IEC 61300-3-7

Edition 3.0 2021-07

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Fibre optic interconnecting devices and passive components – Basic test and measurement procedures –
Part 3-7: Examinations and measurements – Wavelength dependence of attenuation and return loss of single mode components

Dispositifs d’interconnexion et composants passifs fibroniques – Procédures fondamentales d'essais et de mesures –
Partie 3-7: Examens et mesures – Affaiblissement et affaiblissement de réflexion des composants unimodaux en fonction de la longueur d’onde

IEC 61300-3-7:2021-07(en-fr)

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INTERNATIONAL
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INTERNATIONALE

ICS 33.180.20

ISBN 978-2-8322-1052-1

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IEC 61300-3-7 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 third edition cancels and replaces the second edition published in 2009. This edition constitutes a technical revision.

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

a) reduction of the number of alternative methods proposed to bring in-line with industry practice;
b) re-statement of the equations for insertion loss and return loss using logarithmic forms more common in the industry;
c) additional recommendations with respect to the creation of fibre terminations;

d) additional discussion on the characterization of the optical sources used in this document;
e) simplification of bi-directional testing;
f) removal of separate return loss only measurement procedures.

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

Draft	Report on voting
86B/4337/CDV	86B/4425A/RVC

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 parts in the 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 "http://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 3-7: Examinations and measurements – Wavelength dependence of attenuation and return loss of single mode components

1 Scope

This part of IEC 61300-3 describes methods available to measure the wavelength dependence of attenuation and return loss of two-port, single mode passive optical components. It is not, however, applicable to dense wavelength division multiplexing (DWDM) devices. Measurement methods of wavelength dependence of attenuation of DWDM devices are described in IEC 61300-3-29.

There are two measurement cases described in this document:

a) measurement of attenuation only;

b) measurement of attenuation and return loss at the same time.

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 60050-731, *International Electrotechnical Vocabulary (IEV) – Part 731: Optical fibre communication* (available at www.electropedia.org)

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

IEC 61755-2-4, *Fibre optic interconnecting devices and passive components – Connector optical interfaces – Part 2-4: Connection parameters of non-dispersion shifted single-mode physically contacting fibres – Non-angled for reference connection applications*

IEC 61755-2-5, *Fibre optic interconnecting devices and passive components – Connector optical interfaces – Part 2-5: Connection parameters of non-dispersion shifted single-mode physically contacting fibres – Angled for reference connection applications*

IEC TR 61931, *Fibre optic – Terminology*

IEC 62074-1, *Fibre optic interconnecting devices and passive components – Fibre optic WDM devices – Part 1: Generic specification*

3 Terms, definitions, abbreviated terms and quantity symbols

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60050-731, IEC TR 61931 and IEC 62074-1 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

APC	angled physical contact
ASE	amplified spontaneous emission
BBD	broadband detector
BBS	broadband light source
BD	branching device
BPON	broadband passive optical network
CC	coherent control
CWDM	coarse wavelength division multiplexing
DFB	distributed feedback
DOP	degree of polarization
DUT	device under test
DWDM	dense wavelength division multiplexing
ECL	external cavity laser
EDFA	erbium doped fibre amplifier
EDFL	erbium doped fibre laser
EPON	ethernet passive optical network
FBG	fibre Bragg grating
FEC	forward error correction
FP	Fabry-Perot
GPON	gigabit Ethernet passive optical network
IR	infra-red
LD	laser diode
LED	light emitting diode
NLS	narrow band light source
OADM	optical add drop multiplexer
OFA	optical fibre amplifier
OPM	optical power meter
OSA	optical spectrum analyzer
PDL	polarization dependent loss
PON	passive optical network
RA	reference adapter
RBD	reference branching device
RBW	resolution bandwidth
RL	return loss
RP	reference plug
RTM	reference test method
SLED	super light emitting diode
SMSR	side mode suppression ratio

