

Optical fibres

Part 1-41: Measurement methods and test procedures — Bandwidth

The European Standard EN 60793-1-41:2003 has the status of a
British Standard

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National foreword

This British Standard is the official English language version of EN 60793-1-41:2003. It is identical with IEC 60793-1-41:2003. It supersedes BS EN 60793-1-41:2002 which is withdrawn.

The UK participation in its preparation was entrusted by Technical Committee GEL/86, Fibre optics, to Subcommittee GEL/86/1, Optical fibres and cables, which has the responsibility to:

- aid enquirers to understand the text;
- present to the responsible international/European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;
- monitor related international and European developments and promulgate them in the UK.

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Summary of pages

This document comprises a front cover, an inside front cover, the EN title page, pages 2 to 27 and a back cover.

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Part 1-41: Measurement methods and test procedures –
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Fibres optiques
Partie 1-41: Méthodes de mesure
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Largeur de bande
(CEI 60793-1-41:2003)

Lichtwellenleiter
Teil 1-41: Messmethoden
und Prüfverfahren –
Bandbreite
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CENELEC

European Committee for Electrotechnical Standardization
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Foreword

The text of document 86A/841/FDIS, future edition 2 of IEC 60793-1-41, prepared by SC 86A, Fibres and cables, of IEC TC 86, Fibre optics, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as EN 60793-1-41 on 2003-11-01.

This European Standard supersedes EN 60793-1-41:2002. It updates and completes the 2002 edition in particular by the restricted mode launch intended for the laser launch transmission system.

This standard is to be read in conjunction with EN 60793-1-1:2003.

The following dates were fixed:

- latest date by which the EN has to be implemented
at national level by publication of an identical
national standard or by endorsement (dop) 2004-08-01
- latest date by which the national standards conflicting
with the EN have to be withdrawn (dow) 2006-11-01

Annexes designated "normative" are part of the body of the standard.

Annexes designated "informative" are given for information only.

In this standard, annexes A, B, C and ZA are normative and annexes D and E are informative.

Annex ZA has been added by CENELEC.

EN 60793-1-4X consists of the following parts, under the general title: Optical fibres:

- Part 1-40: Measurement methods and test procedures – Attenuation
- Part 1-41: Measurement methods and test procedures – Bandwidth
- Part 1-42: Measurement methods and test procedures – Chromatic dispersion
- Part 1-43: Measurement methods and test procedures – Numerical aperture
- Part 1-44: Measurement methods and test procedures – Cut-off wavelength
- Part 1-45: Measurement methods and test procedures – Mode field diameter
- Part 1-46: Measurement methods and test procedures – Monitoring of changes in optical transmittance
- Part 1-47: Measurement methods and test procedures – Macrobending loss
- Part 1-48: Measurement methods and test procedures – Polarization mode dispersion
- Part 1-49: Measurement methods and test procedures – Differential mode delay

Endorsement notice

The text of the International Standard IEC 60793-1-41:2003 was approved by CENELEC as a European Standard without any modification.

In the official version, for Bibliography, the following note has to be added for the standard indicated:

IEC 60793-1-40 NOTE Harmonized as EN 60793-1-40:2003 (modified).

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OPTICAL FIBRES –

Part 1-41: Measurement methods and test procedures – Bandwidth

1 Scope

This part of IEC 60793 describes two methods for determining and measuring the modal bandwidth of multi-mode optical fibres (see IEC 60793-2-10, IEC 60793-2-30 and IEC 60793-2-40). The baseband frequency response is directly measured in the frequency domain by determining the fibre response to a sinusoidally modulated light source. The baseband response can also be measured by observing the broadening of a narrow pulse of light. The two methods are the following:

Method A – Optical time domain measurement method (pulse distortion)

Method B – Frequency domain measurement method

Each method can be performed using one of two launches: an overfilled launch (OFL) condition or a restricted mode launch (RML) condition.

NOTE These test methods are commonly used in production and research facilities and are not easily accomplished in the field.

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 60793-1-20:2001, *Optical Fibres – Part 1-20: Measurement methods and test procedures – Fibre geometry*

IEC 60793-1-42:2001, *Optical fibres – Part 1-42: Measurement methods and test procedures – Chromatic dispersion*

IEC 60793-1-43:2001, *Optical fibres – Part 1-43: Measurement methods and test procedures – Numerical aperture*

IEC 60793-2-10:2001, *Optical fibres – Part 2-10: Product specifications – Sectional specification for category A1 multimode fibres*

IEC 60793-2-30:2002, *Optical fibres – Part 2-30: Product specifications – Sectional specification for category A3 multimode fibres*

IEC 60793-2-40:2002, *Optical fibres – Part 2-40: Product specifications – Sectional specification for category A4 multimode fibres*

3 Definition

For the purposes of this part of IEC 60793, the following definition applies.

bandwidth (–3 dB)

the value numerically equal to the lowest modulation frequency at which the magnitude of the baseband transfer function of an optical fibre decreases to a specified fraction, generally to one half, of the zero frequency value.

