IEC 61290-4-1

Edition 2.0 2016-09

INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

Optical amplifiers – Test methods –
Part 4-1: Gain transient parameters – Two-wavelength method

Amplificateurs optiques – Méthodes d'essai –
Partie 4-1: Paramètres de gain transitoire – Méthode à deux longueurs d'onde

IEC 61290-4-1:2016-09(en-fr)

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 It also gives information on projects, replaced and withdrawn publications.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 20 000 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
65 000 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.

A propos de l'IEC
La Commission Electrotechnique Internationale (IEC) est la première organisation mondiale qui élabore et publie des Normes internationales pour tout ce qui a trait à l'électricité, à l'électronique et aux technologies apparentées.

A propos des publications IEC
Le contenu technique des publications IEC est constamment revu. Veuillez vous assurer que vous possédez l'édition la plus récente, un corrigendum ou amendement peut avoir été publié.

Catalogue IEC - webstore.iec.ch/catalogue
Application autonome pour consulter tous les renseignements bibliographiques sur les Normes internationales, Spécifications techniques, Rapports techniques et autres documents de l'IEC. Disponible pour PC, Mac OS, tablettes Android et iPad.

Recherche de publications IEC - www.iec.ch/searchpub
La recherche avancée permet de trouver des publications IEC en utilisant différents critères (numéro de référence, texte, comité d'études,…). Elle donne aussi des informations sur les projets et les publications remplacées ou retirées.

IEC Just Published - webstore.iec.ch/justpublished
Restez informé sur les nouvelles publications IEC. Just Published détaille les nouvelles publications parues. Disponible en ligne et aussi une fois par mois par email.

Electropedia - www.electropedia.org
Le premier dictionnaire en ligne de termes électroniques et électriques. Il contient 20 000 termes et définitions en anglais et en français, ainsi que les termes équivalents dans 15 langues additionnelles. Egalement appelé Vocabulaire Electrotechnique International (IEV) en ligne.

Glossaire IEC - std.iec.ch/glossary
65 000 entrées terminologiques électrotechniques, en anglais et en français, extraites des articles Termes et Définitions des publications IEC parues depuis 2002. Plus certaines entrées antérieures extraites des publications des CE 37, 77, 86 et CISPR de l'IEC.

Service Clients - webstore.iec.ch/csc
Si vous désirez nous donner des commentaires sur cette publication ou si vous avez des questions contactez-nous: csc@iec.ch.

IEC 61290-4-1

Edition 2.0 2016-09

INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

Optical amplifiers – Test methods – Part 4-1: Gain transient parameters – Two-wavelength method

Amplificateurs optiques – Méthodes d'essai – Partie 4-1: Paramètres de gain transitoire – Méthode à deux longueurs d'onde

INTERNATIONAL ELECTROTECHNICAL COMMISSION

COMMISSION ELECTROTECHNIQUE INTERNATIONALE

ICS 33.180.30 ISBN 978-2-8322-3659-8

Warning! Make sure that you obtained this publication from an authorized distributor.
Attention! Veuillez vous assurer que vous avez obtenu cette publication via un distributeur agréé.

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

OPTICAL AMPLIFIERS – TEST METHODS –

Part 4-1: Gain transient parameters – Two-wavelength method

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 61290-4-1 has been prepared by subcommittee 86C: Fibre optic systems and active devices, of IEC technical committee 86: Fibre optics.

This second edition cancels and replaces the first edition published in 2011. This edition constitutes a technical revision.

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

a) extended the applicability from only EDFAs to all OFAs;
b) updated definitions for consistency with other documents in the IEC 61290-4 series.

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

CDV	Report on voting
86C/1347/CDV	86C/1397/RVC

Full information on the voting for the approval of this International Standard can be found in the report on voting indicated in the above table.

This document 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* 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.

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.

