

INTERNATIONAL STANDARD



**Fibre optic interconnecting devices and passive components – Fibre optic
passive power control devices –
Part 1: Generic specification**

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**Fibre optic interconnecting devices and passive components – Fibre optic
passive power control devices –
Part 1: Generic specification**

INTERNATIONAL
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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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International Standard IEC 60869-1 has been prepared by subcommittee 86B: Fibre optic interconnecting devices and passive components, of IEC TC 86: Fibre optics.

This fifth edition cancels and replaces the fourth edition published in 2012 and constitutes a technical revision.

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

- a) the terms and definitions have been reviewed;
- b) the requirement concerning the IEC Quality Assessment System has been reviewed;
- c) the clause concerning quality assessment procedures has been deleted;
- d) Annex G, relating to technical information on variable optical attenuators, has been added.

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

FDIS	Report on voting
86B/4139/FDIS	86B/4144/RVD

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

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

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

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FIBRE OPTIC INTERCONNECTING DEVICES AND PASSIVE COMPONENTS – FIBRE OPTIC PASSIVE POWER CONTROL DEVICES –

Part 1: Generic specification

1 Scope

This part of IEC 60869 applies to fibre optic **passive** power control devices. These have all of the following general features:

- they are passive in that they contain no optoelectronic or other transducing elements;
- they have two ports for the transmission of optical power and control of the transmitted power in a fixed or variable fashion;
- ~~– the ports are unconnectorized optical fibre tails or optical fibre pigtails with connectors.~~
- the ports are non-connectorized optical fibre pigtails, connectorized optical fibres or receptacles.

This document establishes generic requirements for the following passive optical devices:

- optical attenuator;
- optical fuse;
- optical power limiter.

~~Test and measurement procedures for the above products are described in IEC 61300-1, the IEC 61300-2 series and the 61300-3 series [1, 2, 3] 1.~~

This document also provides generic information including terminology for the IEC 61753-05x series. Published IEC 61753-05x series documents are listed in Bibliography.

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 60027 (all parts), *Letter symbols to be used in electrical technology*

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

IEC 60617, *Graphical symbols for diagrams* (available at <http://std.iec.ch/iec60617>)

IEC 60695-11-5, *Fire hazard testing – Part 11-5: Test flames – Needle-flame test method – Apparatus, confirmatory test arrangement and guidance*

IEC 60825 (all parts), *Safety of laser products*

IEC 61300 (all parts), *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures*

¹ ~~References in square brackets refer to the Bibliography.~~

IEC TS 62627-09, *Fibre optic interconnecting devices and passive components – Vocabulary for passive optical devices*

~~ISO 129, Technical drawings – Indication of dimensions and tolerances~~

ISO 129-1, *Technical product documentation (TPD) – Presentation of dimensions and tolerances*

ISO 286-1, *Geometrical product specifications (GPS) – ISO-coding code system for tolerances of linear sizes – Part 1: Basis of tolerances, deviations and fits*

ISO 1101, *Geometrical product specifications (GPS) – Geometrical tolerancing – Tolerances of form, orientation, location and run-out*

ISO 8601, *Data elements and interchange formats – Information interchange – Representation of dates and times*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60050-731, IEC TS 62627-09 and the following 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>

NOTE Definitions are given in three sub-groups: basic terms, component terms and performance terms.

3.1 Basic terms

3.1.1

insertion loss

~~reduction in optical power between an input and output port of a passive device, intended to be transparent, expressed in decibel~~

Note 1 to entry: This is defined as follows:

$$IL = -10 \log_{10} (P_1/P_0) = 10 \log_{10} (P_0/P_1)$$

where P_0 is the optical power launched into the input port, and P_1 the optical power received from the output port.

3.1.2

operating wavelength

~~nominal wavelength λ at which a passive device is designed to operate with the specified performance~~

3.1.3

operating wavelength range – passband

~~specified range of wavelengths from $\lambda_{l\min}$ to $\lambda_{l\max}$ about a nominal operating wavelength λ_l , within which an optical passive device is designed to operate with the specified performance~~

3.1.4

return loss

~~fraction of optical input power that is returned from the port of a passive device~~

Note 1 to entry: This is defined as follows:

$$RL = -10 \log_{10} (P_1/P_0) = -10 \log_{10} (P_0/P_1)$$

where P_0 is the optical power launched into the port, and P_1 the optical power received back from the same port.

3.1 Component terms

3.1.1

fibre optic passive power control device

passive optical device (component) which controls a transmittance with a designed wavelength-independent transfer coefficient

Note 1 to entry: The transfer coefficient may be controlled for all intensity of input power or for input power over a threshold power.

3.1.2

optical attenuator

passive optical device (component), which produces a wavelength-independent controlled signal attenuation in an optical fibre transmission line

Note 1 to entry: An attenuator is intended to be wavelength independent.

3.1.3

fixed optical attenuator

optical attenuator in which attenuation is constant

3.1.4

variable optical attenuator

VOA

~~optically passive device, an attenuator that regulates the optical power in fibres, producing a controlled, optical output power, as a result of manual or electrical control input~~
optical attenuator in which attenuation is controllable

Note 1 to entry: Attenuation values of variable optical attenuators are generally controlled by manual or electric means.

Note 2 to entry: This note applies to the French language only.

3.1.5

optical fuse

fibre optic passive power control device, which produces ~~a~~ controlled, permanent, signal blocking ~~at~~ for higher optical power than a predetermined power threshold in an optical fibre transmission line

3.1.6

optical power limiter

fibre optic passive power control device that regulates the optical power in fibres, producing a controlled, constant optical output power P_{limit} of optical limit power, as a result of varying optical input power higher than P_{limit} the input optical limit power, ~~and has no influence at optical powers below P_{limit}~~

3.1.7

plug-receptacle style device

fibre optic device having a combination of two interfacing features, a plug at one end and a receptacle at the other

3.2.5

plug style device

~~device having a combination of two interfacing features, a plug on one end and a socket on the other~~

3.2.6**~~adaptor style device~~**~~device having a combination of two sockets as interfacing features~~**3.2 Performance terms****3.2.1****optical fuse power threshold** P_{th}

optical input power, into an optical fuse, in which the optical output power is blocked

Note 1 to entry: The optical fuse power threshold P_{th} is expressed in watt or dBm.**3.2.2****optical fuse response time**~~total time when the optical fuse output power level is higher than the optical fuse power threshold by 1 dB, starting when the rising power passes the power fuse power threshold plus 1 dB and ending when the declining power passes the fuse power threshold plus 1 dB on its way down~~

time between the start of the input power and the end time when the output optical power has decreased to be less than the predetermined optical power

Note 1 to entry: The predetermined power shall be either of the power threshold, P_{th} minus insertion loss, IL , ($P_{th} - IL$) in dB, or the input power, P_{in} minus the required blocking attenuation at threshold, A_{block} .

Note 2 to entry: The optical fuse response time depends on the optical input power level and the input pulse time.

Note 3 to entry: An example of the input power, P_{in} , is recommended to be 3 dB over of the power threshold, P_{th} , and the rectangle shape pulse of 1 ms ($P_{in} = P_{th} + 3$ dB). An example of the required blocking attenuation at threshold, A_{block} of 30 dB is recommended.**3.2.3****optical fuse blocking attenuation at threshold** A_{block} **optical fuse blocking attenuation at threshold**drop ~~of~~ in optical power through the optical fuse when exposed to more than the optical fuse power threshold P_{th} , ~~and responds~~ with response by blocking the power, expressed in dB**3.2.4****optical power limiter response time**~~total time where the optical power limiter output power level is higher than limit power + 1 dB, starting when the rising power passes the limit power plus 1 dB and ending when the declining power passes the limit power plus 1 dB on its way down~~

length of time between the start of the input power and the end time in decreasing the output power to be less than or equal to the predetermined power

Note 1 to entry: The optical power limiter response time depends on the optical input power level and the input pulse time.

Note 2 to entry: An example of the input power, P_{in} is recommended to be 3 dB over of the optical limit power and the rectangular pulse of 1 ms ($P_{in} = P_{limit} + 3$ dB). An example of the pre-determined optical power of $P_{limit} + 1$ dB is recommended.**3.3.5****optical limit power**~~optical input power, into an optical power limiter, in which the optical output power is latched and cannot exceed this value. The optical limit power P_{limit} is expressed in Watt or dBm~~**3.2.5****input optical limit power** $P_{in-limit}$ optical input power, into an optical power limiter, at which the optical output power is latched and cannot exceed that value, $P_{in-limit}$, which is expressed in watt or dBm

3.2.6

output optical limit power

$P_{\text{out-limit}}$

optical output power from an optical power limiter, at which the optical output power is latched and cannot exceed that value, $P_{\text{out-limit}}$, which is expressed in watt or dBm

3.2.7

minimum insertion loss

~~term applicable only to variable optical attenuators, (VOAs); it is the lowest insertion loss to which the device may be adjusted~~

lowest insertion loss to which a VOA is adjusted

3.2.8

variable attenuation range

range of ~~insertion loss~~ attenuation to which the device may be adjusted

Note 1 to entry: This term is applicable only to VOAs.

