

Optical fibres

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

National foreword

This British Standard is the UK implementation of EN 60793-1-41:2010. It is identical to IEC 60793-1-41:2010. It supersedes BS EN 60793-1-41:2003 which is withdrawn.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.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

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ISBN 978 0 580 64450 4

ICS 33.180.10

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This British Standard was published under the authority of the Standards Policy and Strategy Committee on 30 November 2010.

Amendments/corrigenda issued since publication

Date	Text affected
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English version

**Optical fibres -
Part 1-41: Measurement methods and test procedures -
Bandwidth
(IEC 60793-1-41:2010)**

Fibres optiques -
Partie 1-41: Méthodes de mesure
et procédures d'essai -
Largeur de bande
(CEI 60793-1-41:2010)

Lichtwellenleiter -
Teil 1-41: Messmethoden
und Prüfverfahren -
Bandbreite
(IEC 60793-1-41:2010)

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European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

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Ref. No. EN 60793-1-41:2010 E

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Foreword

The text of document 86A/1294/CDV, future edition 3 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 2010-10-01.

This European Standard supersedes EN 60793-1-41:2003.

The main change with respect to EN 60793-1-41:2003 is the addition of a third method for determining modal bandwidth based on DMD data and to improve measurement procedures for A4 fibres.

This standard should be read in conjunction with EN 60793-1-1 and IEC 60793-1-2, which cover generic specifications.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN and CENELEC shall not be held responsible for identifying any or all such patent rights.

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) | 2011-07-01 |
| – latest date by which the national standards conflicting
with the EN have to be withdrawn | (dow) | 2013-10-01 |

Annex ZA has been added by CENELEC.

Endorsement notice

The text of the International Standard IEC 60793-1-41:2010 was approved by CENELEC as a European Standard without any modification.

In the official version, for Bibliography, the following notes have to be added for the standards indicated:

- | | | |
|--------------------|------|------------------------------|
| [1] IEC 60793-2-10 | NOTE | Harmonized as EN 60793-2-10. |
| [2] IEC 60793-2-30 | NOTE | Harmonized as EN 60793-2-30. |
| [3] IEC 60793-2-40 | NOTE | Harmonized as EN 60793-2-40. |
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Annex ZA (normative)

Normative references to international publications with their corresponding European publications

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.

NOTE When an international publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

<u>Publication</u>	<u>Year</u>	<u>Title</u>	<u>EN/HD</u>	<u>Year</u>
IEC 60793-1-20	-	Optical fibres - Part 1-20: Measurement methods and test procedures - Fibre geometry	EN 60793-1-20	-
IEC 60793-1-42	-	Optical fibres - Part 1-42: Measurement methods and test procedures - Chromatic dispersion	EN 60793-1-42	-
IEC 60793-1-43	-	Optical fibres - Part 1-43: Measurement methods and test procedures - Numerical aperture	EN 60793-1-43	-
IEC 60793-1-49	2006	Optical fibres - Part 1-49: Measurement methods and test procedures - Differential mode delay	EN 60793-1-49	2006

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OPTICAL FIBRES –

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

1 Scope

This part of IEC 60793 describes three methods for determining and measuring the modal bandwidth of multimode optical fibres (see IEC 60793-2-10, IEC 60793-30 series and IEC 60793-40 series). 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 calculated response is determined using differential mode delay (DMD) data. The three methods are:

- Method A – Time domain (pulse distortion) measurement
- Method B – Frequency-domain measurement
- Method C – Overfilled launch modal bandwidth calculated from differential mode delay (OMBc)

Methods A and B can be performed using one of two launches: an overfilled launch (OFL) condition or a restricted mode launch (RML) condition. Method C is only defined for A1a.2 (and A1a.3 in preparation) multimode fibre and uses a weighted summation of DMD launch responses with the weights corresponding to an overfilled launch condition. The relevant test method and launch condition should be chosen according to the type of fibre.

NOTE 1 These test methods are commonly used in production and research facilities and are not easily accomplished in the field.