INTRODUCTION

This part of IEC 61290-4 is devoted to optical amplifiers (OAs). The technology of OAs is quite new and still emerging; hence amendments and new editions to this document can be expected.

Background information on the transient phenomenon in erbium-doped fibre amplifiers and the consequences on fibre optic systems is provided in Annex A and on slew rate effects in Annex B.

OPTICAL AMPLIFIERS – TEST METHODS –

Part 4-1: Gain transient parameters – Two-wavelength method

1 Scope

This part of IEC 61290-4 applies to optical amplifiers (OAs) using active fibres (optical fibre amplifiers (OFAs)) containing rare-earth dopants including erbium-doped fibre amplifiers (EDFAs) and optically amplified elementary sub-systems. These amplifiers are commercially available and widely deployed in service provider networks.

The object of document is to provide the general background for OFA transients and related parameters, and to describe a standard test method for accurate and reliable measurement of the following transient parameters:

a) channel addition or removal transient gain overshoot and transient net gain overshoot;
b) channel addition or removal transient gain undershoot and transient net gain undershoot;
c) channel addition or removal gain offset;
d) channel addition or removal transient gain response time constant (settling time).

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, *Optical amplifiers – Part 1: Generic specification*

3 Terms, definitions and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 61291-1 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1.1
surviving channel
optical signal that remains after a drop event

3.1.2
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 add event

Note 1 to entry: See Figure 1(a).

3.1.3
initial gain
gain of the surviving or pre-existing channel before a drop or add event

3.1.4
final gain
steady-state gain of the surviving or pre-existing channel after a long period of time (i.e. once the gain has stabilized) after a drop or add event

3.1.5
gain offset
change of the gain between initial and final state

Note 1 to entry: Gain offset is expressed in dB.

Note 2 to entry: Gain offset = final gain (in dB) – initial gain (in dB).

Note 3 to entry: Gain offset may be positive or negative for both channel addition and removal events.

3.1.6
gain stability
specified peak-to-peak gain fluctuations of the OFA under steady state conditions (i.e. not in response to a transient event)

3.1.7
transient gain response time constant
settling time
amount of time required to bring the gain of the surviving or pre-existing channel to the final gain

Note 1 to entry: This parameter is the measured time from the beginning of the drop or add event that created the transient gain response to the time at which the surviving or pre-existing channel gain first enters within the gain stability band centred on the final gain.

Note 2 to entry: Hereon, this will also be referred to as "settling time".

3.1.8
transient gain overshoot
difference between the maximum surviving or pre-existing channel gain reached during the OFA transient response to a drop or add event, and the lowest of either the initial gain and final gain

Note 1 to entry: Transient gain overshoot is expressed in dB.

Note 2 to entry: Hereon, this will also be referred to as "gain overshoot".

3.1.9
transient net gain overshoot
difference between the maximum surviving or pre-existing channel gain reached during the OFA transient response to a drop or add event, and the highest of either the initial gain and final gain

Note 1 to entry: The transient net gain overshoot is expressed in dB.

Note 2 to entry: The transient net gain overshoot is the transient gain overshoot minus the gain offset, and represents the actual transient response not related to the shift of the amplifier from the initial steady state condition to the final steady state condition.

Note 3 to entry: Hereon, this will also be referred to as "net gain overshoot".

3.1.10
transient gain undershoot
difference between the minimum surviving or pre-existing channel gain reached during the OFA transient response to a drop or add event, and the highest of either the initial gain and final gain

Note 1 to entry: The transient gain undershoot is expressed in dB.

Note 2 to entry: Hereon, this will also be referred to as "gain undershoot".

3.1.11
transient net gain undershoot
difference between the minimum surviving or pre-existing channel gain reached during the OFA transient response to a drop or add event and the lowest of either the initial gain and final gain

Note 1 to entry: The transient net gain undershoot is expressed in dB.

Note 2 to entry: The transient net gain undershoot is the transient gain undershoot minus the gain offset and represents the actual transient response not related to the shift of the amplifier from the initial steady state condition to the final steady state condition.

