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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 – Méthodes fondamentales d'essais et de mesures –
Partie 3-7: Examens et mesures – Dépendance par rapport à la longueur d'onde de l'affaiblissement et de l'affaiblissement de réflexion des composants unimodaux

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International Standard IEC 61300-3-7 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 2000. It constitutes a technical revision.

Changes from the previous edition of this standard are to reflect changes made to IEC 61300-1 and covers unidirectional and bi-directional methods of measurement.

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

FDIS	Report on voting
86B/2771/FDIS	86B/2803/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 parts of 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 publication will remain unchanged until the maintenance result 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,
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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 the various methods available to measure the wavelength dependence of attenuation $A(\lambda)$ and return loss $RL(\lambda)$, of single-mode passive optical components (POC) used in fibre-optic (FO) telecommunications. 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. Definition of WDM device types is given in IEC 62074-1.

Three measurement cases are herein considered:

- Measurement of $A(\lambda)$ only;
- Measurement of $RL(\lambda)$ only;
- Measurement of $A(\lambda)$ and $RL(\lambda)$ at the same time.

These measurements may be performed in one direction (unidirectional) or bi-directionally.

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 (including any amendments) applies.

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 characterising the amplitude of the spectral transfer function of DWDM components*

IEC 62074-1, *Fibre optic WDM devices – Part 1: Generic specification*

3 Abbreviations and acronyms

For the purposes of this document, the following abbreviations and acronyms apply:

A	attenuation
$A(\lambda)$	wavelength dependent attenuation
ASE	amplified spontaneous emission
BBD	broadband detection
BBS	broadband source

BD	branching devices
CWDM	coarse wavelength division multiplexing
DFB	distributed feedback (laser)
DOP	degree of polarization
DUT	device under test
DWDM	dense wavelength division multiplexing
DWS	discrete wavelength source
ECL	external cavity (tuneable) laser
EDFL	erbium-doped fibre laser
FA	fibre amplifier
FP	Fabry-Perot (laser)
G(λ)	test system constant
IL	insertion loss
IL(λ)	wavelength dependent insertion loss
λ	wavelength
NLS	narrowband light sources
OPM	optical power meter
OSA	optical spectrum analyser
$P_i(\lambda)$	wavelength dependent power incident on the DUT
$P_r(\lambda)$	wavelength dependent power reflected by the DUT (from the input port of the DUT)
$P_t(\lambda)$	wavelength dependent power transmitted through the DUT
$P_G^{RL}(\lambda)$	wavelength dependent reflected power measured for the determination of the test set-up constant
$P_{Gi}^{RL}(\lambda)$	wavelength dependent incident power measured for the determination of the test set-up constant
$P_i^A(\lambda)$	wavelength dependent power incident on the DUT in case of the wavelength dependent attenuation measurement

$P_i^{RL}(\lambda)$ wavelength dependent power incident on the DUT in case of the wavelength dependent return loss measurement

PDL polarization dependent loss

POC passive optical components

PON passive optical network

RBD reference branching device

RBW resolution bandwidth

RL return loss

$RL(\lambda)$ wavelength dependent return loss

RTM reference test method

SMSR side mode suppression ratio

SOA semiconductor amplifier

SOP state of polarization

T termination

TJ temporary joint

TND tuneable narrowband detection (system)

TLS tuneable narrowband light source

TN-OTDR tuneable OTDR

WDM wavelength division multiplexing

4 General

4.1 General description

$A(\lambda)$ and $RL(\lambda)$ are expressed in decibels (dB), transmitted by or reflected from a device under test (DUT) resulting from its insertion within a fibre-optic (FO) telecommunication system. $A(\lambda)$ and $RL(\lambda)$ are obtained by comparing the optical power incident on the DUT with the optical power

- transmitted at the output port of the DUT;
- reflected from the input port of the DUT.

The DUT is inverted in order to get a bi-directional measurement. Measurements should be taken in both directions and averaged expect where the device is intentionally not bidirectional no averaging shall be done.

