IEC 61300-3-55

Edition 1.0 2020-05

INTERNATIONAL STANDARD

NORME INTERNATIONALE

**Fibre optic interconnecting devices and passive components – Basic test and measurement procedures –
Part 3-55: Examinations and measurements – Polarisation extinction ratio and keying accuracy of polarisation maintaining, passive, optical components**

**Dispositifs d'interconnexion et composants passifs fibroniques – Procédures fondamentales d'essais et de mesures –
Partie 3-55: Examens et mesures – Rapport d'extinction de polarisation et précision du détrompage des composants optiques passifs maintenant la polarisation**

IEC 61300-3-55:2020-05(en-fr)

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Part 3-55: Examinations and measurements – Polarisation extinction ratio and keying accuracy of polarisation maintaining, passive, optical components

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

FDIS	Report on voting
86B/4276/FDIS	86B/4290/RVD

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 61300 series, published under the general title *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures*, 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- withdrawn,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.

INTRODUCTION

This document contains and expands the content of IEC 61300-3-24 and IEC 61300-3-40.

FIBRE OPTIC INTERCONNECTING DEVICES AND PASSIVE COMPONENTS – BASIC TEST AND MEASUREMENT PROCEDURES –

Part 3-55: Examinations and measurements – Polarisation extinction ratio and keying accuracy of polarisation maintaining, passive, optical components

1 Scope

This part of IEC 61300 provides methods for measuring the polarisation extinction ratio (PER) of single-mode, polarisation maintaining (PM) optical components based upon PM fibres. This document also provides methods for detecting the input and output orientation of the PM components' principal axes as well as methods for estimating the keying accuracy, i.e. the angular misalignment between the principal axes and the mechanical reference guide key of the connectors, if these are present.

2 Normative references

There are no normative references in this document.

3 Terms, definitions and abbreviated terms

3.1 Terms and definitions

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

ISO and IEC maintain terminological databases for use in 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

3.1.1
principal state of polarisation
PSP
state of polarisation (SOP) that propagates unaltered through an optically anisotropic medium

Note 1 to entry: It is also known as "eigen polarisation".

Note 2 to entry: This note applies to the French language only.

3.1.2
polarisation extinction ratio
PER
fraction of the power of one PSP that leaks onto the orthogonal one as it propagates along the polarisation maintaining component

Note 1 to entry: This note applies to the French language only.

3.2 Abbreviated terms

Term	Description
DUT	device under test

HWP half wave plate
PER polarisation extinction ratio
PM polarisation maintaining
PSP principal state of solarisation
QWP quarter wave plate
SLD super luminescent diode
SMF single-mode fibre
SOP state of polarisation

4 General description

A PM component is a physical system that can retain specific input SOP unaltered as light propagates through it. In linearly birefringent systems, these SOPs correspond to two linear polarisations, also referred to as PSPs, whose polarisation direction is parallel to the two PM-element's principal axes.

While, in ideal PM components, the two principal states of polarisation (PSPs) propagate uncoupled and unaltered, in reality they may exchange energy, effectively deviating from the initial SOP. The origin of such deviations from the ideal behaviour may be:

- intrinsic and ascribable to imperfections in the optical guiding material structure, or
- extrinsic and related to external mechanical (stress), electrical, or thermal changes applied to the PM component or a portion thereof.

How accurately a PM component can hold its PSPs is quantified by the PER. This document defines measurement methods based upon the power coupling between the two nominal PSPs in a linearly birefringent system when incoherent, linearly polarised light is injected into the PM component under test (hereafter PM-DUT).

Where a PM component is a concatenation of several distinct PM sub-elements, the overall system performance will be strongly influenced by how precisely the optical axes of the individual sub-elements are aligned with each other at the interconnecting points. Since optical fibre connectors are most often found at such junctions, it is of primary importance to evaluate and assure that their reference keying mechanisms are properly aligned to the encapsulated fibre's principal axes so that the PSPs may keep propagating unaltered. Methods for determining such angular mismatch are also described. These rely upon the same set-ups used by the methods proposed for the characterisation of the PER performance.