3.2.9

nominal attenuation

supplier specified attenuation value for fixed attenuators and user-set attenuation value for variable attenuators

3.3.8

~~insertion loss setting resolution~~

~~minimal adjustable step size or difference of the insertion loss of the device~~

~~Note 1 to entry: This term is applicable only to VOAs.~~

3.3.9

~~accuracy of setting value of attenuation~~

~~difference between the insertion loss of the device at a given setting and the manually or electrically nominal adjusted value of the insertion loss~~

~~Note 1 to entry: This term is applicable only to VOAs.~~

3.2.10

maximum attenuation

<for variable optical attenuator> attenuation of the maximum value which is set

3.2.11

minimum attenuation

<for variable optical attenuator> attenuation of the minimum value which is set

3.2.12

attenuation setting resolution

minimal adjustable step size or difference of the attenuation of a VOA

Note 1 to entry: This term is applicable only to VOAs.

3.2.13

error of setting value of attenuation

difference between the insertion loss of the device at a given setting and nominal attenuation

Note 1 to entry: This term is applicable only to VOAs.

3.2.14

repeatability of setting attenuation value

~~difference between the insertion loss of the device at a given setting and the value of the insertion loss in previous same settings~~

maximum deviation of the insertion loss of the device at a given setting in multiple times of repeated settings

Note 1 to entry: This term is applicable only to VOAs.

3.2.15

maximum allowed power input

maximum input power that the device can handle without causing ~~dysfunction~~ malfunction or permanent damage, expressed in watt or dBm

Note 1 to entry: This term is applicable to all fibre optic passive power control devices.

Note 2 to entry: This term is equal to optical fuse power threshold to optical fuse.

Note 3 to entry: The maximum input power defined in IEC TS 62627-09 has a different meaning of the maximum input optical power for which a passive optical device keeps the required optical performances.

4 Description of devices

4.1 Optical attenuator

The optical attenuator is a passive optical device used for optical power reduction into or out of an optical device. The optical attenuator is normally used for a broad range of wavelengths, attenuating the power ~~at~~ by a predetermined ~~level~~ attenuation rate.

There are two types of optical attenuator: a fixed optical attenuator and a variable optical attenuator.

The power reduction rate of a fixed optical attenuator is constant. The performance curve of a ~~fixed~~ optical attenuator is shown in Figure 1, where the attenuated power is always lower than the non-attenuated power and proportional to it.

Annex E describes the fixed optical attenuator application note as a users' guide.

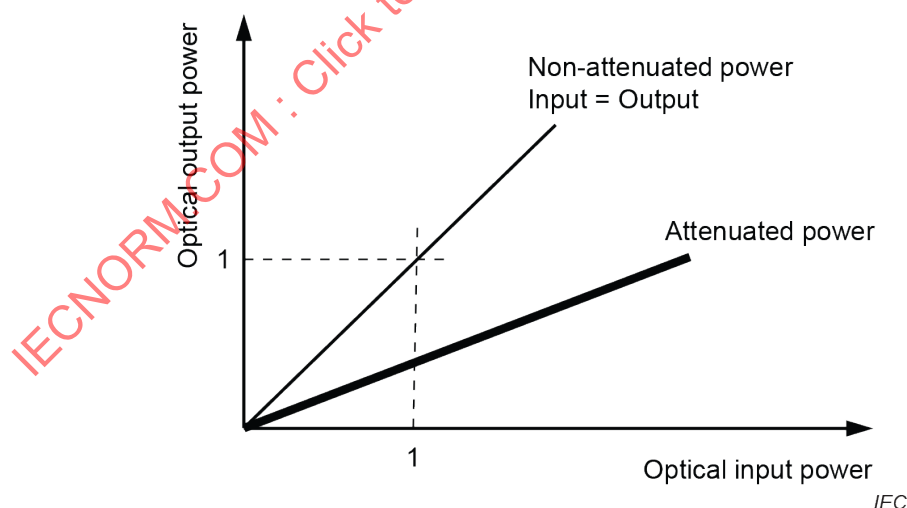


Figure 1 – Fixed optical attenuator operation curve

4.2 ~~Variable optical attenuator (VOA)~~

The performance curve of a variable optical attenuator (VOA) is ~~similar to Figure 1 of an attenuator, where~~ shown in Figure 2. In a manner similar to that of the fixed optical attenuator, the attenuated power is always lower than the non-attenuated power and proportional to it. The VOA produces a controlled, optical output power, as a result of manual or electrical control input. ~~The VOA is a passive device used for optical power reduction into or out of an~~

~~optical device. The optical attenuator is normally used for a broad range of wavelengths, attenuating the power at a pre-adjusted level.~~

Annex F describes the variable optical attenuator application note as a users' guide.

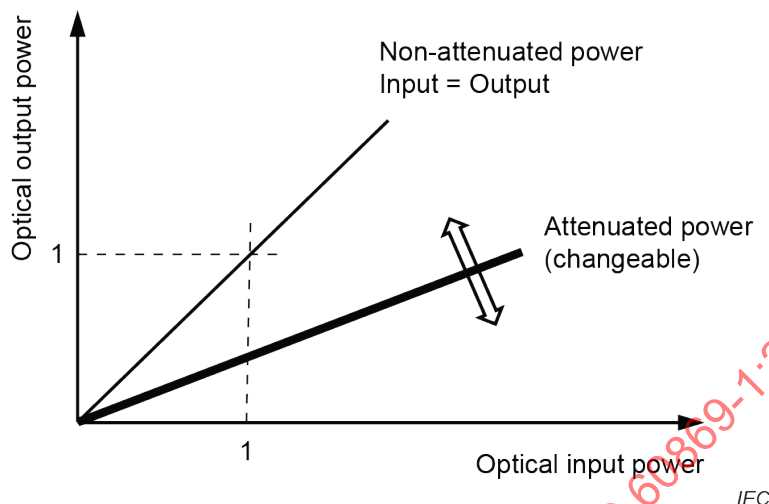
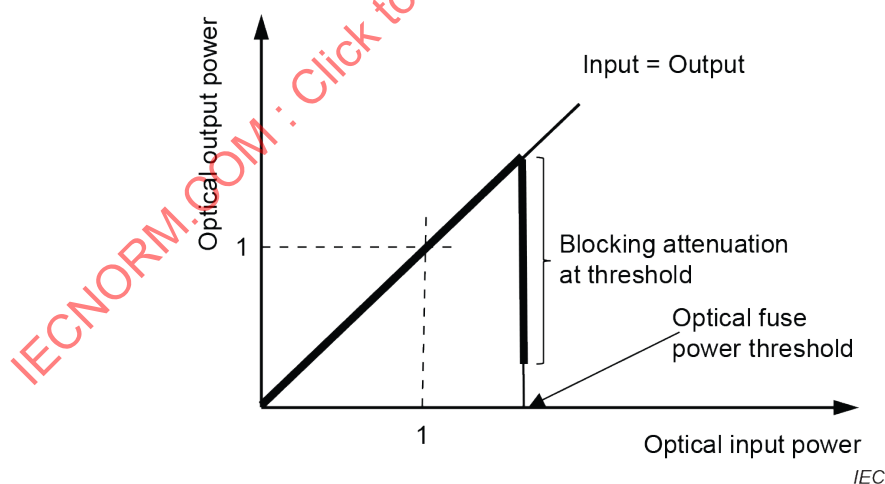


Figure 2 – VOA operation curve

4.2 Optical fuse

The optical fuse (see Figure 3) is a passive device, designed to protect equipment and fibre cables from damage due to optical overpower, spikes and surges. When the input power is lower than a predetermined threshold power, the optical fuse remains transparent, ideally. However, the optical fuse becomes permanently opaque when the optical power exceeds the specified predetermined threshold level. The optical fuse is wavelength independent in the region of its transparency. The optical fuse is bidirectional.



NOTE Figure 3 schematically explains how the optical fuse operates, with the representation of the ideal optical fuse, which has no insertion loss (IL).

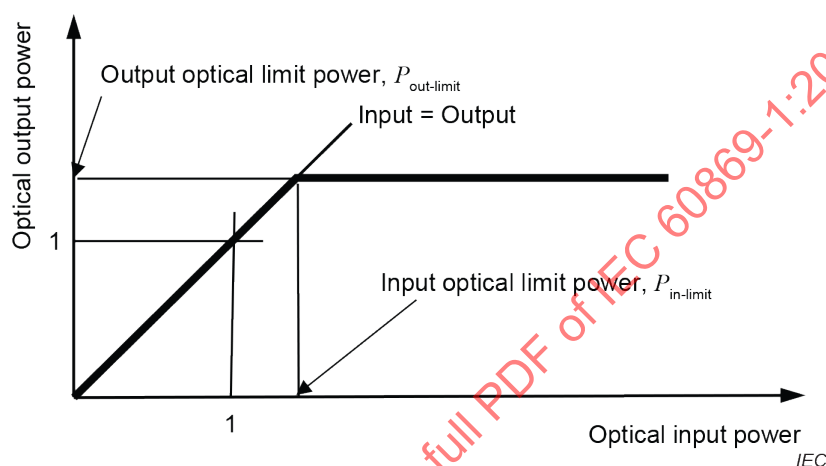
Figure 3 – Optical fuse operation curve

The optical fuse protects against power spikes and surges. The optical fuse is placed either at the input port of an optical device, such as in the case of a detector, or at the output port of a high power device, such as in the case of a laser or optical amplifier. An activated (burnt) fuse permanently blocks the forward optical power without enlarging increasing the reflected power, thus preventing damage. The optical fuse can be used as an eye safety device.

Annexes A and B describe optical fuse configuration and performance examples, and optical fuse application notes.

