

TECHNICAL REPORT



Optical amplifiers – Part 9: Semiconductor optical amplifiers (SOAs)

iTeh Standards
(<https://standards.iteh.ai>)
Document Preview

IEC TR 61292-9:2013

<https://standards.iteh.ai/Catalogue/standards/iec/17885185-eb83-4b35-8f5c-877913ee52bf/iec-tr-61292-9-2013>

Withhold



THIS PUBLICATION IS COPYRIGHT PROTECTED
Copyright © 2013 IEC, Geneva, Switzerland

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from either IEC or IEC's member National Committee in the country of the requester.
If you have any questions about IEC copyright or have an enquiry about obtaining additional rights to this publication, please contact the address below or your local IEC member National Committee for further information.

IEC Central Office
3, rue de Varembe
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
Fax: +41 22 919 03 00
info@iec.ch
www.iec.ch

About the IEC

The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About IEC publications

The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigenda or an amendment might have been published.

Useful links:

IEC publications search - www.iec.ch/searchpub

The advanced search enables you to find IEC publications by a variety of criteria (reference number, text, technical committee,...).

It also gives information on projects, replaced and withdrawn publications.

IEC Just Published - webstore.iec.ch/justpublished

Stay up to date on all new IEC publications. Just Published details all new publications released. Available on-line and also once a month by email.

Electropedia - www.electropedia.org

The world's leading online dictionary of electronic and electrical terms containing more than 30 000 terms and definitions in English and French, with equivalent terms in additional languages. Also known as the International Electrotechnical Vocabulary (IEV) on-line.

Customer Service Centre - webstore.iec.ch/csc

If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: csc@iec.ch.

IEC TR 61292-9:2013

<https://standards.iteh.ai/standards/iec/17885185-eb83-4b35-8f5c-877913ee52bf/iec-tr-61292-9-2013>

TECHNICAL REPORT



**Optical amplifiers –
Part 9: Semiconductor optical amplifiers (SOAs)**

iTech Standards
(<https://standards.iteh.ai>)
Document Preview

<https://standards.iteh.ai/standards/iec/1/885185-eb83-4b35-8f5c-877913ee52bf/iec-tr-61292-9-2013>

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

PRICE CODE

S

ICS 33.160.10; 33.180.30

ISBN 978-2-8322-1169-4

Warning! Make sure that you obtained this publication from an authorized distributor.

CONTENTS

FOREWORD.....	4
INTRODUCTION.....	6
1 Scope.....	7
2 Terms, definitions, abbreviations and symbols.....	7
2.1 Terms and definitions.....	7
2.2 Abbreviations.....	7
2.3 Symbols.....	8
3 Specific features of SOAs.....	9
3.1 SOA chips.....	9
3.2 SOA modules.....	11
3.3 Gain ripple.....	11
3.4 Polarization dependent gain (PDG).....	13
3.4.1 General.....	13
3.4.2 Polarization insensitive SOAs.....	13
3.5 Noise figure (NF).....	13
3.6 Lifetime of carriers.....	14
3.7 Nonlinear effects.....	14
4 Measurement of SOA output power and PDG.....	14
4.1 Narrow-band versus broadband light source.....	14
4.2 Recommended set-up for output power and PDG measurements.....	15
4.3 Examples of measurement results obtained by using the recommended set-up.....	16
Annex A (informative) Applications of SOAs.....	19
A.1 General.....	19
A.2 Polarization mode of SOAs.....	19
A.3 Reach extender for GPON.....	19
A.4 Pre-amplifier in transceivers for 100 GE.....	19
A.5 Monolithic integration of SOAs.....	20
A.6 Reflective SOAs (RSOAs).....	21
Bibliography.....	22
Figure 1 – Schematic diagram of the typical SOA chip.....	9
Figure 2 – Example of gain dependency on forward current of the SOA chip.....	9
Figure 3 – Schematic top view of a typical SOA chip with and without an angled waveguide structure.....	10
Figure 4 – Schematic top view of the typical SOA module.....	11
Figure 5 – Schematic diagram of the optical feedback inside the SOA chip.....	12
Figure 6 – Schematic diagram of gain ripple.....	12
Figure 7 – Output power and PDG dependence on the wavelength of the SOA chip.....	14
Figure 8 – Recommended measurement set-up for optical power and PDG of SOA modules.....	15
Figure 9 – Recommended measurement set-up for optical power and PDG of SOA chips.....	16
Figure 10 – Optical power spectra of three different SOA chips.....	16
Figure 11 – Output power and PDG of the SOA chip sample no. 1 as a function of I_F	17

Figure 12 – Output power and PDG of the SOA chip sample no. 2 as a function of I_F	17
Figure 13 – Output power and PDG of the SOA chip sample no. 3 as a function of I_F	18
Figure A.1 – Schematic diagram of the receiver section of SOA-incorporated CFP transceivers	20
Figure A.2 – Schematic diagram of the DFB-LDs-array type wavelength tuneable LD	20
Figure A.3 – Schematic diagram of the seeded WDM-PON system	21

Witholdrawn

iTech Standards
(<https://standards.iteh.ai>)
Document Preview

IEC TR 61292-9:2013
<https://standards.iteh.ai/catalog/standards/iec/1/885185-eb83-4b35-8f5c-877913ee52bf/iec-tr-61292-9-2013>

INTERNATIONAL ELECTROTECHNICAL COMMISSION

OPTICAL AMPLIFIERS –

Part 9: Semiconductor optical amplifiers (SOAs)

FOREWORD

- 1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
- 2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
- 3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
- 4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
- 5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
- 6) All users should ensure that they have the latest edition of this publication.
- 7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
- 8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
- 9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

The main task of IEC technical committees is to prepare International Standards. However, a technical committee may propose the publication of a technical report when it has collected data of a different kind from that which is normally published as an International Standard, for example "state of the art".

