IEC TR 61292-4

Edition 4.0 2023-01
REDLINE VERSION

TECHNICAL REPORT

colour inside

Optical amplifiers –
Part 4: Maximum permissible optical power for the damage-free and safe use of optical amplifiers, including Raman amplifiers

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 33.160.10; 33.180.30

ISBN 978-2-8322-6365-5

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

_____

OPTICAL AMPLIFIERS –

Part 4: Maximum permissible optical power for the damage-free and safe use of optical amplifiers, including Raman amplifiers

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.

This redline version of the official IEC Standard allows the user to identify the changes made to the previous edition IEC TR 61292-4:2014. A vertical bar appears in the margin wherever a change has been made. Additions are in green text, deletions are in strikethrough red text.

IEC TR 61292-4 has been prepared by subcommittee 86C: Fibre optic systems and active devices, of IEC technical committee 86: Fibre optics. It is a Technical Report.

This fourth edition cancels and replaces the third edition published in 2014. This edition constitutes a technical revision.

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

a) The technical information has been updated to reflect revisions of the relevant references.
b) In particular, the descriptions provided in Clause 5 and Clause 6 have been modified significantly to reflect changes in the cited references. Unnecessary formulas and explanations that overlap with the references have been removed to simplify the document.
c) New information has been added to Annex A on optical fibre burning when light enters an optical fibre with a bubble train formed by a fibre fuse.

The text of this Technical Report is based on the following documents:

Draft	Report on voting
86C/1821/DTR	86C/1832/RVDTR

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 Technical Report 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. The main document types developed by IEC are described in greater detail at www.iec.ch/standardsdev/publications.

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 document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

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- withdrawn,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

IMPORTANT – The "colour inside" logo on the cover page of this document 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.

INTRODUCTION

This document is dedicated to the subject of maximally permissible optical power for damage-free and safe use of optical amplifiers, including Raman amplifiers. Since the technology is quite new and still evolving, amendments and new editions to this document can be expected.

Many new types of optical amplifiers are entering the marketplace, and research is also stimulating the development of many new types of fibre and non-fibre based optical amplifiers. With the introduction of new technologies, such as long-haul, ~~over 40~~ beyond 100 Gb/s, WDM transmission, digital coherent transmission and Raman amplification, some optical amplifiers ~~may involve~~ employ optical pump sources with extremely high optical power – possibly up to several Watts. For example, erbium doped fibre amplifiers that provide extremely high output power are described in IEC TR 61292-8 [1][1], and Raman amplifiers in IEC TR 61292-6 [2].

Excessively high optical power ~~may~~ can cause physical damage to the ~~fibres/~~optical fibres, components and equipment, in addition to presenting a medical ~~danger~~ hazard to the human eye and skin.

The possibility of fibre damage caused by high optical intensity has been discussed at technical conferences and in technical reports for many years. ~~The use of high intensity optical amplifiers may cause problems in the fibre such as a fibre fuse, a heating in the splice point (connection point), and the fibre end-face damage due to dust and the fibre coat burning due to tight fibre bending. IEC SC 86A (Fibres and cables) has published IEC TR 62547, and SC 86B (Fibre optic interconnecting devices and passive components) has published IEC TR 62627-01. IEC TC 31 (Equipment for explosive atmospheres) is also discussing the risk of ignition of hazardous environments by radiation from optical equipment.~~ The use of high intensity optical amplifiers can cause problems in optical fibres, which include fibre fuse, heating in the splice points (connection points), fibre endface damage due to dust, and fibre coat burning due to tight fibre bending. For example, IEC TR 62547 [3] provides guidelines for the measurement of high-power damage sensitivity of single-mode fibre to bends, and IEC TR 62627-01 [4] describes cleaning methods for fibre optic connectors to reduce the risk of fibre endface damage. In addition, other standard groups are discussing the risk of ignition of hazardous environments caused by high-power radiation from optical equipment.

~~Medical aspects have long been discussed at standards groups. IEC TC 76 (Optical radiation safety and laser equipment) precisely describes in IEC 60825-2 the concept of hazard level and labelling and addresses the safety aspects of lasers specifically in relation to tissue damage.~~

~~ITU-T Study Group 15 (Optical and other transport networks) has published Recommendation G.664, which primarily discusses the automatic laser power reduction functionality for safety.~~

The medical aspects of high-power optical radiation have also been addressed by standards. IEC 60825-2 defines the concept of hazard levels and corresponding labelling, which addresses the safety aspects of lasers specifically in relation to tissue damage.