4.3 Optical power limiter

The optical power limiter (see Figure 4) is a passive device that regulates the optical power in fibres, producing a controlled, constant output power $P_{\text{out-limit}}$, as a result of varying input power higher than $P_{\text{in-limit}}$, and has no influence at powers below $P_{\text{in-limit}}$. Under normal operation, when the input power is low, the optical power limiter has no effect on the system. However, when the input power is high, the optical output power is limited to a predetermined level ($P_{\text{out-limit}}$). The optical power limiter can typically operate under continuous wave (CW) input up to 5 dB above $P_{\text{in-limit}}$, and can sustain short duration pulses and spikes (1 s/min) up to 8 dB above $P_{\text{in-limit}}$.



NOTE Figure 4 schematically explains how the optical power limiter operates, with the representation of the ideal optical power limiter, which has no insertion loss (IL).

Figure 4 – Optical power limiter operation curve

The optical power limiter is used at the input of power-sensitive equipment and at the output of high power devices, such as amplifiers, or wherever power regulation is required. The optical power limiter can serve as an eye safety device. The optical power limiter is wavelength independent in the region of its transparency. The optical power limiter is bidirectional. The optical power limiter is, in some cases, combined in line with an optical fuse, ensuring that at high powers, when the optical power limiter fails, the following device is not exposed to damaging power.

Annexes C and D describe optical power limiter configuration and performance examples, and optical power limiter application notes.

5 Requirements

5.1 Classification

5.1.1 General

Power control devices are classified by the following categories:

- type;
- wavelength band;
- style;
- variant;

- environmental category;
- assessment level;
- normative reference extensions.

An example of a typical power control device classification is as follows:

Type:	– continuously variable
Wavelength band:	– L band
Style:	– configuration C
	– LC-LC connectors
Variant:	– means of mounting
Assessment level:	– A

5.1.2 Type

Power control devices types are defined by their intended function.

There are three types of optical attenuators:

- fixed;
- continuously variable;
- discrete step variable.

There is one type of optical fuse having discrete predetermined threshold power.

There is one type of optical power limiter having discrete predetermined limit power.

There are various combinations of the above-mentioned devices, for example a fixed optical attenuator and an optical power limiter in one device, or an optical power limiter and an optical fuse in one device.

There are several technology types for VOAs, such as manual, micro-electromechanical system (MEMS), magnet optics effect, planar lightwave circuit and thermal optic effect, LiNbO₃ crystal based electro-optic effect. Annex G shows the example of technical information on variable optical attenuators.

5.1.3 Wavelength band

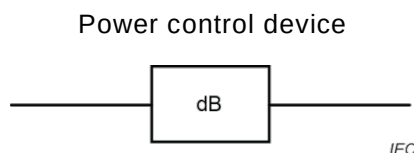
Power control devices types are defined by their wavelength band, O, C or L, and sometimes two or more by a combination of these bands (such as C and L).

5.1.4 Style

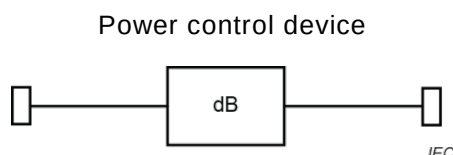
Power control devices may be classified into styles based upon fibre type, connector type, cable type, housing shape and dimensions and configuration.

The configuration of the power control device ports is classified as follows.

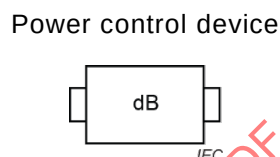
- Configuration A – A device as shown in Figure 5 containing integral optical pigtailed without connectors.

**Figure 5 – Configuration A**

- Configuration B – A device as shown in Figure 6 containing integral optical pigtails, with a connector on each pigtail.

**Figure 6 – Configuration B**

- Configuration C – A device as shown in Figure 7 containing fibre optic connectors as an integral part of the device housing.

**Figure 7 – Configuration C**

- Configuration D – A device containing some combination of the interfacing features of the preceding configurations.

5.1.5 Variant

The power control device variant identifies those features which encompass structurally similar components.

Examples of features which define a variant include, but are not limited to, the following:

- orientation of ports on housing;
- means for mounting.

5.1.6 Assessment level

The detail specification shall include all required tests for quality assessment.

Each test shall be assigned to one of four groups labelled A, B, C and D.

The detail specification shall specify one or more assessment levels, each of which shall be designated by a capital letter. The assessment level defines the relationship between the inspection levels/acceptable quality levels (AQLs) of groups A and B and the inspection periods of groups C and D.

The following are preferred levels:

- Assessment level A
 - group A inspection: inspection level II, AQL = 4 %
 - group B inspection: inspection level II, AQL = 4 %
 - group C inspection: 24-month periods

- group D inspection: 48-month periods
- Assessment level B
 - group A inspection: inspection level II, AQL = 1 %
 - group B inspection: inspection level II, AQL = 1 %
 - group C inspection: 18-month periods
 - group D inspection: 36-month periods
- Assessment level C
 - group A inspection: inspection level II, AQL = 0,4 %
 - group B inspection: inspection level II, AQL = 0,4 %
 - group C inspection: 12-month periods
 - group D inspection: 24-month periods

Groups A and B are subject to lot-by-lot inspection and groups C and D are subject to periodic inspection. One additional assessment level (other than those specified above) may be added in the detail specification. In this case, it shall be designated by the capital letter X.

~~NOTE – AQL = Acceptable Quality Level.~~

5.1.7 Normative reference extensions

Normative reference extensions are used to ~~identify~~ introduce integrated independent standard specifications or other reference documents into blank detail specifications.

~~Unless specified exceptions are noted, additional requirements imposed by an extension are mandatory.~~ Additional requirements imposed by normative reference extensions are mandatory, unless otherwise specified. Usage is primarily intended to merge associated components to form hybrid devices, or integrated functional application requirements that are dependent on technical expertise other than fibre optics.

Published reference documents produced by ITU, consistent with the scope statements of the relevant IEC specification series, may be used as extensions. Published documents produced by regional standardization bodies, such as TIA, CENELEC, JIS, ~~etc.~~ may be referenced in an informative annex attached to the generic specification.

Some optical fibre splice configurations require special qualification provisions which shall not be imposed universally. These cases encompass individual component design configurations, specialised field tooling, or specific application processes. In these cases, requirements are necessary to ensure repeatable performance or adequate safety, and provide additional guidance for complete product specification. These extensions are mandatory whenever used to prepare, assemble or install an optical fibre splice either for field application usage or preparation of qualification test specimens. The relevant specification shall clarify all stipulations. However, design- and style-dependent extensions shall not be imposed universally.

In the event of conflicting requirements, precedence, in descending order, shall be for "generic" to prevail over "mandatory extension", which latter prevails over "blank detail", which latter prevails over "detail", which latter prevails over "application specific extension".

Examples of optical connector extensions are given as follows:

- using IEC 61754-4 and IEC 61754-2 to partially define a future IEC 60874 series specification for a duplex type "SC/BFOC/2,5" hybrid connector adapter;
- using IEC 61754-13 and IEC 60869-1-1 to partially define a future IEC 60874 series specification for an integrated type "FC" present attenuated optical connector;

- using IEC 61754-2 and IEC 61073-4 to partially define a future IEC 60874 series specification for a duplex "BFOC/2,5" receptacle incorporating integral mechanical splices.

Other examples of requirements to normative extensions are the following: some commercial or residential building applications may require direct reference to specific safety codes and regulations or incorporate other specific material flammability or toxicity requirements for specialised locations.

Specialised field tooling may require an extension to implement specific ocular safety, electric shock, burn hazard avoidance requirements, or require isolation procedures to prevent potential ignition of combustible gases.

5.2 Documentation

5.2.1 Symbols

Graphical and letter symbols shall, whenever possible, be taken from IEC 60027 (all parts) and IEC 60617 unless superseded by this document.

5.2.2 Specification system

5.2.2.1 General

This document forms part of a three-level IEC specification system. Subsidiary specifications shall consist of blank detail specifications and detail specifications. This system is shown in Table 1. There are no sectional specifications for power control devices.

Table 1 – Three-level IEC specification structure

Specification level	Examples of information to be included	Applicable to
Basic	– Assessment system rules – Inspection rules – Optical measurement methods – Sampling plans – Identification rule – Marking standards – Dimensional standards – Terminology – Symbols – Preferred number series – SI units	Two or more component families or subfamilies
Generic	– Specific terminology – Specific symbols – Specific units – Preferred values – Marking – Quality assessment procedures – Selection of tests – Qualification approval and/or capability approval procedures	Component family
Blank detail	– Quality conformance test schedule – Inspection requirements – Information common to a number of types	Groups of types having a common test schedule
Detail	– Individual values – Specific information – Completed quality conformance test schedules	Individual type

5.2.2.2 Blank detail specification

The blank detail specification lists all the parameters and features applicable to power control devices including the type, operating characteristics, housing configurations, test methods and performance requirements. The blank detail specification is applicable to any power

control device design and quality assessment requirement. The blank detail specification contains the preferred format for stating the required information in the detail specification.

5.2.2.3 Detail specification

A specific power control device is described by a corresponding detail specification, which is prepared by filling in the blanks of the blank detail specification. Within the constraints imposed by this generic specification, the blank detail specification may be filled in by any national committee of the IEC, thereby defining as an official IEC standard a particular power control device design.

