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Edition 3.0 2012-12

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 à fibres optiques – Méthodes fondamentales d'essais et de mesures –
Partie 3-4: Examens et mesures – Affaiblissement

IEC 61300-3-4:2012

IEC Central Office
3, rue de Varembé
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
Fax: +41 22 919 03 00
info@iec.ch
www.iec.ch

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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

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

This third edition cancels and replaces the second edition published in 2001. It constitutes a technical revision.

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

a) revision of source conditions, launch conditions and power meter parameters;

b) addition of safety recommendations;

c) removal of launch condition details for multimode fibres, now referenced in 61300-1.

The text of this standard is based on the following documents:

FDIS	Report on voting
86B/3494/FDIS	86B/3541/RVD

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

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all the parts in IEC 61300 series, published under the general title, *Fibre optic interconnecting and passive components – Basic test and measurement procedures,* can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication 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- withdrawn,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 dense wavelength division multiplexing (DWDM) components, for which IEC 61300-3-29 should be used.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. 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 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/TR 62316, *Guidance for the interpretation of OTDR backscattering traces*

3 General description

3.1 General

Attenuation is intended to give a value for the decrease of useful power, expressed in decibels, resulting from the insertion of a device under test (DUT), within a length of optical fibre cable. 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 DUTs in this standard 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.

3.2 Precautions

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

The position of the fibres in the test should be fixed between the measurement of P_0 and 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 affect the attenuation measurement.

Components with polarization dependent loss 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 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 safety recommendations in IEC 60825-1, Safety of laser products, should be followed.

4 Apparatus

4.1 Launch conditions and source (S)

Table 1 – Preferred source conditions

No.	Type	Central wavelength nm	Spectral width nm	Source type
S1	Multi-mode	660 ± 30	≥30	Monochromator or LED
S2	Multi-mode	780 ± 30	≥30	Monochromator or LED
S3	Multi-mode	850 ± 30	≥30	Monochromator or LED
S4	Multi-mode	1 300 ± 30	≥30	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, e.g. for CWDM, may 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 and spectral width are defined in IEC 61280-1-3.

The launch condition shall be specified in accordance with Clause 9 of IEC 61300-1:2011.

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 over the duration of the measurement. The stability of the multimode fibre source at 23 °C shall be ± 0,05 dB over the duration of the measurement. The source output power shall be ≥ 20 dB above the minimum measurable power level.

4.2 Optical power meter (D)

The power meter unit consists of an optical detector, the mechanism for connecting to it and associated detection electronics. The connection to the detector will 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 be broken between the measurement of P_0 and P_1, the measurement repeatability shall be within 0,02 dB. A detector with a large sensitive area may 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 be calibrated for the operational wavelength and power level. The power meter stability should be ≤ 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	Multi-mode	± 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.

4.3 Temporary joint (TJ)

This 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 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.

4.4 Fibre

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

Fibres should be in accordance with IEC 60793-2.

4.5 Reference plugs (RP)

Where reference plugs are required to form complete connector assemblies in any of the test methods, the reference plugs become in effect a part of the DUT during the measurement of attenuation. Reference plugs shall be specified in the relevant specification.

4.6 Reference adaptors (RA)

Where reference adaptors are required to form complete connector assemblies in any of the test methods, the reference adaptors become in effect a part of the DUT during the measurement of attenuation. Reference adaptors shall be specified in the relevant specification.

5 Procedure

5.1 Pre-conditioning

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 for at least 1 h prior to testing.

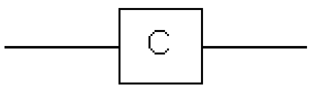
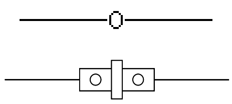
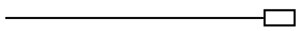
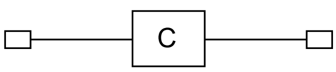
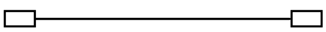
Care should be exercised throughout the test to ensure that mating surfaces are not contaminated with oil or grease. It is recognized that bare fingers can deposit a film of grease.