This document describes two methods for the measurement of PER performance and the keying accuracy: a reference-less method (method A) and a comparative method (method B). Care shall be taken when comparing the results obtained by the two methods because the measured PER values refer to two distinct configurations. Additional information on keying accuracy for PM fiber is found in Annex B.

5 Measurement principles

Both methods A and B rely upon the cross-polariser test procedure, which evaluates the PM performance of a linearly birefringent PM-DUT by assessing the ratio between the power of the linearly polarised components oriented along the two principal axes exiting the optical component compared with the input power coupled into the PM-DUT.

A prerequisite to this measurement procedure is that the polarisation response of the component to be tested is stationary, i.e. the polarisation performance is not actively influenced or modified by external factors (electrical, mechanical, thermal, or other such as fibre and connectors manipulations) during the characterisation process. This requirement distinguishes the cross-polariser procedure from an alternative measurement approach where the power coupling between PSPs is assessed through a dynamic external intervention (mechanical or thermal) and the detection of the evolution of the instantaneous output SOP. This latter approach, also known as "in-line" method, is based upon fundamentally different experimental conditions and, depending on the interpretation of the outcomes, it may lead to different or inconsistent results when compared with those obtained using the cross-polariser procedure.

For a correct evaluation of the PM performance, the cross-polariser test procedure requires that incoherent linearly polarized light, whose polarisation matches one of the input principal axes, is coupled at the input end of the PM-DUT.

The polarisation performance of the PM-DUT is calculated from the transmitted powers carried by the two linear polarisations oriented along the two principal axes of the component being tested.

The orientation of the output optical axes of the PM-DUT is derived from the orientation of the analyser once polariser and analyser are adjusted for absolute minimum power transmission.

6 Apparatuses

6.1 General

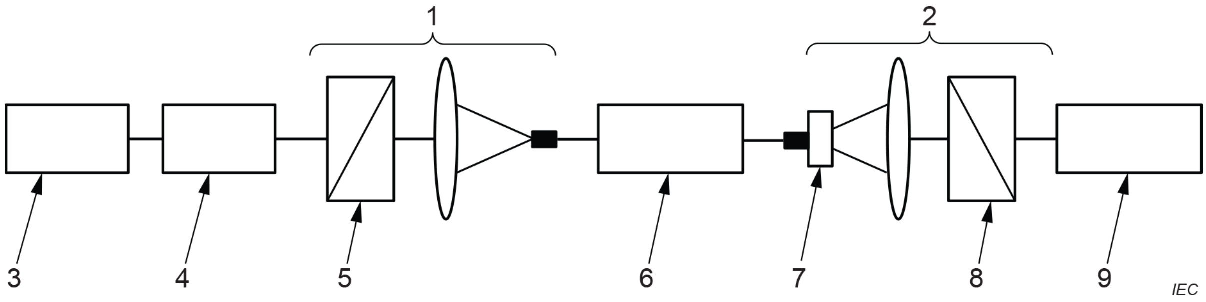
Although based upon the same physical principles, the experimental set-ups used for methods A and B differ especially in the preparation of the input SOP to be injected into the PM-DUT.

6.2 Method A (reference-less approach)

6.2.1 General

Method A is a reference-less, non-contact characterisation procedure that is not limited by constraints imposed by the presence of reference cables, reference connectors, and their wavelength dependence. This procedure is therefore generally well suited to PM-DUTs with high PER values or for measurements that require a higher degree of accuracy. The measurements are not influenced by the orientation accuracy between the fibre's optical axes and the mechanical reference guide key of the PM-DUT's connectors. This is the preferred measurement method for assessing PER.

The test apparatus for both polarisation extinction ratio measurements and for the determination of the mechanical reference guide keying angular misalignment may schematically look like the example shown in Figure 1.



Key

1 input coupling optics
2 output coupling optics
3 incoherent light source
4 depolariser
5 linear polariser
6 PM-DUT
7 reference receptacle
8 linear analyser
9 power detector

Figure 1 – Test apparatus for both polarisation extinction ratio measurements and for the determination of the mechanical reference guide keying angular misalignment

6.2.2 Light source

In order to remove any interference effect between the linear polarisation components oriented along the two principal axes of the PM-DUT, the light source shall be sufficiently incoherent. The coherence length l_c of the source shall satisfy the following constraint:

$$l_c < \frac{1}{10} \frac{L}{L_B} \lambda \tag{1}$$

where

L is the PM-DUT's length;

L_B is the PSPs' beat length;

λ is the source's centre wavelength.

