IEC 62496-2-1

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INTERNATIONAL STANDARD

NORME INTERNATIONALE

Optical circuit boards –
Part 2-1: Measurements – Optical attenuation and isolation

Cartes à circuits optiques –
Partie 2-1: Mesures – Affaiblissement et isolation optiques

IEC 62496-2-1:2011

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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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International Standard IEC 62496-2-1 has been prepared by IEC technical committee 86: Fibre optics.

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

FDIS	Report on voting
86/396/FDIS	86/401/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 the IEC 62496 series, published under the general title *Optical circuit boards* 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- withdrawn,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.

OPTICAL CIRCUIT BOARDS –

Part 2-1: Measurements – Optical attenuation and isolation

1 Scope

IEC 62496-2-1 describes the various methods to measure the optical attenuation and isolation of optical circuit boards (OCBs).

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 60793-2-10, *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 61300-3-1:2003, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 3-1: Examinations and measurements – Visual examination*

IEC 61300-3-4, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 3-4: Examinations and measurements – Attenuation*

IEC 62496-1:2008, *Optical circuit boards – Part 1: General*

IEC 62614, *Fibre optics – Launch condition requirements for measuring multimode attenuation*

ISO 3599, *Vernier callipers reading to 0,1 and 0,05 mm*

ISO 6906, *Vernier callipers reading to 0,02 mm*

3 Precautions

The requirements of IEC 60825-1 and the following test requirements shall be met.

The position of the fibres in the test should be fixed during the measurement to avoid changes in attenuation caused by bending loss.

4 Apparatus

4.1 Launch conditions and source (S)

For multimode measurements, a restricted launch, not an overfilled launch, shall be used. Encircled flux, which is given in IEC 62614, shall be available for the purposes of launching fibre qualification in case of a 50 or 62,5 graded index launch fibre. The required launch conditions can be achieved by including appropriate equipment inside the light source, or by applying mode filters on or in series with the launch cord.

For single-mode measurements, the launch condition shall be in accordance with Annex B of IEC 61300-1.

The source unit consists of an optical emitter, the associated drive electronics and fibre pigtail. Preferred source and launch conditions are given in Table 1.

Table 1 – Preferred source and launch conditions

No.	Type	Centre wavelength nm	Spectral width nm	Stability at 23 °C dB/h	Output power	Launch conditions	Source type
S1	Multimode	660 ± 30	≥30	± 0,05	[a]	TBD	Laser diode or LED
S2	Multimode	780 ± 30	≥30	± 0,05	[a]	TBD	Laser diode or LED
S3	Multimode	850 ± 30	≥30	± 0,05	[a]	IEC 62614	Laser diode or LED
S4	Multimode	980 ± 30	≥30	± 0,05	[a]	TBD	Laser diode or LED
S5	Multimode	1 300 ± 30	≥30	± 0,05	[a]	IEC 62614	Laser diode or LED
S6	Single-mode	1 310 ± 30	≤10	± 0,05	[a]	IEC 61300-1, Annex B.2.2	Laser diode or LED
S7	Single-mode	1 550 ± 30	≤10	± 0,05	[a]	IEC 61300-1, Annex B.2.2	Laser diode or LED

[a] The source output power shall be ≥20 dB above the minimum measured power level.

NOTE 1 Due to their long coherence length, laser source units create a speckle pattern across the core of a multimode fibre that is unstable and which may render difficult or impossible the task of creating case 2 launch conditions in a multimode component. Consequently, for measuring multimode components, lasers, should be avoided in favour of LEDs or other incoherent source units.

NOTE 2 For S5 and S6, where an LED is used, the spectral width is more typically ≤150 nm.

NOTE 3 It is recognized that new components may require the use of other source types such as tunable lasers. It is therefore recommended in these cases that the preferred source characteristics be specified on the basis of the component to be measured.

4.2 Power-meter (D)

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

The measurement system shall be stable within specified limits over the period of time required to measure an optical power. For measurements where the connection to the detector must be broken between the measurement of the optical power, the measurement

repeatability shall be within 0,05 dB. A detector with a large sensitive area may be used to achieve this requirement.

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 OCB at the wavelength being measured. The preferred dynamic range is from 40 dBm to -75 dBm.

4.3 Optical fibre (OF)

Optical fibres used for optical measurements shall meet the requirement of all categories of class A fibres (multimode) given in IEC 60793-2-10, or class B fibres (single-mode) given in IEC 60793-2-50. The preferred launching and receiving fibres are given in Table 2.

To measure an OCB consisting of a multimode waveguide, the launching fibre core diameter should preferably be the same as the core inner diameter of the OCB or less, and the numerical aperture (NA), which is the sine of the acceptance angle of a waveguide or fibre, should be smaller than that of OCB. In this case, the most reproduceable attenuation value could be obtained.