The term “return loss” should not be used as equivalent to reflectance. Both have completely different meanings.

4.2 Spectral conditions

$A(\lambda)$ and $RL(\lambda)$ measurements are made over a wavelength range defined in the DUT specifications. The DUT spectral characteristics also defined in the DUT specifications should be used in turn to define the spectral characteristics of the measurement system, such as its wavelength resolution (spectral difference between two adjacent data points) and uncertainty (spectral uncertainty around each data point) which in turn will define the bandwidth of the measurement system.

4.3 Definition

4.3.1 Attenuation

$A(\lambda)$ refers to the power decrease of light transmitted by the DUT as a function of wavelength. It is expressed as follows:

$$A(\lambda) = -10 \times \log\left[\frac{P_t(\lambda)}{P_i(\lambda)}\right] \text{ [dB]} \quad (1)$$

where

$P_t(\lambda)$ is the optical power, as a function of wavelength, transmitted through the input port of the DUT and measured at the output port of the DUT, expressed in watt;

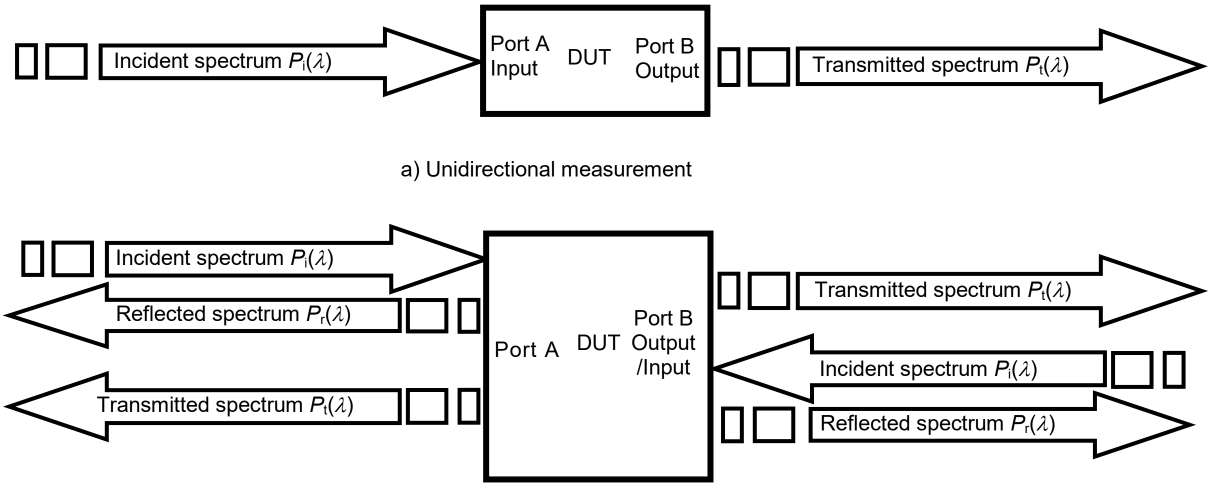
$P_i(\lambda)$ is the optical power, as a function of wavelength, incident on and measured at the input port of the DUT, expressed in watt;

for bi-directional measurement,

$P_t(\lambda)$ is the optical power, as a function of wavelength, transmitted through the output port of the DUT and measured at the input port of the DUT, expressed in watt;

$P_i(\lambda)$ is the optical power, as a function of wavelength, incident on and measured at the output port of the DUT, expressed in watt.

Figure 1 illustrates the process.



a) Unidirectional measurement

b) Bi-directional measurement

IEC 2334/08

Figure 1 – Wavelength dependence of attenuation and return loss

4.3.2 Return loss

$RL(\lambda)$ refers to the power decrease of light reflected by the DUT as a function of wavelength. It is expressed as follows:

$$RL(\lambda) = -10 \times \log\left[\frac{P_r(\lambda)}{P_i(\lambda)}\right] \text{ [dB]} \quad (2)$$

where

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

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

for bi-directional measurement,

$P_r(\lambda)$ is the optical power, as a function of wavelength, reflected by and measured from the output port of the DUT, in units of W;

$P_i(\lambda)$ is the optical power, as a function of wavelength, incident on and measured at the output port of the DUT, in units of W.

