IEC 61300-3-4

Edition 4.0 2023-05
REDLINE VERSION

INTERNATIONAL STANDARD

colour inside

Fibre optic interconnecting devices and passive components – Basic test and measurement procedures –
Part 3-4: Examinations and measurements – Attenuation

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FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.

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This redline version of the official IEC Standard allows the user to identify the changes made to the previous edition IEC 61300-3-4:2012. A vertical bar appears in the margin wherever a change has been made. Additions are in green text, deletions are in strikethrough red text.

IEC 61300-3-4 has been prepared by subcommittee 86B: Fibre optic interconnecting devices and passive components, of IEC technical committee 86: Fibre optics. It is an International Standard.

This fourth edition cancels and replaces the third edition published in 2012. This edition constitutes a technical revision.

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

a) addition of Clause 3 containing terms, definitions and abbreviated terms;
b) addition of a new LSPM measurement method, insertion method (D);
c) addition of Annex A describing attenuation measurement of multicore fibre;
d) changed reference test method to insertion C and alternative test method to substitution or insertion D for power meter and type 4 DUT.

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

Draft	Report on voting
86B/4656/FDIS	86B/4675/RVD

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 International Standard 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/standardsdev/publications.

A list of all the parts in 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 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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FIBRE OPTIC INTERCONNECTING DEVICES AND PASSIVE COMPONENTS – BASIC TEST AND MEASUREMENT PROCEDURES –

Part 3-4: Examinations and measurements – Attenuation

1 Scope

This part of IEC 61300 describes the various methods available to measure the attenuation of optical components. It is not, however, applicable to dense wavelength division multiplexing (DWDM) components, for which IEC 61300-3-29 should be used. It is not, however, applicable to random mate attenuation measurements as described in IEC 61300-3-34 and IEC 61300-3-45 nor for attenuation measurements of dense wavelength division multiplexing (DWDM) devices as described in IEC 61300-3-29.

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

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

IEC 60793-2-50, *Optical fibres – Part 2-50: Product specifications – Sectional specification for class B single-mode fibres*

IEC 60825-1, *Safety of laser products – Part 1: Equipment classification and requirements*

IEC 61300-1:2011, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 1: General and guidance*

IEC 61300-3-1, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 3-1: Examinations and measurements – Visual examination*

IEC 61300-3-2, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 3-2: Examinations and measurements – Polarization dependent loss in a single-mode Fibre optic device*

IEC 61300-3-35, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 3-35: Examinations and measurements – Visual inspection of fibre optic connectors and fibre-stub transceivers*

IEC 61755 (all parts), *Fibre optic interconnecting devices and passive components – Connector optical interfaces for single-mode fibres*

IEC/TR 62316, *Guidance for the interpretation of OTDR backscattering traces*

IEC 63267 (all parts), *Fibre optic interconnecting devices and passive components – Connector optical interfaces for enhanced macro bend loss multimode fibres*

3 Terms, definitions and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 61300-1 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

3.2 Abbreviated terms

ATM	alternative test method
C	passive optical component
CWDM	coarse wavelength division multiplexing
D	optical detector
DUT	device under test
FIFO	fan-in/fan-out device
LED	light emitting diode
LS	optical light source
LSPM	optical light source and power meter
MCF	multicore fibre
OSW	optical switch
OTDR	optical time domain reflectometer
PDL	polarization dependent loss
PM	optical power meter
RA	reference adaptor
RP	reference plug
RTM	reference test method
SCF	single core fibre
TJ	temporary joint

4 General description

4.1 General

Attenuation is intended to give a value for the decrease of ~~useful~~ optical power, expressed in decibels, resulting from the insertion of a DUT, within ~~a length of optical fibre cable~~ an optical link. The term "insertion loss" is sometimes used in place of "attenuation".

The DUT may have more than two optical ports. However, since an attenuation measurement is made across only two ports, the DUT in this document shall be described as having two ports. ~~Eight different DUT configurations are described. The differences between these configurations are primarily in the terminations of the optical ports. Terminations may consist of bare fibre, a connector plug, or a receptacle.~~

The reference method for measuring attenuation is with an optical power meter. Optical time domain reflectometry (OTDR) measurements are presented as an alternative method. Three variations in the measurement of attenuation with a power meter are presented. The reference and alternative methods to be used for each DUT configuration are defined in Table 3. Different test configurations and methods will result in different accuracies of the attenuation being measured. In cases of dispute, the reference test method should be used.

The reference method for measuring attenuation is with an LSPM. OTDR measurements are presented as an alternative method. Three variations in the measurement of attenuation with a LSPM are presented.

4.2 Precautions

The power in the fibre and DUT shall not be at a level high enough to generate non-linear scattering or DUT overloading effects.

The position of the fibres in the test should be fixed between the measurement without the DUT, P_0, and with the DUT inserted, P_1, to avoid changes in attenuation due to bending loss.

In multimode measurements, a change in modal distribution in the measurement system due to fibre disturbance, will can affect the attenuation measurement.

Components with PDL will show different attenuation depending on the input state of polarization from the source. If the component PDL can exceed the acceptable uncertainty in the attenuation measurement, then either an unpolarized or polarization scrambled source can should be used to measure the polarization averaged attenuation, or the methods of IEC 61300-3-2 should be used to measure PDL and attenuation together.

The laser safety recommendations in IEC 60825-1, Safety of laser products, should shall be followed.

5 Apparatus

5.1 Launch conditions and light source (SLS)

The launch condition for LSPM and OTDR shall be specified in accordance with IEC 61300-1:2011 and shall be measured at the output of the launch reference connector.

The source unit consists of an optical emitter, the associated drive electronics and fibre pigtail (if any). Preferred source conditions are given in Table 1. The stability of the single-mode fibre source at 23 °C shall be ±0,01 dB from the initial value over the duration of the measurement. The stability of the multimode fibre source at 23 °C shall be ±0,05 dB from the initial value over the duration of the measurement. The source output power shall be greater than or equal to 20 dB above the minimum measurable power level.

Table 1 – Preferred source conditions

No.	Type	Central wavelength nm	Spectral width RMS nm	Source type
S1	Multimode	660 ± 30	≥30 ≥ 10	Monochromator or LED
S2	Multimode	780 ± 30	≥30 ≥ 10	Monochromator or LED
S3	Multimode	850 ± 30	≥30 ≥ 10	Monochromator or LED
S4	Multimode	1 300 ± 30	≥30 ≥ 10	Monochromator or LED
S5	Single-mode	1 310 ± 30	To be reported	Laser diode monochromator or LED
S6	Single-mode	1 550 ± 30	To be reported	Laser diode monochromator or LED
S7	Single-mode	1 625 ± 30	To be reported	Laser diode monochromator or LED

NOTE 1 It is recognized that some components, for example for CWDM, may can require the use of other source types such as tunable lasers. It is therefore recommended, in these cases, that the preferred source characteristics are specified on the basis of the component to be measured.

NOTE 2 Central wavelength (centroidal wavelength) and spectral width are defined in IEC 61280-1-3.

5.2 Optical power meter (DPM)

The power meter unit consists of an optical detector (D), the mechanism for connecting to it and associated detection electronics. The connection to the detector will should either be with an adaptor that accepts a bare fibre, or a connector plug of the appropriate design.

The measurement system shall be stable within specified limits over the period of time required to measure P_0 and P_1. For measurements where the connection to the detector must shall be broken disconnected between the measurement of P_0 and P_1, the measurement repeatability shall be within less than or equal to 0,02 dB. A detector with a large sensitive area may should be used to achieve this.

The precise characteristics of the detector shall be compatible with the measurement requirements. The dynamic range of the power meter shall be capable of measuring the power level exiting from the DUT at the wavelength being measured.

The preferred power meter parameters are given below in Table 2. The power meter shall should be calibrated for the operational wavelength range and power level to be measured. The power meter stability should be less than or equal to 0,01 dB over the measurement time and operational temperature range. The stability and validity of dark current corrections from zeroing calibration can influence this.

Table 2 – Preferred power meter parameters

Number	Type	Maximum nonlinearity dB	Relative uncertainty dB
D1	Multimode	±0,05 (–60 dBm < input power < –5 dBm)	≤ 0,05
D2	Single-mode	±0,01 (attenuation < 10 dB) ±0,05 (10 dB < attenuation < 60 dB)	≤ 0,02

~~NOTE 1~~ In order to ensure that all light exiting the fibre is detected by the power meter, the sensitive area of the detector and the relative position between it and the fibre should be compatible with the numerical aperture of the fibre.

NOTE ~~2~~ Common sources of relative uncertainty are polarization dependence and interference with reflections from the power meter and fibre connector surfaces. The sensitivity of the power meter to such reflections can be characterized by the parameter spectra ripple, determined as the periodic change in responsivity vs. the wavelength of a coherent light source.

5.3 Temporary joint (TJ)

A temporary joint is a method, device or mechanical fixture for temporarily aligning two fibre ends into a stable, reproducible, low-loss joint. It is used when direct connection of the DUT to the measurement system is not achievable by a standard connector. It may, for example, be a precision V-groove, vacuum chuck, a micromanipulator or a fusion or mechanical splice. The temporary joint shall be stable to within ±10 % of the required measurement ~~accuracy~~ uncertainty in dB over the time taken to measure P_0 and P_1. A suitable refractive index matching material may be used to improve the stability of the TJ.

5.4 Fibre

The fibre in the lead from the source to the TJ, in the test patchcord, and in the substitute patchcord, shall belong to the same category as that used in the DUT.

Fibres ~~should~~ shall be in accordance with IEC 60793-2-10 or IEC 60793-2-50.

5.5 Reference plug (RP)

Where a RP is required to form complete connector assemblies in any of the test methods, the RP becomes, in effect, a part of the DUT during the measurement of attenuation. The RP shall ~~be specified in~~ meet the requirements of the relevant ~~specification~~ optical interface standard found in the IEC 61755 series or IEC 63267 series.

5.6 Reference adaptor (RA)

Where a RA is required to form complete connector assemblies in any of the test methods, the RA becomes, in effect, a part of the DUT during the measurement of attenuation. The RA shall ~~be specified in~~ meet the requirements of the relevant ~~specification~~ optical interface standard found in the IEC 61755 series or IEC 63267 series.

5.7 Termination

A termination may consist of a bare fibre, a connector plug, or a receptacle. When a bare fibre is used as a termination, a TJ or bare fibre adaptor is used depending on the configuration of the test and the location of the bare fibre end. When a DUT has multiple connector plugs or receptacles, they can consist of the same or different types. If the DUT has different connector plugs or receptacles on either end of the DUT, the ATM may be necessary.

6 Procedure

6.1 Preconditioning

The optical interfaces of the DUT shall be clean and free from any debris likely to affect the performance of the test and any resultant measurements. The manufacturer's cleaning procedure shall be followed.

The DUT shall be allowed to stabilize at ~~room temperature~~ standard atmospheric conditions according to IEC 61300-1 for at least 1 h prior to testing.

Care should be exercised throughout the test to ensure that mating surfaces are not contaminated with oil or grease. It is recognized that bare fingers can deposit a film of grease.

6.2 Visual inspection

~~The optical interfaces shall be free from defects or damage which may affect the performance of the test and any resultant measurements. It is recommended that a visual inspection of the optical interfaces of the DUT is made in accordance with IEC 61300-3-1 prior to the start of the test.~~

All connector end faces shall be inspected for cleanliness according to IEC 61300-3-35 and cleaned as needed. Recommended cleaning methods for connector end faces are described in IEC TR 62627-01.

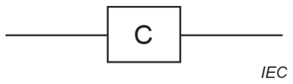
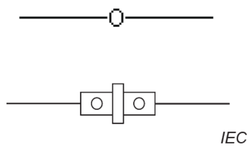
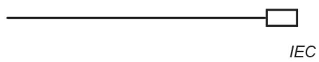
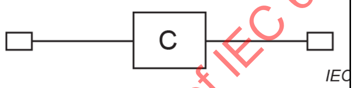
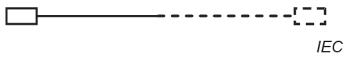
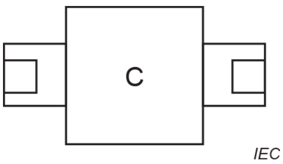
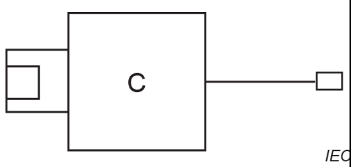
6.3 DUT configuration types and test methods

Eight different DUT configuration types are described in Table 3. The differences between these configuration types are primarily in the terminations of the optical ports. Terminations may consist of bare fibre, a connector plug, or a receptacle.

The RTM and ATM to be used for each DUT configuration type are defined in Table 3. Different test configurations and methods can result in different uncertainties of the attenuation being measured. In cases of dispute, the RTM should be used.

Consideration for devices with multicore fibre can be found in Annex A.

Table 3 – DUT configuration types

Type	Description	DUT	Test methods **Reference test method** RTM	 **Alternative test method** ATM
1	Fibre to fibre (component)		Power meter (cutback)	OTDR
2	Fibre to fibre (splice or field-mountable connector set)		Power meter (insertion A)	Power meter (cutback) Or OTDR
3	Fibre to plug		Power meter (cutback)	OTDR
4	Plug to plug (component)		Power meter (insertion ~~B~~C)	Power meter (substitution or insertion ~~C~~D) or OTDR
5	Plug to plug (patchcord)		Power meter (insertion B)	Power meter (insertion C or insertion D) or OTDR
6	Single plug (pigtail)		Power meter (insertion B)	OTDR
7	Receptacle to receptacle (component)		Power meter (insertion C)	Power meter (substitution or insertion D) or OTDR
8	Receptacle to plug (component)		Power meter (insertion C)	Power meter (substitution or insertion D) or OTDR

An OTDR can be used on components with more than two ports, but in this case the reflected power from the ports not being measured should be suppressed in the attenuation zone.