NOTE If L_B is not otherwise available, refer to IEC 60793-1-60.

In Formula (1), units shall be used consistently.

For PM-DUT's with a typical length of a few metres tested at λ = 1 550 nm, Formula (1) requires a coherence length shorter than approximately 1 mm or, equivalently, a source 3-dB bandwidth in excess of approximately 10 nm.

To minimise inaccuracies that may be introduced by the presence of light that is not strictly guided inside the PM fibre, no more than 0,1 % of the emitted optical power shall lie below the cut-off wavelength of the PM-DUT.

It is also necessary that the optical power launched into the PM-DUT, and thus the power emitted by the incoherent light source, is stable during the duration of the measurement. In order to obtain a PER measurement uncertainty of ±1 dB, variations in the coupled power shall be smaller than 5 %.

The coupled power into the PM-DUT shall stay below the threshold limits for non-linear propagation effects, which for conventional silica-based components is of the order of 10 mW in the spectral range between 700 nm and 1 650 nm approximately (refer to IEC TR 61282-4).

Light emitting diodes (LEDs) or super-luminescent diodes (SLDs) are recommended examples for incoherent light sources. Attention should be paid to Fabry-Perot sources whose time-averaged spectrum may look broad enough but the instantaneous spectrum is substantially narrower.

6.2.3 Polariser and analyser

The combined filtering properties of the polariser and the analyser shall provide a total extinction of at least a factor of 10 higher than the highest PER expected to be measured with the PM-DUT. Recommended candidates are bulk Glan-Thompson polarisers with extinctions of 50 dB or more.

Care shall be taken in positioning both polariser and analyser perpendicular to the light beam. The collimated beam shall fall within the acceptance angle of both polarising elements during the measurement.

Since both devices need to be angularly aligned to the principal axes of the PM-DUT, polariser and analyser are often mounted inside rotation stages. The angular resolution of the positioning shall allow for an absolute accuracy better than ±0,5°.

6.2.4 Depolariser

In the presence of a partially polarised source, it may be necessary to introduce a depolarising element in order to avoid oscillations of the coupled power as the polariser rotates with respect to the PM-DUT. As described in Annex A, the depolariser may be replaced by additional optical elements such as a combination of waveplates that generate circularly polarised light in front of the polariser. Other options are possible and acceptable as long as a high-extinction linear SOP is provided at the PM-DUT's input and the orientation of that SOP is parallel to either one of the principal optical axes of the PM-DUT.

6.2.5 Input and output coupling optics

The combined extinction of all the optical elements along the optical path between the polariser and the analyser shall be at least 10 dB higher than the PER expected to be measured in the PM-DUT.

Care shall be taken to avoid spurious reflections that may get depolarised and coupled into the PM-DUT or into the power detection system.

6.2.6 Power detection system

The power detection system comprises several parts. The response of the photodetector, in the wavelength range of interest, shall be polarisation independent and homogeneous across the active surface and over the entire emission spectrum of the light source. Further, the active surface shall be large enough to capture, at all times, the entire optical power exiting the PM-DUT. The dynamic range of the detector, which may comprise the power meter and possibly a complementary synchronous detection system, shall be broader than the span defined by the maximum and minimum powers observable during the measurements. The complete power detection system shall be linear within ±1 % on a linear scale over the entire dynamic range.

6.2.7 Mechanical holders

The PM-DUT shall be held in place by mechanical mounts that do not induce any stress that may interfere with the PM properties of the PM-DUT. The mechanical arrangement shall also be stable enough to prevent any oscillation larger than ±1 % in the power coupled into the PM element under test.

6.2.8 Reference connector receptacle

If the PM-DUT includes input or output connectors, the reference receptacle provides a holder for the output termination. The receptacle shall possess tight mechanical tolerances to minimize the axial rotational play between mechanical reference guide key and the receptacle counterpart. The orientation of the receptacle with respect to analyser's axis should be known within ±0,5° accuracy.

