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INTERNATIONAL STANDARD

Optical fibres –
Part 1-61: Measurement methods and test procedures – Polarization crosstalk

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FOREWORD

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International Standard IEC 60793-1-61 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/1739/CDV	86A/1781/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- withdrawn,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.

OPTICAL FIBRES –

Part 1-61: Measurement methods and test procedures – Polarization crosstalk

1 Scope

This part of IEC 60793 establishes uniform requirements for measuring the polarization crosstalk of polarization-maintaining (PM) fibres.

This document gives two methods for measuring the polarization crosstalk of PM fibres. Method A is the power ratio method, which uses the maximum and minimum values of output power at a specified wavelength, and Method B is the in-line method, which uses an analysis of the Poincaré sphere.

Details of each method are described in Clause 6.

Crosstalk values obtained by Methods A and B are based on different definitions.

The crosstalk measured by Method A is defined as an "averaged" value over a measured wavelength range. In contrast, the crosstalk value obtained from Method B shows the "worst case" crosstalk value.

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

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

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

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60793-1-1 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

4 Test 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 under the standard conditions, the test may be conducted under conditions other than the standard conditions, provided that no doubts will arise about judgments.

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

5 Reference test method

Since the "averaged" polarization crosstalk value measured by Method A is the parameter specified in the product specification, IEC 60793-2-70[2], Method A is the reference test method (RTM), which shall be the one used to settle disputes.

6 Test methods

6.1 Method A: Power ratio method

6.1.1 Overview of the method

Method A is applicable to PM fibres, fibres having connectors attached to one or both ends of the fibres, and to two or more such entities joined in series. Adjust the optical output to the minimum by rotating both the polarizer and analyser, and measure the optical output as P_{min}. Rotate the analyser 90° and measure the optical output as P_{max}.

Calculate the polarization crosstalk with the second set of values and take the average of the two values as the measured value.

6.1.2 Application

This measuring method shall be applied to the measurement of polarization crosstalk using the maximum and minimum values of optical output at a specified wavelength.

6.1.3 Test apparatus

6.1.3.1 Principle

Figure 1 shows an example of a test apparatus.

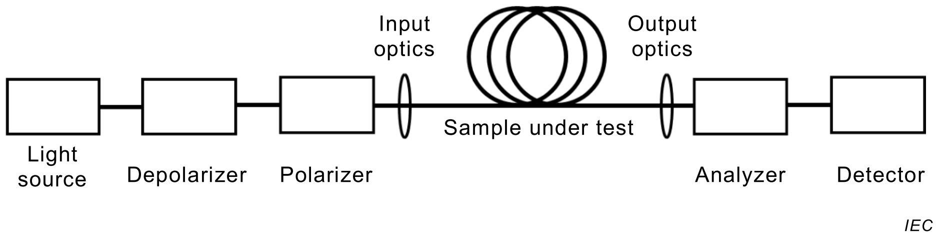

Figure 1 – Example of test apparatus for polarization crosstalk measurement (power ratio method)

6.1.3.2 Light source

The light source to be used shall be one with a specified wavelength and wide spectrum bandwidth (20 nm or more at FWHM), or alternatively, its coherence length (l_c) shall be appropriately short for the sample under test.

$$l_c < \frac{1}{10}\frac{L}{L_B}\lambda \qquad (1)$$

where

L is the sample length;

L_B is the fibre's beat length;

λ is the source centre wavelength.

A LED (light emitting diode) light source or an SLD (super-luminescent diode) light source is recommended for this test. The source power shall be kept below the level required to induce non-linear propagation effects; 10 mW is typically a safe limit. For a LED light source, whose power is low, however, a high-sensitivity detector shall be used.

2 Under preparation. Stage at the time of publication. IEC CCDV 60793-2-70:2016.

6.1.3.3 Input and output optics

The input and output optics shall be relatively strain free, as mounted.

Cladding mode should be minimized at the input end by carefully launching to the fibre to be tested. Cladding mode stripping by bending sometimes causes the deterioration of crosstalk by the bend, therefore it is recommended to avoid it.

6.1.3.4 Detector

The 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. A power meter combining a photo-detector and an electronic processing system can also be used.