When using a launch fibre with a much smaller core diameter than that of the OCB, such as a single-mode fibre, it is likely that a lower attenuation value will be obtained. The NA of a single-mode fibre is much lower than the NA of the multimode OCB such that the launch beam is less affected by the roughness of the core wall.

When measuring an OCB that employs optical fibre, a launching fibre shall be selected that has the same geometrical and optical characteristics as that used in the OCB.

Table 2 – Preferred launching and receiving fibres

OCB medium	Launching fibre	Receiving fibre
Multimode fibre, or Multimode waveguide	50 GI Multimode fibre, 62,5 GI Multimode fibre, or Single-mode fibre	Multimode fibre with core diameter that completely circumscribes the OCB output port, and with the same NA as the OCB output port or more or Direct detection by power-meter
Single-mode fibre, or Single-mode waveguide	Single-mode fibre	Multimode fibre, Single-mode fibre or Direct detection by power-meter

4.4 Mode filter (MF)

The function of a mode filter is to eliminate measurement inaccuracies.

For single-mode measurements the mode filter shall include at least two metres of fibre with two 50 mm-diameter loops.

Mode filters shall be placed between the source and the OCB and, where specified by the test method, before the detector.

4.5 Optical direction changing device (OD)

An optical direction changing device (OD) is a device by which the direction of incident light is changed by 90 °. It may, for example, be a bending fibre, a flexible film waveguide, a fibre with a flat (45 °) angled or curved mirror, or a waveguide with a flat (45 °) angled or curved mirror.

4.6 Temporary joint (TJ)

This is a method, device or mechanical fixture for temporarily aligning two fibre ends, a fibre end and a waveguide end, or a waveguide end and a detector to form a stable, reproducible and low-loss joint. It is used when the OCB cannot be directly connected to the measurement system with a standard connector. It may, for example, be a fusion splice, a mechanical splice realised with a precision V-groove, a butt joint realised with a micromanipulator, or a spatial coupling. The temporary joint shall be stable to within ± 10 % of the measurement accuracy required in dB over the time taken to measure optical power P. A suitable refractive index matching material may be used to improve the stability of the TJ.

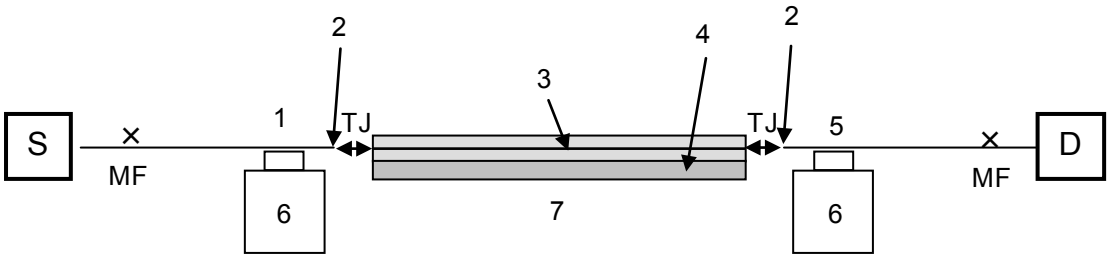
For the butt joint, the alignment of the system shall be adequate to ensure the reproducibility or launched power. Figure 1(a) shows an example of the launch apparatus. Launching and receiving fibres are mounted on XYZ and $\theta_x\theta_y\theta_z$ translation stages (micromanipulators), and the OCB shall be placed between these fibre ends. The refractive index matching material is used between the OCB and the fibres. The preferred resolutions of the micromanipulators operated by stepping motors are ≤ 0,1 µm and ≤ 1,5 µm for the single mode and the multimode measurements, respectively.

The input port of the OCB is connected to the fibre from the source (S), and the receiving fibre to the detector (D) is positioned to the output port of the OCB. First, launching fibre position shall be tuned to realize the minimum attenuation, i.e. maximize optical power captured by receiving fibre. Then, receiving fibre position shall be tuned to realize the minimum attenuation. After that, the launching and receiving fibre tuning shall be alternated until the attenuation converges to the smallest value. A suitable refractive index matching material filling the two gaps between the OCB and the two fibre ends may also improve the measurement stability.