In addition, IEC TR 60825-17 [5] describes safety measures to protect against effects caused exclusively by thermal, opto-mechanical and related effects in passive optical components and optical cables used in high power optical fibre communication systems. Moreover, ITU-T Recommendation G.664 [6] discusses the safety feature of automatic laser power reduction.

With the recently growing interest in high power fibre amplifiers and fibre Raman amplifiers, however, some difficulties have been identified among optical amplifier users and manufacturers in fully understanding the technical details and requirements across all such standards and agreements.

---

[1] Numbers in square brackets refer to the Bibliography.

This document provides a simple informative guideline on the maximum optical power permissible for optical amplifiers for optical amplifier users and manufacturers.

OPTICAL AMPLIFIERS –

Part 4: Maximum permissible optical power for the damage-free and safe use of optical amplifiers, including Raman amplifiers

1 Scope ~~and object~~

This part of IEC 61292, which is a Technical Report, applies to all commercially available optical amplifiers (OAs), including optical fibre amplifiers (OFAs) using active fibres as well as Raman amplifiers. Semiconductor optical amplifiers (SOAs) using semiconductor gain media are also included.

This document provides informative guidelines on the threshold of high optical power that ~~causes~~ can cause high-temperature damage of the fibre. Also discussed is optical safety for manufacturers and users of optical amplifiers by ~~reiterating substantial~~ quoting parts of existing standards and agreements on eye and skin safety.

~~To identify the maximum permissible optical power in the optical amplifier from damage-free and safety viewpoints,~~ This document identifies the following values for maximum permissible optical power in the optical amplifier for damage-free and safe operation:

a) the optical power limit that causes thermal damage to the fibre, such as fibre fuse and fibre-coat burning;

b) the maximum permissible exposure (MPE) to which the eyes/skin can be exposed without consequent injury;

c) the optical power limit in the fibre that causes MPE on the eyes/skin after free-space propagation from the fibre;

d) the absolute allowable optical power level for damage-free and safe ~~level of optical power~~ operation of the optical amplifier by comparing a) and c).

The objective of this document is to minimize potential confusion and misunderstanding in the industry that ~~might~~ can cause unnecessary alarms and hinder the progress and acceptance of advancing optical amplifier technologies in the market.

It is important ~~to point out~~ that the reader ~~should~~ always refers to the latest international standards and agreements, because the technologies concerned are rapidly evolving.

The present document will be frequently reviewed and updated in a timely manner by incorporating the results of various studies related to OAs and OA-supported optical systems.

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 60825-1:2007, *Safety of laser products – Part 1: Equipment classification and requirements*~~

~~IEC 60825-2:2004, *Safety of laser products – Part 2: Safety of optical fibre communication systems (OFCS)*~~
~~Amendment 1 (2006)~~
~~Amendment 2 (2010)~~

~~IEC TR 60825-14:2004, *Safety of laser products – Part 14: A user's guide*~~

~~IEC TR 62547, *Guidelines for the measurement of high-power damage sensitivity of single-mode fibres to bends – Guidance for the interpretation of results*~~

~~IEC TR 62627-01, *Fibre optic interconnecting devices and passive components – Part 01: Fibre optic connector cleaning methods*~~

~~ITU-T Recommendation G.664:2012, *Optical safety procedures and requirements for optical transport systems*~~

IEC 61291-1:2018, *Optical amplifiers – Part 1: Generic specification*

IEC TR 61292-4

Edition 4.0 2023-01

TECHNICAL REPORT

colour inside

Optical amplifiers –
Part 4: Maximum permissible optical power for the damage-free and safe use of optical amplifiers, including Raman amplifiers

IEC TR 61292-4:2023-01(en)

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

_____

OPTICAL AMPLIFIERS –

Part 4: Maximum permissible optical power for the damage-free and safe use of optical amplifiers, including Raman amplifiers

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.

IEC TR 61292-4 has been prepared by subcommittee 86C: Fibre optic systems and active devices, of IEC technical committee 86: Fibre optics. It is a Technical Report.

This fourth edition cancels and replaces the third edition published in 2014. This edition constitutes a technical revision.

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

a) The technical information has been updated to reflect revisions of the relevant references.
b) In particular, the descriptions provided in Clause 5 and Clause 6 have been modified significantly to reflect changes in the cited references. Unnecessary formulas and explanations that overlap with the references have been removed to simplify the document.
c) New information has been added to Annex A on optical fibre burning when light enters an optical fibre with a bubble train formed by a fibre fuse.

