TECHNICAL REPORT

IEC TR 61292-5

First edition
2004-07

Optical amplifiers –

Part 5: Polarization mode dispersion parameter – General information

Reference number
IEC/TR 61292-5:2004(E)

Publication numbering

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International Electrotechnical Commission
Международная Электротехническая Комиссия

PRICE CODE M

For price, see current catalogue

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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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.
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IEC 61292-5, 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/579A/DTR	86C/608/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.

IEC 61292 consists of the following parts, under the new general title *Optical amplifiers:*

Part 1: Parameters of amplifier components

Part 2: Theoretical background for noise figure evaluation using the electrical spectrum analyzer

Part 3: Classification, characteristics and applications.

Part 4: Maximum permissible optical power for the damage-free and safe use of optical amplifiers, including Raman amplifiers[1)]

Part 5: Polarization mode dispersion parameter – General information

Future standards in this series will carry the new general title as cited above. Titles of existing standards in this series will be updated at the time of the next edition.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

The committee has decided that the contents of this publication will remain unchanged until the maintenance result 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.

1) To be published.

OPTICAL AMPLIFIERS –

Part 5: Polarization mode dispersion parameter – General information

1 Scope

This part of IEC 61292, which is a Technical Report, applies to all commercially available optical amplifiers (OAs) including those using fibres (OFAs), semiconductors (SOAs), and waveguides (POWA), as classified in IEC 61292-3.

This Technical Report presents general information about polarization mode dispersion (PMD), related to the application of the two commonly used methods to test PMD in OAs, the Jones matrix eigenanalysis (JME) and the Poincaré sphere analysis (PSA), which have been demonstrated to be formalistically equivalent [4,5][2)].

This report is complementary to the International Standards describing the JME procedure (IEC 61290-11-1) and the PSA procedure (IEC 61290-11-2).

2 Normative references

The following referenced documents are indispensable for the understanding 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 61290-11-1, *Optical amplifier test methods – Part 11-1: Polarization mode dispersion – Jones matrix eigenanalysis method (JME)*

IEC 61290-11-2, *Optical fibre amplifier test methods – Part 11-2: Polarization mode dispersion – Poincaré sphere analysis method* [3)]

IEC 61292-3, *Optical amplifiers – Part 3: Classification, characteristics and applications*

3 Acronyms and abbreviations

ASE	amplified spontaneous emission
BBS	broadband source
DGD	differential group delay
DOP	degree of polarization
JME	Jones matrix eigenanalysis
OA	optical amplifier
OFA	optical fibre amplifier
OSA	optical spectrum analyser
PDG	polarization dependent gain
PDL	polarization dependent loss

2) Numbers in brackets refer to the Bibliography.

3) To be published.

PMD	polarisation mode dispersion
PMF	polarization-maintaining fibre
POWA	planar optical waveguide amplifier
PSA	Poincaré sphere analysis
PSP	principal states of polarization
RBW	resolution bandwidth
RMS	root mean square
SMSR	side mode suppression ratio
SOA	semiconductor optical amplifier
SOP	state of polarization
TLS	tuneable laser source

4 General Information

PMD refers to how the polarized light and in particular the principal states of polarization (PSPs) from a short pulse of a narrowband light source are modified when going through a device such as an OA. This process is mathematically explained by the concepts of polarization transfer function, the Jones vector and the polarization dispersion matrix, the Stokes vector and the Poincaré sphere, the PSPs and their mode coupling, the polarization dispersion vector and the differential group delay (DGD).

The following clauses will discuss some of these concepts as specifically applied to OAs.

4.1 Principal states of polarization and mode coupling

OAs are usually defined by a combination of optical components (passive or active gain medium); in some cases, an optical fibre is used as the active gain medium (see IEC 61292-3).