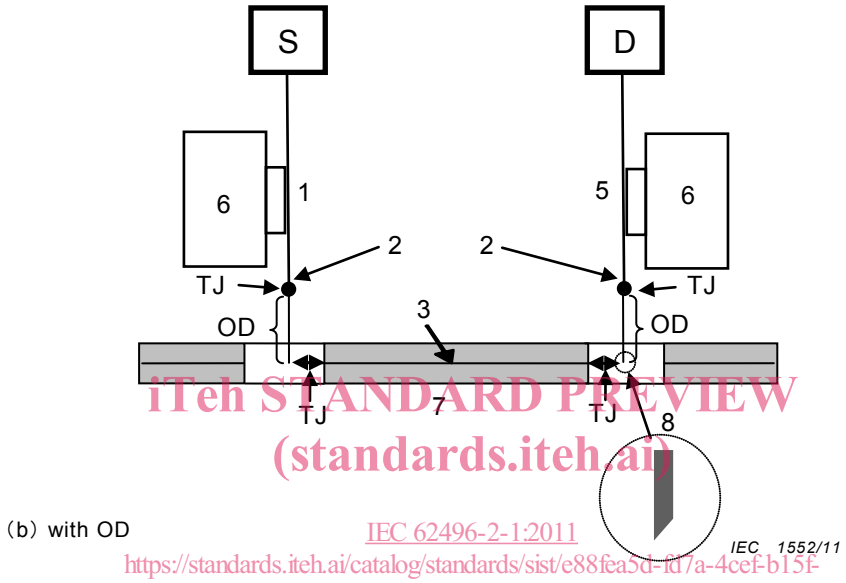
Alternatively, if it is not easy to detect the initial output power from the OCB by the receiving fibre, the following method shall be used. The input port of the OCB is connected to the fibre from the source, and then a large area detector is positioned over the output port. First launching fibre position shall be tuned to realize the minimum attenuation, i.e. maximize optical power captured by receiving detector. Then once launch fibre position is optimised, replace detector at receiving end with receiving fibre, which is connected to detector, and tune receiving fibre position until power captured by receiving fibre is maximized. After that, tune the positions of the launching and receiving fibres in alternation until the attenuation converges to the smallest value.

Figure 1(b) shows an example of the launch apparatus including an optical direction changing device (OD). Launching and receiving fibres are joined to the ODs with 45 ° angled mirrors, and are mounted on XYZ and $\theta_x\theta_y\theta_z$ translation stages (micromanipulators). The OCB shall be placed perpendicular to the launching/receiving fibre directions. The input and output ports of the OCB are connected to the 45 ° angled mirrors in OD. The launching and receiving fibre tuning shall be performed in the same way as mentioned above.

NOTE Care should be taken in using the refractive index matching material. Residual matching material after the measurement affects the performance of the following test. It also affects the reliability of the connecting part if the measured OCB is connected with the fibre optic interconnecting device and so on. For the measurement of the OCB with a 45 ° angled mirror, it is possible that the excess matching material attaches to the mirror surface. This affects the performance of the measurement.



(a) without OD



(b) with OD

Key

1 Launching fibre mount

2 Fibre end

3 Fibre/channel waveguide

4 Printed circuit board

5 Receiving fibre mount

6 XYZ and $\theta_x\theta_y\theta_z$ translation stage (micromanipulator)

7 Optical circuit board

8 45 ° angled mirror

Figure 1 – Launch apparatus for butt-joint connection, (a) without OD, (b) with OD

5 Procedure

5.1 Pre-conditioning

The optical interfaces of the OCB 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.

NOTE Care should be exercised throughout the test to ensure that mating surfaces are not contaminated with oil, grease, or refractive index matching material previously used in the test. It is recognized that bare fingers can deposit a film of grease.

5.2 Visual inspection

It is recommended that a visual inspection is made of the optical interfaces of the OCB in accordance with IEC 61300-3-35 prior to the start of the test.

5.3 Connectivity inspection

Before the measurement, the relationship between the input and output ports of the OCB shall be confirmed, that is, a from/to port table should be obtained. It is recommended that light is transmitted through each optical path, and output light from each output port is observed with a CCD camera or by a visual inspection.

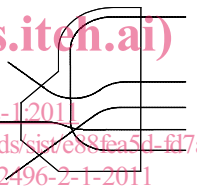
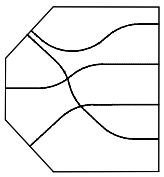
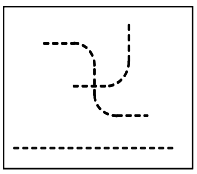
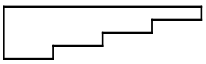
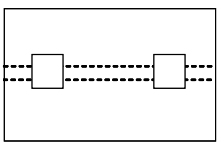
NOTE 1 The preferred light source is a laser diode, LED, or lamp source (halogen or Xe). The wavelength is arbitrary.

NOTE 2 When visible light or red light is used, a visual inspection may be useful.