SOP state of polarization

SSE source spontaneous emission

TJ temporary joint

TLS tuneable laser source

TND tuneable narrow band detection

TNLS tuneable narrow band light source

UV ultra violet

WDM wave division multiplexing

3.3 Quantity symbols

λ_k array of n (k = 1 to n) wavelengths to be measured, expressed in nm

$P_i(\lambda_k)$ input optical power to the device under test (DUT) of the k^{th} wavelength to be measured, expressed in dBm

$P_t(\lambda_k)$ output optical power from the output port of the DUT of the k^{th} wavelength to be measured, expressed in dBm

$P_r(\lambda_k)$ output optical power at the input port of the DUT propagating away from the input port of the k^{th} wavelength to be measured, expressed in dBm

$P_r'(\lambda_k)$ output optical power at the branching port of the reference branching device (RBD) propagating away from the input port of the RBD of the k^{th} wavelength to be measured, expressed in dBm

$A(\lambda_k)$ attenuation of the DUT at k^{th} wavelength, expressed in dB

$RL(\lambda_k)$ return loss of the DUT at k^{th} wavelength, expressed in dB

$RL^*(\lambda_k)$ calculated return loss of the DUT at k^{th} wavelength corrected for measurement apparatus RL, expressed in dB

$RL_0(\lambda_k)$ return loss of the measurement apparatus at k^{th} wavelength, expressed in dB

4 General description

4.1 General

Attenuation, $A(\lambda_k)$, is the relative decrease of transmitted optical power due to the insertion or addition of a component within a fibre-optic system. Return loss, $RL(\lambda_k)$, is the relative optical power reflected from a component inserted within a fibre-optic system. $A(\lambda_k)$ and $RL(\lambda_k)$ are expressed in decibels (dB) and are obtained by comparing the optical power incident on the DUT with the optical powers transmitted or reflected at the ports of the DUT. These terms are defined in IEC TR 61931.

4.2 Light source and detector conditions

$A(\lambda_k)$ and $RL(\lambda_k)$ are measured over a wavelength range defined by the DUT specifications. The spectral properties of the measurement system should be selected for the measurement of the attenuation performance specification of the DUT. These properties should include:

- wavelength setting resolution (wavelength difference between two adjacent data points);
- wavelength setting uncertainty;
- 3 dB spectral bandwidth of the light source or the tuneable narrowband detector (TND);
- source spontaneous emission (SSE) noise floor relative to peak power for the light source;
- degree of polarization (DOP).

The following performance guidelines shall be followed.

– The wavelength setting resolution shall be less than half the smallest resolvable attenuation feature. For example, when the attenuation changes over 1 nm the wavelength resolution shall be less than 0,5 nm.
– The 3 dB spectral bandwidth for the light source or the TND shall be less than half the wavelength resolution of the measurement.
– When the DOP of the source is more than 5 %, the polarization dependence of the detection system shall be considered as part of the total insertion loss uncertainty.

The impact of the source SSE noise floor on the uncertainty of the measurement depends strongly on the wavelength dependence of the DUT. For CWDM components, this shall be considered. The total ASE power over the measurement range limits the dynamic range of the measurement.

Additional information can be found in Annex B.

4.3 General explanation of attenuation and return loss

4.3.1 Attenuation

Attenuation, $A(\lambda_k)$, is the relative optical power reduction caused by the insertion of the DUT into an optical path and is illustrated in Figure 1. It is a function of wavelength. It is expressed as shown in Formula (1):

$$A(\lambda_k) = P_i(\lambda_k) - P_t(\lambda_k) \quad \text{(dB)} \tag{1}$$

where

$P_i(\lambda_k)$ is the optical power, as a function of wavelength, incident on and measured at the input port of the DUT, expressed in dBm;

$P_t(\lambda_k)$ is the optical power, as a function of wavelength, transmitted through and measured at the output port of the DUT, expressed in dBm.