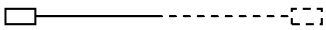
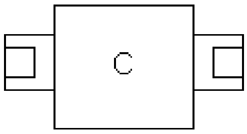
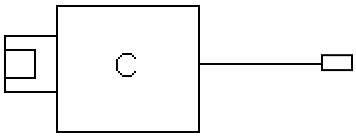
5.2 Visual inspection

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.

5.3 DUT configurations and test methods

Table 3 – DUT configurations

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)	Power meter (insertion C) Or OTDR
5	Plug to plug (patchcord)		Power meter (insertion B)	Power meter (insertion C) Or OTDR

Type	Description	DUT	Test methods	
			Reference test method RTM	**Alternative test method** ATM
6	Single plug (pigtail)		Power meter (insertion B)	OTDR
7	Receptacle to receptacle (component)		Power meter (insertion C)	Power meter (substitution) Or OTDR
8	Receptacle to plug (component)		Power meter (insertion C)	Power meter (substitution) Or OTDR

C is a passive optical component which may have more than the two ports indicated. Insertion measurements and cutback measurements may be expected to give equivalent measurements for type 2 DUTs.

Due to measurement considerations, the OTDR method may be less accurate than other measurement methods but may be the only test applicable.

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.

5.4 Attenuation measurements with a power meter

5.4.1 General

The measurement of attenuation using cutback, substitution or insertion is based on the use of an optical power meter,as described in 4.2.

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

$$A = -10\log\frac{P_1}{P_0} \text{ dB} \qquad (1)$$

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.

5.4.2 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.

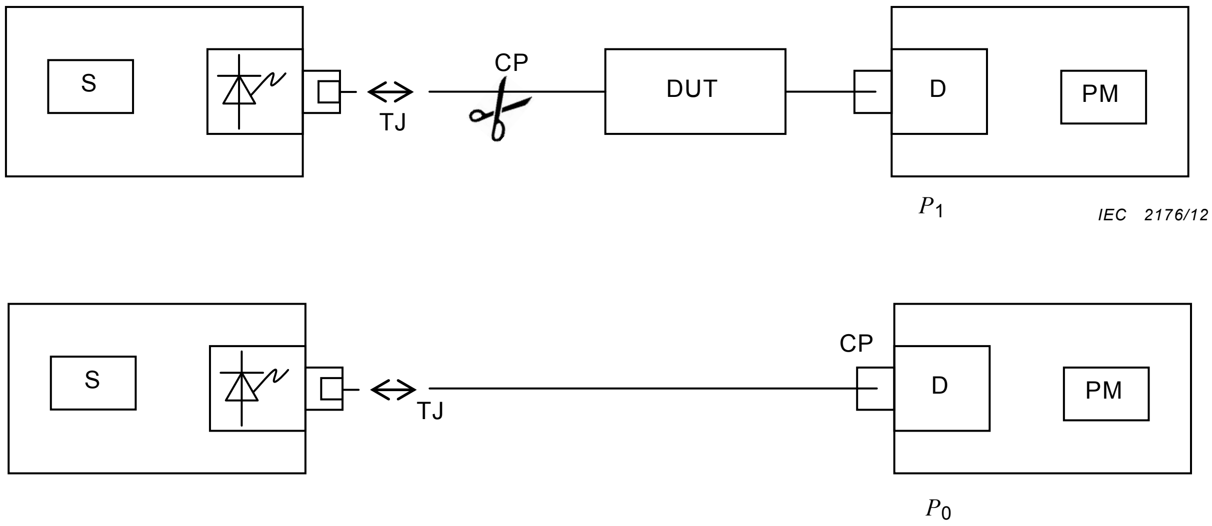


Figure 1 – Cutback method – Type 1, Type 2 and Type 3 DUTs

For a Type 3, fibre-to-plug DUT, a reference adaptor and a reference plug 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 with pigtail leads, and is measured as a Type 1 DUT.

5.4.3 Substitution method

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

For a type 4 DUT, reference adaptors are added to the reference plugs on both the source lead and the test patchcord (see Figure 2).

