IEC 60793-1-60

Edition 1.0 2017-02

INTERNATIONAL STANDARD

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Optical fibres –
Part 1-60: Measurement methods and test procedures – Beat length

IEC 60793-1-60:2017-02(en)

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INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 33.180.10

ISBN 978-2-8322-3865-3

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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Part 1-60: Measurement methods and test procedures – Beat length

FOREWORD

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International Standard IEC 60793-1-60 has been prepared by subcommittee 86A: Fibres and cables, of IEC technical committee 86: Fibre optics.

The text of this International Standard is based on the following documents:

CDV	Report on voting
86A/1737/CDV	86A/1782/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 in the IEC 60793 series, published under the general title *Optical fibres*, can be found on the IEC website.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

A bilingual version of this publication may be issued at a later date.

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OPTICAL FIBRES –

Part 1-60: Measurement methods and test procedures – Beat length

1 Scope

This part of IEC 60793 defines test methods for both the phase beat length, and the group beat length. These two parameters are defined differently, and will give different results depending on the type of polarization-maintaining (PM) fibre.

The phase beat length is the relevant parameter for the fibres ability to maintain a high extinction ratio. This is described in more details in Annexes A and B.

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 60068-1, *Environmental testing – Part 1: General and guidance*

IEC 60793-1-1, *Optical fibres – Part 1-1: Measurement methods and test procedures – General and guidance*

IEC 60793-1-48, *Optical fibres – Part 1-48: Measurement methods and test procedures – Polarization mode dispersion*

IEC 60793-2-70[1], *Optical fibres – Part 2-70: Product specifications – Sectional specifications for polarization-maintaining fibres*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60793-1-1 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
phase beat length
$L_{B(\text{phase})}$
distance over which two orthogonal polarization modes are delayed by one cycle (2_{π})

3.2
group beat length
$L_{B(\text{group})}$
distance over which the group delay difference is one cycle (2_{π})

Note 1 to entry A group delay is based on group refractive index.

[1] Under preparation. Stage at the time of publication: IEC CCDV 60793-2-70:2017.

4 Testing conditions

Unless otherwise specified, the test shall be conducted under the standard conditions specified in IEC 60068-1. However, when it is difficult to make measurements in the standard conditions, the test may be conducted in conditions other than the standard conditions provided that no doubts will arise about judgments.

5 Reference test method

Since the phase beat length is the parameter specified in the product specification, IEC 60793-2-70, both phase beat length test methods described in 7.1 are defined as the reference test method (RTM). Test method for group beat length described in 7.2 can be used as an alternative test method (ATM) when the correlation between phase and group beat lengths is confirmed in advance (as shown in Annex B).

6 Specimen

A specimen length should be the minimum necessary to set up the test apparatus. If the specimen is extra long, take care that no stresses will be induced in the specimen.

7 Test methods

7.1 Phase beat length measurement methods

7.1.1 General

The phase beat length measurement method is based on applying a point-like perturbation along a short length of the fibre under test, and either monitor the changes in output power, or monitor changes in output state of polarization (SOP) at one wavelength versus travel distance.

The perturbation can either be a lateral force or an electromagnet.

In this document, the test methods where output power is monitored using an electromagnet, and where SOP is monitored using a lateral force, are both described.

7.1.2 Monitoring of output power using an electromagnet

7.1.2.1 Apparatus

7.1.2.1.1 General apparatus

See Figure 1 for a diagram of the test set-up.

An electromagnet is moved along the optical fibre longitudinal axis for Faraday rotation.

