IEC 61746-2

Edition 1.0 2010-06

INTERNATIONAL STANDARD

Calibration of optical time-domain reflectometers (OTDR) – Part 2: OTDR for multimode fibres

IEC Central Office
3, rue de Varembé
CH-1211 Geneva 20
Switzerland
Email: inmail@iec.ch
Web: 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.

- Catalogue of IEC publications: www.iec.ch/searchpub

The IEC on-line Catalogue enables you to search by a variety of criteria (reference number, text, technical committee,…). It also gives information on projects, withdrawn and replaced publications.

- IEC Just Published: www.iec.ch/online_news/justpub

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

- Electropedia: www.electropedia.org

The world's leading online dictionary of electronic and electrical terms containing more than 20 000 terms and definitions in English and French, with equivalent terms in additional languages. Also known as the International Electrotechnical Vocabulary online.

- Customer Service Centre: www.iec.ch/webstore/custserv

If you wish to give us your feedback on this publication or need further assistance, please visit the Customer Service Centre FAQ or contact us:

Email: csc@iec.ch
Tel.: +41 22 919 02 11
Fax: +41 22 919 03 00

IEC 61746-2

Edition 1.0 2010-06

INTERNATIONAL STANDARD

Calibration of optical time-domain reflectometers (OTDR) – Part 2: OTDR for multimode fibres

INTERNATIONAL ELECTROTECHNICAL COMMISSION

PRICE CODE X

ICS 33.180.01

ISBN 978-2-88912-026-0

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

CALIBRATION OF OPTICAL TIME-DOMAIN REFLECTOMETERS (OTDR) –

Part 2: OTDR for multimode fibres

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 61746-2 has been prepared by IEC technical committee 86: Fibre optics.

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

CDV	Report on voting
86/336/CDV	86/359/RVC

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 IEC 61746 series, under the general title *Calibration of optical time-domain reflectometers (OTDR)*, 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.

INTRODUCTION

In order for an optical time-domain reflectometer (OTDR) to qualify as a candidate for complete calibration using this standard, it must be equipped with the following minimum feature set:

a) the ability to measure type A1a or A1b IEC 60793-2-10 fibres;

b) a programmable index of refraction, or equivalent parameter;

c) the ability to present a display of a trace representation, with a logarithmic power scale and a linear distance scale;

d) two markers/cursors, which display the loss and distance between any two points on a trace display;

e) the ability to measure absolute distance (location) from the OTDR's zero-distance reference;

f) the ability to measure the displayed power level relative to a reference level (for example, the clipping level).

Calibration methods described in this standard may look similar to those provided in Part 1 of this series. However, there are differences: mix of different fibre types, use of mode conditioner or different arrangement of the fibres. This leads to different calibration processes as well as different uncertainties analysis.

CALIBRATION OF OPTICAL TIME-DOMAIN REFLECTOMETERS (OTDR) –

Part 2: OTDR for multimode fibres

1 Scope

This part of IEC 61746 provides procedures for calibrating multimode optical time domain reflectometers (OTDR). It covers OTDR measurement errors and uncertainties. The test of the laser(s) source modal condition is included as an optional measurement.

This standard does not cover correction of the OTDR response.

2 Normative references

The following referenced documents are indispensable for the application 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 60793-2-10, *Optical fibres – Part 2-10: Product specifications – Sectional specification for category A1 multimode fibres*

IEC 60793-2-50, *Optical fibres – Part 2-50: Product specifications – Sectional specification for class B single-mode fibres*

IEC 61280-1-4, *Fibre optic communication subsystem test procedures – Part 1-4: General communication subsystems – Light source encircled flux measurement method*

IEC 61280-4-1, *Fibre optic communication subsystem test procedures – Part 4-1: Installed cable plant – Multimode attenuation measurement*

IEC 61745, *End-face image analysis procedure for the calibration of optical fibre geometry test sets*

ISO/IEC 17025, *General requirements for the competence of testing and calibration laboratories*

3 Terms, definitions and symbols

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

NOTE For more precise definitions, the references to IEC 60050-731 should be consulted.

3.1
attenuation
A
loss

optical power decrease in decibels (dB)

NOTE If P_{in} (watts) is the power entering one end of a segment of fibre and P_{out} (watts) is the power leaving the other end, then the attenuation of the segment is

$$A = 10\log_{10}\left(\frac{P_{in}}{P_{out}}\right) \quad \text{dB} \tag{1}$$

[IEV 731-01-48, modified]

3.2
attenuation coefficient
α
attenuation (3.1) of a fibre per unit length

[IEV 731-03-42, modified]

3.3
attenuation dead zone
for a reflective or attenuating event, the region after the event where the displayed trace deviates from the undisturbed backscatter trace by more than a given vertical distance ΔF

NOTE The attenuation dead zone (see Figure 1 below) will depend on the following event parameters: reflectance, loss, displayed power level and location. It may also depend on any fibre optic component in front of the event.

