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Edition 1.0 2009-12

INTERNATIONAL STANDARD

NORME INTERNATIONALE

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

Étalonnage des réflectomètres optiques dans le domaine temporel (OTDR) –
Partie 1 : OTDR pour fibres unimodales

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

CALIBRATION OF OPTICAL TIME-DOMAIN REFLECTOMETERS (OTDR) –

Part 1: OTDR for single mode fibres

FOREWORD

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International Standard IEC 61746-1 has been prepared by IEC technical committee 86: Fibre optics.

This bilingual version (2014-06) correponds to the English version, published in 2009-12.

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.

The French version of this standard has not been voted upon.

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- withdrawn,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.

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*

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
loss
A
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

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

[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.

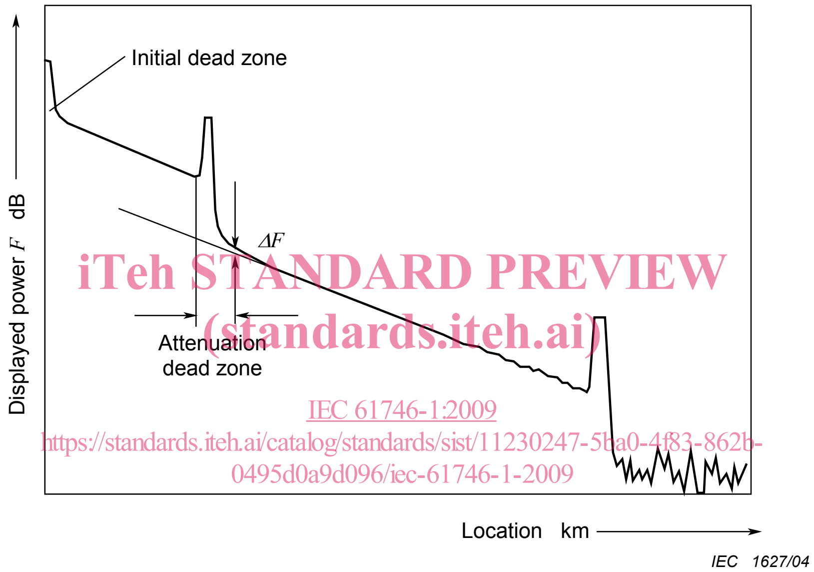

Figure 1 – Definition of attenuation dead zone

3.4
backscatter parameter
K
at a given point along the fibre, the backscattered propagating power per unit incident energy

NOTE 1 K is given by the following formula:

$$K = S\alpha_{\mathrm{S}} \frac{v}{2} \quad \mathrm{s}^{-1} \tag{2}$$

where

α_{S} is the scattering coefficient, e.g.; in m^{-1};

S is the backscatter capture fraction. It depends on other standard fibre parameters such as the mode field diameter in single mode fibre;

v is the group velocity (in m/s);

= c / N where c is the speed of the light in vacuum, N the group index of the fibre.

NOTE 2 See also Annex G.

3.5
backscatter coefficient
C
for a given pulse, the ratio of backscattered power at the input side of the fibre to the pulse input power

NOTE 1 It represents the backscatter parameter for a given pulse width. The backscatter coefficient is defined from the backscatter parameter (3.4) using the following formula:

$$C\ (\Delta T) = K\Delta T \quad (3)$$

where ΔT is the pulse width, e.g. in seconds.

Usually the backscatter coefficient is expressed in dB for a given pulse width, ΔT.

$$C_{\mathrm{dB}}(\Delta T) = 10\log_{10}(K\Delta T) \quad (4)$$

NOTE 2 The pulse width, ΔT in the previous formula is used to normalise $C\ (\Delta T)$. Usual values for ΔT are 1 ns and 1 µs. See also Annex G.

3.6
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/IEC Guide 99 [11] in the bibliography.

3.7
centroidal wavelength
λ_{avg}
power-weighted mean wavelength of a light source in vacuum

[IEC 61280-1-3, definition 2.1.4]

3.8
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 scale displays five times the logarithm of the received power, plus a constant offset.

3.9
distance
D
spacing between two features

NOTE Usually expressed in metres.

3.10
distance sampling error
$\Delta L_{\mathrm{sample}}$
maximum distance (3.9) 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.

3.11
distance scale deviation
ΔS_L
difference between the average displayed distance (3.9) $< D_{otdr} >$ 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:

$$\Delta S_L = \frac{< D_{otdr} > - D_{ref}}{D_{ref}} = \frac{< D_{otdr} >}{D_{ref}} - 1 \qquad (5)$$

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

3.12
distance scale factor
S_L
average displayed distance (3.9) distance divided by the correspondent reference distance (3.27)

NOTE S_L is given by the following formula:

$$S_L = \frac{< D_{otdr} >}{D_{ref}} \qquad (6)$$

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

3.13
distance scale uncertainty
$u_{\Delta SL}$
uncertainty of the distance scale deviation (3.11)

NOTE 1 Usually expressed in m/m.

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

$$u_{\Delta SL} = u\left(\frac{< D_{otdr} >}{D_{ref}} - 1\right) = u\left(\frac{< D_{otdr} >}{D_{ref}}\right) \qquad (7)$$

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

3.14
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 B fibre (see IEC 60793-2-50).

3.15
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

3.16
location
L
spacing between the front panel of the OTDR and a feature in a fibre

NOTE Usually expressed in metres.

3.17
location deviation
ΔL
displayed location (3.16) 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.

3.18
location offset
ΔL_0
constant term of the location deviation (3.17) 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.

3.19
location offset uncertainty
$u_{\Delta L0}$
uncertainty of the location offset (3.18)

3.20
location readout uncertainty
$u_{Lreadout}$
uncertainty of the location (3.16) measurement samples caused by both the distance sampling error (3.10) and the uncertainty type A of the measurement samples

3.21
loss deviation
ΔA
difference between the displayed loss of a fibre component A_{otdr} and the reference loss (3.29), in dB

NOTE 1 ΔA is given by the following formula:

$$\Delta A = A_{otdr} - A_{ref} \tag{8}$$

NOTE 2 The loss deviation usually depends on the displayed power level, F.

3.22
loss uncertainty
$u_{\Delta A}$
uncertainty of the loss deviation (3.21), in dB