NOTE Various methods of reporting the results are described in the annexes, but the results shall be expressed in terms of the –3 dB (optical power) frequency unless otherwise specified by the detail specification.

4 Apparatus

4.1 Radiation source

4.1.1 Optical time domain measurement method (pulse distortion measurement) (Method A)

Use a radiation source such as an injection laser diode that produces short duration, narrow spectral width pulses for the purposes of the measurement. The pulse distortion measurement method requires the capability to switch the energy of the light sources electrically, optically or mechanically.

4.1.2 Frequency domain measurement method (Method B)

Use a radiation source such as a continuous wave (CW) injection laser diode for the purposes of the measurement. The frequency domain measurement method requires the capability to modulate the energy of the light sources electrically, optically or mechanically.

4.1.3 For both methods

- a) Use a radiation source with a center wavelength that is known and within ± 10 nm of the nominal specified wavelength. For injection laser diodes, laser emission coupled into the fibre must exceed spontaneous emission by a minimum of 15 dB (optical).
- b) Use a source with sufficiently narrow linewidth to assure the measured bandwidth is at least 90 % of the intermodal bandwidth. This is accomplished by calculating the normalized intermodal dispersion limit, NIDL (refer to Annex A). For A4 fibre, the linewidth of the laser diode is narrow enough to neglect its contribution to bandwidth measurement.
- c) For A1 and A3 fibres, calculate the normalized intermodal dispersion limit (NIDL, see Annex A) for each measurement wavelength from the optical source spectral width for that wavelength as follows:

$$NIDL = IDF/\Delta\lambda$$

where:

NIDL is the normalized intermodal dispersion limit in GHz·km;

$\Delta\lambda$ is the source full width half maximum (FWHM) spectral width in nm;

IDF is the intramodal dispersion factor (GHz·km·nm) from Annex A according to the wavelength of the source.

NIDL is not defined for wavelengths from 1 200 nm to 1 400 nm. The source spectral width for these wavelengths shall be less than or equal to 10 nm, FWHM.

NOTE The acceptability of an NIDL value depends upon the specific user's test requirements. For example, a 0,5 GHz·km NIDL would be satisfactory for checking that fibres had minimum bandwidths greater than some value less than 500 MHz·km, but would not be satisfactory for checking that fibres had minimum bandwidths greater than 500 MHz·km. If the NIDL is too low, a source with smaller spectral width is required.

- d) The radiation source shall be stable throughout the duration of a single pulse and over the time during which the measurement is made.

4.2 Launch system

4.2.1 Overfilled launch (OFL)

4.2.1.1 OFL condition for A1 fibre

Use a mode scrambler between the light source and the test sample to produce a controlled launch irrespective of the radiation properties of the light source. The output of the mode scrambler shall be coupled to the input end of the test sample in accordance with Annex E. The fibre position shall be stable long enough to perform the measurement. A viewing system may be used to aid fibre alignment where optical imaging is used.

Provide means to remove cladding light from the test sample. Often the fibre coating is sufficient to perform this function. Otherwise, it will be necessary to use cladding mode strippers near both ends of the test sample. The fibres may be retained on the cladding mode strippers with small weights, but care must be taken to avoid microbending at these sites.

NOTE Bandwidth measurements obtained by the overfilled launch (OFL) support the use of category A1 multimode fibres, especially in LED applications at 850 nm and 1300 nm. Some laser applications may also be supported with this launch, but could result in reduced link lengths (at 850 nm) or restrictions on the laser sources (at 1300 nm).

4.2.1.2 OFL condition for A3 and A4 fibres

OFL is obtained with a geometrical optic launch in which the maximum theoretical numerical aperture of the fibre is exceeded by the launching cone and in which the diameter of the launched spot is in the order of the core diameter of the fibre.

4.2.2 Restricted mode launch (RML)

4.2.2.1 RML condition for A1 fibre

The RML for bandwidth is created by filtering the overfilled launch (as defined by Annex E) with a RML fibre. The OFL is defined by Annex E and it needs to be only large enough to overfill the RML fibre both angularly and spatially. The RML fibre has a core diameter of $23,5 \mu\text{m} \pm 0,1 \mu\text{m}$, and a numerical aperture of $0,208 \pm 0,01$. The fibre must have a graded-index profile with an alpha of approximately 2 and an OFL bandwidth greater than 700 MHz·km at 850 and 1300 nm. For convenience, the clad diameter should be 125 μm . The RML fibre should be at least 1,5 m in length to eliminate leaky modes; and it should be less than 5 m in length to avoid transient loss effects. The launch exiting the RML fibre is then coupled into the fibre under test.