Detail specifications shall specify the following, as applicable:

- type (see 5.1.2);
- wavelength band (see 5.1.3);
- style (see 5.1.4);
- variant(s) (see 5.1.5);
- variant identification number(s) (see 5.7.2);
- all tests required;
- assessment level (see 5.1.6);
- performance requirements (see 5.6).

5.2.3 Drawings

5.2.3.1 General

The drawings and dimensions given in detail specifications shall not restrict details of construction, nor shall they be used as manufacturing drawings.

5.2.3.2 Projection system

Either first-angle or third-angle projection shall be used for the drawings in documents covered by this document. All drawings within a document shall use the same projection system, and the drawings shall state which system is used.

5.2.3.3 Dimensional system

All dimensions shall be given in accordance with ISO 129-1, ISO 286-1 and ISO 1101.

The metric system shall be used in all specifications.

Dimensions shall not contain more than five significant digits.

When units are converted, a note shall be added in each relevant specification, and the conversion between systems of units shall use a factor of 25,4 mm to 1 inch.

5.2.4 Tests and measurements

5.2.4.1 Measurement method

The size measurement method to be used for dimensions shall be specified in the detail specification for any dimensions which are specified within a total tolerance zone of 0,01 mm or less.

5.2.4.2 Reference components

Reference components for measurement purposes, if required, shall be specified in the detail specification.

5.2.4.3 Gauges

Gauges, if required, shall be specified in the relevant specification.

5.2.5 Test data sheets

Test data sheets shall be prepared for each test conducted as required by a detail specification. The data sheets shall be included in the qualification report and in the periodic inspection report.

Data sheets shall contain the following information as a minimum:

- title of test and date;
- specimen description including the variant identification number (see 5.7.2);
- test equipment used;
- all applicable test details;
- all measurement values and observations;
- sufficient detailed documentation to provide traceable information for failure analysis.

5.2.6 Instructions for use

Instructions for use, when required, shall be given by the manufacturer and shall consist of the following:

- assembly and connection instructions;
- cleaning method;
- safety aspects;
- additional information as necessary.

5.3 Standardization system

5.3.1 Interface standards

The interface standards provide both manufacturer and user with all the information they require to make or use the product in conformity with the physical features of that standard interface. Interface standards fully define and dimension the features essential for the mating and unmating of optical fibre connectors and other components. They also serve to position the optical datum target, where defined, relative to other reference data.

Interface standards ensure that connectors and adapters that comply with the standard will fit together. The standards may also contain tolerance grades for ferrules and alignment devices. Tolerance grades are used to provide different levels of alignment precision.

The interface dimensions may also be used to design other components that will mate with the connectors. For example, an active device mount can be designed using the adapter interface dimensions. The use of these dimensions combined with those of a standard plug provides the designer with assurance that the standard plugs will fit into the optical device mount. They also provide the optical datum target location of the plugs.

Standard interface dimensions do not, by themselves, guarantee optical performance. They guarantee connector mating at a specified fit. Optical performance is currently guaranteed via the manufacturing specification. Products from the same or different manufacturing specifications using the same standard interface will always fit together. Guaranteed

performance can be given by any single manufacturer only for products delivered to the same manufacturing specification. However, it can be reasonably expected that some level of performance will be obtained by mating products from different manufacturing specifications, although the level of performance cannot be expected to be any better than that of the lowest specified performance.

5.3.2 Performance standards

Performance standards contain a series of test sets and measurements (which may or may not be grouped into a specified schedule, depending on the requirements of those standards) with clearly defined conditions, severities and pass/fail criteria. The tests are intended to be run on a one-off basis to prove any product's ability to satisfy the performance standards' requirements. Each performance standard has a different set of tests and/or severities (and/or groupings), and represents the requirements of a market sector, user group or system location.

A product that has been shown to meet all the requirements of a performance standard can be declared as complying with a performance standard but should then be controlled by a quality assurance/quality conformance programme.

A key point for the application of the test and measurements standards (particularly with regard to insertion loss and return loss) in conjunction with interface standards of inter-product compatibility, may be defined. The conformity of each individual product with this document will be ensured.

5.3.3 Reliability standards

Reliability standards are intended to ensure that a component can meet performance specifications under stated conditions for a stated time period.

For each type of component, the following elements need to be identified (and appear in the standard):

- failure modes (observable general mechanical or optical effects of failure);
- failure mechanisms (general causes of failure, common to several components);
- failure effects (detailed causes of failure, specific to the component).

These are all related to environmental and material aspects.

Initially, just after component manufacture, there is an "infant mortality phase" during which many components would fail if they were deployed in the field. To avoid early field failure, all components may be subjected to a screening process in the factory, involving environmental stresses that may be mechanical, thermal, and humidity-related. This is to induce known failure mechanisms in a controlled environmental situation to occur earlier than would normally be seen in the unscreened population. For those components that survive (and are then sold), there is a reduced failure rate since these mechanisms have been eliminated.

Screening is an optional part of the manufacturing process, rather than a test method. It will not affect the "useful life" of a component, defined as the period during which it performs according to specifications. Eventually, other failure mechanisms appear, and the failure rate increases beyond some defined threshold. At this point, the useful life ends, the "wear-out region" begins, and the component ~~must~~ shall be replaced.

At the beginning of the useful life, performance testing on a sample population of components may be applied by the supplier, by the manufacturer, or by a third party. This is to ensure that the component meets performance specifications over the range of intended environments at this initial time. Reliability testing, on the other hand, is applied to ensure that the component meets performance specifications for at least a specified minimum useful lifetime or with a

specified maximum failure rate. These tests are usually done by utilising the same performance testing, with increased duration and severity to accelerate the failure mechanisms.

A reliability theory relates component reliability testing to component parameters and to lifetime or failure rate under testing. The theory then extrapolates these to lifetime or failure rate under less stressful service conditions. The reliability specifications include values of the component parameters needed to ensure the specified minimum lifetime or maximum failure rate in service.

5.3.4 Interlinking

The standards relevant to fibre optic ~~connectors~~ passive power control devices are given in Figure 8. A large number of test and measurement standards are already in place. The quality assurance / qualification approval standards produced under the banner of the IECQ have already been in place for many years.

With regard to standards relating to interface, performance, optical interface, reliability, and tests and measurements, the matrix given in Table 2 demonstrates some of the options available for product standardization once all of these ~~three~~ standards are in place.

Product A is fully IEC standardized, having a standard interface and meeting defined optical interface performance and reliability requirements.

Product B is a product with a proprietary interface, but which meets defined IEC optical interface, performance and reliability requirements.

Product C is a product with a proprietary interface, which meets defined IEC optical interface and performance standards but does not comply with reliability requirements.

Product D is a product which complies with an IEC standard interface which complies with the IEC optical interface standard but which does not meet the requirements of either an IEC performance standard or those of reliability documentation.

Product E is a product which complies with both an IEC standard interface and a performance standard, but does not meet the optical interface or reliability requirements.

Obviously, the matrix is more complex than that shown in Table 2, since a number of interface, performance and reliability documents will be able to be cross-related. In addition, the products may all be subject to a quality assurance programme that could be conducted under IEC approval, or even under a national or company quality assurance system.

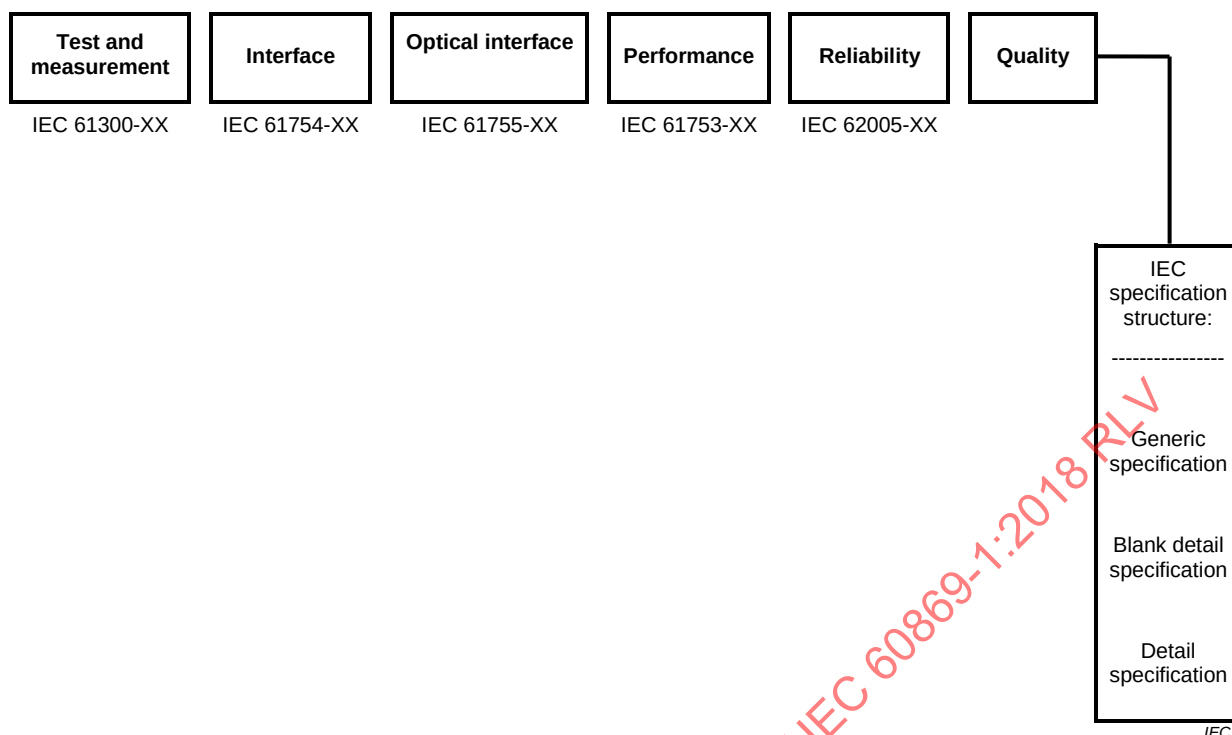


Figure 8 – Standardization structure

Table 2 – Standards' interlink matrix

	Interface standard	Optical interface standard	Performance standard	Reliability documentation
Product A	YES	YES	YES	YES
Product B	NO	YES	YES	YES
Product C	NO	YES	YES	NO
Product D	YES	YES	NO	NO
Product E	YES	NO	YES	NO

5.4 Design and construction

5.4.1 Materials

The devices shall be manufactured from materials which meet the requirements of the relevant specification.