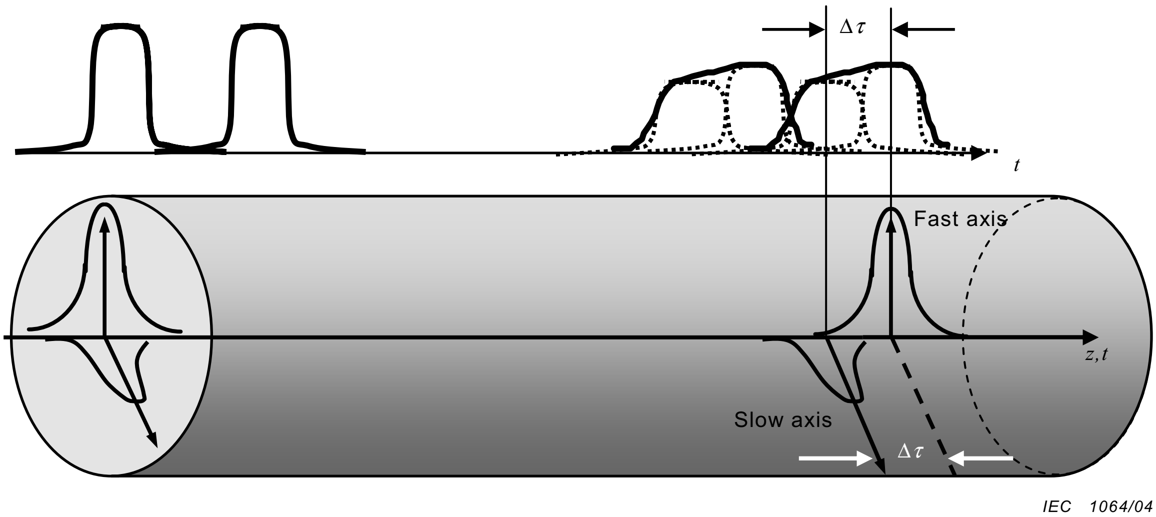
Some components have a deterministic behaviour while others behave stochastically, depending on their complexity and design. An optical fibre is deterministic if its length is short or if its birefringence axis is fixed, such as in the case of a polarization-maintaining fibre (PMF). The fibre will have a stochastic behaviour if it has a long length such as the fibre installed in cable plant. The length from which the fibre behaves stochastically is still under investigation.

Most OAs are expected to behave in semi-random mode coupling.

4.2 Differential group delay and polarization mode dispersion

In OAs, the DGD may vary as a function of wavelength (or frequency) even if this variation is smooth, small or sometimes predictable. In that case, the concept of PMD expressed as the RMS value or average value of the variation of the DGD as a function of wavelength (or optical frequency) and the concept of maximum value of that DGD variation can be used. For OAs the DGD and PMD are reported in ps.

In OAs, PMD together with polarization dependent loss (PDL) and polarization dependent gain (PDG) may introduce waveform distortion, leading to unacceptable bit error rate increase. Figure 1 illustrates the case where at the output of the DUT the bits are not only broadened (in absence of PDL/PDG) but also distorted (in presence of PDL/PDG). In presence of PDL, there is a loss of degree of polarization (DOP) for one PSP.



Key

t time

z direction of propogation along the fibre

Figure 1 – Effect of PMD on transmission of an information bit pulse in a device

5 Test method calculations

The mathematical formulation, as well as examples of calculation of JME and PSA, are found in IEC 61290-11-1 and IEC 61290-11-2, respectively.

6 Measurement issues

The following clauses pertain specifically to PMD measurement issues for OAs

6.1 Source degree of polarization and amplified spontaneous emission

The test methods require a polarized signal at the input of the polarimeter. Although the test source is highly polarized, the DOP at the output of the OA may be significantly reduced by the unpolarized amplified spontaneous emission (ASE).

The source DOP and measured signal DOP should be at least 25 % within the optical bandwidth of the SOP measurement. This is of particular concern when using a tuneable laser source (TLS) without a tracking optical filter at the OA output, because the total ASE power out of the OA, i.e. the ASE spectrum integrated over all wavelengths, impinges on the photodetectors whatever the selected wavelength. In this case, proper saturation conditions must be ensured in order for the DOP at the output port of the DUT to be high enough, e.g. >30 %, for accurate measurement.

Figure 2 shows a typical OFA output spectrum from a TLS input as viewed on an optical spectrum analyser (OSA) with a resolution bandwidth (RBW) of 0,5 nm (~65 GHz around 1 550 nm).