5.4 OCB configurations and measurement methods

Table 3 and Table 4 show measurement methods of attenuation and isolation for each OCB coinfigurations, respetively.

Table 3 – Measurement methods of attenuations

OCB configuration	Description	Measurement methods	
		Reference	Alternative
Configuration A (4.1.2, IEC 62496-1:2008)	Fibre to fibre (OCB containing fibre whose ends are outside the board) 	Cut-back	Insertion (A) or Insertion (B)
Configuration B (4.1.2, IEC 62496-1:2008)	Flat end to flat end (OCB made of optical fibre or channel waveguide) 	Insertion (A)	Cut-back
Configuration C-1 (4.1.2, IEC 62496-1:2008)	Mirror/grating to mirror/grating (OCB made of channel waveguide) 	Insertion (A)	Insertion (B)
Configuration C-2 (4.1.2, IEC 62496-1:2008)	Mirror/grating to mirror/grating (OCB made of slab waveguide) 	Insertion (A)	None
Configuration D (4.1.2, IEC 62496-1:2008)	Flat end to flat end in groove or via-hole (OCB made of optical fibre or channel waveguide) 	Insertion (A)	None

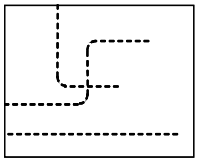
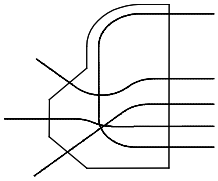
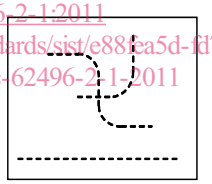
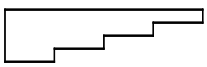
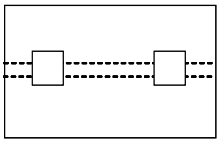
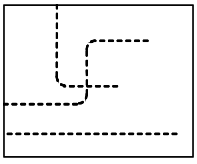
OCB configuration	Description	Measurement methods	
		Reference	Alternative
Configuration E (4.1.2, IEC 62496-1:2008)	Mirror/grating to/from flat end (OCB made of channel waveguide) NOTE This is one of various types of configuration E. 	Insertion (A)	None

Table 4 – Measurement methods of isolations

OCB configuration	Description	Measurement methods	
		Reference	Alternative
Configuration A (4.1.2, IEC 62496-1:2008)	Fibre to fibre (OCB containing fibre whose ends are outside the board) 	Insertion (C)	Insertion (D)
Configuration B (4.1.2, IEC 62496-1:2008)	Flat end to flat end (OCB made of optical fibre or channel waveguide) 	Insertion (C)	None
Configuration C-1 (4.1.2, IEC 62496-1:2008)	Mirror/grating to mirror/grating (OCB made of channel waveguide) 	Insertion (C)	None
Configuration C-2 (4.1.2, IEC 62496-1:2008)	Mirror/grating to mirror/grating (OCB made of slab waveguide) 	None	None
Configuration D (4.1.2, IEC 62496-1:2008)	Flat end to flat end in groove or via-hole (OCB made of optical fibre or channel waveguide) 	Insertion (C)	None
Configuration E (4.1.2, IEC 62496-1:2008)	Mirror/grating to/from flat end (OCB made of channel waveguide) Note: this is one of various types of configuration E. 	Insertion (C)	None
NOTE There is no measurement method of isolation for configuration C.			

5.5 Attenuation measurement with a power-meter

5.5.1 General

The attenuation consists of "propagation loss" and "coupling loss", where the propagation loss is the residual loss other than the coupling loss, which may stem from scattering and absorption in the waveguide. The coupling loss occurs at the interfaces of the input and output ports, where it depends on the mode field of the launching and receiving fibres. Accordingly, the types, diameters, and NAs of the launching and receiving fibres that are employed to measure the attenuation shall be described in the test report.

The attenuation measurement is based on the use of an optical power-meter.

Measuring the attenuation, A, requires two kinds of power to be measured using the power-meter:

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

where

P_1 is the power measured through the OCB. This power is the output power from a given port of the OCB;

P_0 is the power measured without the OCB in the circuit.

NOTE Before the measurement, a connectivity inspection shall be performed if the OCB has multiple input and output ports.

5.5.2 Cut-back method

5.5.2.1 For configuration A, the attenuation measurement shall be in accordance with 5.4.1 of IEC 61300-3-4.

A mechanical splice realised with a precision V-groove or a fusion splice is used as a TJ. The input port of the OCB is connected to the fibres from the source with the TJ. The given output port is connected to the detectors, and P_1 is measured. The fibre is cut at a cutting point (CP), and P_0 is measured (see Figure 2).