

INTERNATIONAL STANDARD

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Second edition
2003-02

Fibre optic interconnecting devices and passive components – Basic test and measurement procedures –

Part 3-6: Examinations and measurements – Return loss

*Dispositifs d'interconnexion et composants passifs
à fibres optiques –
Méthodes fondamentales d'essais et de mesures –*

*Partie 3-6:
Examens et mesures – Puissance réfléchie*



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International Electrotechnical Commission, 3, rue de Varembé, PO Box 131, CH-1211 Geneva 20, Switzerland
Telephone: +41 22 919 02 11 Telefax: +41 22 919 03 00 E-mail: inmail@iec.ch Web: www.iec.ch



Commission Electrotechnique Internationale
International Electrotechnical Commission
Международная Электротехническая Комиссия

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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

Part 3-6: Examinations and measurements – Return loss

FOREWORD

- 1) The IEC (International Electrotechnical Commission) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of the 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, the IEC publishes International Standards. 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. The 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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International Standard IEC 61300-3-6 has been prepared by subcommittee 86B: Fibre optic interconnecting devices and passive components, of IEC technical committee 86: Fibre optics.

This second edition cancels and replaces the first edition published in 1997 and its amendments 1 (1998) and 2 (1999). This edition constitutes a technical revision.

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

FDIS	Report on voting
86B/1778/FDIS	86B/1832/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.

IEC 61300 consists of the following parts, under the general title *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures*:

- Part 1: General and guidance
- Part 2: Tests
- Part 3: Examinations and measurements

The committee has decided that the contents of this publication will remain unchanged until 2007. At this date, the publication will be

- reconfirmed;
- withdrawn;
- replaced by a revised edition, or
- amended.

A bilingual version of this publication may be issued at a later date.

Withdrawn

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

Part 3-6: Examinations and measurements – Return loss

1 Scope

This part of IEC 61300 presents procedures for the measurement of the return loss (RL) of a fibre optic device under test (DUT). RL, as used in this standard, is the ratio of the power (P_i) incident on, or entering, the DUT to the total power reflected (P_r) by the DUT, expressed in decibels:

$$RL = -10 \cdot \log\left(\frac{P_r}{P_i}\right) \quad (1)$$

Return loss is a positive number.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60793-2 (all parts), *Optical fibres – Product specifications*

IEC 61300-1, *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 61300-3-39, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 3-39: Examinations and measurements – PC optical connector reference plug selection*

3 General description

Four methods will be presented for measuring optical return loss:

- measurement with an optical continuous wave reflectometer (OCWR) (method 1);
- measurement with an optical time domain reflectometer (OTDR) (method 2);
- measurement with an optical low coherence reflectometry (OLCR) (method 3);
- measurement with an optical frequency domain reflectometry (OFDR) (method 4).

These four measurement methods have different characteristics and different applications in terms of spatial resolution and detectable RL (in annex A a comparison of return loss detectable by the four different methods is reported).

3.1 Method 1

This technique is the nearest to the theoretical definition of return loss given by equation (1). It measures directly the incident power and the reflected power. It is not affected by instrumental data processing and it gives absolute measurement values, which are not relative to a reference reflection (technique A). This method has some limiting factors: it cannot spatially resolve two different reflections on the line and its dynamic range is limited by the characteristics of the branching device and by the ability to suppress the reflections beyond the one from the DUT.

3.2 Method 2

This method allows measurement of RL from reflection points on an optical line, with a spatial resolution in the metre range and with a dynamic range of more than 75 dB (depending on the pulse width) using an OTDR instrument.

The OTDR measurement method is very suitable for field measurements where it is necessary to measure RLs on long optical lines.

3.3 Method 3

The purpose of this method is to measure reflection profiles of single-mode optical devices with a micrometre spatial resolution and a high dynamic range (>90 dB) by using optical low-coherence interference.

The reflection profile is defined as a distribution of reflections at individual end-faces and/or connected points in single-mode optical devices. When the reflection at a particular point is $-R$ (dB), the return loss at this point is given by R (dB). This method measures the reflection at a point by detecting the power of a beat signal produced by optical interference between the reflected light and the reference light. When a component with dispersed reflections is analysed, each reflection can be identified and located, provided their separation is greater than the spatial resolution of the measurement system.

3.4 Method 4

The purpose of this procedure is to measure the return loss of single-mode optical devices with a spatial resolution in the centimetre range and high dynamic range (>70 dB) by using optical frequency domain reflectometry.