When non-flammable materials are required, the requirement shall be specified in the relevant specification, and the needle-flame test (see IEC 60695-11-5) shall be referenced.

5.4.2 Workmanship

Devices and associated hardware shall be manufactured to a uniform quality and shall be free of sharp edges, burrs or other defects that would affect life, serviceability or appearance. Particular attention shall be given to neatness and thoroughness of marking, plating, soldering, bonding, etc.

5.5 Quality

Power control devices shall be controlled by the quality assessment procedures.

5.6 Performance

Power control devices shall meet the performance requirements specified in the relevant specification standards.

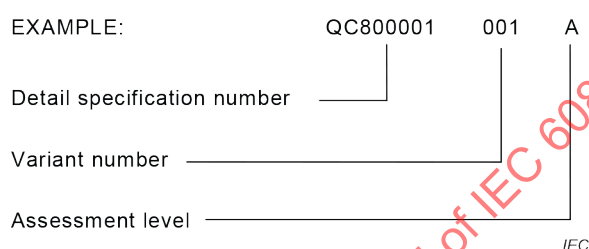
5.7 Identification and marking

5.7.1 General

Devices, associated hardware and shipping packages shall be permanently and legibly identified and marked when required by the relevant specification.

5.7.2 Variant identification number

Each variant in a detail specification shall be assigned a variant identification number; this number shall be set out as follows.



5.7.3 Component marking

Component marking, if required, shall be specified in the detail specification. The preferred order of marking is the following:

- port identification;
- manufacturer's part number (including serial number, if applicable);
- manufacturer's identification mark or logo;
- manufacturing date;
- variant identification number;
- any additional marking required by the detail specification.

If space does not allow for all the required marking on the component, each unit shall be individually packaged with a data sheet containing all of the required information which is not marked.

5.7.4 Package marking

Several power control devices may be packaged together for shipment.

Package marking, if required, shall be specified in the detail specification. The preferred order of marking is the following:

- manufacturer's identification mark or logo;
- manufacturer's part numbers;
- manufacturing date codes (year/week, see ISO 8601);
- variant identification number(s);
- type designations;
- assessment levels;
- any additional marking required by the detail specification.

When applicable, individual unit packages (within the sealed package) shall be marked with the reference number of the certified record of released lots, the manufacturer's factory identity code and the component identification.

5.8 Packaging

Packages shall include instructions for use when required by the specification.

5.9 Storage conditions

Where short-term degradable materials, such as adhesives, are supplied with the package of connector parts, the manufacturer shall mark these with the expiry date (year and week numbers according to ISO 8601) together with any requirements or precautions concerning safety hazards or environmental conditions for storage.

5.10 Safety

Optical power control devices, when used on an optical fibre transmission system and/or equipment, may emit potentially hazardous radiation from an uncapped or unterminated output port or fibre end. Safety instructions shall be according to IEC 60825 (all parts) relating to laser safety.

The manufacturers of optical power control devices shall make available sufficient information to alert system designers and users about the potential hazard and shall indicate the required precautions and working practices.

In addition, each relevant specification shall include the following text:

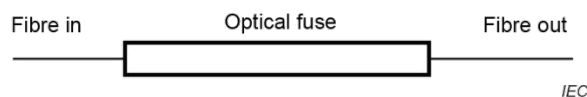
WARNING-~~NOTE~~

– Care should be taken when handling small diameter fibres to prevent puncturing the skin, especially in the eye area. Direct viewing of the end of an optical fibre or an optical fibre connector when it is propagating energy is not recommended unless prior assurance has been obtained as to the safety of the energy output level.

Annex A (informative)

Optical fuse configuration and performance examples

Examples of optical fuse configurations are given in Figures A.1 and A.2.



NOTE Typical dimensions are 4 mm to 6 mm diameter and 40 mm length.

Figure A.1 – Optical fuse, ~~pigtail~~ non-connectorized style

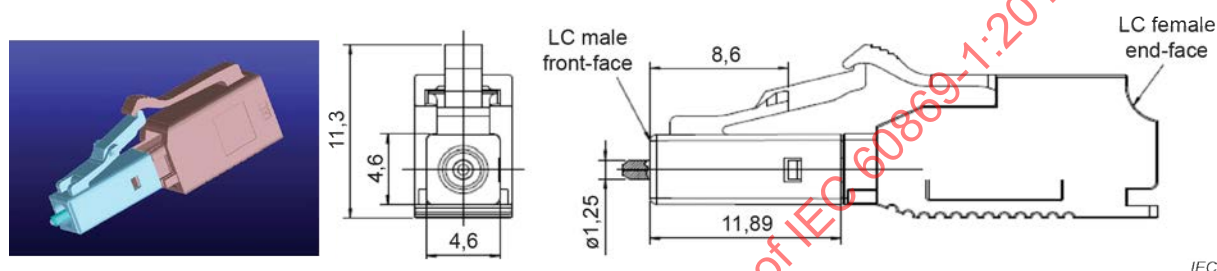


Figure A.2 – Optical fuse, plug-receptacle style (LC-plug)

Optical fuses are manufactured in various optical power threshold values, and it is recommended that continuous optical power applied to a fuse be no more than 3 dB below the threshold values.

~~The response time of the optical fuse is defined as the total time where the optical fuse output power level is higher than the predetermined threshold + 1 dB. An example of optical fuse response time is given in Figure A.3. Here the input pulse duration is 1 ms with rise time of 10 µs and a steady-state of power threshold + 3 dB. Figure A.3 illustrates the parameters. Figure A.4 shows an example of an optical fuse having power threshold of ~30 dBm (1W) and an output power drop at threshold of ~25 dB.~~

The response time of the optical fuse is the total length of time between the start of the input power (for example $P_{in} = P_{th} + 3 \text{ dB}$, 1 ms rectangle pulse) and the end time when the output optical power has decreased to be less than $P_{th} - IL \text{ dB}$ or $P_{in} - A_{block}$ (for example 30 dB). An example of optical fuse response time is given in Figure A.3. Here the input pulse duration is 1 ms with rise time of 10 µs and a steady-state of $(P_{th} + 3) \text{ dB}$. Figure A.3 illustrates the parameters.

Figure A.4 shows an input power vs output power of an optical fuse, having power threshold approximately 30 dBm (1 W), showing output power drop at threshold of approximately 25 dB.

In this case, the rise time is the elapsed time for input power to reach 90 % of its steady-state value from the time it starts.

