IEC 61290-4-3

Edition 1.0 2015-05

INTERNATIONAL STANDARD

colour inside

Optical amplifiers – Test methods
Part 4-3: Power transient parameters – Single channel optical amplifiers in output power control

IEC 61290-4-3:2015-05(en)

IEC Central Office
3, rue de Varembé
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.

IEC Catalogue - webstore.iec.ch/catalogue
The stand-alone application for consulting the entire bibliographical information on IEC International Standards, Technical Specifications, Technical Reports and other documents. Available for PC, Mac OS, Android Tablets and iPad.

IEC publications search - www.iec.ch/searchpub
The advanced search enables 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 It also gives information on projects, replaced and withdrawn publications.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 online 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 15 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

IEC Glossary - std.iec.ch/glossary
More than 60 000 electrotechnical terminology entries in English and French extracted from the Terms and Definitions clause of IEC publications issued since 2002. Some entries have been collected from earlier publications of IEC TC 37, 77, 86 and CISPR.

IEC 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 61290-4-3

Edition 1.0 2015-05

INTERNATIONAL STANDARD

colour inside

Optical amplifiers – Test methods
Part 4-3: Power transient parameters – Single channel optical amplifiers in output power control

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 33.180.30

ISBN 978-2-8322-2670-4

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

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

____

OPTICAL AMPLIFIERS – TEST METHODS

Part 4-3: Power transient parameters – Single channel optical amplifiers in output power control

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.

International Standard IEC 61290-4-3 has been prepared by subcommittee 86C: Fibre optic systems and active devices, of IEC technical committee 86: Fibre optics.

This International Standard is to be used in conjunction with IEC 61291-1:2012, on the basis of which it was established.

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

FDIS	Report on voting
86C/1310/FDIS	86C/1329/RVD

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 of the IEC 61290 series, published under the general title *Optical amplifiers – Test methods*[1] 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 website 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.

[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 4-3: Power transient parameters – Single channel optical amplifiers in output power control

1 Scope

This part of IEC 61290 applies to output power controlled optically amplified, elementary sub-systems. It applies to optical fibre amplifiers (OFA) using active fibres containing rare-earth dopants, presently commercially available, as indicated in IEC 61291-1, as well as alternative optical amplifiers that can be used for single channel output power controlled operation, such as semiconductor optical amplifiers (SOA).

The object of this standard is to provide the general background for optical amplifier (OA) power transients and its measurements and to indicate those IEC standard test methods for accurate and reliable measurements of the following transient parameters:

a) Transient power response
b) Transient power overcompensation response
c) Steady-state power offset
d) Transient power response time

The stimulus and responses behaviours under consideration include:

1) Channel power increase (step transient)
2) Channel power reduction (inverse step transient)
3) Channel power increase/reduction (pulse transient)
4) Channel power reduction/increase (inverse pulse transient)
5) Channel power increase/reduction/increase (lightning bolt transient)
6) Channel power reduction/increase/reduction (inverse lightning bolt transient)

These parameters have been included to provide a complete description of the transient behaviour of an output power transient controlled OA. The test definition defined here are applicable if the amplifier is an OFA or an alternative OA. However, the description in Annex A of this document concentrates on the physical performance of an OFA and provides a detailed description of the behaviour of OFA; it does not give a similar description of other OA types.

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 61291-1:2012, *Optical amplifiers – Part 1: Generic specification*

3 Terms, definitions and abbreviations

3.1 Terms and definitions

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

3.1.1
input signal
optical signal that is input to the OA

3.1.2
input power excursion
relative input power difference in dB before, during and after the input power stimulus event that causes an OA transient power excursion.

3.1.3
input power rise time
time it takes for the input optical signal to rise from 10 % to 90 % of the total difference between the initial and final signal levels during an increasing power excursion event

Note 1 to entry: see Figure A.2

3.1.4
input power fall time
time it takes for the input optical signal to fall from 10 % to 90 % of the total difference between the initial and final signal levels during a decreasing power excursion event

Note 1 to entry: see Figure A.2

3.1.5
slew rate
maximum rate of change of the input optical signal during a power excursion event

3.1.6
transient power response
maximum or minimum deviation (overshoot or undershoot) in dB between the OA's target power and the observed power excursion induced by a change in an input channel power excursion

Note 1 to entry: Once the output power of an amplified channel deviates from its target power, the control electronics in the OA should attempt to compensate for the power difference or transient power response, bringing the OA output power back to its original target level.