One of the prime benefits of this technique is the ability to spatially resolve the desired reflection from undesired ones, such as all of the connectors or unterminated ports on the DUT, without any dead zone. Moreover, the OFDR method is highly reliable and the apparatus can be compact.

Measurement in the frequency domain is based on the ability to convert information in the time domain by means of an inverse Fourier transform. In this way with a source modulated from some kHz to 1 GHz, it is possible to resolve two reflective points on an optical line separated by some centimetres.

3.5 Selection of reference measurement method

Due to the different characteristics of these methods, and their different application fields, the reference method depends on the type of DUT. For a component with $RL \leq 55$ dB the reference is method 1, for a component with $RL > 55$ dB the reference is method 2 using a pulse duration less than 100 ns. In cases in which it is necessary to resolve more reflection points separated by a distance of less than 5 m, the reference shall be method 3.

4 Apparatus and symbols

4.1 Device under test (DUT)

Where the DUT is the mounted connector on one end of a component, the reference mating plug shall be considered one-half of the DUT connection on the temporary joint (TJ) side and have the same end-face finish and minimum performance as the connectors to be measured.

Where the DUT is an entire component assembly terminated with pigtailed with or without connectors, reference plugs with pigtailed and, as required, reference adapters are to be added to those ports with connector terminations so as to form complete connector assemblies with pigtailed. Reference mating plugs shall then be considered one-half of the TJ and have the same end-face finish and minimum performance as the connectors to be measured. All unused ports shall be terminated as stated in 4.2.5.

Unless otherwise specified, reference plugs shall meet IEC 61300-3-39. The reference adapters shall meet the appropriate IEC connector interface dimensions and ensure a high degree of repeatability and reproducibility. It is recommended that the test adapters be tested and visually inspected after every 100 matings and replaced after 500 matings.

4.2 Method 1: measurements with OCWR

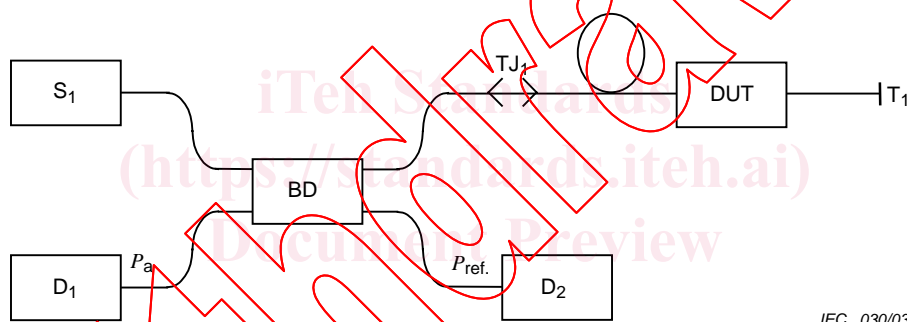


Figure 1 – Measurement set-up of return loss OCWR method

The circuit in Figure 1 is representative of, but is not the only, circuit that may be used for OCWR return loss measurement. The requirements are that the values measured satisfy the following two conditions:

- P_a (power measured by the detector D_1) shall be proportional to the power reflected from the DUT, P_r , plus the reflected power originating in the measurement circuit outside of the DUT, P_0 :

$$P_a = C_1 P_r + P_0 \quad (\text{mW}) \quad (2)$$

- P_{ref} (power measured by the detector D_2) shall be proportional to the power incident on the DUT, P_i :

$$P_{\text{ref}} = C_2 P_i \quad (\text{mW}) \quad (3)$$

where

P_r is the power reflected from the DUT (equation (1));

P_i is the power incident on the DUT (equation (1));

P_0 is the system reflected power originating in the measurement circuit;

C_1 is the branching device transfer coefficient;

C_2 is the splitting ratio of the branching device;

The following is a list of the apparatus and components used in the measurement of return loss using an OCWR (see Figure 1).

4.2.1 Branching device (BD)

The splitting ratio of the BD shall be stable and be insensitive to polarization ($<0,1$ dB). The directivity shall be at least 10 dB higher than the maximum return loss to be measured (see 5.4.4).

4.2.2 Detector (D1, D2 and D3)

The detector used consists of an optical detector, the associated electronics, and a means of connecting to an optic fibre. The optical connection may be a receptacle for an optical connector, a fibre pigtail or a bare fibre adapter.

The detectors are linear. Since all of the measurements are differential, however, it is not necessary that the calibration be absolute. Care shall be taken to suppress the reflected power from the detector D_2 during the measurement.

