parameters measurements and to indicate those IEC standard test methods for accurate and reliable measurements of the following OFA parameters, as defined in clause 3 of IEC 61291-1:

a) noise figure (*NF*);

b) noise factor (*F*);

c) multiple path interference (MPI) figure of merit;

d) signal-spontaneous noise figure;

e) (equivalent) spontaneous-spontaneous optical bandwidth ($B_{sp\text{-}sp}$);

f) forward amplified spontaneous emission (ASE) power level;

g) reverse ASE power level;

h) ASE bandwidth.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of IEC 61290. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of IEC 61290 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 61290-3-1, *Optical fibre amplifiers – Basic specification – Part 3-1: Test methods for noise figure parameters – Optical spectrum analyzer* [1)]

IEC 61290-3-2, *Optical fibre amplifiers – Basic specification – Part 3-2: Test methods for noise figure parameters – Electrical spectrum analyzer* [1)]

IEC 61291-1:1998, *Optical fibre amplifiers – Part 1: Generic specification*

NOTE A list of informative references is given in the bibliography.

1) To be published.

3 Noise figure generalities

The noise figure is one of the most important parameters of an OFA. Following the definition in IEC 61291-1, the noise factor, i.e. the linear form of the noise figure, can be expressed by:

$$F = \frac{SNR_{input}}{SNR_{output}} = \frac{< i_{signal}^2 >_{in}}{< i_{noise}^2 >_{in}} \times \frac{< i_{noise}^2 >_{out}}{< i_{signal}^2 >_{out}}$$
$$F = \frac{1}{G^2} \frac{< i_{noise}^2 >_{out}}{< i_{noise}^2 >_{in}} \qquad (1)$$

where

SNR denotes signal-to-noise ratios;

i denotes photocurrents in an ideal photodetector with a quantum efficiency of 1;

G denotes the optical signal gain.

The input noise current is, by definition, the shot noise current caused by the optical input signal. This excludes other noise sources on the input side.

The output noise current is the sum of five contributions. Each of these contributions can be expressed by a partial noise factor:

a) signal shot noise factor, $F_{shot,sig}$, from shot noise from amplified input signal;

b) ASE shot noise factor, $F_{shot,ase}$, from shot noise from amplified spontaneous emission;

c) signal-spontaneous noise factor, $F_{sig\text{-}sp}$, from signal beating with ASE;

d) spontaneous-spontaneous noise factor, $F_{sp\text{-}sp}$, from ASE beating with itself;

e) noise factor from multiple path interference (MPI), F_{mpi}.

The total noise factor (in linear, not logarithmic units) is:

$$F_{total} = F_{shot,sig} + F_{shot,ase} + F_{sig-sp} + F_{sp-sp} + F_{mpi} \qquad (2)$$

The noise figure can be calculated using:

$$NF = 10\log(F_{total}) \qquad (3)$$

Equation (2) can be used for optical noise figure measurements, as well as for estimating the influence of various parameters in electrical noise figure measurements. It represents a complete noise figure model of an OFA.

4 Noise figure contributions

The signal shot noise factor is:

$$F_{\text{shot,sig}} = \frac{1}{G} \tag{4}$$

where G is the gain at the signal wavelength.

The ASE shot noise factor is:

$$F_{\text{shot,ase}} = \frac{P_{\text{ase}}}{G^2 P_{\text{in}}} \tag{5}$$

where

P_{ase} is the wavelength-integrated ASE power;

P_{in} is the optical input signal power.

The signal-spontaneous noise factor is:

$$F_{\text{sig-sp}} = 2\frac{\rho_{\text{ase,p}}}{G h \nu_{\text{sig}}} \tag{6}$$

where

$\rho_{\text{ase,p}}$ is the optical power density of spontaneous emission, in the same polarization state as the output signal, at the signal wavelength, in W/Hz;

h is Planck's constant;

$\nu_{\text{sig}} = c/\lambda_{\text{sig}}$ is the optical signal frequency, in Hz.

The spontaneous-spontaneous noise factor is:

$$F_{\text{sp-sp}} = \frac{\rho_{\text{ase}}^{2} B_{\text{sp-sp}}}{2 h \nu_{\text{sig}} G^2 P_{\text{in}}} \tag{7}$$

where

ρ_{ase} is the optical power density of total (unpolarized) spontaneous emission, at the signal wavelength, in W/Hz;

$B_{\text{sp-sp}}$ is the equivalent spontaneous-spontaneous optical bandwidth defined in IEC 61291-1; it depends on power and wavelength of input signal.

NOTE When $B_{\text{sp-sp}}$ is known, there is no need for separate measurement of $F_{\text{sp-sp}}$ because it can be calculated from the signal spontaneous noise factor and the input power.

Multiple path interference (MPI) noise is generated by beating between the output signal and one or more doubly reflected replicae of the output signal. Two or more reflection points inside the OFA are necessary to generate MPI noise. When all reflection points are separated by more than the coherence length of the optical source, then the MPI noise factor is [1][1]:

$$F_{\text{mpi}} = \frac{2P_{\text{in}}}{h\nu\pi} \frac{\Delta\nu}{f^2 + \Delta\nu^2} \sum_i \left(p_i G_{\text{cav,i}}\right) \tag{8}$$

[1] Figures in square brackets refer to the bibliography.