The text of this Technical Report is based on the following documents:

Draft	Report on voting
86C/1821/DTR	86C/1832/RVDTR

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 Technical Report 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. The main document types developed by IEC are described in greater detail at www.iec.ch/standardsdev/publications.

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 document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

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

IMPORTANT – The "colour inside" logo on the cover page of this document 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.

INTRODUCTION

This document is dedicated to the subject of maximally permissible optical power for damage-free and safe use of optical amplifiers, including Raman amplifiers. Since the technology is quite new and still evolving, amendments and new editions to this document can be expected.

Many new types of optical amplifiers are entering the marketplace, and research is also stimulating the development of many new types of fibre and non-fibre based optical amplifiers. With the introduction of new technologies, such as long-haul, beyond 100 Gb/s, WDM transmission, digital coherent transmission and Raman amplification, some optical amplifiers employ optical pump sources with extremely high optical power – possibly up to several Watts. For example, erbium doped fibre amplifiers that provide extremely high output power are described in IEC TR 61292-8 [1][1], and Raman amplifiers in IEC TR 61292-6 [2].

Excessively high optical power can cause physical damage to the optical fibres, components and equipment, in addition to presenting a medical hazard to the human eye and skin.

The possibility of fibre damage caused by high optical intensity has been discussed at technical conferences and in technical reports for many years. The use of high intensity optical amplifiers can cause problems in optical fibres, which include fibre fuse, heating in the splice points (connection points), fibre endface damage due to dust, and fibre coat burning due to tight fibre bending. For example, IEC TR 62547 [3] provides guidelines for the measurement of high-power damage sensitivity of single-mode fibre to bends, and IEC TR 62627-01 [4] describes cleaning methods for fibre optic connectors to reduce the risk of fibre endface damage. In addition, other standard groups are discussing the risk of ignition of hazardous environments caused by high-power radiation from optical equipment.

The medical aspects of high-power optical radiation have also been addressed by standards. IEC 60825-2 defines the concept of hazard levels and corresponding labelling, which addresses the safety aspects of lasers specifically in relation to tissue damage.

In addition, IEC TR 60825-17 [5] describes safety measures to protect against effects caused exclusively by thermal, opto-mechanical and related effects in passive optical components and optical cables used in high power optical fibre communication systems. Moreover, ITU-T Recommendation G.664 [6] discusses the safety feature of automatic laser power reduction.

With the recently growing interest in high power fibre amplifiers and fibre Raman amplifiers, however, some difficulties have been identified among optical amplifier users and manufacturers in fully understanding the technical details and requirements across all such standards and agreements.

This document provides a simple informative guideline on the maximum optical power permissible for optical amplifiers for optical amplifier users and manufacturers.

---

[1] Numbers in square brackets refer to the Bibliography.

OPTICAL AMPLIFIERS –

Part 4: Maximum permissible optical power for the damage-free and safe use of optical amplifiers, including Raman amplifiers

1 Scope

This part of IEC 61292, which is a Technical Report, applies to all commercially available optical amplifiers (OAs), including optical fibre amplifiers (OFAs) using active fibres as well as Raman amplifiers. Semiconductor optical amplifiers (SOAs) using semiconductor gain media are also included.

This document provides informative guidelines on the threshold of high optical power that can cause high-temperature damage of the fibre. Also discussed is optical safety for manufacturers and users of optical amplifiers by quoting parts of existing standards and agreements on eye and skin safety.

This document identifies the following values for maximum permissible optical power in the optical amplifier for damage-free and safe operation:

a) the optical power limit that causes thermal damage to the fibre, such as fibre fuse and fibre-coat burning;
b) the maximum permissible exposure (MPE) to which the eyes/skin can be exposed without consequent injury;
c) the optical power limit in the fibre that causes MPE on the eyes/skin after free-space propagation from the fibre;
d) the absolute allowable optical power level for damage-free and safe operation of the optical amplifier by comparing a) and c).

The objective of this document is to minimize potential confusion and misunderstanding in the industry that can cause unnecessary alarms and hinder the progress and acceptance of advancing optical amplifier technologies in the market.

It is important that the reader always refers to the latest international standards and agreements, because the technologies concerned are rapidly evolving.

The present document will be frequently reviewed and updated in a timely manner by incorporating the results of various studies related to OAs and OA-supported optical systems.

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 61291-1:2018, *Optical amplifiers – Part 1: Generic specification*