The detector response (including supplemental equipment such as a lock-in amplifier) shall be linear to within 5 % from the minimum to the maximum measured power and independent of the input polarization state.

6.1.3.5 Depolarizer

When the input light from the light source is polarized, a depolarizer shall be provided to enable the input of a certain level of optical power into the optical fibre even when the polarizer is rotated. Alternatively, a polarization controller could be used for depolarizing, instead of the depolarizer.

6.1.3.6 Polarizer and analyser

A linear polarizer is an optical device capable of outputting linearly polarized light having a certain direction of electric field vector when it has received light in an arbitrary state of polarization. The polarizer to be used shall have a polarisation extinction ratio (PER) sufficient for measuring the polarization crosstalk of the optical fibre under test. The PER of the polarizer and of the analyser should be at least 10 dB higher than the maximum expected crosstalk.

6.1.4 Test procedure

6.1.4.1 Preparation

In the case of fibres, prepare a V-groove or bare fibre adapter to connect the polarizer, the analyser and the optical fibre under the test. Remove the primary coating from both ends of the known length of the optical fibre under the test, and cleave the ends into mirror surfaces perpendicular to the axis of the optical fibre. Connect the polarizer with one end of the optical fibre, using a V-groove or similar means. Connect the other end of the optical fibre to the analyser, and connect the analyser with the detector, so that all the output light can be received.

Set the fibres on a V-groove or similar device, taking care that no stresses will be induced in the optical fibre, especially in the cladding. For example, when fixing the optical fibre with a V-groove, place a soft cloth, such as a gauze, between the optical fibre and the cladding holder so that the cladding holder may not cause any stress directly to the cladding. Also, the bare fibre adapter, when used, shall be of a type that does not cause stresses in the jacket of the optical fibre core.

In the case of components having connectors, the connector itself can be used for connecting the polarizer, the analyser and the optical component under test.

6.1.4.2 Measurement and calculation

A proper zeroing of the power meter needs to be done prior to any measurement. Adjust the optical output to the minimum by rotating both the polarizer and analyser, and record the optical output as P_{min1}. Rotate only the analyser 90° and record the optical output as P_{max1}.

After rotating the polarizer 90° roughly, adjust the optical output to the minimum by rotating both the polarizer and analyser, and record the optical output as P_{min2}. Then rotate only the analyser 90° and record the optical output as P_{max2}.

$$CT_1 = 10\log(P_{\min1} / P_{\max1}) \quad \text{(dB)} \tag{2}$$

$$CT_2 = 10\log(P_{\min2} / P_{\max2}) \quad \text{(dB)} \tag{3}$$

The polarization crosstalk CT_A is given by:

$$CT_A = (CT_1 + CT_2)/2 \tag{4}$$

6.2 Method B: In-line polarimetric method

6.2.1 General

The crosstalk measured by Method B is defined as the "worst case" crosstalk. The measured crosstalk value by Method B represents the accumulated crosstalk due to temperatures and mechanical stresses all along the PM fibre.

The measurement methods and definitions of Methods A and B are totally different ones and therefore will give different results.

Method B is applicable to single sections of PM fibre, to cascaded PM fibres, and to PM fibres interconnected with optical devices. It is also applicable to polarization-maintaining components that lack PM fibre pigtails, in which case the measurement is performed on a PM fibre jumper connected to the output of the component. The method requires gently stretching or heating approximately 0,1 m to 0,3 m of PM fibre in order to generate at least a 90° arc (on Poincaré sphere) of the fraction of a cycle of phase shift between the fast and slow waves.

6.2.2 Limitations of the method

The optical source shall be spectrally narrow (e.g., DFB laser or tunable laser source), depending on the length of the fibre under test.

The crosstalk at any point in a concatenation of PM fibres and/or components is the instantaneous result of the temperatures and mechanical stresses acting at all upstream elements. Thus, in order to obtain a "worst case" local crosstalk value, it is necessary to limit applying the method to single fibres or patch cords (without concatenation).

6.2.3 Measurement process

The fibre is gently stretched or heated in the region in which the crosstalk is to be measured. This stimulus produces an arc on the unit radius Poincaré sphere, as shown in Figure 2. Figure 2 a) shows the front view of data arc and fitted circle, and Figure 2 b) shows the 90°-rotated cutaway view defining the geometrical relationships.