Figure 1 illustrates the process.

4.4 Device under test

The DUT may have more than two ports. However, since measurement of $A(\lambda)$ is made across only two ports, be they unidirectional or bi-directional, the DUT in this standard shall be described as having two ports. The same is true for measurement of $RL(\lambda)$, except that in this case, the measurement is made from only one port at a time.

Eight different DUT configurations are herein considered and described in Table B.1 of Annex B. The differences between these configurations are primarily in the terminations of the optical ports. Terminations may consist of bare fibre, connector plug, or receptacle. The various types of product that are herein under consideration are illustrated in Table B.2 of Annex B.

4.5 Measurement methods

The characterization of the DUT spectral response can be carried out on several discrete wavelengths along a wavelength range of interest, continuously over the range or a combination of the above. The way this characterization is performed defines the various test methods.

Four methods, A to D, are described for measuring $A(\lambda)$ and $RL(\lambda)$. The methods are listed below in the order of their introduction. For some methods, multiple configurations are possible.

Table 1 summarizes the different test methods and their main characteristics.

NOTE Different test configurations and methods will result in different accuracies of the attenuation being measured. In cases of dispute, the RTM should be used.

Table 1 – Test methods and characteristics

Method	Name	Light source	Detection system	Example	Comments
A	BBS	BBS	TND	BBS + DUT + OSA	Alternate
B	TLS	To be depolarised + coherence control			
B.1	TLS + BBD	TLS	BBD	TLS + DUT + OPM	
B.1.1	TLS in start-stop-measure mode + BBD	TLS in start-stop-measure mode	BBD	TLS + DUT + OPM	Alternate
B.1.2	TLS in sweep mode + BBD	TLS in sweep mode	BBD	TLS + DUT + OPM	Alternate
B.2	TLS + TND	TLS	TND	TLS + DUT + OSA	
B.2.1	TLS in start-stop-measure mode + TND	TLS in start-stop-measure mode	TND	TLS + DUT + OSA	RTM
B.2.2	TLS in sweep mode + TND	TLS in sweep mode	TND	TLS + DUT + OSA	Alternate
C	Set of *N* NLS	To be depolarised + coherence control			
C.1	*N* NLS + BBD	*N* NLS	BBD	*N* NLS + N x 1 coupler + DUT + OPM	Alternate
C.2	*N* NLS + TND	*N* NLS	TND	*N* NLS + N x 1 coupler + DUT + OSA	Alternate
D	TN-OTDR	TN OTDR	TN-OTDR	TN-OTDR + DUT	Alternate

4.5.1 Method A – Broadband light source (BBS)

In Method A, a broadband light source (BBS) is used with a tuneable narrowband filtering detection system (TND).

A possible implementation of Method A is the use of the BBS with an optical spectrum analyser (OSA). Method A has the advantage of providing all the required wavelength range in a single test and the test sampling rate is defined by the TND. Measurement of the wavelength dependence should be done using the BBS having high quality spectral power density. Use of a suitable TND spectral filter is recommended for an accurate measurement.

4.5.2 Method B – Tuneable narrowband light source (TLS)

In Method B, a tuneable narrowband light source (TLS) is used with two possible different detection systems.

4.5.2.1 Method B.1 – Tuneable narrowband light source and broadband detection system

In Method B.1, a TLS is used with a broadband detection system (BBD).