Note 3 to entry: Hereon this will also be referred to as "net gain undershoot".

3.2 Abbreviated terms

AGC automatic gain control

AOM acousto-optic modulator

BER bit error rate

DFB distributed feedback

DWDM dense wavelength division multiplexing

EDFA erbium-doped fibre amplifier

FWHM full-width half-maximum

NEM network equipment manufacturer

NSP network service provider

O/E optical-to-electronic

OA optical amplifier

OFA optical fibre amplifier

OSNR optical signal-to-noise ratio

SHB spectral-hole-burning

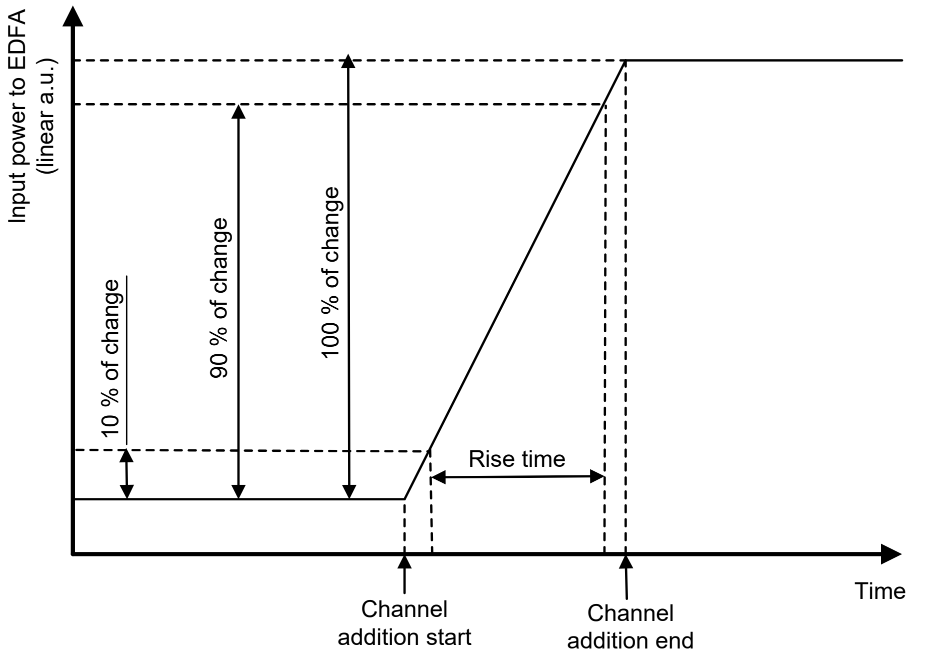
VOA variable optical attenuator

WDM wavelength division multiplexing

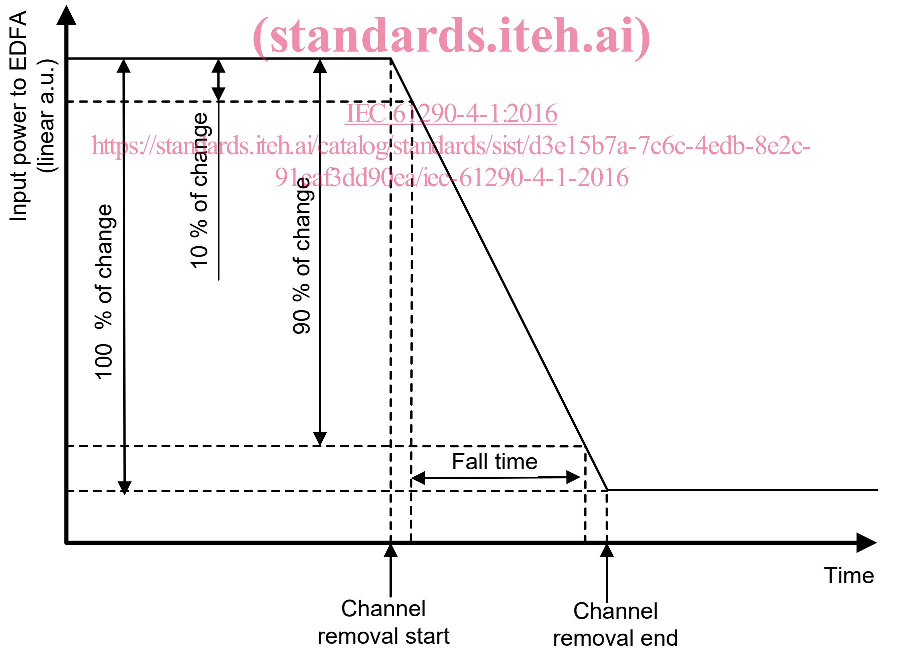
4 Measurement apparatus