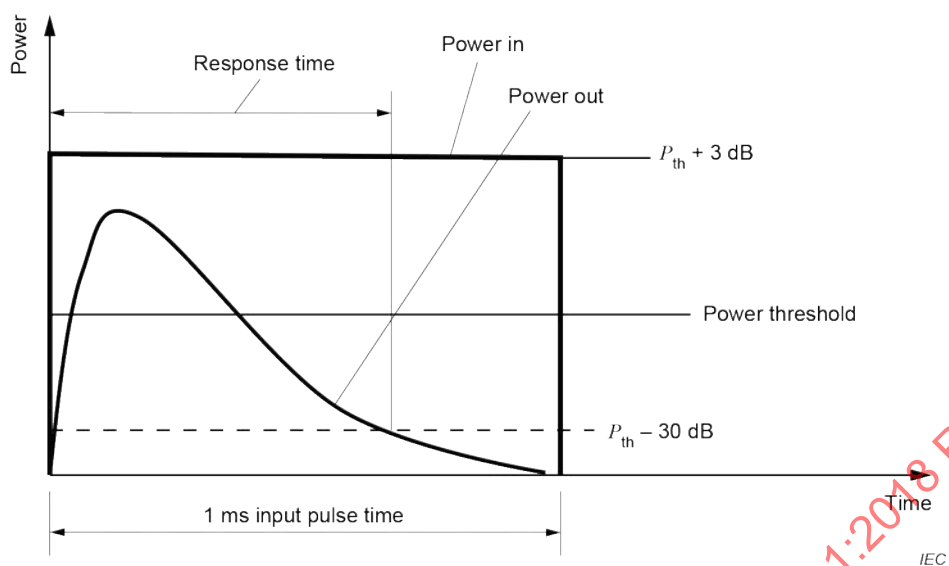


Figure A.3 – Response time curve of an optical fuse

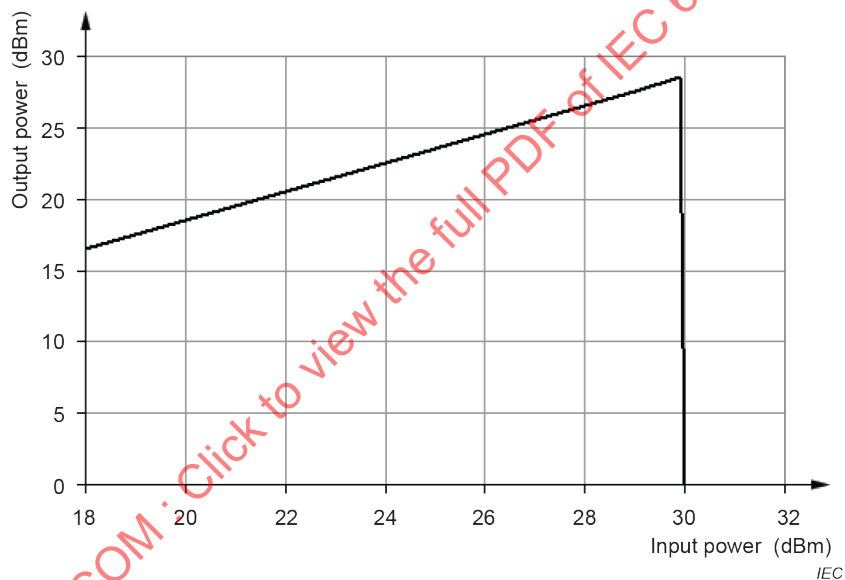


Figure A.4 – Optical fuse, power threshold approx. 30 dBm (1 W), output power drop at threshold approx. 25 dB

Annex B (informative)

Optical fuse application notes

The passive optical fuse is a device, which can be used for optical over-power safety. The optical fuse is activated ~~by~~ at a broad range of wavelengths, shutting off the optical power propagation from input to output at a predetermined optical power level.

The main characteristics of the optical fuse are the following:

- the transmitted optical communication data is unaffected by the optical fuse as long as the optical power is below the predetermined threshold power;
- the optical fuse is wavelength independent for the optical communication ~~regions~~ ranges;
- the response time is < 100 µs, offering fast response;
- used in SMF, MM, and PM fibres;
- can be used as a stand-alone unit or an integrated unit into an optical sub-system as an internal part.

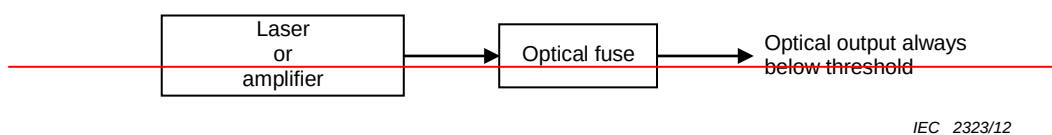
The optical fuse can be used as an add-on at the output port of:

- ~~lasers,~~
- transmitters and
- amplifiers.
- ~~modulators.~~

The optical fuse can be used as an add-on at the input port of:

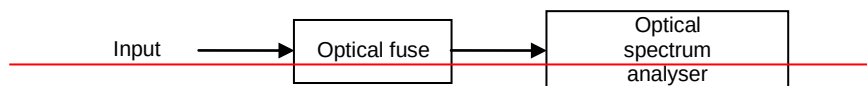
- ~~power meters,~~
- optical switches,
- test equipment (e.g. ~~spectrometers,~~ optical power meters, wavelength meters, optical spectrum analysers, ~~detectors~~), and
- receivers.
- ~~MUX-DEMUX units.~~

~~Thus the next device can be protected~~ The next device is therefore protected from damage by the light source, as shown in Figure B.1.



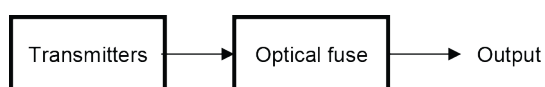
IEC 2323/12

Figure B.1a – Placement at output of active devices



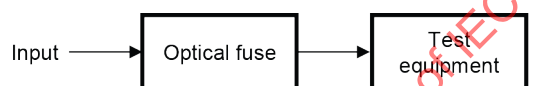
IEC 2324/12

Figure B.1b – Placement at input of active devices



IEC

a) Placement at output



IEC

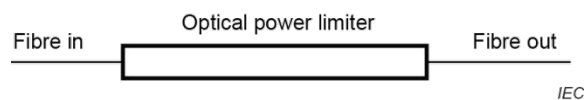
b) Placement at input

Figure B.1 – Placement of an optical fuse

Annex C (informative)

Optical power limiter configuration and performance examples

The optical power limiter configurations are shown in Figures C.1 and C.2.



NOTE Typical dimensions are 6 mm diameter and 50 mm length.

Figure C.1 – Optical power limiter, ~~pigtail~~ non-connectorized style

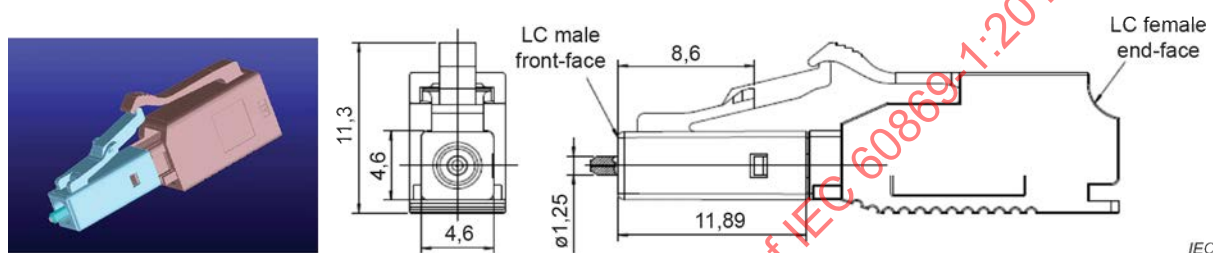


Figure C.2 – Optical power limiter, plug-receptacle style (LC ~~plug~~)

Optical power limiters are manufactured ~~in~~ with various limit power values.

An experimental example of optical power limiter behaviour appears in Figure C.3; here, the input power was varied up from 0 to +18 dBm and back a few tens of cycles, showing curves that are identical within 0,2 dBm (black lines).

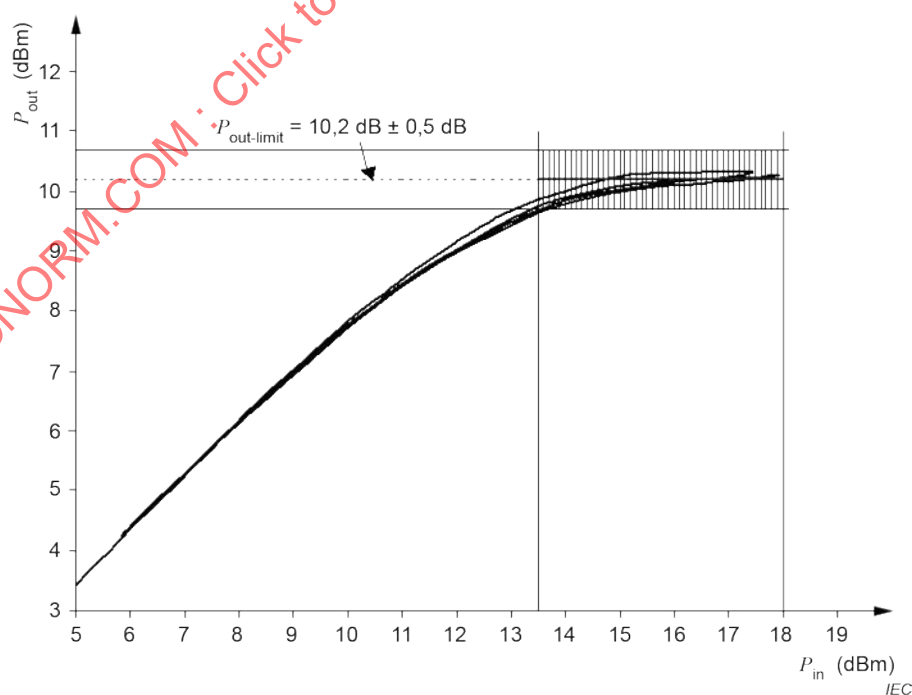


Figure C.3 – Optical power limiter – Experimental

~~Response time is the total time where the optical power limiter output power level is above ($P_{\text{limit}} + 1$ dB) power line, when exposed to a square wave input power, 1 ms long, having a rise time of 10 μ s and a steady-state power of $P_{\text{limit}} + 3$ dB.~~

The response time of the optical limiter is the total time elapsing between the start of the input power (for example $P_{\text{in}} = P_{\text{limit}} + 3$ dB, 1 ms rectangle pulse) and the end time when the output power has decreased to be less than or equal to the predetermined power (for example the output power is less than $P_{\text{limit}} + 1$ dB). Figure C.4 illustrates the parameters.

In this case, the rise time is the elapsed time for input power to reach 90 % of its steady-state value from the time it starts.