NOTE 1 C is a passive optical component which ~~may~~ can have more than the two ports indicated.

NOTE 2 Insertion measurements and cutback measurements ~~may~~ can be expected to give equivalent measurements for type 2 DUTs.

NOTE 3 Due to measurement considerations, the OTDR method ~~may be less accurate~~ can have more uncertainty than other measurement methods but ~~may~~ can be the only test applicable.

6.4 Attenuation measurements with a ~~power meter~~ LSPM

6.4.1 General

The measurement of attenuation using cutback, substitution or insertion is based on the use of ~~an optical power meter~~ a PM, as described in 5.2.

Two measurements of power are required for each measurement of attenuation, A, with a power meter:

$$A = -10\log\frac{P_1}{P_0}\ \text{dB} \tag{1}$$

where

P_1 is the measurement of power with the DUT in the path;

P_0 is the measurement of power without the DUT in the path.

Suitable connections shall be provided between the fibre and the detector. Connections may be with either an adaptor to connect a bare fibre or with a connector adaptor for the appropriate connector plug.

6.4.2 Cutback method

For a type 1 and type 2 DUT, one lead of the DUT is connected to the source with a TJ. The other lead is connected to the detector, and P_1 is measured (see Figure 1). The fibre is cut at CP, and P_0 is measured.

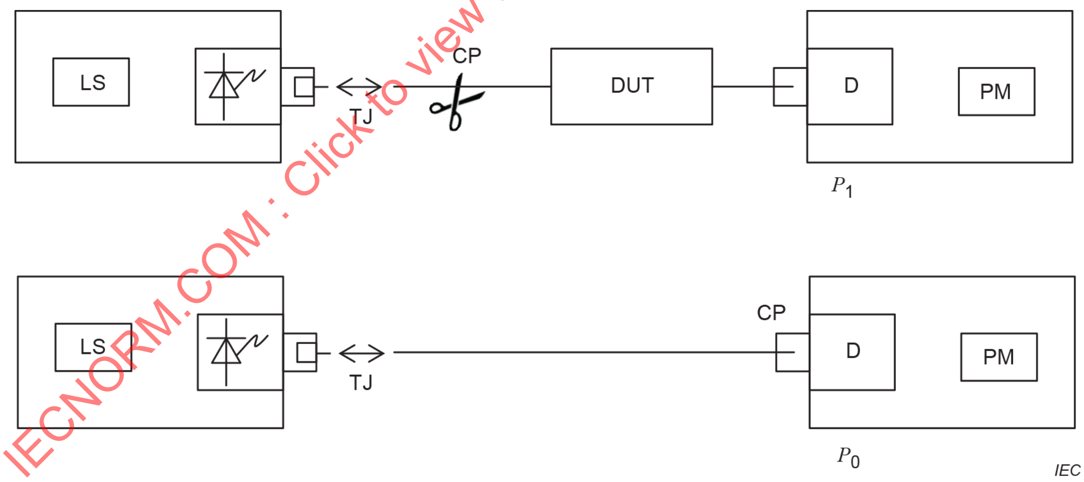


Figure 1 – Cutback method – Type 1, type 2 and type 3 DUT

For a type 3, fibre-to-plug DUT, a RA and a RP with a pigtail are added to the DUT to form a complete connector assembly. Attenuation of a type 3 DUT is the attenuation of the complete connector assembly (plug-adaptor-plug) with pigtail leads and is measured as a type 1 DUT.

6.4.3 Substitution method

In the substitution method, P_1 is measured with the DUT in the ~~circuit~~ measurement set-up, and P_0 is measured with a substitute patchcord in place of the DUT (see Figure 2).

For a type 4 DUT, a RA is added to the RP on both the source lead and the test patchcord (see Figure 2).

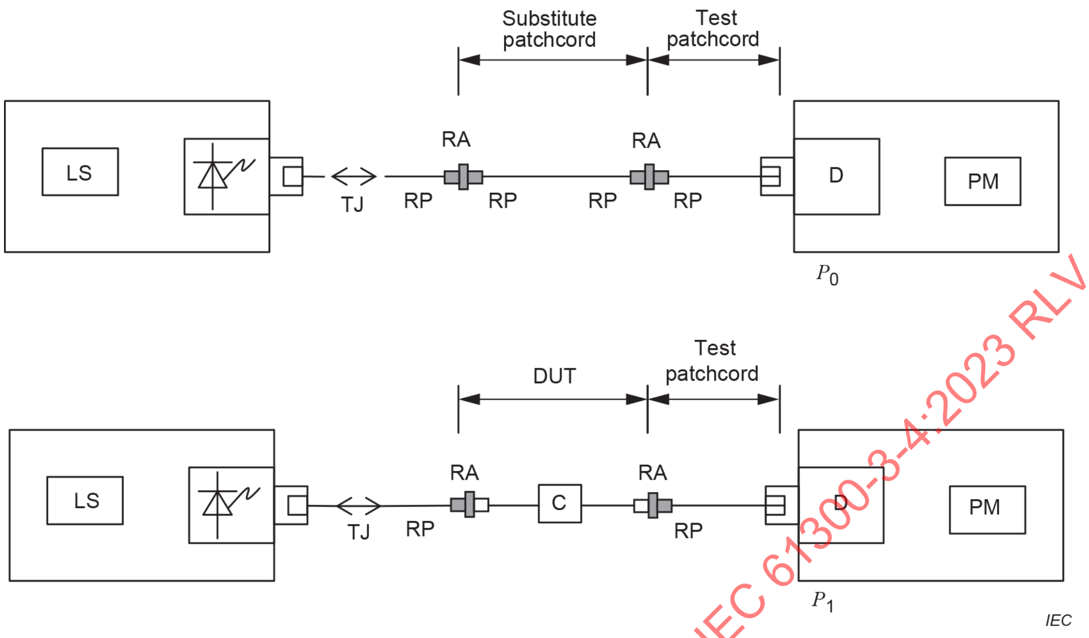


Figure 2 – Substitution method – Type 4, type 7, and type 8 DUT

For a type 7 DUT, the measurement is made in the same way as a plug-to-plug DUT, except that reference adaptors are not required for the measurement of P_1 (see Figure 2).

For a type 8 DUT, the measurement is made in the same way as for a plug-to-plug DUT, except that only one reference adaptor is required for the measurement of P_1 (see Figure 2). In this case, the reference adaptor shall be the one nearest the source.

Substitution measurements ~~may~~ can be expected to give somewhat lower results of attenuation than insertion measurements for types 4, ~~5, 6, and~~ 7, and 8 DUTs. This is due to the fact that in the substitution method the reference power, P_0, includes the attenuation of the "substitute patchcord" with its connections to the measurement system. Therefore, the value of P_0 in the substitution method is lower than in the insertion method.

6.4.4 Insertion method (A)

For a type 2 fibre-to-fibre DUT (splice- or field-mountable connector set), P_0 is measured with a length of fibre between the temporary joint and the detector, the fibre is cut, the splice- or field-mountable connector set is installed, and P_1 is measured (see Figure 3). The fibres can be similar fibres or dissimilar fibres as long as they are compatible with each other. If dissimilar fibres are used, care should be taken to ensure the effects of dissimilar fibres are considered in the measurement results (see IEC TR 62000 for guidance on single-mode fibres).

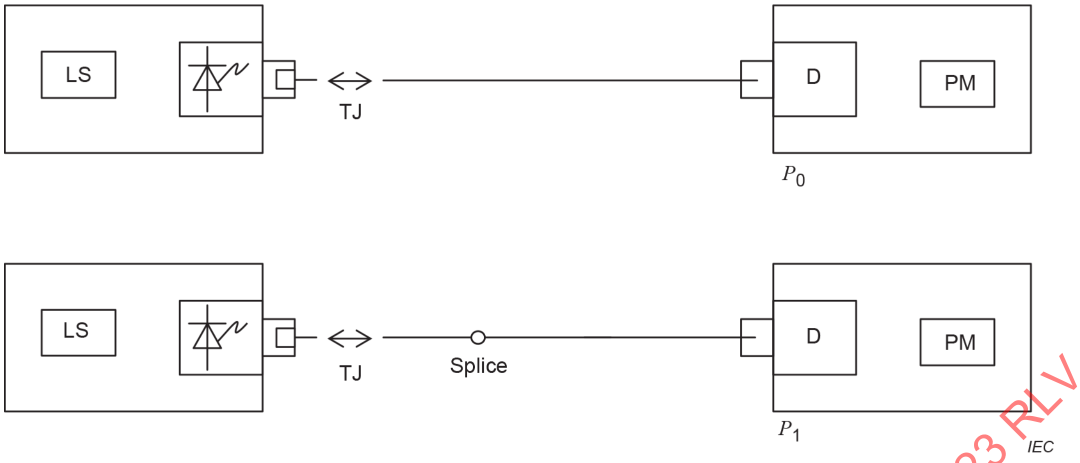


Figure 3 – Insertion method (~~C1~~A) – Type 2 DUT

6.4.5 Insertion method (B) with direct coupling to power meter

For a type 5 and type 6 DUT, P_0 is measured with the detector connected to a RP on the fibre from the TJ. An RA and the DUT are added, and P_1 is measured (see Figure 4).

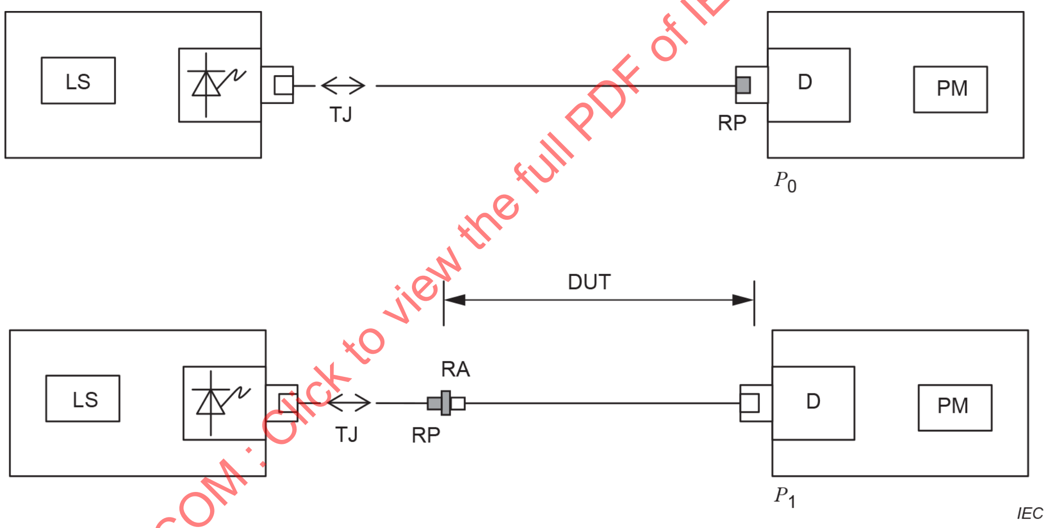


Figure 4 – Insertion method (~~C2~~B) – Type 5 and type 6 DUT

This measurement includes only the connector plug on the source end of the DUT in the measurement. To measure both ends of the DUT, the measurement shall be repeated with the patchcord reversed.

For a type 6 DUT, the measurement requires an adaptor for a bare fibre at the detector.

6.4.6 Insertion method (C) with additional test patchcord

For a type 4 plug-to-plug (component) DUT or a type 5 plug-to-plug (patchcord) DUT, P_0 is measured with the test patchcord connected between the detector and the lead from the TJ. The DUT and another RA are added to measure P_1 (see Figure 5). In the case where the DUT has two different connector plugs, it may be useful to consider using the insertion method (D).

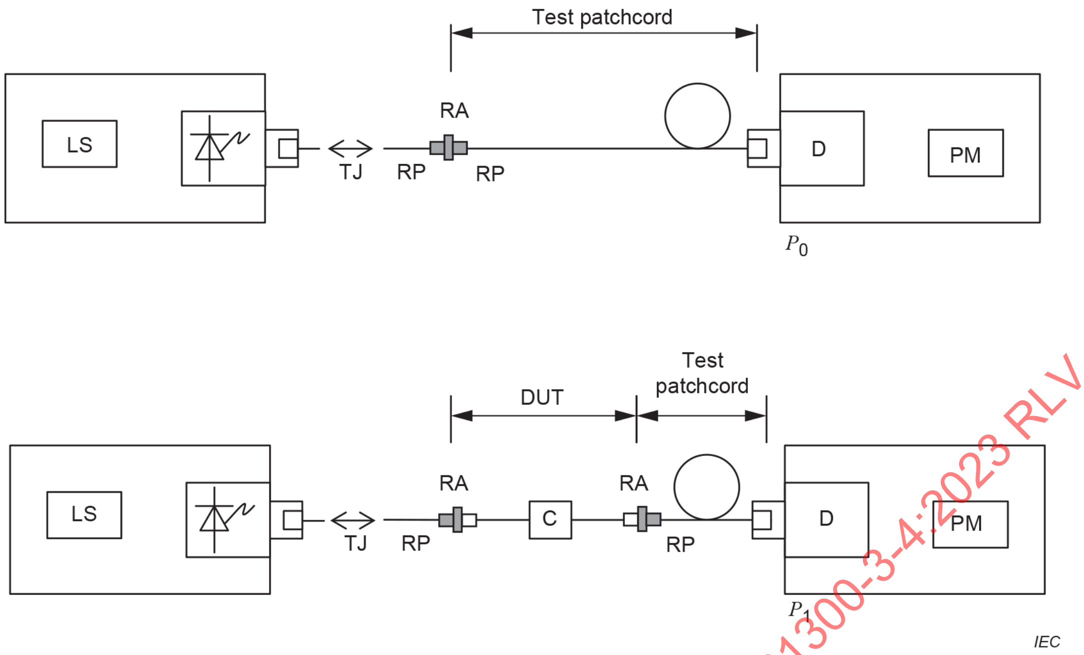


Figure 5 – Insertion method (~~C3~~C) – Type 4, type 5, type 7 and type 8 DUT

For a type 7 receptacle-to-receptacle DUT, an RA is not required for the measurement of P_1.