6.2.9 PM-DUT

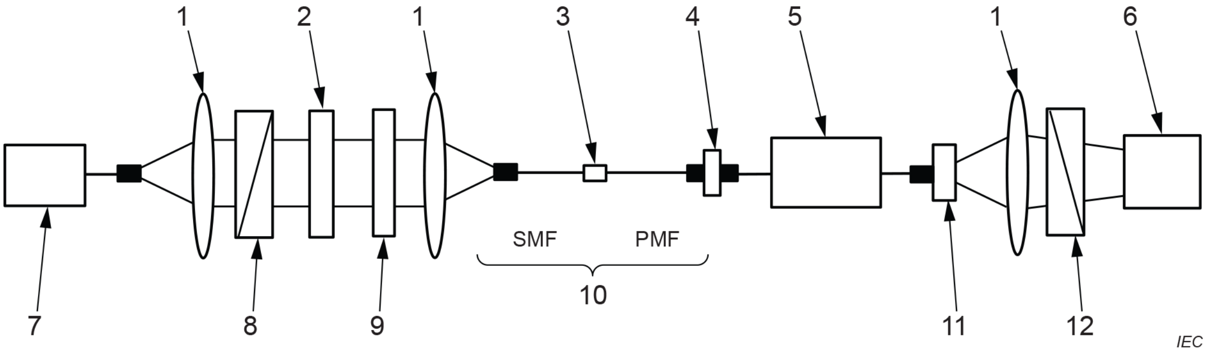
The linear birefringence properties of the PM-DUT shall be stationary during the measurement procedure. This means that the PM-DUT's birefringence remains unchanged during the measurement so that the two orthogonal, linear PSPs may always be considered constant.

6.3 Method B (comparative approach)

6.3.1 General

Method B relies on a comparative measurement where the PER performance of the PM-DUT is assessed against a known reference cable consisting of a calibrated PM fibre with a calibrated connector (see 6.2.4). The PM-DUT's PER is extracted from the measurement of an arrangement comprising the PM-DUT, the reference and the connection between the two. The accuracy of this method is therefore coupled to the quality of the reference and the accuracy of the mechanical alignment between the fibre's optical axes and the mechanical reference guide key of both the reference and the PM-DUTs. Method B can be used for the characterisation of PM-DUTs whose PM performance is appreciably lower than that of the reference, or it is suitable for the characterisation of PM-DUTs for which the prerequisites for method A cannot be met (e.g. when light guided by the cladding cannot be suppressed satisfactorily).

The test apparatus may schematically look like the example shown in Figure 2. The additional elements of the test apparatus compared with the apparatus of method A are needed to allow for contact measurements against a reference cable.



Key

1 coupling optics
2 QWP
3 temporary joint
4 mating adaptor
5 PM-DUT
6 power detector
7 incoherent light source
8 linear polariser
9 HWP
10 reference cable
11 reference receptacle
12 linear analyser

Figure 2 – Test apparatus for both polarisation extinction ratio measurements and for the determination of the mechanical reference guide key angular misalignment using a reference

6.3.2 Light source

For the incoherent light source, the same requirements described in 6.2.2 apply.

6.3.3 Polariser, waveplates and analyser

The input assembly consisting of a linear polariser, a quarter waveplate (QWP) and a half waveplate (HWP) is one of a variety of possible configurations needed to prepare the initial SOP. The latter is determined such that, when propagating through the reference cable, it emerges linearly polarised and aligned parallel to the mechanical reference guide key of the output connector of the reference cable.

NOTE Since the reference cable can contain a portion of standard single-mode fibre (SMF), it is possible the input state of polarisation coupled into the reference cable is not linear.

Furthermore, due to the wavelength dependence of both QWP and HWP, these shall be compatible with the operating wavelength of both source and PM-DUT. While the elements described so far may typically rely upon bulk optics components, the same functionality may be achieved through fibre-based elements or a combination of bulk and fibre optic components.

Additional requirements as listed in 6.2.3 apply.

6.3.4 Reference cable

The purpose of the reference cable is to provide a mode intensity distribution compatible with the PM-DUT in order to maximise the power coupling between the two fibres' cores and minimise the power dispersed into the PM-DUT's fibre cladding. The reference cable may