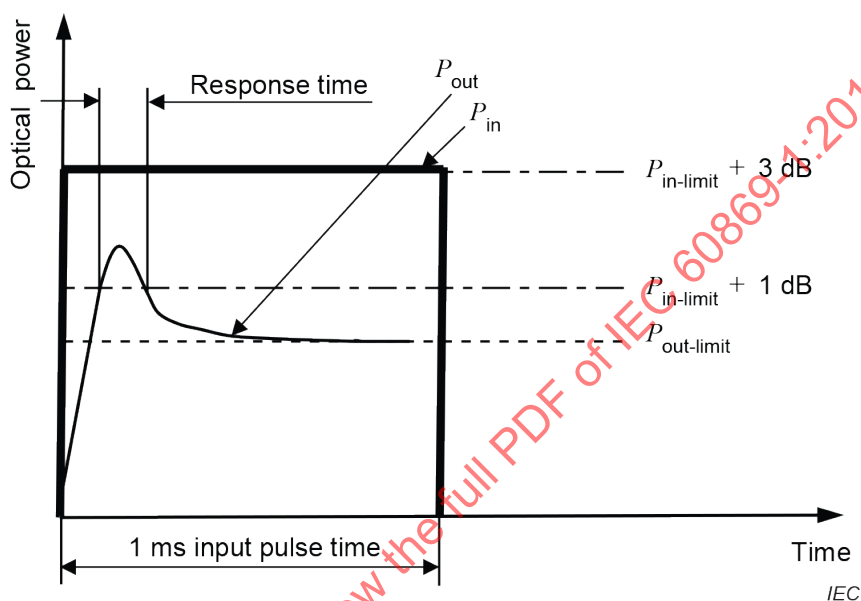


Figure C.4 – Schematic optical power limiter response time; 1 ms input pulse time

Optical limit power, P_{limit} is measured experimentally as the average between $P_{\text{out max.}}$ and $P_{\text{out min.}}$ within a 3 dB input power range during a cycle of P_{out} as a function of P_{in} , as depicted in Figure C.5.

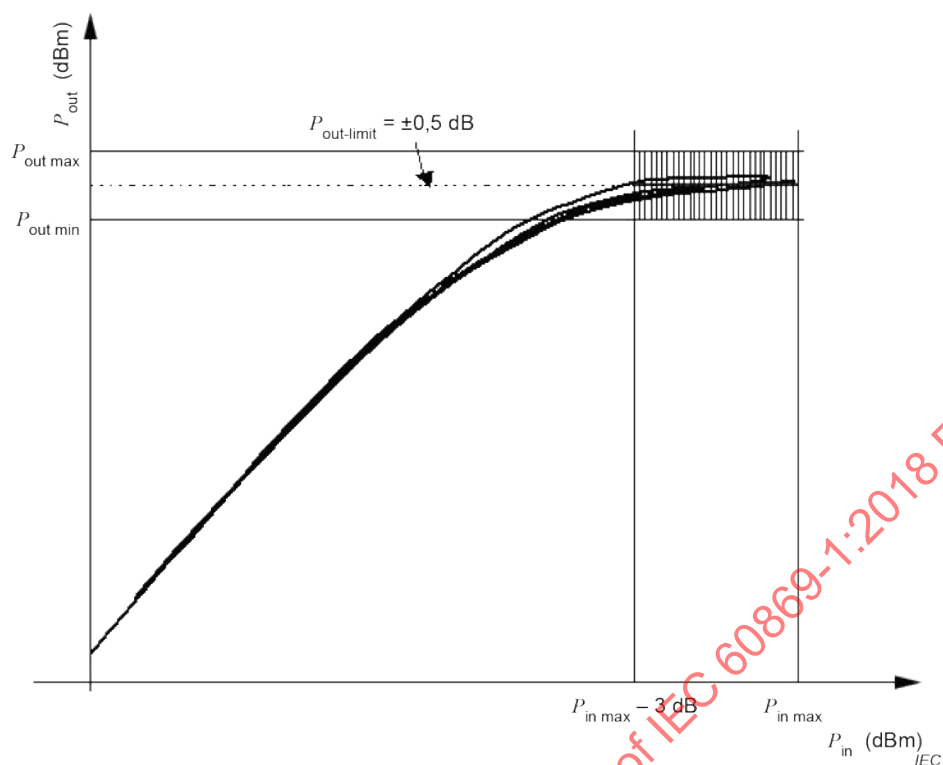


Figure C.5 – Schematic power definitions

The optical power limiter can typically operate under CW input up to 5 dB above P_{limit} , and can accommodate short duration pulses and spikes (1 s/min) up to 8 dB above P_{limit} as shown in Figure C.6.

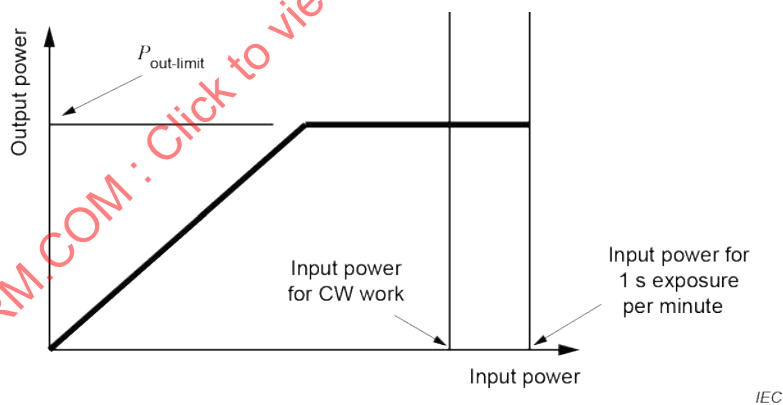


Figure C.6 – Optical power limiter, input power definitions

Annex D (informative)

Optical power limiter application notes

The optical power limiter regulates the optical power. It is used at the input to power-sensitive equipment, and at the output of high power components, such as amplifiers or lasers, where power regulation is required. The optical power limiter can serve as a protection device and as an eye safety power regulator. Under normal operation, when the input power is low, the limiter has no effect on the system. However, when the input power is high, the output power is limited to a certain level (P_{limit}). The limiter is wavelength-independent in the region of its transparency.

The main characteristics of the optical power limiter are the following:

- the transmitted optical communication data is unaffected by the optical power limiter;
- the optical power limiter is wavelength independent for the optical communication regions;
- the response time is $< 500 \mu\text{s}$, offering fast response (at $P_{\text{in}} = P_{\text{in max.}}$);
- used in SMF, MM, and PM fibres;
- can be used as a stand-alone unit or an integrated unit into an optical sub-system as an internal part.

The optical power limiter can be used as an add-on at the output port of:

- ~~lasers,~~
- transmitters and
- amplifiers.
- ~~modulators.~~

The optical power limiter can be used as an add-on at the input port of:

- ~~power meters,~~
- optical switches,
- test equipment (e.g. ~~spectrometers,~~ optical power meters, wavelength meters, optical spectrum analysers, ~~detectors~~) and
- receivers.
- ~~MUX-DEMUX devices.~~

The optical power limiter can be used to protect the next device from damage by the light source.

The optical power limiter is, in some cases, combined in line with an optical fuse, ensuring that at high powers, ~~when~~ if the limiter fails, the following device is not exposed to damaging power, as shown in Figure D.1.

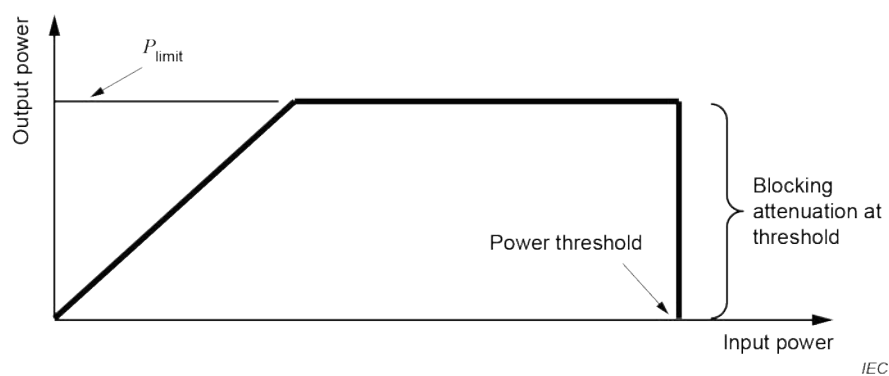


Figure D.1 – Optical power limiter and optical fuse, combined, operation curve

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Annex E (informative)

Fixed optical attenuator application note

The fixed optical attenuator is a passive device that has fixed attenuation, which can be used for optical power control and optical over-power safety. The fixed optical attenuator handles a broad range of wavelengths, reducing the optical power propagation from input to output at a predetermined amount. Fixed attenuators can be of plug-style attenuators or ~~fixed~~ pigtailed style attenuators.

The main characteristics of the fixed optical attenuator are the following:

- the transmitted optical communication data is unaffected by the fixed optical attenuator;
- the fixed optical attenuator is wavelength independent for the optical communication regions;
- the ~~fixed optical attenuator~~ response time is immediate;
- ~~the fixed optical attenuator is~~ used in SMF, MM, and PM fibres;
- ~~the fixed optical attenuator~~ can be used as a stand-alone unit or an integrated unit into an optical sub-system as an internal part.