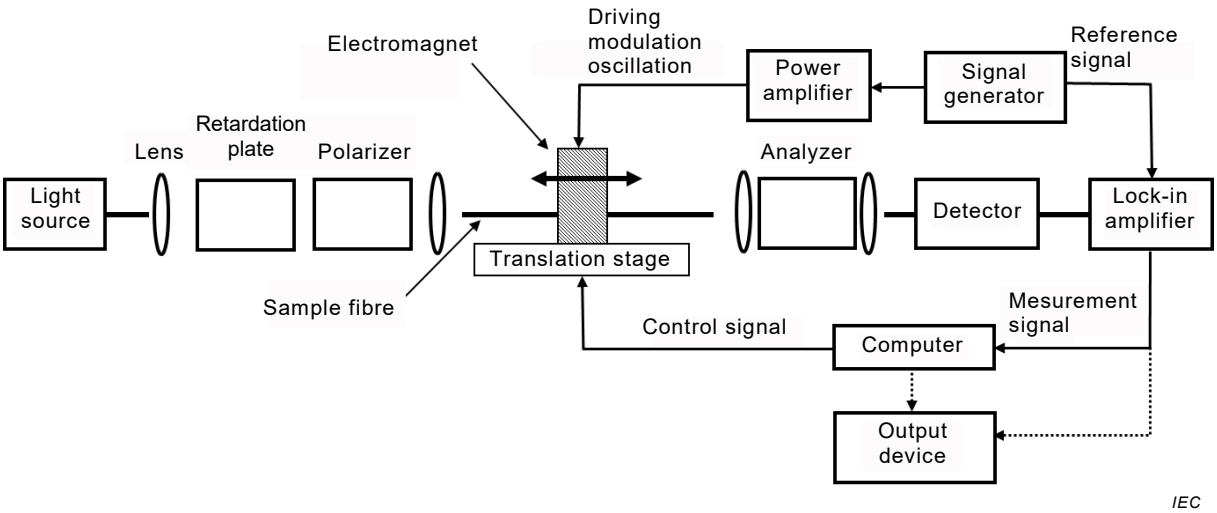

Figure 1 – Apparatus of phase beat length measurement using an electromagnet

7.1.2.1.2 Light source

A light source which has a narrow spectrum line-width such as a DFB laser shall be used.

7.1.2.1.3 Retardation plate

A retardation plate (λ/4 retarder) shall be provided to enable the input of certain level of optical power into the fibre even when the polarizer is rotated. The retardation plate converts the polarization of incident light from linear polarization into circular polarization.

7.1.2.1.4 Polarizer and analyser

A polarizer and an analyser shall be capable of outputting linearly polarized light having a certain direction of electric field vector when they have received light in a state of polarization.

7.1.2.1.5 Detector

A detector to be used shall have a light receiving area that can detect all the optical power emitted from the output end of the optical fibre.

7.1.2.1.6 Electromagnet for Faraday rotation

An electromagnet for Faraday rotation rotates the polarization of the light in a fibre by applying an electromagnetical field along the fibre longitudinal axis. The polarization rotation shall be modulated by an electrical signal from outside to improve measurement sensitivity. The interaction length should be smaller than the specified beat length (for example, around 1 mm) enough for detecting the beat length with appropriate accuracy. The applied electromagnetical field should be large enough for detecting the beat length with appropriate accuracy. Annex C describes the examples of electromagnet equipment for Faraday rotation.

7.1.2.1.7 Translation stage

A translation stage shall be able to move the electromagnet along the fibre longitudinal axis. The translation stage shall have the moving range and pitch which are sufficient to measuring the beat length of the sample fibre.

7.1.2.1.8 Lock-in amplifier

A lock-in amplifier shall be used to improve measurement sensitivity. The lock-in amplifier shall have response time enough to respond to the modulation speed of the electromagnet.

7.1.2.1.9 Signal generator

A signal generator provides modulated signal to the lock-in amplifier and the electromagnet.

7.1.2.1.10 Power amplifier

A power amplifier may be used as necessary. The power amplifier shall provide enough power for the electromagnet.

7.1.2.1.11 Computer

A computer should control the pulse stage and process the output signal from the lock-in amplifier.

7.1.2.1.12 Output device

An output device is used to output a measurement profile processed by the computer. The output device may directly output the signal level of the lock-in amplifier by such as a plotter.

7.1.2.2 Procedure

7.1.2.2.1 Preparation and adjustment

Prepare a V-groove or bare fibre adapter to connect the sample fibre under test to the polarizer and analyser. Remove the primary coating from both ends of the fibre under test, and cleave the ends into mirror surfaces perpendicular to the axis of the fibre. Connect one end of the fibre to the polarizer, either the V-groove or the bare fibre adapter. Connect the other end of the fibre to the analyser, and connect the analyser with the detector, so that all the input light can be received.

Rotate the polarizer and analyser to minimize the optical output power through the analyser. Next, adjust the analyser to maximize the output voltage of the lock-in amplifier.

7.1.2.2.2 Measurement

Move the electromagnet by driving the pulse stage. Memorize a relationship between the electromagnet travel distance Z and the lock-in amplifier output V. The relationship as shown in Figure 2 can be obtained. Measure N times of the travel distances, ΔZ_i which is a half period of the sequence of V.