When the input power to an OFA operating in saturation changes sharply, the gain of the amplifier will typically exhibit a transient response before settling back into the required gain. This response is dictated both by the optical characteristics of the active fibre within the OFA as well as the performance of the automatic gain control (AGC) mechanism.

Since a change in input power typically occurs when part of the dense wavelength division multiplexing (DWDM) channels within the specified transmission band are dropped or added, definitions are provided that describe a dynamic event leading to transient response. Rise and fall time definitions are shown in Figure 1.



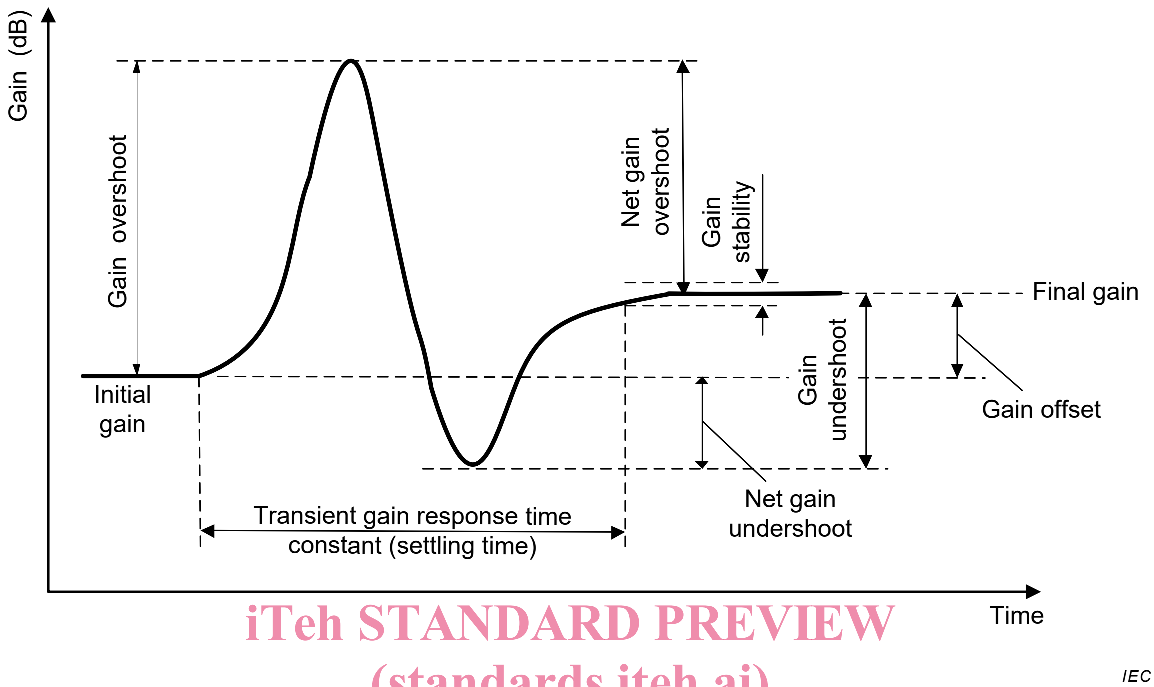
(a) Definitions of rise and fall times in the case of a channel addition event