NOTE 2 OFL has been used for the modal bandwidth value for LED-based applications for many years. However, no single launch condition is representative of the laser (e.g. VCSEL) sources that are used for gigabit and higher rate transmission. This fact drove the development of IEC 60793-1-49 for determining the effective modal bandwidth of laser optimized 50 μm fibres. See IEC 60793-2-10:2004 or later and IEC 61280-4-1:2003 or later for more information.

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

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

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

IEC 60793-1-49:2006, *Optical fibres – Part 1-49: Measurement methods and test procedures – Differential mode delay*

3 Terms and definitions

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

3.1 bandwidth (–3 dB)

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. The bandwidth is denoted in this document as f_3 dB.

NOTE It is known that there can be various calculations, sometimes called markdowns, to avoid reporting extremely high values associated with “plateaus”. For example the 1,5 dB frequency, multiplied by $\sqrt{2}$ is one treatment used in IEC 60793-1-49. If such a calculation is used it should clearly be reported.

3.2 transfer function

discrete function of complex numbers, dependent on frequency, representing the frequency-domain response of the fibre under test

NOTE Method A determines the frequency response by processing time domain data through Fourier transforms. Method B can only measure the transfer function if an instrument which measures phase as well as amplitude is used. Method C is similar to Method A as it uses Fourier transforms in a similar manner. The transfer Function is denoted in this document as $H(f)$.

3.3 power spectrum

discrete function of real numbers, dependent on frequency, representing the amplitude of the frequency-domain response of the fibre under test

NOTE Methods A and C determine the power spectrum from the transfer function. Method B determines the transfer function by taking the ratio of the amplitude measured through the fibre under test and the reference. The power spectrum is denoted in this document as $|H(f)|$.

3.4 impulse response

discrete function of real numbers, dependent on time, representing the time-domain response of the fibre under test to a perfect impulse stimulus. The impulse response is derived, in all methods, through the inverse Fourier transform of the transfer function. The impulse response is denoted in this document as $h(t)$.

4 Apparatus

4.1 Radiation source

4.1.1 Method A – Time domain (pulse distortion) measurement

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 or optically. Some light sources shall be electrically triggered to produce a pulse; in this case a means shall be provided to produce triggering pulses. An electrical function generator or equivalent can be used for this purpose. Its output should be used to both induce pulsing in the light source and to trigger the recording system. Other light sources may self-trigger; in this case, means shall be provided to synchronize the recording system with the pulses coming from the light source. This may be accomplished in some cases electrically; in other cases optoelectronic means may be employed.

4.1.2 Method B – Frequency domain measurement

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 or optically. Connect the modulation output of the tracking generator or network analyzer through any required driving amplifiers to the modulator.

4.1.3 Method C – Overfilled launch modal bandwidth calculated from differential mode delay (OMBc)

Use a radiation source as described in IEC 60793-1-49.

4.1.4 For methods A and B

- Use a radiation source with a centre wavelength that is known and within ± 10 nm of the nominal specified wavelength. For injection laser diodes, laser emission coupled into the fibre shall exceed spontaneous emission by a minimum of 15 dB (optical).
- 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 any laser diode is narrow enough to neglect its contribution to bandwidth measurement.
- For A1 and A3 fibres, calculate the NIDL (see Annex A) for each wavelength's measurement from the optical source spectral width for that wavelength as follows:

$$\text{NIDL} = \frac{\text{IDF}}{\Delta\lambda}, \text{ in GHz}\cdot\text{km}$$

where:

$\Delta\lambda$ 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 a 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.

- The radiation source shall be spectrally 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 D. The fibre position shall be stable for the complete duration of the measurement. A viewing system may be used to aid fibre alignment where optical imaging is used.

The OFL prescription in Annex D, based on the allowed variance of light intensity on the input of the fibre under test, can result in large (>25 %) variations in the measured results for high bandwidth (>1 500 MHz·km) A1a fibres. Subtle differences in the launches of conforming equipment are a cause of these differences. Method C is introduced as a means of obtaining an improvement.