For a type 8 receptacle-to-plug DUT, only one RA is required for the measurement of P_1.

6.4.7 Insertion method (D) with additional test patchcord

For a type 4 plug-to-plug (component) DUT or a type 5 plug-to-plug (patchcord) DUT, P_0 is measured with the detector connected to a RP on the fibre from the TJ. The DUT, test patchcord, and RA are added to measure P_1 (see Figure 6). This insertion method is especially useful when the DUT has two different conntector plug types.

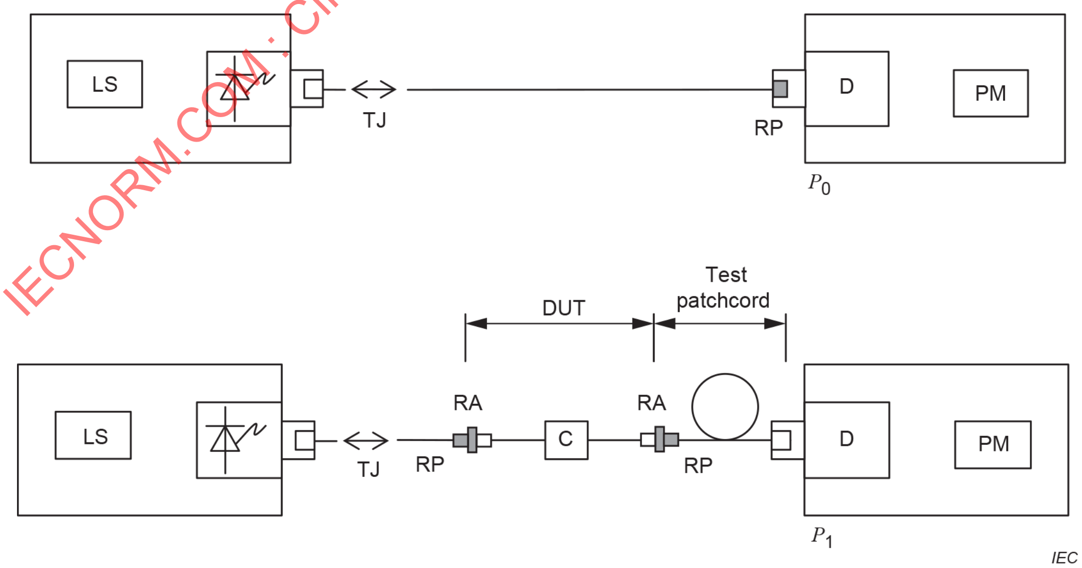


Figure 6 – Insertion method (D) – Type 4, type 5, type 7 and type 8 DUT

For a type 7 receptacle-to-receptacle DUT, an RA is not required for the measurement of P_1.

For a type 8 receptacle-to-plug DUT, only one RA is required for the measurement of P_1.

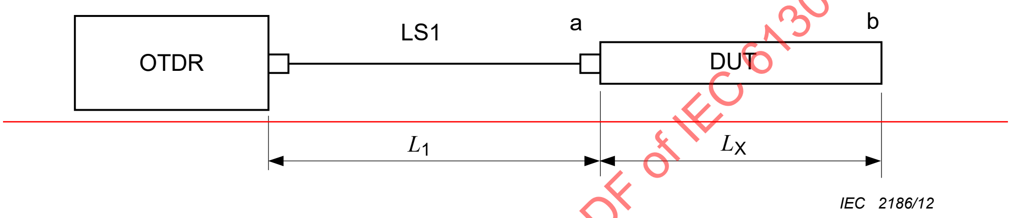
6.5 Attenuation measurements with an OTDR

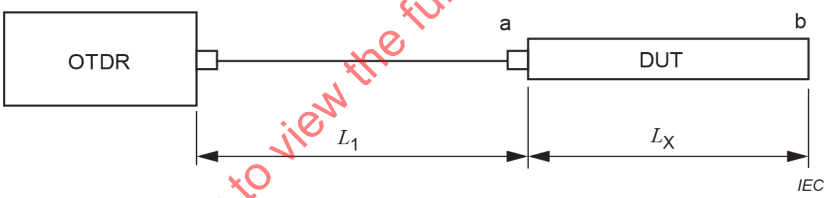
6.5.1 Measurement description

An OTDR measures the level of radiation scattered back by the optical line and collected by the receiver of the instrument. Using an OTDR, it is possible to measure and to evaluate both point events due, for example, to passive components such as splices, connectors, attenuators, etc. or losses due to the attenuation of fibre sections terminated by passive components.

There are two ~~principal measurement methods used~~ methods of OTDR measurement depending on the DUT configuration type (see Table 3):

- method 1 – one launch section (see Figure 7) is applicable to DUT types 1, 2, 3;
- method 2 – two launch sections (see Figure 8) are applicable to DUT types 4, 5, 6, 7, 8.





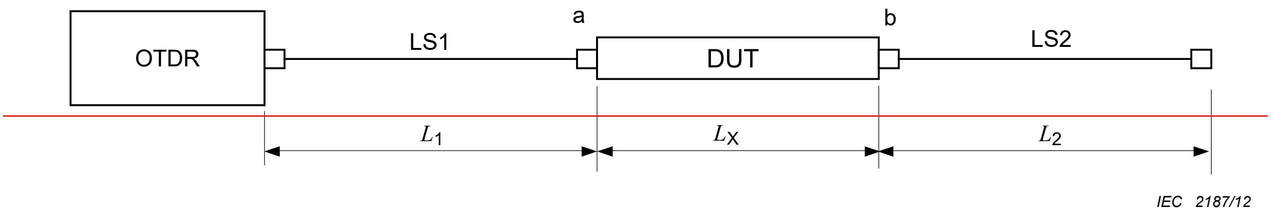
Key

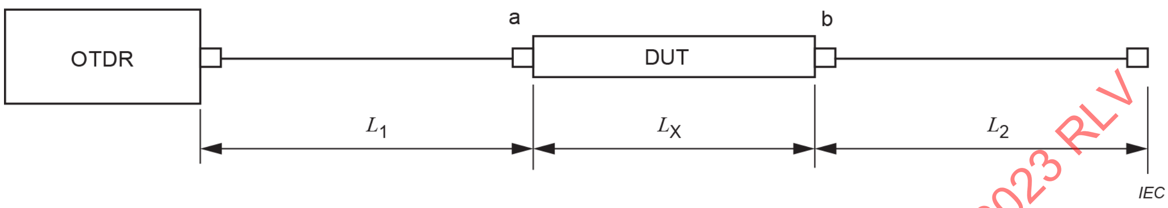
a, b reflective events

L_1 fibre launch section optical length

L_X DUT section optical length

Figure 7 – Method 1 – One launch section





Key

a, b reflective events

L_1 fibre launch section optical length

L_2 fibre launch section optical length

L_x DUT section optical length

Figure 8 – Method 2 – Two launch sections

Fibre launch sections ~~LS1~~L_1 and ~~LS2~~L_2 provide separation between the OTDR equipment and the events to be measured and ensure stable measurement conditions. Their minimum optical length is determined by the ability of the OTDR to resolve the measurement of attenuation and is commonly referred to as the attenuation dead zone ~~(DZ_{att})~~. The maximum optical length of the launch section is limited by requirement to minimize the OTDR distance resolution and to minimize optical losses of measured route.

If the DUT section length, L_X, is greater than the OTDR resolution (L_X > ~~DZ_{att}~~ attenuation dead zone), then the attenuation for each event, a and b, will be displayed separately. Where L_X < ~~DZ_{att}~~ attenuation dead zone, the OTDR will be unable to distinguish between events a and b and the DUT will be shown as one attenuation event.

Where the DUT is terminated with either a connector plug or a receptacle, an RP and RA are added, as necessary, to form complete connector assemblies. These connector assemblies are considered part of the DUT.

Where the component has pigtails, connector points are required. The pigtail lengths shall be greater than the OTDR resolution for each event to be displayed separately.

6.5.2 Bidirectional measurement

The value of attenuation is determined from the intensity difference of back-scattering before and after the DUT, so the launch section ~~LS2~~L_2 is needed if the DUT does not itself have sufficiently long pigtails, compared to the attenuation dead zone. Since the backscattering coefficient of the fibre before and after the DUT can differ, the OTDR measurement shall be made from both ends of the assembly of DUT and launch sections, without changing the ordering of this assembly. The attenuation result is the average of the apparent attenuation from the two OTDR measurements.

Differences in the backscatter coefficient of the fibre on either side of the DUT will result in an error in a one-way OTDR measurement. The error in a measurement made in one direction will be positive and the error in the other direction will be negative. The use of an average of readings taken in opposite directions cancels the error due to differences in the backscatter coefficient of the two fibres.

Referring to the two measured attenuation values, illustrated in 6.5.4, as A_1 and A_2, the average attenuation is calculated as:

$$A = \frac{A_1 + A_2}{2} \text{ (dB)}. \qquad (2)$$

See IEC TR 62316 for further details.

6.5.3 Measurement method

Configure the apparatus as shown in Figure 7 or Figure 8 with the OTDR equipment connected to side a.

- Set the OTDR measurement characteristics.
- Take an attenuation measurement in direction a-b and save the resulting OTDR data for evaluation.

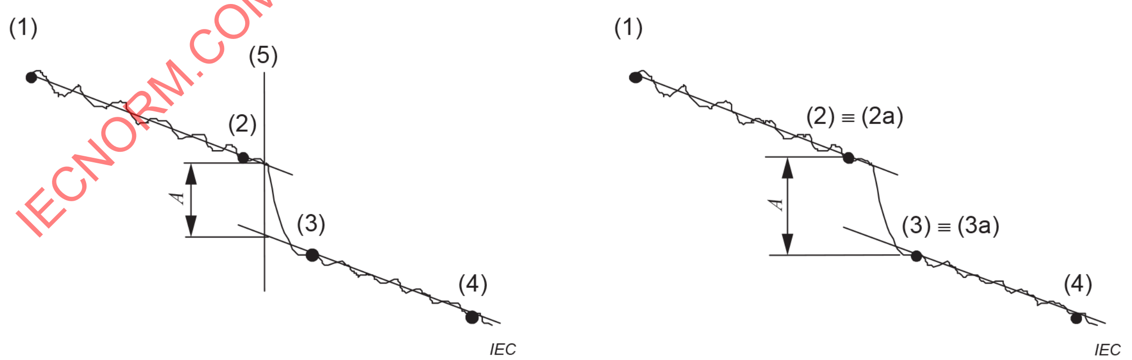
Configure the apparatus as shown in Figure 7 or Figure 8 with the OTDR equipment connected to side b.

- Set the same OTDR measurement characteristics as for the side a.
- Take an attenuation measurement in direction b-a and save the resulting OTDR data for evaluation.

6.5.4 Evaluation procedure

6.5.4.1 General

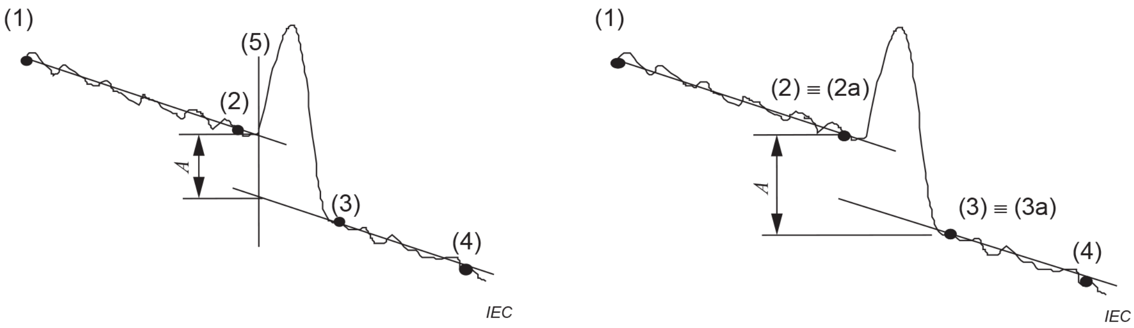
A typical OTDR display of the backscatter signal from a DUT with a non-reflective event is illustrated in Figure 9 a) and Figure 9 b).



a) Five-point evaluation **b) Four-point evaluation**

Figure 9 – Non-reflective event evaluation

A typical OTDR display of the backscatter signal from a DUT with a reflective event is illustrated in Figure 10 a) and Figure 10 b). To avoid the reflection peak affecting the attenuation measurement, the distance between the reference markers and the peak should be suitably long. Alternatively, a suitable filter, specified in the relevant specification, should be used to mask the reflection.



a) **Five-point evaluation** b) **Four-point evaluation**

Figure 10 – Reflective event evaluation

6.5.4.2 Five-point evaluation

Set evaluation points (1) and (2) on the fibre section in front of the DUT and (3) and (4) on the fibre section behind the DUT. Set the position of decision point (5). Attenuation, A, shall be calculated as the power level difference at point (5) between the least squares approximation curve of the fibre section in front of the DUT and the least squares approximation curve of the fibre behind the DUT.