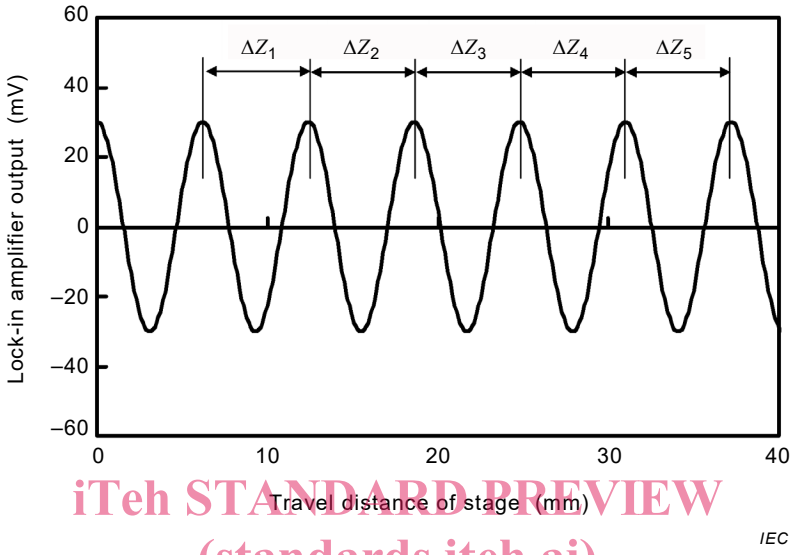

Figure 2 – Example of measurement profile by electromagnet

7.1.2.3 Calculation

The phase beat length $L_{B(\text{phase})}$ is given by:

$$L_{B(\text{phase})} = \frac{2\sum_{i=1}^{N} \Delta Z_i}{N} \quad (1)$$

where

$L_{B(\text{phase})}$ is the phase beat length;

ΔZ_i is the travel distance of the stage where the lock-in amplifier output changes by the half period;

N is the number of the half period.

7.1.3 Monitoring of SOP using a lateral force

7.1.3.1 Apparatus

7.1.3.1.1 General apparatus

See Figure 3 for a diagram of the test set-up.

By applying a lateral force at a point that moves along the fibre axis and simultaneously measure the SOP, the $L_{B(\text{phase})}$ can be obtained.

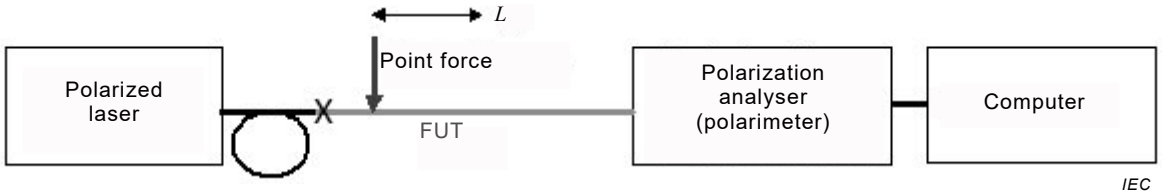

Figure 3 – Set-up for measuring $L_{B(\text{phase})}$ when monitoring SOP together with a moving lateral force

7.1.3.1.2 Light source

A polarized laser source with a narrow spectrum line-width, such as a distributed feedback laser (DFB) shall be used.

7.1.3.1.3 Polarization analyser

Any commercial available polarization analyser (polarimeter) can be used.

7.1.3.1.4 Translation stage

A translation stage shall be able to move the lateral force along the fibre longitudinal axis. The translation stage shall have the sufficient moving range to measure the beat length of the sample fibre. It is recommended to have a range long enough to ensure five to ten periods in order to average the result.

The length of interaction between the lateral force and the sample fibre should be significantly smaller than the specified beat length (e.g. 1/10).

7.1.3.1.5 Computer

A computer should be used to combine the SOP data and the displacement data.

7.1.3.2 Procedure

7.1.3.2.1 Preparation and adjustment

The fibre sample shall be placed straight on a flat and smooth surface. It is important to avoid any twisting of the fibre sample.

Since a specific input SOP is not needed (or needs to be known) [1][2], the input end of the fibre sample can be spliced to any type of pigtail fibre connected to the light source.

The output end of the sample fibre can be connected directly to the polarization analyser by using for example a bare fibre adapter.

7.1.3.2.2 Measurement

Move the lateral force to one end of the fibre sample and lower it onto the fibre sample.

Then move the lateral force slowly along the length of the fibre sample.

Observe the SOP on the polarization analyser. One full circle corresponds to one period.

The diameter of the circle showed on the Poincaré sphere gets larger for increasing lateral force (see Figure 4 below).

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2 Numbers in square brackets refer to the Bibliography.