Provide means to remove cladding light from the test sample. Often the fibre coating is sufficient to perform this function. Otherwise, it will be necessary to use cladding mode strippers near both ends of the test sample. The fibres may be retained on the cladding mode strippers with small weights, but care shall be taken to avoid microbending at these sites.

NOTE 1 In order to achieve the highest accuracy, tight tolerances are required on the geometry and profile of the RML fibre. In order to achieve the highest measurement reproducibility, tight alignment tolerances are required in the connection between the launch RML fibre and the fibre under test to ensure the RML fibre is centered to the fibre under test.

NOTE 2 - Modal bandwidth measurements on type A1b fibres obtained by this restricted mode launch at 850 nm have been shown to correlate with the effective modal bandwidth produced by 850-nm laser transmitters only when such transmitters meet certain launch conditions. More specifically, for type A1b fibres, 850-nm restricted mode launch (RML) bandwidth $\geq 385 \text{ MHz} \cdot \text{km}$ provides a minimum of 385 MHz·km effective modal bandwidth for sources meeting the following three launch conditions: Nominal operating wavelength = 850 nm; encircled flux $\leq 25\%$ at 4.5- μm radius; encircled flux $\geq 75\%$ at 15- μm radius. Encircled flux measured per IEC 61280-1-4.

4.2.2.2 RML condition for A3 and A4 fibres

4.2.2.2.1 RML condition for A3 fibre

RML condition for A3 fibre is created with geometrical optic launch which corresponds to a numerical aperture launch of 0,3.

Spot size shall be larger or equal to the size of core.

4.2.2.2.2 RML condition for A4 fibre

The restricted mode launch (RML) for A4 fibre is created by filtering the overfilled launch with a mandrel wrapped mode filter, shown in Figure 1. The mode filter shall be made with the fibre of the same category as the fibre under test. In order to avoid redundant loss, the length of fibre should be 1 m. The diameter of the mandrel shall be 20 times as large as that of the fibre cladding and the number of coils shall be 5.

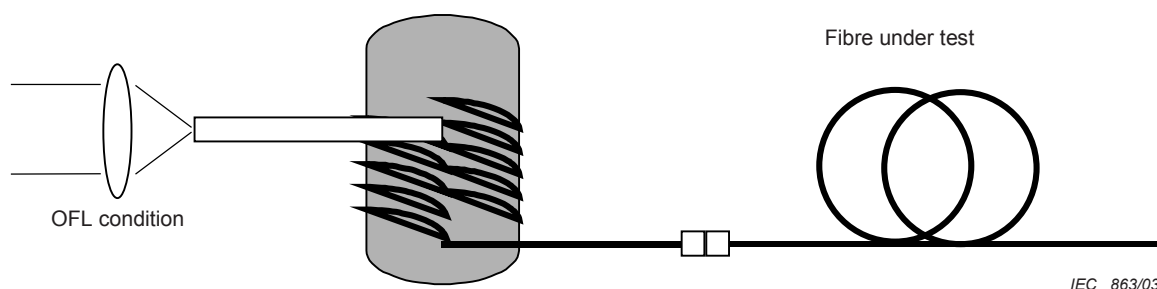


Figure 1 – A mandrel wrapped mode filter

NOTE Do not apply any excessive stress in winding fibre onto the mandrel. The wound fibre may be fixed to the mandrel with an adhesive. Unwound parts of fibre should be set straight.

4.3 Detection system

The output optical detection apparatus shall be capable of coupling all guided modes from the test sample to the detector active area such that the detection sensitivity is not significantly mode-dependent. The detector shall respond linearly over the range of power detected. An optical attenuator may be used to control the optical intensity on the detector.

A device shall be available to position the specimen output end with sufficient stability and reproducibility to meet the conditions of 4.6.

An optical detector shall be used that is suitable for use at the test wavelength, linear in amplitude response, spatially uniform to within 10 %, and sufficiently large to detect all emitted power.

The detected optical signal shall be displayed on a suitable instrument, such as a high speed, sampling oscilloscope with calibrated sweep rate for the time domain method and an electrical spectrum analyzer for the frequency domain measurement. The detection electronics as well as any signal preamplifier shall be linear in amplitude response (non-linearities less than 5 %) over the range of encountered signals.