4.3.2 Return loss

Return loss, $RL(\lambda_k)$ is the optical power reflected by the DUT relative to the incident power. It is a function of wavelength and is illustrated in Figure 1. It is expressed as shown in Formula (2):

$$RL(\lambda_k) = P_i(\lambda_k) - P_r(\lambda_k) \quad \text{(dB)} \tag{2}$$

where

$P_i(\lambda_k)$ is the optical power, as a function of wavelength, incident on and measured at the input port of the DUT, expressed in dBm;

$P_r(\lambda_k)$ is the optical power, as a function of wavelength, reflected by and measured from the input port of the DUT, expressed in dBm.

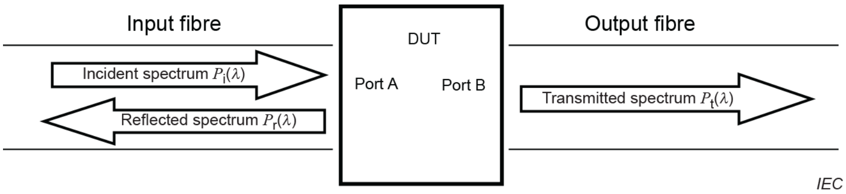


Figure 1 – Generic explanation of attenuation and return loss

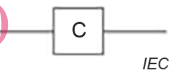
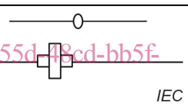
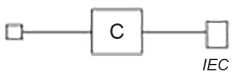
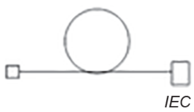
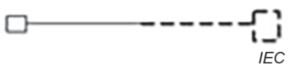
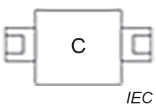
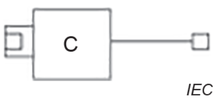
4.4 Device under test (DUT)

The DUT may have more than two ports. Only two ports are relevant for attenuation testing (input and output port) and only one is relevant for return loss testing (input port). It is not a requirement to measure attenuation and return loss at the same time.

Eight two-port DUT configurations are described in Table 1. Port connections may consist of bare fibre, connector plug, or receptacle. IEC 61300-3-4 describes multiple connection methods in detail. This document focuses on type 4 and type 7. If a multiport DUT is to be measured, all unused ports shall be terminated. For additional details, refer to Annex C.

A summary of the applicable DUT can be found in Annex A.

Table 1 – Device under test categories

Type	Description	DUT
1	Fibre to fibre (component)	
2	Fibre to fibre (splice or field-mountable connector set)	
3	Fibre to plug	
4	Plug to plug (component)	
5	Plug to plug (patchcord)	
6	Single plug (pigtail)	
7	Receptacle to receptacle (component)	
8	Receptacle to plug (component)	

Key

C: optical component

NOTE Type 1 can be measured using a temporary joint replacing optical connectors.

4.5 Measurement methods

The following measurement configurations are defined in Table 2. The applicable reference test method (RTM) is shown in Table 3.

Table 2 – Measurement methods

Method	Name	Light source	Detection system	Example
A	Broadband light source	BBS	TND	BBS + DUT + OSA
B	Tuneable narrow band light source	TNLS	BBD	TLS + DUT + OPM
C	Set of multiple fixed narrow band light sources	NLS	BBD	N x DFB-LD + DUT + OPM

Table 3 – Reference test methods

Resolution bandwidth (RBW)	Wavelength band	RTM	Alternative
< 0,1 nm	Any	Method B	Method A
≥ 0,1 nm	C-band and L-band	Method B	Method A, method C
≥ 0,1 nm	Not C-band and L-band	Method A	Method B, method C

a) Method A – Broadband light source (BBS)

In method A, a broadband light source (BBS) is used with a tuneable narrowband detector (TND). A common implementation is to use an optical spectrum analyzer (OSA) for the TND. In this implementation, the OSA controls the wavelength range, the measurement wavelength and resolution bandwidth. The optical power and bandwidth of the BBS shall be large enough to cover the attenuation of the DUT and the power measurement dynamic range of the OSA.