Where, during the sequence of measurements, a detector is disconnected and reconnected, the coupling efficiency for the two measurements shall be maintained.

4.2.3 Source (S_1 and S_2)

The source consists of an optical emitter, associated drive electronics, an excitation unit, and a fibre connector or fibre pigtail. A second source S_2 may be used for calibration, as illustrated in Figure 6. Where a second source is used, the central wavelength and spectral width of S_2 shall be the same as S_1 .

4.2.4 Temporary joint (TJ)

A temporary joint is a joint that is made to connect the DUT into the measurement circuit. Examples of temporary joints are a connector, splice, vacuum chuck or micro-manipulator. The loss of the TJ shall be stable and the TJ shall have a return loss of at least 10 dB greater than the maximum return loss to be measured (see 5.4.4).

Where a return loss greater than 50 dB is to be measured, a fusion splice is advised in order to guarantee the prescribed measurement precision.

4.2.5 Termination (T)

Fibre terminations marked T shall have a high return loss. Three types of terminations are suggested:

- angled fibre ends: the value of the angle depends on the fibre type; however, it shall be higher than 12° ;
- the application of an index match material to the fibre end;
- attenuation in the fibre, for example, with a mandrel wrap (not applicable to multimode fibre).

Where attenuation is used as a termination, it may be applied between components. For example, the measurement of P_0 in Figure 5 may be made by applying attenuation between TJ_1 and the DUT in Figure 8.

The fibre termination shall have a return loss of at least 20 dB greater than the maximum return loss to be measured.

Where a return loss greater than 50 dB is to be measured, the “attenuation in the fibre” termination technique is advised in order to guarantee the prescribed measurement precision.

4.3 Method 2: measurements with OTDR

The measurement set up for the RL measurement using an OTDR is shown in Figure 2. The following is a list of the apparatus and components used in the measurement.

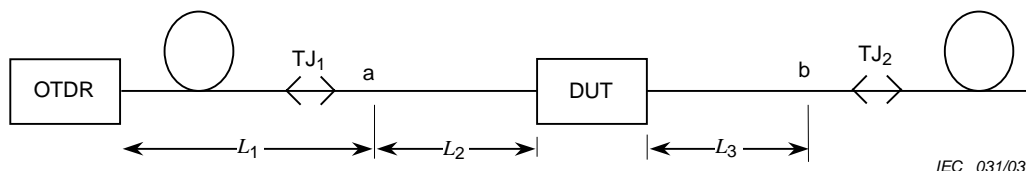


Figure 2 – Measurement set-up of return loss with OTDR method

4.3.1 Optical time domain reflectometer (OTDR)

An instrument able to measure the optical power backscattered along a fibre as a function of time. With this instrument it is possible to measure several characteristics of an optical line (attenuation, splice loss, splice location, fibre uniformity, breaks) by looking at the fibre from only one end. The return loss from a discontinuity in the fibre is one of the parameters that can be measured.

An attenuator at the OTDR receiver input may be required to reduce the optical power to a level that does not saturate the OTDR receiver (see 5.5.4).

4.3.2 Fibre sections (L_1 , L_2 , and L_3)

Sections of fibre that are to be included in an OTDR measurement. Section L_1 is required by most OTDRs to provide separation between the OTDR and the events to be measured. Sections L_2 and L_3 provide the space required for the OTDR to resolve the measurement of the return loss of the DUT. The fibre between points "a" and "b" shall have the same backscatter coefficient (see equation (15)).

Where the DUT is terminated with connectors, the connectors are part of the DUT, they shall fall between sections L_2 and L_3 .

4.3.3 Temporary joints (TJ)

A temporary joint is a joint that is made to connect the DUT into the measurement circuit. Examples of temporary joints are a connector, splice, vacuum chuck, or micromanipulator. The temporary joints shall be out of the "a"-"b" zone. The loss of the TJ shall be stable and shall have an RL sufficiently high that it does not affect the OTDR trace in the measurement zone.

In the case in which the temporary joints TJ₁ or TJ₂ fall between "a" and "b", the absolute value of the loss of these joints as measured by a one-way OTDR measurement shall be less than 0,10 H (see 5.5.4). To obtain this low H value, it may be necessary to work with several different fibre combinations to match the backscatter characteristics of the pigtails attached to the DUT.

4.4 Method 3: measurements with OLCR

The description of the apparatus shown in Figure 3 indicates only the principle of the method.

NOTE A practical measuring system needs to use various modifications, for example, to make a measurement independently of the state of polarization of the returning signal.