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TECHNICAL REPORT

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Application guidelines for nonlinear coefficient measuring methods

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Application guidelines for nonlinear coefficient measuring methods

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APPLICATION GUIDELINES FOR NONLINEAR COEFFICIENT MEASURING METHODS

FOREWORD

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IEC TR 62285 has been prepared by subcommittee 86A: Fibres and cables, of IEC technical committee 86: Fibre optics. It is a Technical Report.

This third edition cancels and replaces the second edition published in 2005. It constitutes a technical revision.

This edition includes the following signification technical changes with respect to the previous revision:

a) change fibre type of pigtail to B-652.D fibre or fibre of same type with the fibre under test;
b) modifications on Figure A.1 and Formulas (A.3), (A.4);
c) add example values and recommended method A test conditions for B-G.654.E fibre, update Table C.1.

The text of this Technical Report is based on the following documents:

Draft	Report on voting
86A/2190/DTR	86A/2325/RVDTR

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this Technical Report is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under 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- withdrawn,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.

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APPLICATION GUIDELINES FOR NONLINEAR COEFFICIENT MEASURING METHODS

1 Scope

This document provides guidelines for uniform measurements of the nonlinear coefficient of class B single-mode fibres (see IEC 60793-2-50) in the 1 550 nm region.

Measurements of the nonlinear coefficient are used to characterise specific single-mode fibre designs for the purpose of system design relative to power levels and distortion or noise effects derived from the nonlinear optical behaviour.

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 (all parts), *Optical fibres – Part 1: Measurement methods and test procedures*

IEC 60793-2, *Optical fibres – Part 2: Product specifications – General*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60793-2 and IEC 60793-1 (all parts) 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 Abbreviated terms and symbols

4.1 Abbreviated terms

ASE	amplified spontaneous emission
BPF	bandpass filter
CW	continuous wave
EDFA	erbium doped fibre amplifier
FWM	four-wave mixing
OSA	optical spectrum analyser
SPM	self-phase modulation
SBS	stimulated Brillouin scattering
VA	variable attenuator
XPM	cross-phase modulation

4.2 Symbols

A_{eff}	effective area
D	chromatic dispersion coefficient
I	intensity
k	slope
L	specimen length
$J_n()$	Bessel function of the first kind of integer order n
L_{eff}	effective length
$n\mathrm{Lc}$	non-linear coefficient
n_2	Kerr nonlinear refractive index
n_2/A_{eff}	non-linear coefficient
P	input power
P_{peak}	peak input power
R	ratio
ν	optical frequency
α	attenuation coefficient (Np/m)
α_{dB}	attenuation coefficient (dB/km)
φ	non-linear phase shift
λ	wavelength
ω	angular optical frequency

5 Background and overview of methods

The nonlinear coefficient ($n\mathrm{Lc}$) is the ratio of the Kerr nonlinear refractive index n_2 to the effective area A_{eff} [1] [1], expressed as:

$$nLc = \frac{n_2}{A_{eff}} \quad (1)$$

The nonlinear coefficient is related to the following nonlinear optical distortion effects as a combined parameter:

– self-phase modulation (SPM);
– cross-phase modulation (XPM);
– four-wave mixing (FWM).

Other fibre attributes, such as chromatic dispersion and polarisation mode dispersion, also influence the transmission.

Two methods are given, with details specific to each in normative annexes. They are:

– Method A Continuous wave dual-frequency;
– Method B Pulsed single-frequency.

1 The numbers in square brackets refer to the Bibliography.

Both methods require injecting very high power (5 dBm or more) into the fibre, measurement of this power (absolute) and measurement of the output spectrum (which is modified by nonlinear effects). Both methods use calculations that combine these measured results with those derived from other measurements such as attenuation (see IEC 60793-1-40) and chromatic dispersion (see IEC 60793-1-42). Both methods have limitations on the length of fibre that can be measured – in relationship with the chromatic dispersion at the wavelength being measured.

Method A [1] requires injecting the light of two wavelengths into the fibre. The light of both wavelengths is constant at various power levels. At higher power, the lights beat due to the nonlinear effect and produce an output spectrum that is spread. The relationship of the power level to a particular metric of spectrum spreading is used to calculate the nonlinear coefficient.

Method B [3], [4] requires injecting pulsed light at a single wavelength. The pulses would be of duration substantially less than 1 ns and the input peak power of these pulses would be measured and related to the nonlinear spreading of the output spectrum.

6 Apparatus

6.1 General

The following apparatus is common to both measurement methods. Annex A and Annex B include layout drawings and other equipment requirements for each of the methods, respectively.

6.2 Light source

See Annex A and Annex B for detailed characteristics of the light sources.

6.3 Input optics

The input optics can include one or more lasers, polarisation controllers, couplers, polarisers, amplifiers, bandpass filters, variable attenuators and power meters. Oscilloscopes may be needed for method B. See Annex A and Annex B for specific details.

6.4 Input positioner

Provide means of positioning the input end of the specimen to the input optics. Typically, this connection is with a fusion splice to a short (1 m) pigtail of type B-652.D fibre or fibre of same type with the fibre under test.

6.5 Cladding mode stripper

Use a device that extracts cladding modes. Under some circumstances, the fibre coating will perform this function.

6.6 Output positioner

Provide a suitable means for aligning the fibre to the output optics. Typically, this connection is with a fusion splice to a pigtail of type B-652.D fibre or fibre of same type with the fibre under test.

6.7 Output optics

The output optics include a power meter and optical spectrum analyser (OSA). An oscilloscope may be required for method B. See Annex A and Annex B for details.