6.5.4.3 Four-point evaluation

Set evaluation points (1) and (2) on the fibre section in front of the DUT and (3) and (4) on the fibre section behind the DUT. Attenuation, A, shall be calculated as the power-level difference between point (2a) of the least squares approximation curve of the fibre section in front of the DUT and point (3a) of least squares approximation curve of the fibre behind the DUT.

7 Details to be specified and reported

The following details, as applicable, shall be specified in the relevant specification and shall be reported in the test report:

- test method;
- source characteristics;
- performance requirements (allowable attenuation);
- power meter characteristics;
- relevant fibre parameters;
- OTDR characteristics:
  - wavelength;
  - ~~refractive index value used,~~
  - range;
  - pulse width;
  - averaging time;
  - optical lengths L_1, L_2, L_x.
- measurement uncertainty (refer to IEC TR 62627-04);
- deviations from this test method.

Annexe A
(informative)

Consideration of multicore fibre

A.1 General

When considering DUT utilizing multicore fibre (MCF), the fundamental attenuation procedures and apparatus described in this document are still applicable. However, it is necessary to add an optical switch and a fan-out device to the measurement system between the source and MCF DUT so that each core within the fibre can be measured as if it were a standalone fibre. The resulting measurement system is similar to the measurement system for multifiber connectors and passive components.

Clause A.2 describes the additional considerations, above and beyond the text in the document, which is needed to satisfy the attenuation measurement of a MCF DUT.

A.2 Additional apparatus

A.2.1 Optical switch (OSW)

An optical switch is a passive component possessing one or more ports which selectively transmits, redirects or blocks optical power in an optical fibre transmission line. The optical switch should be located between the source and fan-out device and allows the light emitted by the source to be transmitted to one leg of the fan-out device which in turn transmits the light through the associated core in the multifibre DUT and allows switching the light path to the subsequent cores.

A.2.2 Fan-in/fan-out device (FIFO)

The fan-in/fan-out device encompasses a means of splitting the MCF into individual, standard single core fibres (SCF). The device can take the form of a MCF connector plug (MCF plug), a core splitting device (waveguide, splitter, etc.) and individual, SCF legs. A general depiction of a FIFO device can be seen in Figure A.1.

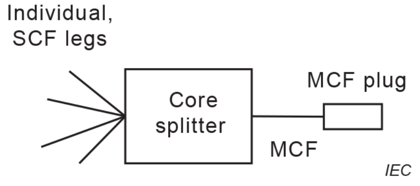


Figure A.1 – FIFO device example

A.3 Test setup and procedure – LSPM

The test setup and procedure for a MCF DUT using LSPM are similar to the methods described in 6.4 with the addition of the apparatus as specified in Clause A.2. For simplicity, a type 5 DUT with MCF and MCF connector plugs is considered with the test setup for insertion method B as shown in Figure A.2. This approach can be extrapolated to the other insertion methods for different DUT configuration types.

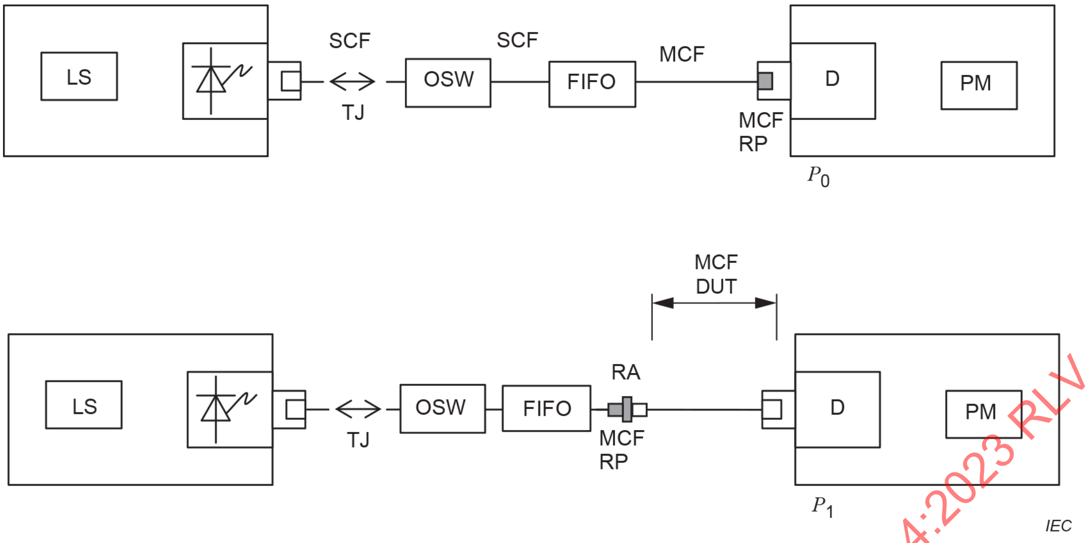


Figure A.2 – Insertion method B – Type 5 MCF DUT

The reference power measurement, P_0, and MCF DUT power measurement, P_1, should be taken individually for each core in the MCF. Formula (1) should be considered individually for each core to calculate the respective attenuation for each core in the MCF DUT.

A.4 Test setup and procedure – OTDR

The test setup and procedure for a MCF DUT using OTDR are similar to the methods described in 6.5 with the addition of the apparatus as specified in Clause A.2. For simplicity, the method using a one launch section is considered as shown in Figure A.3. This approach can be extrapolated to the method using two launch sections.

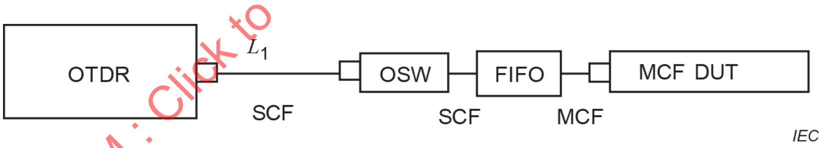


Figure A.3 – Method 1 – One launch section MCF DUT

Bibliography

~~IEC 61300-3-29, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 3-29 Examinations and measurements – Measurement techniques for characterizing the amplitude of the Spectral transfer function of DWDM components*~~

IEC 61280-1-3, *Fibre optic communication subsystem test procedures – Part ~~3-~~1-3: General communication subsystems –~~ Central wavelength and spectral width measurement~~ Measurement of entral wavelength, spectral width and additional spectral characteristics*

IEC 61300-3-2, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 3-2: Examinations and measurements – Polarization dependent loss in a single-mode fibre optic device*

IEC 61300-3-29, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 3-29: Examinations and measurements – Spectral transfer characteristics of DWDM components*

IEC 61300-3-34, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 3-34: Examinations and measurements – Attenuation of random mated connectors*

IEC 61300-3-45, *Fibre optic interconnecting devices and passive components - Basic test and measurement procedures - Part 3-45: Examinations and measurements - Attenuation of random mated multi-fibre connectors*

IEC TR 62000, *Guidelines for combining different single-mode fibre sub-categories*

IEC TR 62316, *Guidance for the interpretation of OTDR backscattering traces for single-mode fibres*

IEC TR 62627-01, *Fibre optic interconnecting devices and passive components – Part 01: Fibre optic connector cleaning methods*

IEC TR 62627-04, *Fibre optic interconnecting devices and passive components – Part 04: Example of uncertainty calculation: Measurement of the attenuation of an optical connector*

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IEC 61300-3-4

Edition 4.0 2023-05

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Fibre optic interconnecting devices and passive components – Basic test and measurement procedures –
Part 3-4: Examinations and measurements – Attenuation

Dispositifs d'interconnexion et composants passifs fibroniques – Procédures fondamentales d’essais et de mesures –
Partie 3-4: Examens et mesures – Affaiblissement

IEC 61300-3-4:2023-05(en-fr)

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

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

Part 3-4: Examinations and measurements – Attenuation

FOREWORD

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IEC 61300-3-4 has been prepared by subcommittee 86B: Fibre optic interconnecting devices and passive components, of IEC technical committee 86: Fibre optics. It is an International Standard.

This fourth edition cancels and replaces the third edition published in 2012. This edition constitutes a technical revision.

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

a) addition of Clause 3 containing terms, definitions and abbreviated terms;
b) addition of a new LSPM measurement method, insertion method (D);
c) addition of Annex A describing attenuation measurement of multicore fibre;
d) changed reference test method to insertion C and alternative test method to substitution or insertion D for power meter and type 4 DUT.

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

Draft	Report on voting
86B/4656/FDIS	86B/4675/RVD

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 International Standard 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/standardsdev/publications.

A list of all the parts in 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 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.

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

Part 3-4: Examinations and measurements – Attenuation

1 Scope

This part of IEC 61300 describes the various methods available to measure the attenuation of optical components. It is not, however, applicable to random mate attenuation measurements as described in IEC 61300-3-34 and IEC 61300-3-45 nor for attenuation measurements of dense wavelength division multiplexing (DWDM) devices as described in IEC 61300-3-29.

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

IEC 60793-2-50, *Optical fibres – Part 2-50: Product specifications – Sectional specification for class B single-mode fibres*

IEC 60825-1, *Safety of laser products – Part 1: Equipment classification and requirements*

IEC 61300-1, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 1: General and guidance*

IEC 61300-3-35, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 3-35: Examinations and measurements – Visual inspection of fibre optic connectors and fibre-stub transceivers*

IEC 61755 (all parts), *Fibre optic interconnecting devices and passive components – Connector optical interfaces for single-mode fibres*

IEC 63267 (all parts), *Fibre optic interconnecting devices and passive components – Connector optical interfaces for enhanced macro bend loss multimode fibres*

3 Terms, definitions and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 61300-1 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

3.2 Abbreviated terms

ATM	alternative test method
C	passive optical component
CWDM	coarse wavelength division multiplexing
D	optical detector
DUT	device under test
FIFO	fan-in/fan-out device
LED	light emitting diode
LS	optical light source
LSPM	optical light source and power meter
MCF	multicore fibre
OSW	optical switch
OTDR	optical time domain reflectometer
PDL	polarization dependent loss
PM	optical power meter
RA	reference adaptor
RP	reference plug
RTM	reference test method
SCF	single core fibre
TJ	temporary joint

4 General description

4.1 General

Attenuation is intended to give a value for the decrease of optical power, expressed in decibels, resulting from the insertion of a DUT, within an optical link. The term "insertion loss" is sometimes used in place of "attenuation".

The DUT may have more than two optical ports. However, since an attenuation measurement is made across only two ports, the DUT in this document shall be described as having two ports.

The reference method for measuring attenuation is with an LSPM. OTDR measurements are presented as an alternative method. Three variations in the measurement of attenuation with a LSPM are presented.

4.2 Precautions

The power in the fibre and DUT shall not be at a level high enough to generate non-linear scattering or DUT overloading effects.

The position of the fibres in the test should be fixed between the measurement without the DUT, P_0, and with the DUT inserted, P_1, to avoid changes in attenuation due to bending loss.

In multimode measurements, a change in modal distribution in the measurement system due to fibre disturbance can affect the attenuation measurement.

Components with PDL will show different attenuation depending on the input state of polarization from the source. If the component PDL can exceed the acceptable uncertainty in the attenuation measurement, then either an unpolarized or polarization scrambled source should be used to measure the polarization averaged attenuation, or the methods of IEC 61300-3-2 should be used to measure PDL and attenuation together.

The laser safety recommendations in IEC 60825-1 shall be followed.

5 Apparatus

5.1 Launch conditions and light source (LS)

The launch condition for LSPM and OTDR shall be in accordance with IEC 61300-1 and shall be measured at the output of the launch reference connector.

The source unit consists of an optical emitter, the associated drive electronics and fibre pigtail (if any). Preferred source conditions are given in Table 1. The stability of the single-mode fibre source at 23 °C shall be ±0,01 dB from the initial value over the duration of the measurement. The stability of the multimode fibre source at 23 °C shall be ±0,05 dB from the initial value over the duration of the measurement. The source output power shall be greater than or equal to 20 dB above the minimum measurable power level.

Table 1 – Preferred source conditions

No.	Type	Central wavelength nm	Spectral width RMS nm	Source type
S1	Multimode	660 ± 30	≥ 10	Monochromator or LED
S2	Multimode	780 ± 30	≥ 10	Monochromator or LED
S3	Multimode	850 ± 30	≥ 10	Monochromator or LED
S4	Multimode	1 300 ± 30	≥ 10	Monochromator or LED
S5	Single-mode	1 310 ± 30	To be reported	Laser diode monochromator or LED
S6	Single-mode	1 550 ± 30	To be reported	Laser diode monochromator or LED
S7	Single-mode	1 625 ± 30	To be reported	Laser diode monochromator or LED

It is recognized that some components, for example for CWDM, can require the use of other source types such as tunable lasers. It is therefore recommended, in these cases, that the preferred source characteristics are specified on the basis of the component to be measured.

NOTE Central wavelength (centroidal wavelength) and spectral width are defined in IEC 61280-1-3.

5.2 Optical power meter (PM)

The power meter unit consists of an optical detector (D), the mechanism for connecting to it and associated detection electronics. The connection to the detector should either be with an adaptor that accepts a bare fibre, or a connector plug of the appropriate design.