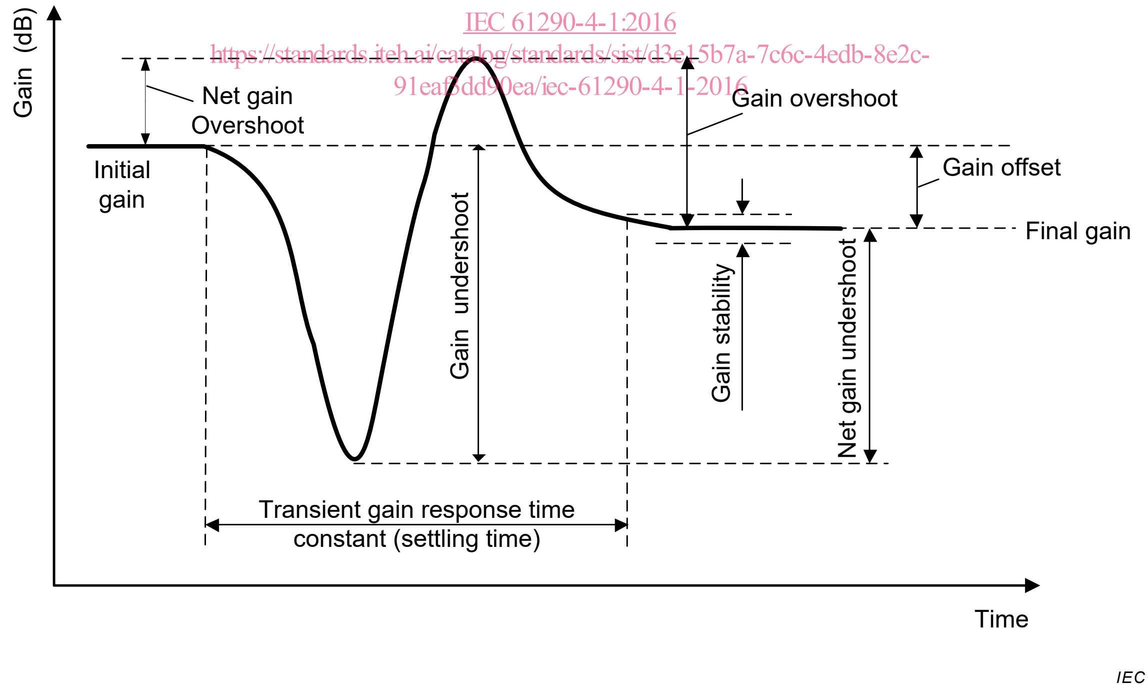
(b) Definitions of rise and fall times in the case of a channel removal event

Figure 1 – Definitions of rise and fall times

The parameters generally used to characterize the transient gain behaviour of a gain controlled OFA for the case of channel removal are defined in Figure 2(a). The figure specifically represents the time dependence of the gain of one of the surviving channels when channels are removed. Likewise, the transient gain behaviour for the case when channels are added is shown in Figure 2(b). The main transient parameters are: transient gain response time constant (settling time), gain offset, transient net gain overshoot, and transient gain net undershoot. The transient gain overshoot and undershoot are particularly critical to carriers and network equipment manufacturers (NEMs) given that the speed and amplitude of gain fluctuations compound through the network as the optical signal passes through an increasing number of cascaded amplifiers. Properly designed optical amplifiers have very small values for these transient parameters.



(a) OFA transient gain response for a channel removal event



(b) OFA transient gain response for a channel addition event

Figure 2 – OFA transient gain response

Figure 3 shows a typical setup to characterize the transient response properties of OFAs.

