

This is a preview - click here to buy the full publication



IEC 61746-1

Edition 1.0 2009-12

INTERNATIONAL STANDARD

**Calibration of optical time-domain reflectometers (OTDR) –
Part 1: OTDR for single mode fibres**

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

PRICE CODE **XC**

ICS 33.180.01

ISBN 978-2-88910-553-3

CONTENTS

FOREWORD.....	6
INTRODUCTION.....	8
1 Scope.....	9
2 Normative references.....	9
3 Terms, definitions and symbols.....	9
4 Preparation for calibration.....	16
4.1 Organization.....	16
4.2 Traceability.....	16
4.3 Preparation.....	16
4.4 Test conditions.....	16
4.5 Documentation.....	16
5 Distance calibration – General.....	17
5.1 General.....	17
5.2 Location deviation model.....	17
5.3 Using the calibration results.....	19
5.4 Measuring fibre length.....	19
6 Distance calibration methods.....	20
6.1 General.....	20
6.2 External source method.....	20
6.2.1 Short description and advantage.....	20
6.2.2 Equipment.....	20
6.2.3 Calibration of the equipment.....	21
6.2.4 Measurement procedure.....	22
6.2.5 Calculations and results.....	23
6.2.6 Uncertainties.....	24
6.3 Concatenated fibre method.....	25
6.3.1 Short description and advantages.....	25
6.3.2 Equipment.....	25
6.3.3 Measurement procedures.....	27
6.3.4 Calculations and results.....	27
6.3.5 Uncertainties.....	28
6.4 Recirculating delay line method.....	29
6.4.1 Short description and advantage.....	29
6.4.2 Equipment.....	29
6.4.3 Measurement procedure.....	31
6.4.4 Calculations and results.....	31
6.4.5 Uncertainties.....	32
7 Loss calibration – General.....	33
7.1 General.....	33
7.2 Determination of the displayed power level F	33
7.3 Selection of an appropriate reference loss A_{ref}	34
7.4 Development of a test plan.....	35
7.5 Polarization dependence.....	37
7.6 Calculation of the calibration results.....	38
7.7 Using the calibration results.....	38
8 Loss calibration methods.....	38

8.1	General	38
8.2	Fibre standard method	39
8.2.1	Short description and advantage	39
8.2.2	Equipment	39
8.2.3	Measurement procedure	40
8.2.4	Calculations and results	41
8.2.5	Uncertainties	41
8.3	External source method (see Figure 16)	42
8.3.1	Short description and advantage	42
8.3.2	Equipment	42
8.3.3	Calibration of the reference loss	43
8.3.4	Measurement procedure	44
8.3.5	Calculations and results	45
8.3.6	Uncertainties	45
8.4	Splice simulator method	46
8.4.1	Short description and advantage	46
8.4.2	Equipment	46
8.4.3	Procedure	47
8.4.4	Calculations and results	49
8.4.5	Uncertainties	49
8.5	Power reduction method	50
8.5.1	Short description and advantage	50
8.5.2	Equipment	51
8.5.3	Measurement procedure	52
8.5.4	Calculations and results	53
8.5.5	Uncertainties	53
9	Reflectance calibration	54
9.1	Objective	54
9.2	Reflectance measurements (see Figure 23)	54
9.3	Use of the backscatter parameter, K	54
9.4	Range of reflectance measurement	55
9.5	Development of a test plan	56
9.6	Equipment	57
9.7	Measurement procedure	58
9.7.1	Preparation	58
9.7.2	Taking reflectance measurements	58
9.7.3	Calculation and results	58
9.7.4	Uncertainties	58
Annex A (normative)	Recirculating delay line for distance calibration	60
Annex B (normative)	Optical fibre standard for loss calibration	64
Annex C (normative)	Standard splice simulator for loss calibration	68
Annex D (normative)	Mathematical basis	72
Annex E (normative)	Reflectance standard	75
Annex F (normative)	Simple version of reflectance standard	81
Annex G (informative)	OTDR basis: Backscatter theory – Reflectance measurements using an OTDR – Determination of fibre backscatter parameter	85
Bibliography	90