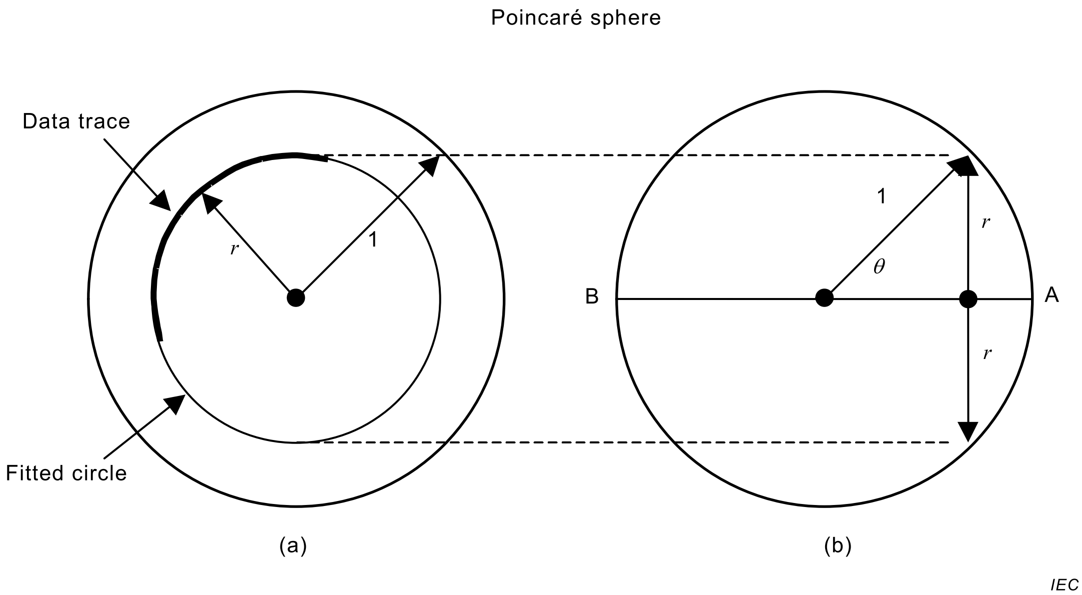

Figure 2 – Poincaré sphere representations for Method B

Points A and B represent the polarization modes (eigenmodes) of the fibre.

A circle is fitted to the arc and the radius r of the circle is recorded. The crosstalk value CT_{B} is calculated from the radius according to:

$$CT_B = 10\log\frac{1-\sqrt{1-r^2}}{1+\sqrt{1-r^2}} \tag{5}$$

6.2.4 Mathematical basis

The following derivation pertains to the Poincaré sphere representations shown in Figure 2. The ratio of power in the output principal states is given by:

$$\frac{P_{\mathrm{B}}}{P_{\mathrm{A}}} = \frac{1-\cos\theta}{1+\cos\theta} \tag{6}$$

The radius of the circle is related to θ by:

$$\theta = \sin^{-1}(r) \tag{7}$$

Therefore:

$$\cos\theta = \sqrt{1-r^2} \tag{8}$$

The crosstalk value is given by:

$$CT_{\mathrm{B}} = 10\log\frac{1-\sqrt{1-r^2}}{1+\sqrt{1-r^2}} \tag{9}$$

Alternatively, in terms of the angular length of the arc, crosstalk is given by:

$$CT_{\mathrm{B}} = 10\log\frac{1-\cos\theta}{1+\cos\theta} \tag{10}$$

7 Results

7.1 Information available with each measurement

Report the following information on each measurement:

– date and title of measurement;
– length of specimen;
– identification of specimen;
– measurement wavelength;
– crosstalk;
– measurement method.

7.2 Information available upon request

The following information shall be available upon request:

– configuration of specimen: free coil or spool;
– bending diameter of specimen;
– description of measurement apparatus arrangement;
– details of measurement apparatus;
– relative humidity and temperature of measurement;
– date of latest calibration of equipment;
– type of optical source used and its spectral width (FWHM).

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