3.1.7
transient power settling time
amount of time taken to restore the power of the OA to a stable power level close to the target power level

Note 1 to entry: This parameter is measured from the time when stimulus event that created the power fluctuation to the time at which the OA power response is stable and within specification.

3.1.8
transient power overcompensation response
maximum deviation in dB between the amplifier's target output power and the power resulting from the control electronics instability

Note 1 to entry: Transient power overcompensation response occurs after a power excursion, when an amplifier's control electronics attempts to bring the power back to the amplifier's target level. The control process is iterative, and control electronics may initially overcompensate for the power excursion until subsequently reaching the desired target power level.

Note 2 to entry: The transient power overcompensation response parameter is generally of lesser magnitude than the transient power response and has the opposite sign.

3.1.9
steady state power offset
difference in dB between the final and initial output power of the OA, prior to the power excursion stimulus event

Note 1 to entry: Normally, the steady state power level following a power excursion differs from the OA power before the input power stimulus event. The transient controller attempts to overcome this offset using feedback.

3.2 Abbreviations

AFF	ASE flattening filter
AGC	automatic gain controller
APC	automatic power control
ASE	amplified spontaneous emission
ASEP	amplified spontaneous emission power
BER	bit error ratio
DFB	distributed feedback (laser)
DWDM	dense wavelength division multiplexing
EDF	Erbium-doped fibre
EDFA	Erbium-doped fibre amplifier
GFF	gain flattening filter
NEM	network equipment manufacturers
NSP	network service providers
O/E	optical-to-electrical
OA	optical amplifier
OD	optical damage
OFA	optical fibre amplifier
OSA	optical spectrum analyser
OSNR	optical signal-to-noise ratio
PDs	photodiodes
PID	proportional integral derivative
SOA	semiconductor optical amplifier
SAR	signal-to-ASE ratio
SigP	signal power
SOP	state of polarization
VOA	variable optical attenuator
WDM	wavelength division multiplexing

4 Apparatus

4.1 Test set-up

Figure 1 shows a generic set-up to characterise the transient response properties of output power controlled single channel OAs.

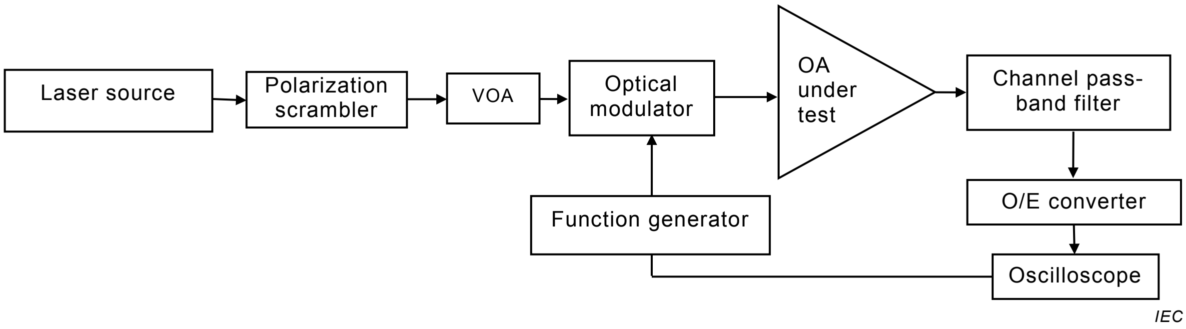

Figure 1 – Power transient test set-up

4.2 Characteristics of test equipment

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

a) Laser source for supplying the OA input signal with the following characteristics:

- Ability to support the range of signal wavelengths for which the OA under test is to be tested. This could be provided for example by a tuneable laser, or a bank of distributed feedback (DFB) lasers.
- An achievable average output power such that at the input to the OA under test the power will be above the maximum specified input power of the OA, including loss of any subsequent test equipment between the laser source and OA under test.

b) Polarization scrambler to randomize the incoming polarization state of the laser source, or to control it to a defined state of polarization (SOP). The polarization scrambler is optional.

c) Variable optical attenuator (VOA) with a dynamic range sufficient to support the required range of surviving signal levels at which the OA under test is to be tested.