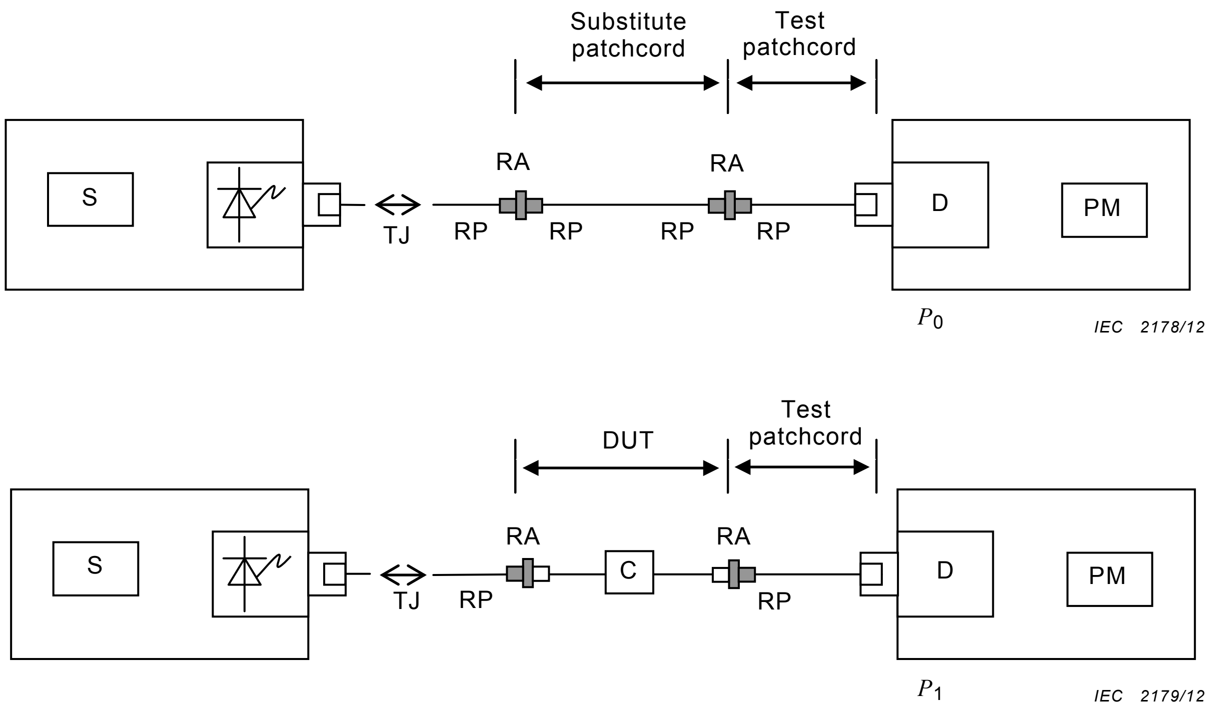


Figure 2 – Substitution method – Type 4 DUT

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 be expected to give somewhat lower results of attenuation than insertion measurements for types 4, 5, 6, and 7 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.

5.4.4 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).

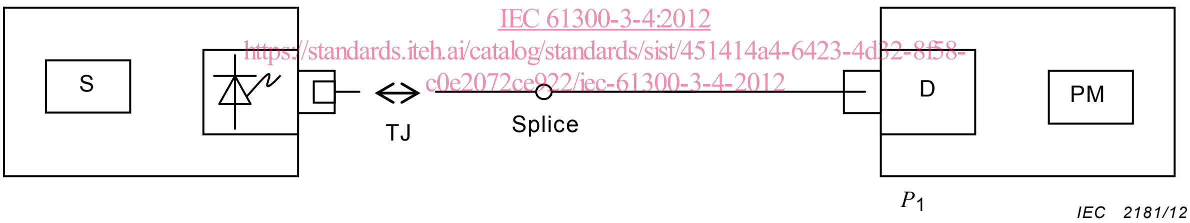


Figure 3 – Insertion method (C1) – Type 2 DUT

5.4.5 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 reference plug on the fibre from the temporary joint. A reference adaptor and the DUT are added, and P_1 is measured (see Figure 4).