IEC/TR 61292-9, which is a technical report, has been prepared by subcommittee 86C: Fibre optic systems and active devices, of IEC technical committee 86: Fibre optics.

The text of this technical report is based on the following documents:

Enquiry draft	Report on voting
86C/1148/DTR	86C/1183/RVC

Full information on the voting for the approval of this technical report 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 61292 series, published under the general title *Optical amplifiers*, can be found on the IEC website.

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.

A bilingual version of this publication may be issued at a later date.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

iTech Standards
(<https://standards.iteh.ai>)
Document Preview

IEC TR 61292-9:2013

<https://standards.iteh.ai/catalog/standards/iec/1/885185-eb83-4b35-8f5c-877913ee52bf/iec-tr-61292-9-2013>

INTRODUCTION

Optical amplifiers (OAs) are necessary components as booster, line and pre-amplifiers for current optical network systems. IEC TC86/SC86C, has published many standards for OAs and most of them are focused on optical fibre amplifiers (OFAs), which are commonly deployed in commercial optical network systems. Recently, semiconductor optical amplifiers (SOAs) have attracted attention for applications in gigabit passive optical network (GPON) and 100 Gbit Ethernet (GbE) systems. This is because SOA chips are as small as laser diodes (LDs) and only require an electrical current.

Although SOAs for the 1 310 nm or 1 550 nm bands have been extensively studied since the 1980s, the use of SOAs is still limited to laboratories or field trials. This is due to specific performance features of SOAs such as gain ripple and polarization dependent gain (PDG). Thus, there are very few IEC standards addressing SOAs. One example is IEC/TR 61292-3, which is a technical report for classification, characteristics and applications of OAs including SOAs. However, it only deals with general information on SOAs and does not contain the detail information on test methods that are necessary to measure precisely the particular parameters of SOAs.

This technical report provides a better understanding of specific features of SOAs as well as information on measuring gain and PDG. It is anticipated that future standards will address performance and test methodology.

iTech Standards
(<https://standards.iteh.ai>)
Document Preview

IEC TR 61292-9:2013

<https://standards.iteh.ai/catalog/standards/iec/1/885185-eb83-4b35-8f5c-877913ee52bf/iec-tr-61292-9-2013>

WITHDRAWN

OPTICAL AMPLIFIERS –

Part 9: Semiconductor optical amplifiers (SOAs)

1 Scope

IEC/TR 61292-9, which is a technical report, focuses on SOAs, especially the specific features and measurement of gain and PDG.

In this report, only the amplifying application of SOAs is described.

Other applications, such as modulation, switching and non-linear functions, are not covered.

Potential applications of SOAs, however, such as reflective SOAs (RSOAs) for the seeded wavelength division multiplexing passive optical network (WDM-PON), are briefly reviewed in Annex A.

2 Terms, definitions, abbreviations and symbols

2.1 Terms and definitions

For the purposes of this document, the following terms, definitions, abbreviations and symbols apply.

2.1.1

SOA

generic term that includes the “SOA chip” and the “SOA module”

2.1.2

SOA chip

semiconductor chip which is the active component of the SOA module

2.1.3

SOA module

fibre-pigtailed optical component that consists of the SOA chip, lenses, optical isolators (if necessary), a thermoelectric cooler (TEC), a thermistor, a package and fibres

2.2 Abbreviations

AR	anti-reflection
ASE	amplified spontaneous emission
BPF	band pass filter
CFP	100 Gbit form-factor pluggable
CW	continuous wave
DEMUX	demultiplexer
DFB	distributed feedback
EDFA	erbium-doped fibre amplifier
FWM	four-wave mixing
GbE	gigabit Ethernet
GPON	gigabit capable passive optical network

LD	laser diode
MSA	multi-source agreement
MMI	multi-mode interference
MQWs	multiple quantum wells
NF	noise figure
OA	optical amplifier
OFA	optical fibre amplifier
OLT	optical line termination
ONU	optical network unit
OPM	optical power meter
PC	polarization controller
PD	photodiode
PDCE	polarization dependence of coupling efficiency
PDG	polarization dependent gain
PIC	photonic integrated circuit
POL	polarizer
PON	passive optical network
RSOA	reflective semiconductor optical amplifier
SLD	superluminescent diode
SMF	single mode fibre
SOA	semiconductor optical amplifier
TE	transverse electric
TEC	thermoelectric cooler
TIA	transimpedance amplifier
TM	transverse magnetic
VOA	variable optical attenuator
WDM	wavelength division multiplexing
XGM	cross gain modulation
XPM	cross phase modulation

2.3 Symbols

G	optical gain
I_F	forward current
T_{TE}	TE mode confinement factor
T_{TM}	TM mode confinement factor
L	chip length
n_{eff}	effective refractive index
NF	noise figure
n_{sp}	spontaneous emission factor
λ	wavelength
$\Delta\lambda_{ripple}$	period of gain ripple
$PDCE$	polarization dependence of coupling efficiency
PDG_{active}	polarization dependence of active layer gain
PDG_{total}	total polarization dependence of single pass gain