NOTE If the output power of the laser source can be varied over the required dynamic range, then a VOA is not needed.

d) Optical modulator to modify the OA input signal to the defined power excursion with the following characteristics.

- Extinction ratio at rewrite without putting number higher than the maximum drop level for which the OA under test is to be tested.
- Switching time fast enough to support the fastest slew rate for which the OA under test is to be tested.

e) Channel pass-band filter: an optical filter designed to distinguish the signal wavelength with the following characteristics. Note the use of a channel pass-band filter is optional.

- Ability to support the range of signal wavelengths for which the OA under test is to be tested. This could be provided for example by a tuneable filter, or a series of discrete filters.
- 1dB pass-band of at least ±20 GHz centred around the signal wavelength.
- At least 20 dB attenuation level below the minimum insertion loss across the entire specified transmission band of the OA under test except within a range of ±100 GHz centred around the signal wavelength.

f) Opto-electronic (O/E) convertor to detect the filtered output of the OA under test with the following characteristics.

- A sufficiently wide optical and electrical bandwidth to support the fastest slew rate for which the OA is to be tested.
- A linear response within a ±5 dB range of all signal levels for which the OA under test is to be tested.

g) Oscilloscope to measure and capture the transient response of the optically filtered output of the OA under test, with a sufficiently wide electrical bandwidth to support the fastest slew rate for which the OA is to be tested.

h) Function generator to generate the input power transient waveforms to drive the optical modulator, with electrical pulse width short enough and electrical slew rate high enough to support the fastest slew rate for which the OA under test is to be tested.

5 Test sample

The OA shall operate under nominal operating conditions. If the OA is likely to cause laser oscillations due to unwanted reflections, optical isolators should be used to isolate the OA under test. This will minimize signal instability.

6 Procedure

6.1 Test preparation

In the set-up shown in Figure 1, the input optical signal power injected into the amplifier being tested is generated from a suitable laser source. The optical power is passed through an optional polarization scrambler to allow randomization or control of the signal polarization state and is subsequently adjusted with a VOA to the desired optical input power levels. The signal then passes through an optical modulator driven by a function generator that provides the desired input power test waveform to stimulate the transient input power excursions. The signal is then injected into the amplifier being tested. A channel pass-band filter (such as a tuneable optical filter, fixed optical filter or similar component) may be used to select only the relevant channel wavelength under test, followed by an O/E converter and an oscilloscope at the output of the amplifier. The output channel selected by the optional channel pass-band filter and its transient response is monitored with the O/E converter and oscilloscope. Waveforms similar to those shown in Figure A.3 are captured via the oscilloscope for subsequent computer processing.

Prior to measurement of the transient response, the input power waveform trace shall be recorded. Use the set-up of Figure 1 without the OFA under test. The input optical connector from the optical modulator is connected to the channel pass filter.

For this test to stimulate a power excursion at the input of the OA under test, the source laser power at the OA input is set at some typical power level. The function generator waveform is chosen to increase or decrease the input power to the OA under test with power excursions and slew rate relevant to the defined test condition. For example, for a typical number in the case of an optical receiver, the input power to the OA could be increased by 7 dB in a timeframe of 50 μs and then held at this power value to simulate a power increase transient power response (step transient) condition as shown in Figure A.1(1). For alternative transient control measurements, the signal generator waveform is controlled appropriately, and the VOA is adjusted accordingly.

6.2 Test conditions

Several sequential transient control measurements can be performed according to the optical amplifier's specified operating conditions. Examples of power excursion scenarios are shown in Table 1. These measurements are typically performed over a broad range of input power levels.