A possible implementation of Method B.1 is the use of the TLS with an optical power meter (OPM). The TLS can be used in two different modes with the BBD:

a) Method B.1.1 – Step-by-step tuneable narrowband light source and broadband detection system

In this method, the bandwidth of the measurement is defined by the TLS linewidth. A linewidth too narrow will create spurious noise, coherence interference effects and unnecessary amount of data; a linewidth too wide will not provide enough resolution to the DUT spectral response. An estimate of the DUT bandwidth and the application of the Nyquist criterion are required in order to properly define the TLS linewidth.

b) Method B.1.2 – Swept tuneable narrowband light source and broadband detection system

In this method, the bandwidth of the measurement is defined by the bandwidth of the detection system, not by the TLS linewidth. An estimate of the DUT bandwidth and the application of the Nyquist criterion are required in order to properly define the bandwidth of the detection system.

4.5.2.2 Method B.2 – Tuneable narrowband light source and tuneable narrowband detection system

In Method B.2, a TLS is used with a TND. Synchronization between both ends of the measurement system is required. This method is particularly useful for very narrowband components.

A possible implementation of Method B.2 is the use of the TLS with an OSA. The TLS can be used in two different modes with the TND:

a) Method B.2.1 – Step-by-step tuneable narrowband light source and tuneable narrowband detection system

The measurement bandwidth for Method B.2.1 is the same as in Method B.1.1.

b) Method B.2.2 – Swept tuneable narrowband light source and tuneable narrowband detection system

The measurement bandwidth for Method B.2.2 is the same as in Method B.1.2.

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

In Method C, a set of *N* narrowband light sources (NLS) is used with two possible different detection systems. This method is particularly useful when the DUT spectral response is expected to be quite non-uniform and the regions of non-uniformity need to be carefully assessed.

A possible implementation of Method C is the use of a set of *N* DFB lasers with *N* x 1 coupler and/or 1 x *N* splitter on each side of the DUT with one OPM for each DFB.

4.5.3.1 Method C.1 – NLS and BBD

Method C.1 is a variation of Method B.1 in which the TLS is replaced by the set of *N* NLS.

4.5.3.2 Method C.2 – NLS and TND

Method C.2 is a variation of Method B.2 in which the TLS is replaced by the set of *N* NLS.

4.5.4 Method D – Tuneable OTDR

In Method D, a tuneable narrowband light is emitted by TN-OTDR and appropriate detection by the TN-OTDR is used.

4.5.5 Reference method

The reference test method (RTM) for measuring $A(\lambda)$ and $RL(\lambda)$ shall be Method B.2.1.

5 Apparatus

The following subclauses describe the test set-up components.

5.1 Wavelength source

The following subclauses describe the various available sources for performing the measurements.

5.1.1 Method A – Broadband light source

The BBS is used in Method A. The BBS emits a broadband light over a wavelength range with various characteristics depending on its type. The BBS may be a white light source, an LED (surface emitted or edge emitted), a superluminescent LED (SLED) or an amplified spontaneous emission (ASE) source from an optical fibre amplifier (FA) or from a semiconductor amplifier (SOA).

The BBS shall cover the specified wavelength range. The wavelength range shall be wide enough to cover the specified DUT bandwidth and the output power high enough for $A(\lambda)$ and $RL(\lambda)$ to be measured. The spectral power density stability shall be better than ±0,05 dB during 8 h consecutive.

The test set-up specifications shall meet the detailed requirements of the DUT $A(\lambda)$ and $RL(\lambda)$ as defined in the DUT specifications. As a consequence, the BBS requirements shall be carefully defined in order to make sure that Method A and set-up will meet those specifications. The main BBS characteristics are shown in Clause B.1 of Annex B.

5.1.2 Method B – Tuneable narrowband light source

The TLS is used in Method B. The TLS emits a narrowband light that can be spectrally tuned over a wavelength range with various characteristics depending on its type. The TLS may be a BBS with a tuneable filter, an external cavity tuneable laser (ECL), a tuneable DFB laser (DFB) and a tuneable erbium-doped fibre laser (EDFL). Clause B.2 of Annex B describes the main characteristics of various TLS types.

The test set-up specifications and the selection of the particular sub-sets of Method B shall meet the detailed requirements of the DUT $A(\lambda)$ and $RL(\lambda)$ as defined in the DUT specifications. As a consequence, the TLS requirements shall be carefully defined in order to