Figure 1 – Definition of attenuation dead zone	10
Figure 2 – Representation of the location deviation $\Delta L(L)$	18
Figure 3 – Equipment for calibration of the distance scale – External source method	21
Figure 4 – Set-up for calibrating the system insertion delay.....	22
Figure 5 – Concatenated fibres used for calibration of the distance scale.....	26
Figure 6 – Distance calibration with a recirculating delay line	30
Figure 7 – OTDR trace produced by recirculating delay line	30
Figure 8 – Determining the reference level and the displayed power level	34
Figure 9 – Measurement of the OTDR loss samples	35
Figure 10 – Region A, the recommended region for loss measurement samples	36
Figure 11 – Possible placement of sample points within region A.....	36
Figure 12 – External source method for testing the polarization dependence of the OTDR	37
Figure 13 – Reflection method for testing the polarization dependence of the OTDR	37
Figure 14 – Loss calibration with a fibre standard	39
Figure 15 – Placing the beginning of section D_1 outside the attenuation dead zone.....	40
Figure 16 – Loss calibration with the external source method.....	43
Figure 17 – Location and measurements for external source method	44
Figure 18 – Set-up for loss calibration with splice simulator	46
Figure 19 – OTDR display with splice simulator	47
Figure 20 – Measurement of the splice loss.....	48
Figure 21 – Loss calibration with "fibre-end" variant of the power reduction method	51
Figure 22 – Loss calibration with "long-fibre" variant of the power reduction method.....	52
Figure 23 – Parameters involved in reflectance measurements	54
Figure 24 – The same reflectance at the end of three fibres with different values of the backscatter parameter shows different pulse amplitudes	55
Figure 25 – Maximum and minimum values for the pulse amplitude, ΔF	56
Figure 26 – Range of reflectance measurement.....	56
Figure 27 – Determining the default displayed power level and the default location	57
Figure 28 – Set-up for reflectance calibration.....	58
Figure A.1 – Recirculating delay line.....	60
Figure A.2 – Measurement set-up for loop transit time T_b	61
Figure A.3 – Calibration set-up for lead-in transit time T_a	62
Figure B.1 – Determination of a highly linear power range.....	65
Figure B.2 – Testing the longitudinal backscatter uniformity of the fibre standard	66
Figure C.1 – Splice simulator and idealized OTDR signature.....	68
Figure C.2 – Determination of the reference loss A_{ref}	70
Figure E.1 – Reflectance standard description and trace.....	75
Figure E.2 – Calibration set up and reference points for calibration	78
Figure F.1 – Reflectance standard description and trace.....	81
Figure F.2 – Calibration set up and reference points for calibration	83
Figure G.1 – OTDR signals used for determining reflectance	86
Figure G.2 – Set-up for measurement of the backscatter coefficient	88

Table 1 – Attenuation coefficients defining region A 35

INTERNATIONAL ELECTROTECHNICAL COMMISSION

CALIBRATION OF OPTICAL TIME-DOMAIN REFLECTOMETERS (OTDR) –

Part 1: OTDR for single mode 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 61746-1 has been prepared by IEC technical committee 86: Fibre optics.

This first edition of IEC 61746-1 cancels and replaces the second edition of IEC 61746, published in 2005. It constitutes a technical revision.

The main technical changes are the adaptation of Clause 4, the suppression of Clause 10, the improvement and the addition of some definitions, the change of some calculations and the change of graphical symbology to IEC/TR 61930.

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

FDIS	Report on voting
86/347/FDIS	86/362/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.

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 standard 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) a programmable index of refraction, or equivalent parameter;
- b) the ability to present a display of a trace representation, with a logarithmic power scale and a linear distance scale;
- c) two markers/cursors, which display the loss and distance between any two points on a trace display;
- d) the ability to measure absolute distance (location) from the OTDR's zero-distance reference;
- e) the ability to measure the displayed power level relative to a reference level (for example, the clipping level);
- f) the ability to evaluate the reflectance of a reflective event.

CALIBRATION OF OPTICAL TIME-DOMAIN REFLECTOMETERS (OTDR) –

Part 1: OTDR for single mode fibres

1 Scope

This part of IEC 61746 provides procedures for calibrating single-mode optical time domain reflectometers (OTDR). It only covers OTDR measurement errors and uncertainties.

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 60793-1-40, *Optical fibres – Part 1-40: Measurement methods and test procedures – Attenuation*

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

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

ITU-T Recommendation G.650.1:2002, *Definitions and test methods for linear, deterministic attributes of single-mode fibre and cable*

ITU-T Recommendation G.650.2:2002, *Definitions and test methods for statistical and non-linear attributes of single-mode fibre and cable*