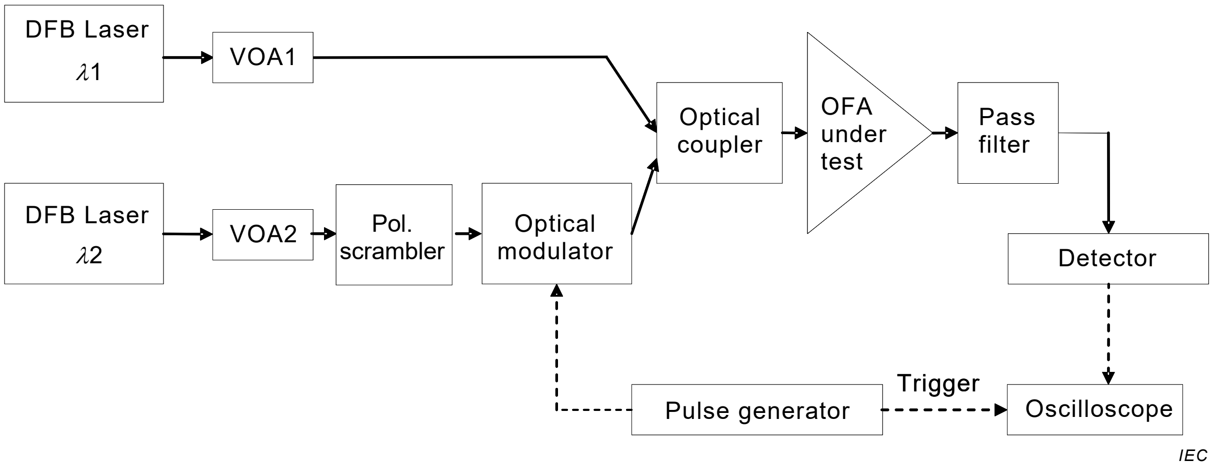


Figure 3 – Generic transient control measurement setup

5 Test specimen

The OFA shall operate at nominal operating conditions. If the OFA is likely to cause laser oscillations due to unwanted reflections, optical isolators should be used to bracket the OFA under test. This will minimize signal instability and measurement inaccuracy.

6 Procedure

In the setup shown in Figure 3, the input signal power into the amplifier being tested is the combination of two distributed feedback (DFB) lasers with wavelengths approximately 1 nm apart. One of the wavelengths represents add or drop channels while the other represents pre-existing or surviving channels. Each wavelength channel is subsequently adjusted with a variable optical attenuator (VOA) to the desired optical input power levels. One optical modulator driven by a function generator acts as an on/off switch, to simulate add and drop events. The two optical channels are subsequently combined onto the same fibre before the signal is directed to the amplifier being tested. A tuneable filter, an optical-to-electronic (O/E) converter and an oscilloscope are placed in tandem at the output of the amplifier. The pre-existing or surviving channel is selected with the tuneable filter and its transient response is monitored with the O/E converter and oscilloscope. A waveform similar to the one shown in Figure 2 is displayed on the oscilloscope's screen.

To simulate a drop event at the input of the amplifier being tested, the two lasers are set so that their total input power is equal to the amplifier's typical input power (e.g. 1 dBm). Therefore, the two lasers at –2 dBm each represent 20 optical channels having –15 dBm power per channel. When the function generator turns the modulator into the “off” position, the second laser is completely suppressed, changing the system's channel loading. For instance, when one laser is switched off, it simulates a 3 dB "drop" or a change in the system's channel loading from 40 channels to 20 channels. Similarly, when the modulator is changed into an "on" state, the addition of a second laser simulates a 3 dB add in optical power, or a change in the system's channel loading from 20 channels to 40 channels. For other transient control measurements, the VOAs can be adjusted accordingly so that the input power levels will differ by an appropriate value.

Several transient control measurements can be performed, according to the operating conditions and specifications that are provided. Measurements may also be taken for various add and drop scenarios as shown in Table 1. These measurements are typically performed over a broad range of input power levels.