b) Method B – Tuneable narrowband light source (TNLS)

In method B, a tuneable narrowband light source (TNLS) is used with a broadband detection system (BBD). The most likely implementation of method B is the use of a tuneable laser source (TLS) with an optical power meter (OPM). In this method, the TLS controls the wavelength range, the measurement wavelength and resolution bandwidth. Given the narrow linewidth and high DOP, care shall be taken to minimize the test system background return loss. This will help to avoid coherent interference in the power measurement.

c) Method C – Set of multiple fixed narrowband light sources (NLS)

In method C, a set of narrowband light sources are used with a broadband detector (BBD). This method is suitable for a DUT which has a small wavelength dependent loss and is specified for operation over a wide wavelength range. A common implementation of method C is the use of a set of fixed laser sources with an N x 1 optical branching device or optical switch. The use of a switch prevents the need to turn off the light sources not in use. This can reduce the time needed for laser power stabilization. An OPM is typically used as the BBD.

5 Apparatus

5.1 General

All methods share a common basic setup:

- optical source;
- source depolarizer (optional);

- return path branching device (for RL measurement);
- temporary joint (TJ);
- fibre;
- reference plug (RP);
- reference adapter (RA);
- termination (for RL measurement);
- power detection system.

5.2 Optical source

5.2.1 Method A – Broadband light source (BBS)

A BBS is used for the source in method A. The BBS emits light over a continuous wavelength range with various characteristics depending on its type. Examples of a BBS are a white light source (i.e. tungsten lamp), a light emitting diode (LED), a super-luminescent LED (SLED) or an optical fibre amplifier (OFA) without an input optical signal.

The wavelength range shall be wide enough to cover the entire specified DUT wavelength operating range. The output power shall be high enough for $A(\lambda_k)$ and $RL(\lambda_k)$ to be measured. The spectral power density instability shall be smaller than ±0,05 dB as observed for at least 30 min.

5.2.2 Method B – Tuneable narrowband light source (TNLS)

A TNLS emits a narrow spectrum of light that can be spectrally tuned over the specified wavelength range. There are various characteristics depending on its type. Examples of applicable TNLS technologies are a BBS with a tuneable filter, an external cavity tuneable laser, a tuneable DFB laser diode and a tuneable erbium-doped fibre laser. The wavelength accuracy and spectral bandwidth shall be specified. Typical values are provided in Annex B.

5.2.3 Method C – Set of multiple fixed narrowband light sources (NLS)

Method C is based on a set of N discrete wavelengths. The wavelengths may be emitted by sources such as a Fabry-Perot (FP) laser diode (LD) or distributed feedback (DFB) LD.

The set of NLS shall cover the specified wavelength range to be measured. When using a $N \times 1$ fibre optic branching device or fibre optic switch, N is equal to the number of wavelengths to be measured and NLS used.

When a TLS is used as the NLS, the requirement for a TLS is same as that for a NLS.

5.3 Depolarizer

The measurement results [$A(\lambda_k)$ and $RL(\lambda_k)$] shall be averaged as a function of the state of polarization (SOP). Sources based on lasers will be highly polarized (DOP is nearly equal to 100 %) while sources like LED and BBS will be highly depolarized (DOP is less than 5 %). For sources with high DOP, a depolarizer will be required. The depolarizer shall reduce the DOP to < 5 %.

There are two approaches for obtaining the polarization averaged value of $A(\lambda_\mathrm{k})$ and $RL(\lambda_\mathrm{k})$.

- Direct approach: A depolarizer based on an active or passive device is connected at the output port of the source in order to reduce its DOP. This allows direct measurement of the averaged $A(\lambda_k)$ and $RL(\lambda_k)$. The averaging time of the power detection system shall be greater than 2 times the quoted de-polarization time.