The measurement system shall be stable within specified limits over the period of time required to measure P_0 and P_1. For measurements where the connection to the detector shall be disconnected between the measurement of P_0 and P_1, the measurement repeatability shall be less than or equal to 0,02 dB. A detector with a large sensitive area should be used to achieve this.

The dynamic range of the power meter shall be capable of measuring the power level exiting from the DUT at the wavelength being measured.

The preferred power meter parameters are given below in Table 2. The power meter should be calibrated for the wavelength range and power level to be measured. The power meter stability should be less than or equal to 0,01 dB over the measurement time and temperature range. The stability and validity of dark current corrections from zeroing calibration can influence this.

Table 2 – Preferred power meter parameters

Number	Type	Maximum nonlinearity dB	Relative uncertainty dB
D1	Multimode	±0,05 (–60 dBm < input power < –5 dBm)	≤ 0,05
D2	Single-mode	±0,01 (attenuation < 10 dB) ±0,05 (10 dB < attenuation < 60 dB)	≤ 0,02
In order to ensure that all light exiting the fibre is detected by the power meter, the sensitive area of the detector and the relative position between it and the fibre should be compatible with the numerical aperture of the fibre. NOTE Common sources of relative uncertainty are polarization dependence and interference with reflections from the power meter and fibre connector surfaces. The sensitivity of the power meter to such reflections can be characterized by the parameter spectra ripple, determined as the periodic change in responsivity vs. the wavelength of a coherent light source.			

5.3 Temporary joint (TJ)

A temporary joint is a method, device or mechanical fixture for temporarily aligning two fibre ends into a stable, reproducible, low-loss joint. It is used when direct connection of the DUT to the measurement system is not achievable by a standard connector. It may, for example, be a precision V-groove, vacuum chuck, a micromanipulator or a fusion or mechanical splice. The temporary joint shall be stable to within ±10 % of the required measurement uncertainty in dB over the time taken to measure P_0 and P_1. A suitable refractive index matching material may be used to improve the stability of the TJ.

5.4 Fibre

The fibre in the lead from the source to the TJ, in the test patchcord, and in the substitute patchcord, shall belong to the same category as that used in the DUT.

Fibres shall be in accordance with IEC 60793-2-10 or IEC 60793-2-50.

5.5 Reference plug (RP)

Where a RP is required to form complete connector assemblies in any of the test methods, the RP becomes, in effect, a part of the DUT during the measurement of attenuation. The RP shall meet the requirements of the relevant optical interface standard found in the IEC 61755 series or IEC 63267 series.

5.6 Reference adaptor (RA)

Where a RA is required to form complete connector assemblies in any of the test methods, the RA becomes, in effect, a part of the DUT during the measurement of attenuation. The RA shall meet the requirements of the relevant optical interface standard found in the IEC 61755 series or IEC 63267 series.

5.7 Termination

A termination may consist of a bare fibre, a connector plug, or a receptacle. When a bare fibre is used as a termination, a TJ or bare fibre adaptor is used depending on the configuration of the test and the location of the bare fibre end. When a DUT has multiple connector plugs or receptacles, they can consist of the same or different types. If the DUT has different connector plugs or receptacles on either end of the DUT, the ATM may be necessary.

6 Procedure

6.1 Preconditioning

The optical interfaces of the DUT shall be clean and free from any debris likely to affect the performance of the test and any resultant measurements. The manufacturer's cleaning procedure shall be followed.

The DUT shall be allowed to stabilize at standard atmospheric conditions according to IEC 61300-1 for at least 1 h prior to testing.

Care should be exercised throughout the test to ensure that mating surfaces are not contaminated with oil or grease. It is recognized that bare fingers can deposit a film of grease.

6.2 Visual inspection

All connector end faces shall be inspected for cleanliness according to IEC 61300-3-35 and cleaned as needed. Recommended cleaning methods for connector end faces are described in IEC TR 62627-01.

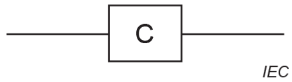
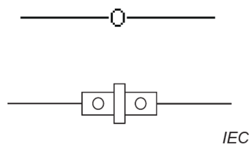
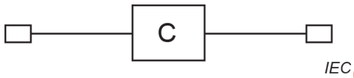
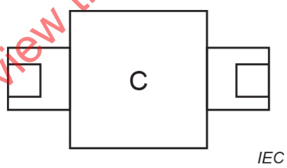
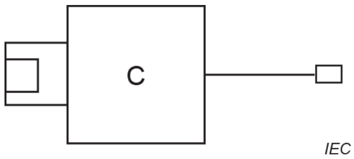
6.3 DUT configuration types and test methods

Eight different DUT configuration types are described in Table 3. The differences between these configuration types are primarily in the terminations of the optical ports. Terminations may consist of bare fibre, a connector plug, or a receptacle.

The RTM and ATM to be used for each DUT configuration type are defined in Table 3. Different test configurations and methods can result in different uncertainties of the attenuation being measured. In cases of dispute, the RTM should be used.

Consideration for devices with multicore fibre can be found in Annex A.

Table 3 – DUT configuration types

Type	Description	DUT	Test methods	
			Reference test method RTM	**Alternative test method** ATM
1	Fibre to fibre (component)		Power meter (cutback)	OTDR
2	Fibre to fibre (splice or field-mountable connector set)		Power meter (insertion A)	Power meter (cutback) Or OTDR
3	Fibre to plug		Power meter (cutback)	OTDR
4	Plug to plug (component)		Power meter (insertion C)	Power meter (substitution or insertion D) or OTDR
5	Plug to plug (patchcord)		Power meter (insertion B)	Power meter (insertion C or insertion D) or OTDR
6	Single plug (pigtail)		Power meter (insertion B)	OTDR
7	Receptacle to receptacle (component)		Power meter (insertion C)	Power meter (substitution or insertion D) or OTDR
8	Receptacle to plug (component)		Power meter (insertion C)	Power meter (substitution or insertion D) or OTDR

An OTDR can be used on components with more than two ports, but in this case the reflected power from the ports not being measured should be suppressed in the attenuation zone.

NOTE 1 C is a passive optical component which can have more than the two ports indicated.

NOTE 2 Insertion measurements and cutback measurements can be expected to give equivalent measurements for type 2 DUTs.

NOTE 3 Due to measurement considerations, the OTDR method can have more uncertainty than other measurement methods but can be the only test applicable.

6.4 Attenuation measurements with a LSPM

6.4.1 General

The measurement of attenuation using cutback, substitution or insertion is based on the use of a PM, as described in 5.2.

Two measurements of power are required for each measurement of attenuation, A, with a power meter:

$$A = -10\log\frac{P_1}{P_0}\ \text{dB} \tag{1}$$

where

P_1 is the measurement of power with the DUT in the path;

P_0 is the measurement of power without the DUT in the path.

Suitable connections shall be provided between the fibre and the detector. Connections may be with either an adaptor to connect a bare fibre or with a connector adaptor for the appropriate connector plug.

6.4.2 Cutback method

For a type 1 and type 2 DUT, one lead of the DUT is connected to the source with a TJ. The other lead is connected to the detector, and P_1 is measured (see Figure 1). The fibre is cut at CP, and P_0 is measured.

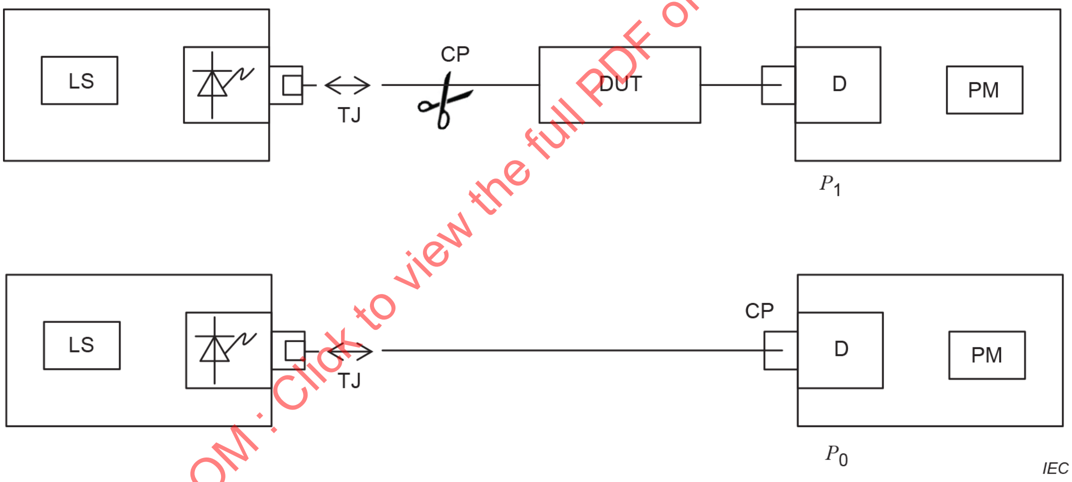


Figure 1 – Cutback method – Type 1, type 2 and type 3 DUT

For a type 3, fibre-to-plug DUT, a RA and a RP with a pigtail are added to the DUT to form a complete connector assembly. Attenuation of a type 3 DUT is the attenuation of the complete connector assembly (plug-adaptor-plug) with pigtail leads and is measured as a type 1 DUT.

6.4.3 Substitution method

In the substitution method, P_1 is measured with the DUT in the measurement set-up, and P_0 is measured with a substitute patchcord in place of the DUT (see Figure 2).

For a type 4 DUT, a RA is added to the RP on both the source lead and the test patchcord (see Figure 2).

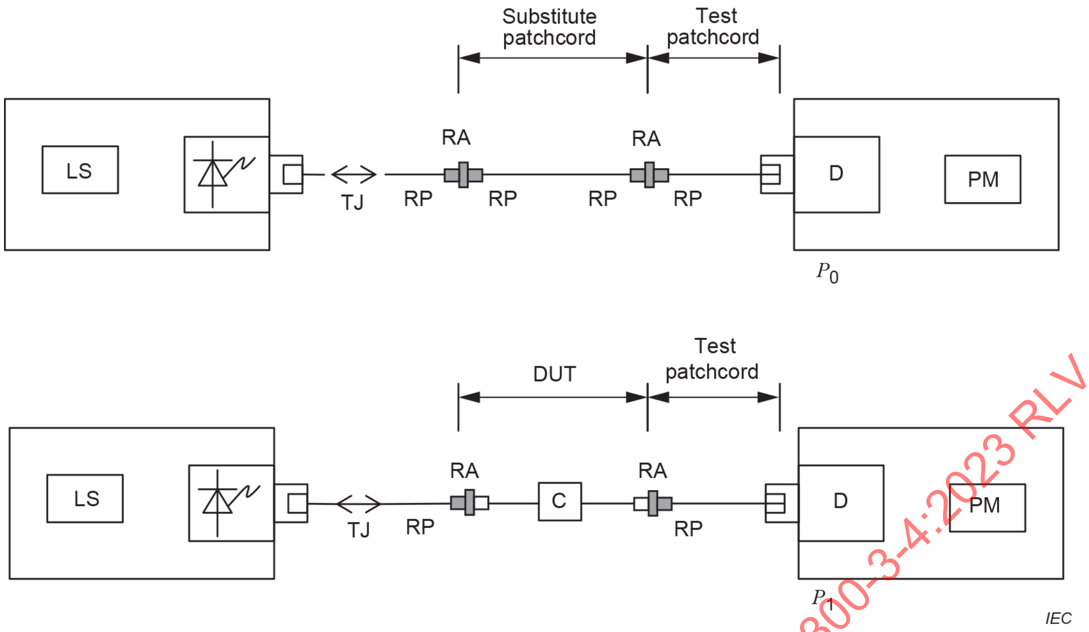


Figure 2 – Substitution method – Type 4, type 7, and type 8 DUT

For a type 7 DUT, the measurement is made in the same way as a plug-to-plug DUT, except that reference adaptors are not required for the measurement of P_1 (see Figure 2).

For a type 8 DUT, the measurement is made in the same way as for a plug-to-plug DUT, except that only one reference adaptor is required for the measurement of P_1 (see Figure 2). In this case, the reference adaptor shall be the one nearest the source.

Substitution measurements can be expected to give somewhat lower results of attenuation than insertion measurements for types 4, 7, and 8 DUTs. This is due to the fact that in the substitution method the reference power, P_0, includes the attenuation of the "substitute patchcord" with its connections to the measurement system. Therefore, the value of P_0 in the substitution method is lower than in the insertion method.

6.4.4 Insertion method (A)

For a type 2 fibre-to-fibre DUT (splice- or field-mountable connector set), P_0 is measured with a length of fibre between the temporary joint and the detector, the fibre is cut, the splice- or field-mountable connector set is installed, and P_1 is measured (see Figure 3). The fibres can be similar fibres or dissimilar fibres as long as they are compatible with each other. If dissimilar fibres are used, care should be taken to ensure the effects of dissimilar fibres are considered in the measurement results (see IEC TR 62000 for guidance on single-mode fibres).