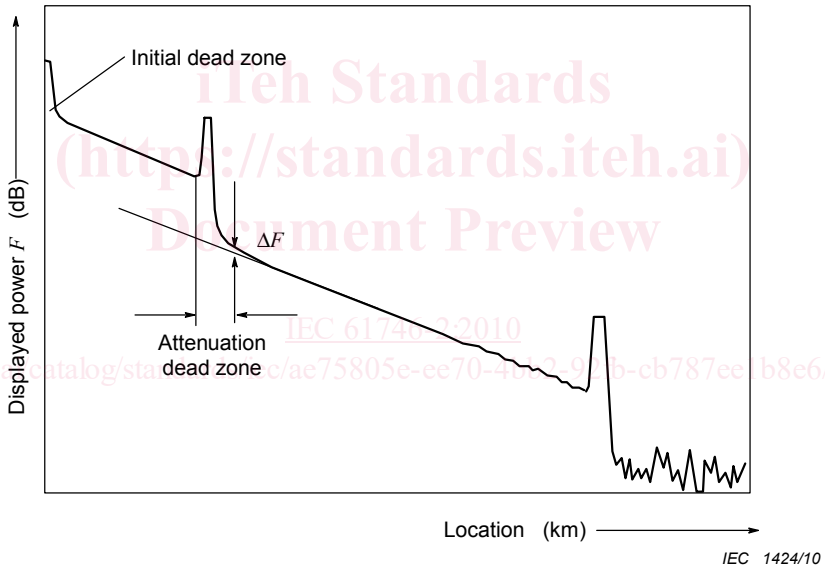

Figure 1 – Definition of attenuation dead zone

3.4
calibration
set of operations which establish, under specified conditions, the relationship between the values indicated by the measuring instrument and the corresponding known values of that quantity

NOTE See ISO *Guide International vocabulary of basic and general terms in metrology*.

3.5
centroidal wavelength
λ_{avg}
power-weighted mean wavelength of a light source in vacuum

[IEC 61280-1-3, definition 2.1.4]

3.6
displayed power level
F
level displayed on the OTDR's power scale

NOTE 1 Unless otherwise specified, F is defined in relation to the clipping level (see Figure 8).

NOTE 2 Usually, the OTDR power scale displays five times the logarithm of the received power, plus a constant offset.

3.7
distance
D
spacing between two features

NOTE Usually expressed in metres.

3.8
distance sampling error
$\Delta L_{\mathbf{sample}}$
maximum distance (3.7) error attributable to the distance between successive sample points

NOTE 1 Usually expressed in metres.

NOTE 2 The distance sampling error is repetitive in nature; therefore, one way of quantifying this error is by its amplitude.

3.9
distance scale deviation
$\Delta S_{\mathbf{L}}$
difference between the average displayed distance (3.7) $< D_{\text{otdr}} >$ and the correspondent reference distance (3.27) D_{ref} divided by the reference distance (3.27)

NOTE 1 Usually expressed in m/m.

NOTE 2 ΔS_{L} is given by the following formula

$$\Delta S_{\text{L}} = \frac{< D_{\text{otdr}} > - D_{\text{ref}}}{D_{\text{ref}}} = \frac{< D_{\text{otdr}} >}{D_{\text{ref}}} - 1 \qquad (2)$$

where $< D_{\text{otdr}} >$ is the displayed distance on a fibre averaged over at least one sample spacing.

3.10
distance scale factor
$S_{\mathbf{L}}$
average displayed distance (3.7) divided by the correspondent reference distance (3.27)

NOTE 1 S_{L} is given by the following formula

$$S_L = \frac{< D_{\text{otdr}} >}{D_{\text{ref}}} \qquad (3)$$

where $< D_{\text{otdr}} >$ is the displayed distance between two features on a fibre (actual or simulated) averaged over at least one sample spacing.

3.11
distance scale uncertainty
$u_{\mathbf{\Delta SL}}$
uncertainty of the distance scale deviation (3.9)

NOTE 1 Usually expressed in m/m.

NOTE 2 $u_{\Delta SL}$ is given by the following formula

$$u_{\Delta SL} = u\left(\frac{< D_{otdr} >}{D_{ref}} - 1\right) = u\left(\frac{< D_{otdr} >}{D_{ref}}\right) \quad (4)$$

NOTE 3 In the above formula, $u()$ is understood as the standard uncertainty of ().

3.12
dynamic range at 98 % (one-way)
amount of fibre attenuation (3.1) that causes the backscatter signal to equal the noise level at 98 % (3.24)

NOTE It can be represented by the difference between the extrapolated point of the backscattered trace (taken at the intercept with the power axis) and the noise level expressed in decibels, using a standard category A fibre (see IEC 60793-2-10).

3.13
encircled flux
EF

fraction of cumulative near field power to total output power as a function of radial distance from the centre of the core

3.14
group index
N
factor by which the speed of light in vacuum has to be divided to yield the propagation velocity of light pulses in the fibre

3.15
location
L
spacing between the front panel of the OTDR and a feature in a fibre

NOTE Usually expressed in metres

3.16
location deviation
ΔL
displayed location (3.15) of a feature L_{otdr} minus the reference location (3.28) L_{ref}

NOTE 1 Usually expressed in metres.

NOTE 2 This deviation is a function of the location.

3.17
location offset
ΔL_0
constant term of the **location deviation** (3.16) model

NOTE 1 Usually expressed in metres.

NOTE 2 This is approximately equivalent to the location of the OTDR front panel connector on the instrument's distance scale.

NOTE 3 For a perfect OTDR, the location offset is zero.

3.18
location offset uncertainty
$u_{\Delta L0}$
uncertainty of the location offset (3.17)