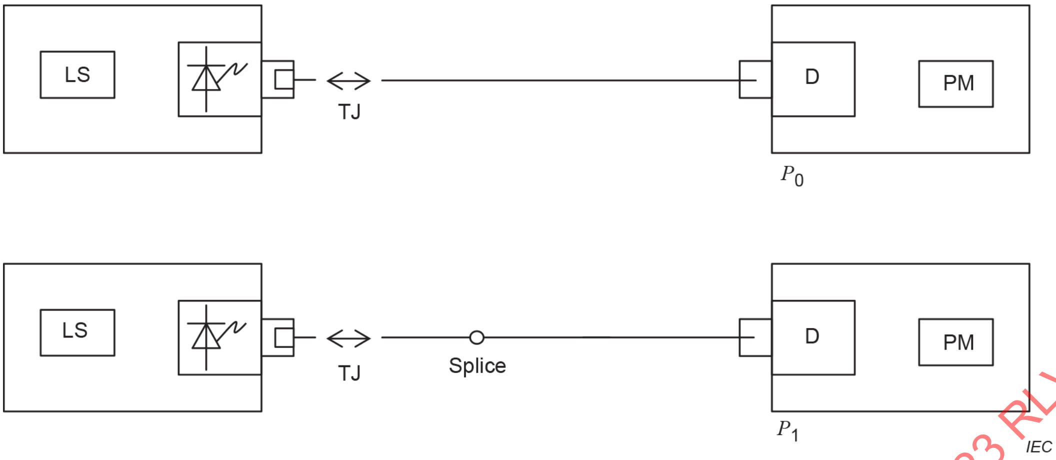


Figure 3 – Insertion method (A) – Type 2 DUT

6.4.5 Insertion method (B) with direct coupling to power meter

For a type 5 and type 6 DUT, P_0 is measured with the detector connected to a RP on the fibre from the TJ. An RA and the DUT are added, and P_1 is measured (see Figure 4).

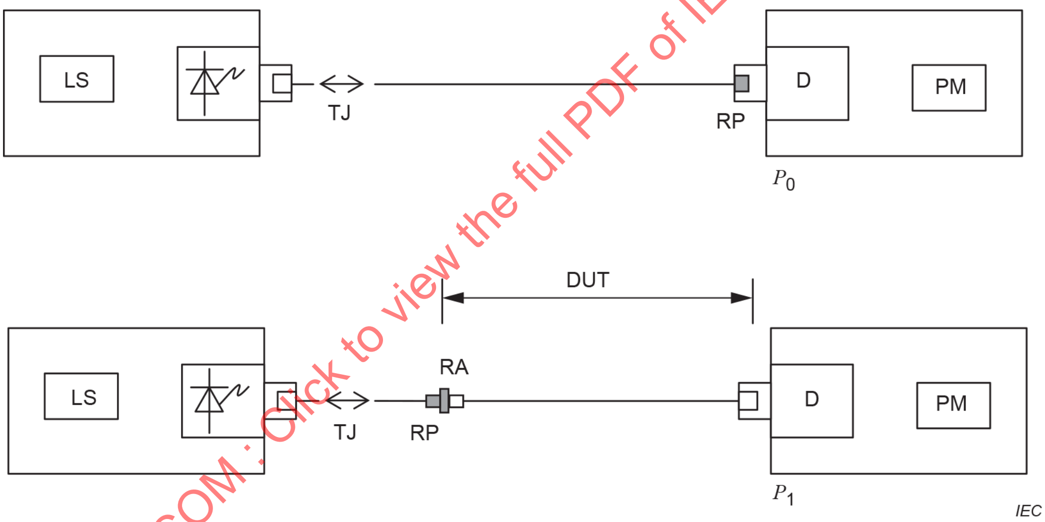


Figure 4 – Insertion method (B) – Type 5 and type 6 DUT

This measurement includes only the connector plug on the source end of the DUT in the measurement. To measure both ends of the DUT, the measurement shall be repeated with the patchcord reversed.

For a type 6 DUT, the measurement requires an adaptor for a bare fibre at the detector.

6.4.6 Insertion method (C) with additional test patchcord

For a type 4 plug-to-plug (component) DUT or a type 5 plug-to-plug (patchcord) DUT, P_0 is measured with the test patchcord connected between the detector and the lead from the TJ. The DUT and another RA are added to measure P_1 (see Figure 5). In the case where the DUT has two different connector plugs, it may be useful to consider using the insertion method (D).

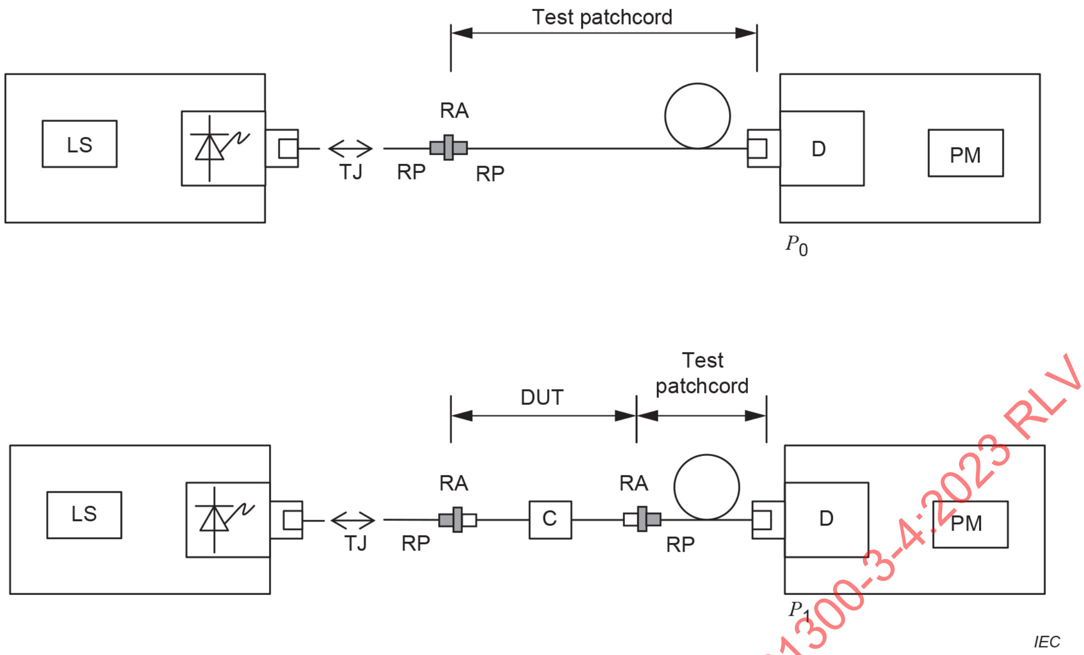


Figure 5 – Insertion method (C) – Type 4, type 5, type 7 and type 8 DUT

For a type 7 receptacle-to-receptacle DUT, an RA is not required for the measurement of P_1.

For a type 8 receptacle-to-plug DUT, only one RA is required for the measurement of P_1.

6.4.7 Insertion method (D) with additional test patchcord

For a type 4 plug-to-plug (component) DUT or a type 5 plug-to-plug (patchcord) DUT, P_0 is measured with the detector connected to a RP on the fibre from the TJ. The DUT, test patchcord, and RA are added to measure P_1 (see Figure 6). This insertion method is especially useful when the DUT has two different conntector plug types.

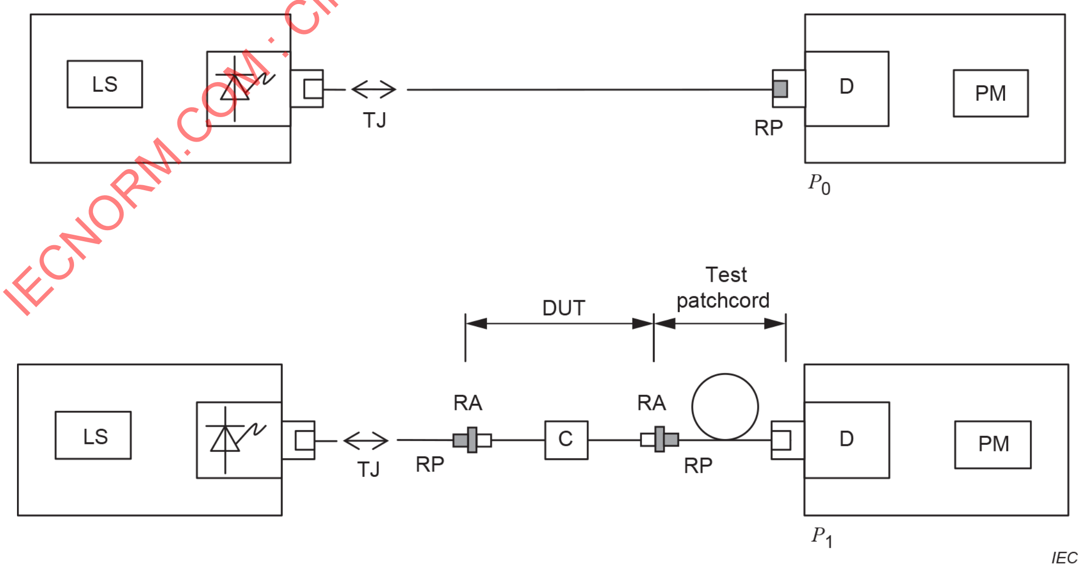


Figure 6 – Insertion method (D) – Type 4, type 5, type 7 and type 8 DUT

For a type 7 receptacle-to-receptacle DUT, an RA is not required for the measurement of P_1.

For a type 8 receptacle-to-plug DUT, only one RA is required for the measurement of P_1.

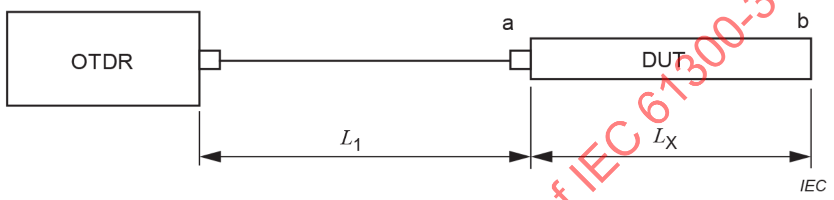
6.5 Attenuation measurements with an OTDR

6.5.1 Measurement description

An OTDR measures the level of radiation scattered back by the optical line and collected by the receiver of the instrument. Using an OTDR, it is possible to measure and to evaluate both point events due, for example, to passive components such as splices, connectors, attenuators, etc. or losses due to the attenuation of fibre sections terminated by passive components.

There are two methods of OTDR measurement depending on the DUT configuration type (see Table 3):

- method 1 – one launch section (see Figure 7) is applicable to DUT types 1, 2, 3;
- method 2 – two launch sections (see Figure 8) are applicable to DUT types 4, 5, 6, 7, 8.



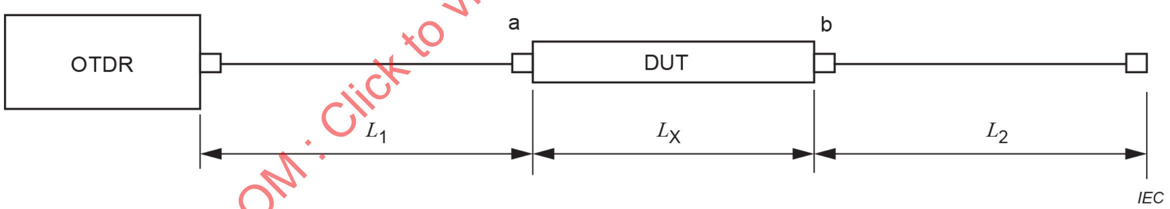
Key

a, b reflective events

L_1 fibre launch section optical length

L_X DUT section optical length

Figure 7 – Method 1 – One launch section



Key

a, b reflective events

L_1 fibre launch section optical length

L_2 fibre launch section optical length

L_x DUT section optical length

Figure 8 – Method 2 – Two launch sections

Fibre launch sections L_1 and L_2 provide separation between the OTDR equipment and the events to be measured and ensure stable measurement conditions. Their minimum optical length is determined by the ability of the OTDR to resolve the measurement of attenuation and is commonly referred to as the attenuation dead zone. The maximum optical length of the launch section is limited by requirement to minimize the OTDR distance resolution and to minimize optical losses of measured route.

If the DUT section length, L_X, is greater than the OTDR resolution (L_X > attenuation dead zone), then the attenuation for each event, a and b, will be displayed separately. Where L_X < attenuation dead zone, the OTDR will be unable to distinguish between events a and b and the DUT will be shown as one attenuation event.

Where the DUT is terminated with either a connector plug or a receptacle, an RP and RA are added, as necessary, to form complete connector assemblies. These connector assemblies are considered part of the DUT.

Where the component has pigtails, connector points are required. The pigtail lengths shall be greater than the OTDR resolution for each event to be displayed separately.

6.5.2 Bidirectional measurement

The value of attenuation is determined from the intensity difference of back-scattering before and after the DUT, so the launch section L_2 is needed if the DUT does not itself have sufficiently long pigtails, compared to the attenuation dead zone. Since the backscattering coefficient of the fibre before and after the DUT can differ, the OTDR measurement shall be made from both ends of the assembly of DUT and launch sections, without changing the ordering of this assembly. The attenuation result is the average of the apparent attenuation from the two OTDR measurements.

Differences in the backscatter coefficient of the fibre on either side of the DUT will result in an error in a one-way OTDR measurement. The error in a measurement made in one direction will be positive and the error in the other direction will be negative. The use of an average of readings taken in opposite directions cancels the error due to differences in the backscatter coefficient of the two fibres.

Referring to the two measured attenuation values, illustrated in 6.5.4, as A_1 and A_2, the average attenuation is calculated as:

$$A = \frac{A_1 + A_2}{2} \text{ (dB).} \qquad (2)$$

See IEC TR 62316 for further details.

6.5.3 Measurement method

Configure the apparatus as shown in Figure 7 or Figure 8 with the OTDR equipment connected to side a.

– Set the OTDR measurement characteristics.
– Take an attenuation measurement in direction a-b and save the resulting OTDR data for evaluation.

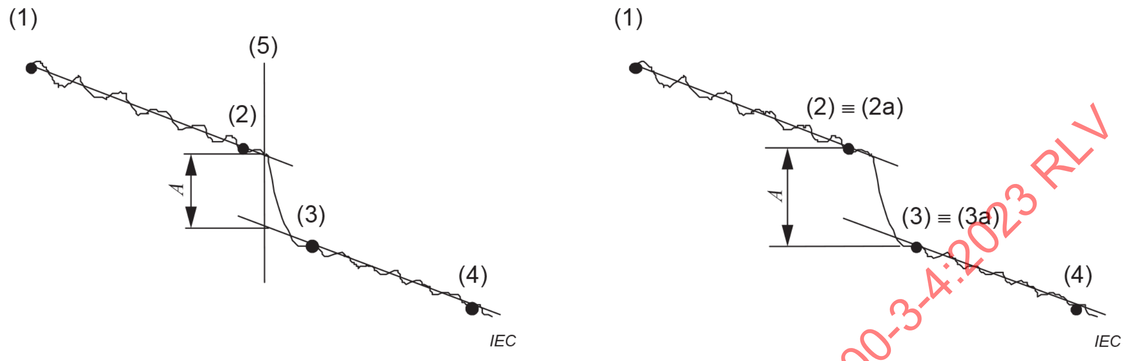
Configure the apparatus as shown in Figure 7 or Figure 8 with the OTDR equipment connected to side b.

– Set the same OTDR measurement characteristics as for the side a.
– Take an attenuation measurement in direction b-a and save the resulting OTDR data for evaluation.

6.5.4 Evaluation procedure

6.5.4.1 General

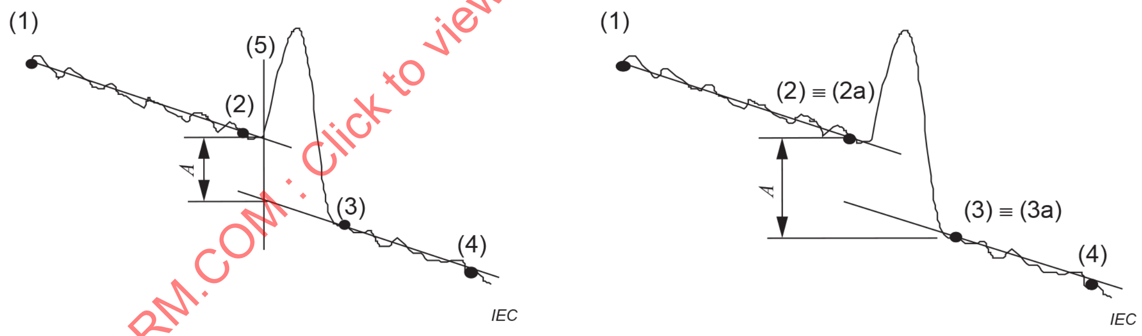
A typical OTDR display of the backscatter signal from a DUT with a non-reflective event is illustrated in Figure 9 a) and Figure 9 b).



a) **Five-point evaluation** b) **Four-point evaluation**

Figure 9 – Non-reflective event evaluation

A typical OTDR display of the backscatter signal from a DUT with a reflective event is illustrated in Figure 10 a) and Figure 10 b). To avoid the reflection peak affecting the attenuation measurement, the distance between the reference markers and the peak should be suitably long. Alternatively, a suitable filter, specified in the relevant specification, should be used to mask the reflection.



a) **Five-point evaluation** b) **Four-point evaluation**

Figure 10 – Reflective event evaluation

6.5.4.2 Five-point evaluation

Set evaluation points (1) and (2) on the fibre section in front of the DUT and (3) and (4) on the fibre section behind the DUT. Set the position of decision point (5). Attenuation, A, shall be calculated as the power level difference at point (5) between the least squares approximation curve of the fibre section in front of the DUT and the least squares approximation curve of the fibre behind the DUT.

6.5.4.3 Four-point evaluation

Set evaluation points (1) and (2) on the fibre section in front of the DUT and (3) and (4) on the fibre section behind the DUT. Attenuation, A, shall be calculated as the power-level difference between point (2a) of the least squares approximation curve of the fibre section in front of the DUT and point (3a) of least squares approximation curve of the fibre behind the DUT.

7 Details to be specified and reported

The following details, as applicable, shall be specified in the relevant specification and shall be reported in the test report:

- test method;
- source characteristics;
- performance requirements (allowable attenuation);
- power meter characteristics;
- relevant fibre parameters;
- OTDR characteristics:
  - wavelength;
  - range;
  - pulse width;
  - averaging time;
  - optical lengths L_1, L_2, L_x.
- measurement uncertainty (refer to IEC TR 62627-04);
- deviations from this test method.

Annex A
(informative)

Consideration of multicore fibre

A.1 General

When considering DUT utilizing multicore fibre (MCF), the fundamental attenuation procedures and apparatus described in this document are still applicable. However, it is necessary to add an optical switch and a fan-out device to the measurement system between the source and MCF DUT so that each core within the fibre can be measured as if it were a standalone fibre. The resulting measurement system is similar to the measurement system for multifiber connectors and passive components.

Clause A.2 describes the additional considerations, above and beyond the text in the document, which is needed to satisfy the attenuation measurement of a MCF DUT.

A.2 Additional apparatus

A.2.1 Optical switch (OSW)

An optical switch is a passive component possessing one or more ports which selectively transmits, redirects or blocks optical power in an optical fibre transmission line. The optical switch should be located between the source and fan-out device and allows the light emitted by the source to be transmitted to one leg of the fan-out device which in turn transmits the light through the associated core in the multifibre DUT and allows switching the light path to the subsequent cores.

A.2.2 Fan-in/fan-out device (FIFO)

The fan-in/fan-out device encompasses a means of splitting the MCF into individual, standard single core fibres (SCF). The device can take the form of a MCF connector plug (MCF plug), a core splitting device (waveguide, splitter, etc.) and individual, SCF legs. A general depiction of a FIFO device can be seen in Figure A.1.

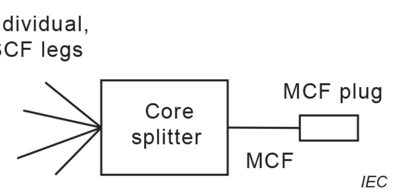


Figure A.1 – FIFO device example

A.3 Test setup and procedure – LSPM

The test setup and procedure for a MCF DUT using LSPM are similar to the methods described in 6.4 with the addition of the apparatus as specified in Clause A.2. For simplicity, a type 5 DUT with MCF and MCF connector plugs is considered with the test setup for insertion method B as shown in Figure A.2. This approach can be extrapolated to the other insertion methods for different DUT configuration types.

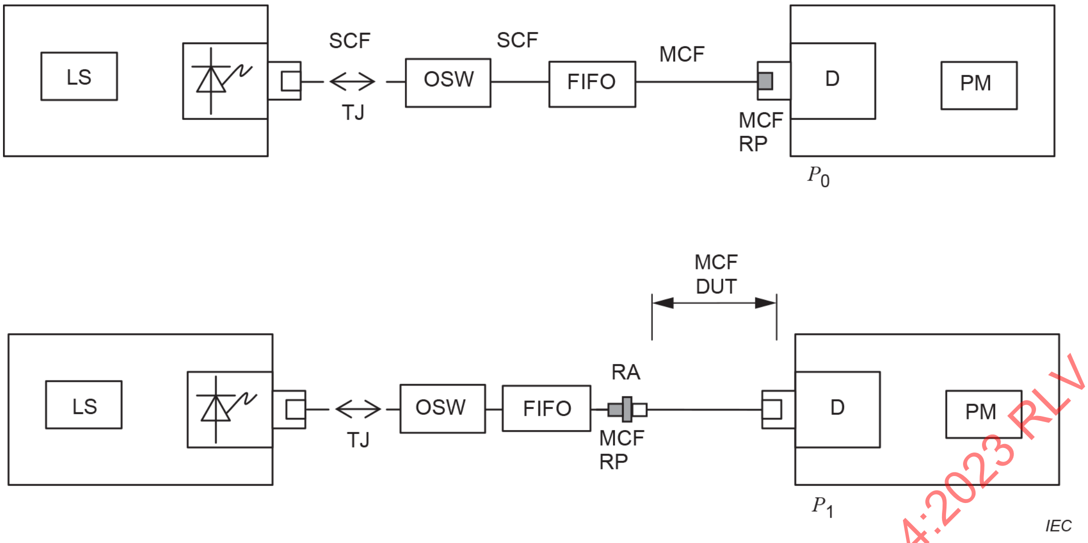


Figure A.2 – Insertion method B – Type 5 MCF DUT

The reference power measurement, P_0, and MCF DUT power measurement, P_1, should be taken individually for each core in the MCF. Formula (1) should be considered individually for each core to calculate the respective attenuation for each core in the MCF DUT.

A.4 Test setup and procedure – OTDR

The test setup and procedure for a MCF DUT using OTDR are similar to the methods described in 6.5 with the addition of the apparatus as specified in Clause A.2. For simplicity, the method using a one launch section is considered as shown in Figure A.3. This approach can be extrapolated to the method using two launch sections.

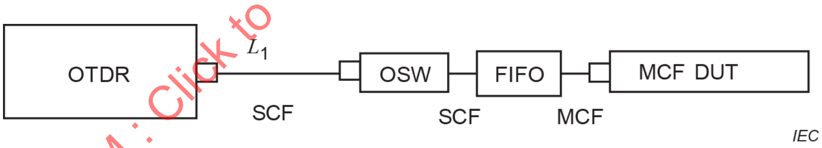


Figure A.3 – Method 1 – One launch section MCF DUT

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IEC 61300-3-2, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 3-2: Examinations and measurements – Polarization dependent loss in a single-mode fibre optic device*

IEC 61300-3-29, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 3-29: Examinations and measurements – Spectral transfer characteristics of DWDM components*

IEC 61300-3-34, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 3-34: Examinations and measurements – Attenuation of random mated connectors*

IEC 61300-3-45, *Fibre optic interconnecting devices and passive components - Basic test and measurement procedures - Part 3-45: Examinations and measurements - Attenuation of random mated multi-fibre connectors*

IEC TR 62000, *Guidelines for combining different single-mode fibre sub-categories*

IEC TR 62316, *Guidance for the interpretation of OTDR backscattering traces for single-mode fibres*

IEC TR 62627-01, *Fibre optic interconnecting devices and passive components – Part 01: Fibre optic connector cleaning methods*

IEC TR 62627-04, *Fibre optic interconnecting devices and passive components – Part 04: Example of uncertainty calculation: Measurement of the attenuation of an optical connector*

SOMMAIRE

COMMISSION ÉLECTROTECHNIQUE INTERNATIONALE

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DISPOSITIFS D'INTERCONNEXION ET COMPOSANTS PASSIFS FIBRONIQUES – PROCÉDURES FONDAMENTALES D'ESSAIS ET DE MESURES –

Partie 3-4: Examens et mesures – Affaiblissement

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Cette quatrième édition annule et remplace la troisième édition parue en 2012. Cette édition constitue une révision technique.

Cette édition inclut les modifications techniques majeures suivantes par rapport à l'édition précédente:

a) ajout de l'Article 3 relatif aux termes, définitions et abréviations;
b) ajout d'une nouvelle méthode de mesure LSPM, la méthode par insertion (D);

c) ajout de l'Annexe A qui décrit le mesurage de l'affaiblissement de la fibre multicœur;

d) modification de la méthode d'essai de référence par insertion C et de la méthode d'essai alternative par substitution ou par insertion D pour l'appareil de mesure de la puissance et le DUT de type 4.

Le texte de cette Norme internationale est issu des documents suivants:

Projet	Rapport de vote
86B/4656/FDIS	86B/4675/RVD

Le rapport de vote indiqué dans le tableau ci-dessus donne toute information sur le vote ayant abouti à son approbation.

La langue employée pour l'élaboration de cette Norme internationale est l'anglais.

Ce document a été rédigé selon les Directives ISO/IEC, Partie 2, il a été développé selon les Directives ISO/IEC, Partie 1 et les Directives ISO/IEC, Supplément IEC, disponibles sous www.iec.ch/members_experts/refdocs. Les principaux types de documents développés par l'IEC sont décrits plus en détail sous www.iec.ch/standardsdev/publications.

La liste de toutes les parties de la série IEC 61300, publiées sous le titre général, *Dispositifs d'interconnexion et composants passifs fibroniques – Procédures fondamentales d'essais et de mesures*, peut être consultée sur le site web de l'IEC.

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DISPOSITIFS D'INTERCONNEXION ET COMPOSANTS PASSIFS FIBRONIQUES – PROCÉDURES FONDAMENTALES D'ESSAIS ET DE MESURES –

Partie 3-4: Examens et mesures – Affaiblissement

1 Domaine d'application

La présente partie de l'IEC 61300 décrit les différentes méthodes disponibles qui permettent de mesurer l'affaiblissement des composants optiques. Toutefois, elle n'est applicable ni aux mesurages de l'affaiblissement dû à l'accouplement aléatoire décrits dans l'IEC 61300-3-34 et l'IEC 61300-3-45 ni aux mesurages de l'affaiblissement des dispositifs de multiplexage par répartition en longueur d'onde à forte densité (DWDM - *dense wavelengths division multiplexer*) décrits dans l'IEC 61300-3-29.

2 Références normatives

Les documents suivants sont cités dans le texte de sorte qu'ils constituent, pour tout ou partie de leur contenu, des exigences du présent document. Pour les références datées, seule l'édition citée s'applique. Pour les références non datées, la dernière édition du document de référence s'applique (y compris les éventuels amendements).

IEC 60793-2-10, *Fibres optiques – Partie 2-10: Spécifications de produits – Spécification intermédiaire pour les fibres multimodales de catégorie A1*

IEC 60793-2-50, *Fibres optiques – Partie 2-50: Spécifications de produits – Spécification intermédiaire pour les fibres unimodales de classe B*

IEC 60825-1, *Sécurité des appareils à laser – Partie 1: Classification des matériels et exigences*

IEC 61300-1, *Dispositifs d'interconnexion et composants passifs fibroniques – Procédures fondamentales d'essais et de mesures – Partie 1: Généralités et recommandations*

IEC 61300-3-35, *Dispositifs d'interconnexion et composants passifs à fibres optiques – Procédures fondamentales d'essais et de mesures – Partie 3-35: Examens et mesures – Examen visuel des connecteurs à fibres optiques et des émetteurs-récepteurs à embase fibrée*

IEC 61755 (toutes les parties), *Dispositifs d'interconnexion et composants passifs fibroniques – Interfaces optiques de connecteur pour fibres unimodales*

IEC 63267 (toutes les parties), *Fibre optic interconnecting devices and passive components – Connector optical interfaces for enhanced macro bend loss multimode fibres* (disponible en anglais seulement)

3 Termes, définitions et abréviations

3.1 Termes et définitions

Pour les besoins du présent document, les termes et définitions de l'IEC 61300-1 s'appliquent.

L'ISO et l'IEC tiennent à jour des bases de données terminologiques destinées à être utilisées en normalisation, consultables aux adresses suivantes:

- IEC Electropedia: disponible à l'adresse http://www.electropedia.org/
- ISO Online browsing platform: disponible à l’adresse http://www.iso.org/obp

3.2 Abréviations

ATM	(alternative test method) méthode d'essai alternative
C	composant optique passif
CWDM	(coarse wavelength division multiplexing) multiplexage par répartition en longueur d'onde grossière
D	détecteur optique
DUT	(device under test) dispositif en essai
FIFO	(fan-in/fan-out device) dispositif d’entrance/sortance
LED	diode électroluminescente
LS	(optical light source) source lumineuse optique
LSPM	(optical light source and power meter) mesureur de puissance de la source lumineuse optique
MCF	(multicore fibre) fibre multicœur
OSW	(optical switch) commutateur optique
OTDR	(optical time domain reflectometer) réflectomètre optique dans le domaine temporel
PDL	(polarization dependent loss) perte dépendant de la polarisation
PM	(optical power meter) appareil de mesure de la puissance optique
RA	(reference adaptor) raccord de référence
RP	(reference plug) fiche de référence
RTM	(reference test method) méthode d’essai de référence
SCF	(single core fibre) fibre unipolaire
TJ	(temporary joint) jonction temporaire

4 Description générale

4.1 Généralités

L’affaiblissement est destiné à fournir une valeur de diminution de la puissance optique, exprimée en décibels, résultant de l’insertion d’un DUT dans une liaison optique. Le terme de "perte d’insertion" est parfois utilisé à la place du terme "affaiblissement".

Le DUT peut comporter plus de deux ports optiques. Cependant, le mesurage de l'affaiblissement étant réalisé avec deux ports seulement, la description du DUT, dans le présent document, doit faire référence à deux ports.

La méthode de référence pour le mesurage de l'affaiblissement utilise un LSPM. Les mesurages avec un OTDR sont présentés à titre de méthodes alternatives. Trois variantes de mesurage de l'affaiblissement avec un LSPM sont présentées ici.

4.2 Précautions à prendre

Le niveau de puissance dans la fibre et dans le DUT ne doit pas atteindre un niveau tel qu'il génère des effets de diffusion non linéaires et des effets de surcharge du DUT.

Il convient de fixer la position des fibres au cours de l'essai entre le mesurage sans le DUT, P_0 et avec le DUT inséré, P_1 afin d'éviter les variations d'affaiblissement dues aux pertes liées aux courbures.

Dans les mesurages multimodaux, une modification de la répartition modale dans le système de mesure, due aux perturbations des fibres, peut affecter le mesurage de l'affaiblissement.

Les composants avec des PDL présentent une valeur d'affaiblissement différente selon l'état d'entrée de la polarisation en provenance de la source. Lorsque la composante PDL peut dépasser l'incertitude acceptable dans le mesurage de l'affaiblissement, alors il convient d'utiliser une source de brouillage non polarisée ou polarisée pour mesurer l'affaiblissement moyenné sur la polarisation soit il convient d'utiliser les méthodes de l'IEC 61300-3-2 pour mesurer ensemble la PDL et l'affaiblissement.

Les recommandations relatives à la sécurité des lasers de l'IEC 60825-1 doivent être suivies.

5 Appareillage

5.1 Conditions d'injection et source lumineuse (LS)

Les conditions d'injection du LSPM et de l'OTDR doivent être conformes à l'IEC 61300-1 et doivent être mesurées à la sortie du connecteur d'injection de référence.

L'unité source comprend un émetteur optique, les dispositifs électroniques de commande associés et la fibre amorce (le cas échéant). Les conditions concernant les sources préférentielles sont données dans le Tableau 1. La stabilité de la source pour les fibres unimodales à 23 °C doit être de ±0,01 dB de la valeur initiale tout au long du mesurage. La stabilité de la source pour les fibres multimodales à 23 °C doit être de ±0,05 dB de la valeur initiale tout au long du mesurage. La puissance de sortie de la source doit être supérieure ou égale à 20 dB au-dessus du niveau de puissance minimal mesurable.

Tableau 1 – Conditions concernant la source préférentielle

No	Type	Longueur d'onde centrale nm	Largeur spectrale (efficace) RMS nm	Type de source
S1	Multimodal	660 ± 30	≥ 10	Monochromateur ou LED
S2	Multimodal	780 ± 30	≥ 10	Monochromateur ou LED
S3	Multimodal	850 ± 30	≥ 10	Monochromateur ou LED
S4	Multimodal	1 300 ± 30	≥ 10	Monochromateur ou LED
S5	Unimodal	1 310 ± 30	À consigner	Diode laser monochromateur ou LED
S6	Unimodal	1 550 ± 30	À consigner	Diode laser monochromateur ou LED
S7	Unimodal	1 625 ± 30	À consigner	Diode laser monochromateur ou LED
Il est reconnu que certaines composantes, par exemple les CWDM, peuvent nécessiter l'utilisation d'autres types de sources, tels que les lasers accordables. Il est par conséquent recommandé de spécifier, dans ces cas, les caractéristiques de source préférentielles sur la base des composantes destinées à être mesurées. NOTE La longueur d'onde centrale (longueur d'onde centroïdale) et la largeur spectrale sont définies dans l'IEC 61280-1-3.				

5.2 Appareil de mesure de la puissance optique (PM)

L'appareil de mesure de la puissance comprend un détecteur optique (D), le mécanisme destiné à le connecter à ce dernier, et l'électronique de détection associée. Il convient de réaliser le raccordement au détecteur soit au moyen d'un raccord qui accepte une fibre nue, soit au moyen d'une fiche de connecteur de conception appropriée.

Le système de mesure doit être stable dans les limites spécifiées sur la période exigée pour le mesurage de P_0 et P_1. Pour les mesurages qui nécessitent une coupure de la connexion au détecteur entre le mesurage de P_0 et P_1, la répétabilité de mesure doit être inférieure ou égale à 0,02 dB. À cet effet, il convient d'utiliser un détecteur à large surface sensible.

La plage dynamique de l'appareil de mesure de la puissance doit être à même de mesurer le niveau de puissance sortant du DUT à la longueur d'onde mesurée.

Les paramètres préférentiels de l'appareil de mesure de la puissance sont donnés dans le Tableau 2 ci-dessous. Il convient d'étalonner l'appareil de mesure de la puissance pour la plage de longueurs d'onde et le niveau de puissance à mesurer. Il convient que la stabilité de l'appareil de mesure de la puissance soit inférieure ou égale à 0,01 dB sur la durée de mesure et la plage de température. La stabilité et la validité des corrections du courant d'obscurité de l'étalonnage de mise à zéro peuvent influencer cet aspect.

Tableau 2 – Paramètres préférentiels de l'appareil de mesure de la puissance

Nombre	Type	Non-linéarité maximale dB	Incertitude relative dB
D1	Multimodal	±0,05 (-60 dBm < puissance en entrée < -5 dBm)	≤ 0,05
D2	Unimodal	±0,01 (affaiblissement < 10 dB) ±0,05 (10 dB < affaiblissement < 60 dB)	≤ 0,02

Afin d'assurer que toute la lumière sortant de la fibre est détectée par l'appareil de mesure de la puissance, il convient que la surface sensible du détecteur et la position relative entre celui-ci et la fibre soient compatibles avec l'ouverture numérique de la fibre.

NOTE Les sources communes d'incertitude relative sont la dépendance par rapport à la polarisation et les perturbations avec les réflexions de l'appareil de mesure de la puissance et des surfaces du connecteur à fibres optiques. La sensibilité de l'appareil de mesure de la puissance à de telles réflexions peut être caractérisée par le paramètre d'ondulation spectrale, déterminé comme la variation périodique en réponse par rapport à la longueur d'onde d'une source de lumière cohérente.

5.3 Jonction temporaire (TJ)

La jonction temporaire est une méthode, un dispositif ou un appareil mécanique permettant d'aligner temporairement deux extrémités de fibres dans une liaison stable, reproductible et à faible perte. Elle est utilisée lorsque le raccordement direct du DUT au système de mesure n'est pas réalisable par un connecteur normalisé. Il peut s'agir, par exemple, d'un plateau de serrage à vide de précision à rainure en V, d'un plateau de maintien par dépression, d'un micromanipulateur ou d'une épissure par fusion ou mécanique. La jonction temporaire doit être stable dans les limites de ±10 % de l'incertitude de mesure exigée en dB sur la période utilisée pour le mesurage de P_0 et P_1. Un matériau adaptateur d'indice de réfraction approprié peut être utilisé pour améliorer la stabilité de la TJ.

5.4 Fibre

Les fibres dans le lien entre la source et la jonction temporaire, dans le cordon de brassage d'essai et le cordon de brassage de substitution, doivent appartenir à la même catégorie que celles utilisées dans le DUT.

Les fibres doivent être conformes à l'IEC 60793-2-10 ou à l'IEC 60793-2-50.

5.5 Fiche de référence (RP)

Lorsqu'une RP doit former des ensembles de connecteurs complets dans n'importe laquelle de ces méthodes d'essai, la RP devient effectivement une partie du DUT pendant le mesurage de l'affaiblissement. La RP doit satisfaire aux exigences de la norme d'interface optique correspondante qui figurent dans les séries IEC 61755 ou IEC 63267.

5.6 Raccord de référence (RA)

Lorsqu'une RA doit former des ensembles de connecteurs complets dans n'importe laquelle de ces méthodes d'essai, la RA devient effectivement une partie du DUT pendant le mesurage de l'affaiblissement. La RA doit satisfaire aux exigences de la norme d'interface optique correspondante qui figurent dans les séries IEC 61755 ou IEC 63267.

5.7 Sortie

Une sortie peut être constituée d'une fibre nue, d'une fiche de connecteur ou d'une embase. Lorsqu'une fibre nue est utilisée comme sortie, une TJ ou un raccord de fibre nue est utilisé(e) en fonction de la configuration de l'essai et de l'emplacement de l'extrémité de la fibre nue. Lorsqu'un DUT possède plusieurs fiches de connecteur ou d'embases, celles-ci peuvent être de types identiques ou différents. Lorsque le DUT a des fiches de connecteur ou des embases différentes à chaque extrémité, une ATM peut être nécessaire.

6 Procédure

6.1 Préconditionnement

Les interfaces optiques du DUT doivent être propres et exemptes de débris susceptibles d'affecter la performance de l'essai et de tout mesurage qui en résulte. La procédure de nettoyage du fabricant doit être suivie.

Le DUT doit pouvoir se stabiliser aux conditions atmosphériques normalisées selon l'IEC 61300-1 pendant au moins 1 h avant les essais.

Il convient de veiller, au cours de l'essai, à ce que les surfaces d'accouplement ne soient pas contaminées par de l'huile ou de la graisse. Il est reconnu que les doigts nus peuvent déposer un film de graisse.

6.2 Examen visuel

La propreté de toutes les extrémités des connecteurs doit être contrôlée conformément à l'IEC 61300-3-35, et un nettoyage doit être effectué au besoin. Les méthodes de nettoyage recommandées pour les extrémités des connecteurs sont décrites dans l'IEC TR 62627-01.

6.3 Types de configuration du DUT et méthodes d'essai

Huit types de configuration différents de DUT sont décrits dans le Tableau 3. Les différences entre ces types de configuration concernent principalement les sorties des ports optiques. Les sorties peuvent être constituées d'une fibre nue, d'une fiche de connecteur ou d'une embase.

Les méthodes d'essai de référence et alternatives à utiliser pour chaque type de configuration de DUT sont définies dans le Tableau 3. Différentes configurations et méthodes d'essai peuvent aboutir à des incertitudes différentes de l'affaiblissement mesuré. En cas de litige, il convient d'utiliser la méthode d'essai de référence.

Les considérations relatives aux dispositifs avec fibre multicœur sont données à l'Annexe A.