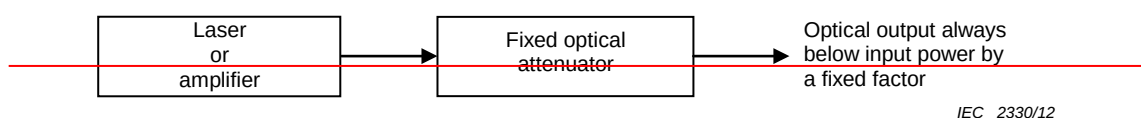
The fixed optical attenuator can be used as an add-on at the output port of:

- ~~lasers,~~
- transmitters and
- amplifiers.
- ~~modulators.~~

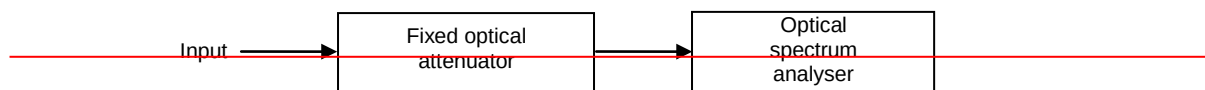
The fixed optical attenuator can be used as an add-on at the input port of:

- ~~power meters;~~
- optical switches;
- test equipment (e.g. ~~spectrometers,~~ optical power meters, wavelength meters, optical spectrum analysers, ~~detectors~~); and
- receivers.
- ~~MUX-DEMUX units.~~

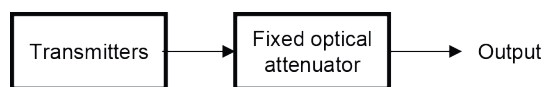
The next device ~~can be~~ is therefore protected from damage by the light source, as shown in Figure E.1.



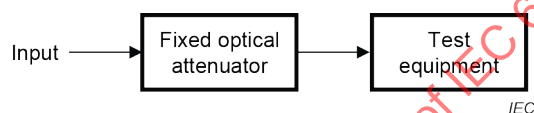
IEC 2330/12

Figure E.1a – Placement at output of active devices

IEC 2331/12

Figure E.1b – Placement at input of active devices

IEC

a) Placement at output

IEC

b) Placement at input**Figure E.1 – Placement of a fixed optical attenuator**

Annex F (informative)

Variable (manually or electrically) optical attenuator application note

The variable (manually or electrically) optical attenuator is a passive device, which produces controlled signal attenuation in an optical fibre transmission line. It can be used for optical power control or over-power safety. The variable (manually or electrically) optical attenuator handles a broad range of wavelengths, reducing the optical power propagation from input to output at a controlled, variable amount. The variable (manually or electrically) optical attenuator can be of plug-style or pigtailed style.

The main characteristics of the variable (manually or electrically) optical attenuator are:

- ~~the variable, manual or electrical, optical attenuator has~~ attenuation according to a manual or electrical setting;
- the transmitted optical communication data is unaffected by the variable, manual or electrical, optical attenuator;
- the variable, manual or electrical, optical attenuator is wavelength independent for the optical communication regions;
- ~~the variable, manual or electrical, optical attenuator response time is immediate;~~
- ~~the variable, manual or electrical, optical attenuator is~~ used in SMF, MM, and PM fibres;
- ~~the variable, manual or electrical, optical attenuator~~ can be used as a stand-alone unit or an integrated unit into an optical sub-system as an internal part.

The variable (manually or electrically) optical attenuator can be used as an add-on at the output port of:

- ~~lasers,~~
- transmitters and
- amplifiers.
- ~~modulators.~~

Here the variable (manually or electrically) optical attenuator ~~is controlling~~ controls the ~~input~~ output power and ~~setting~~ sets it to a desired level.

The variable, ~~manual or electrical,~~ optical attenuator can be used as an add-on at the input port of:

- ~~power meters,~~
- optical switches,
- test equipment (e.g. ~~spectrometers,~~ optical power meters, wavelength meters, optical spectrum analysers, ~~detectors~~), and
- receivers,
- ~~MUX-DEMUX units.~~

The variable (manually or electrically) optical attenuator ~~is controlling~~ controls the output power or ~~protecting~~ protects the next device from damage by the light source, as shown in Figure F.1.

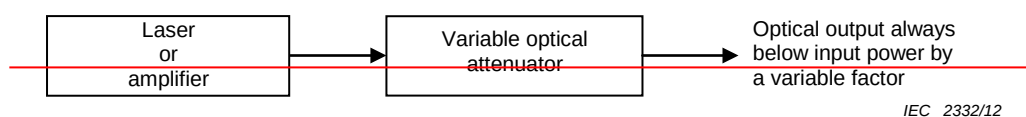


Figure F.1a – Placement at output of active devices

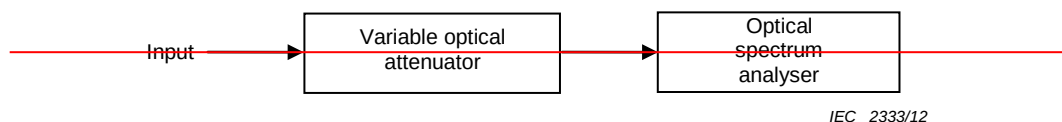
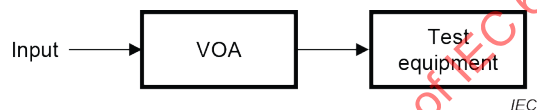


Figure F.1b – Placement at input of active devices



a) Placement at output



b) Placement at input

Figure F.1 – Placement of a variable, manual or electrical, optical attenuator

Annex G (informative)

Example of technology of variable optical attenuators

G.1 Example technology of micro-electromechanical system (MEMS) based VOA

Figure G.1 shows the example technology of MEMS based VOA. An optical beam from the input port fibre focuses on the MEMS mirror by the lens; it is then reflected and reaches the output port fibre through the lens. When the MEMS mirror tilts due to electrostatic force by applying a voltage, the beam focuses on the side of the output port fibre. This makes for increasing attenuation. By controlling the applied voltage, the tilt angle of the mirror is changed and thus the attenuation is changed.

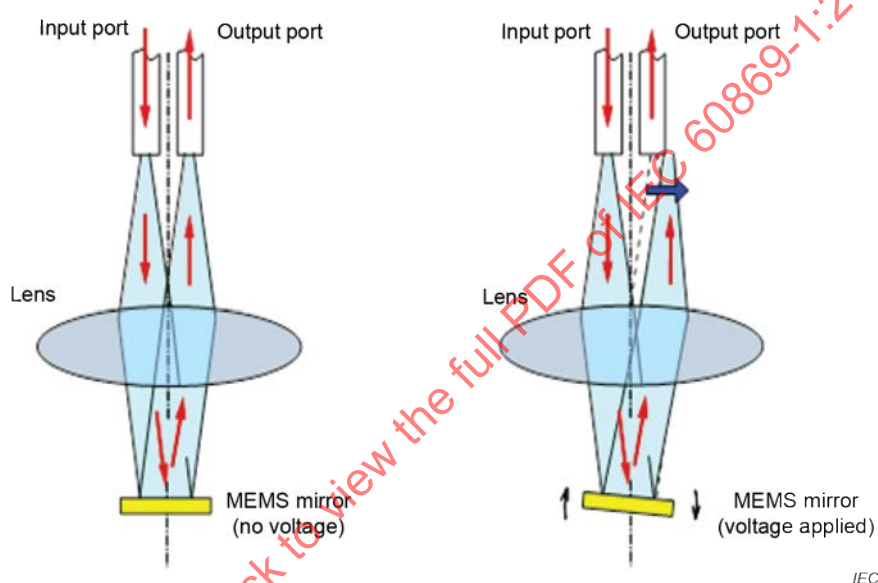
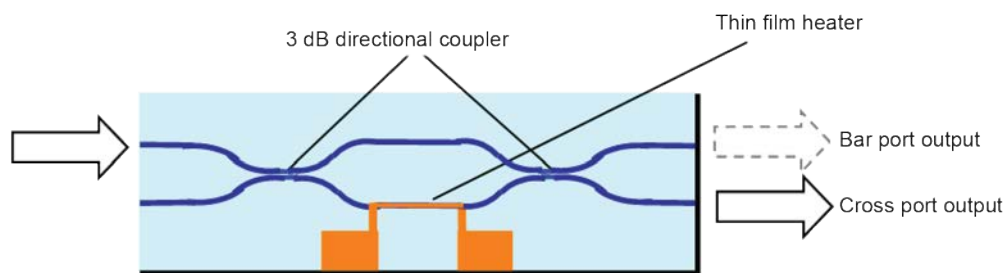


Figure G.1 – Example technology of MEMS based VOA

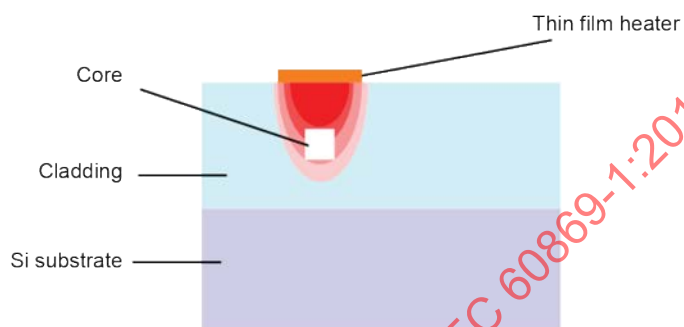
G.2 Example technology of planar lightwave circuit (PLC) based and thermo-optic (TO) based VOA

Figure G.2 shows the example technology of PLC and TO based VOA. Connecting two 3-dB directional couplers in silica waveguide, the Mach-Zehnder interferometer is fabricated. The electrode on the bottom arm is attached. When the electrode is heated by applying electrical current, the refractive index changes, causing the optical phase difference in the two arms, resulting in output optical power change. Figure G.3 shows the relationship of the phase and attenuation.



IEC

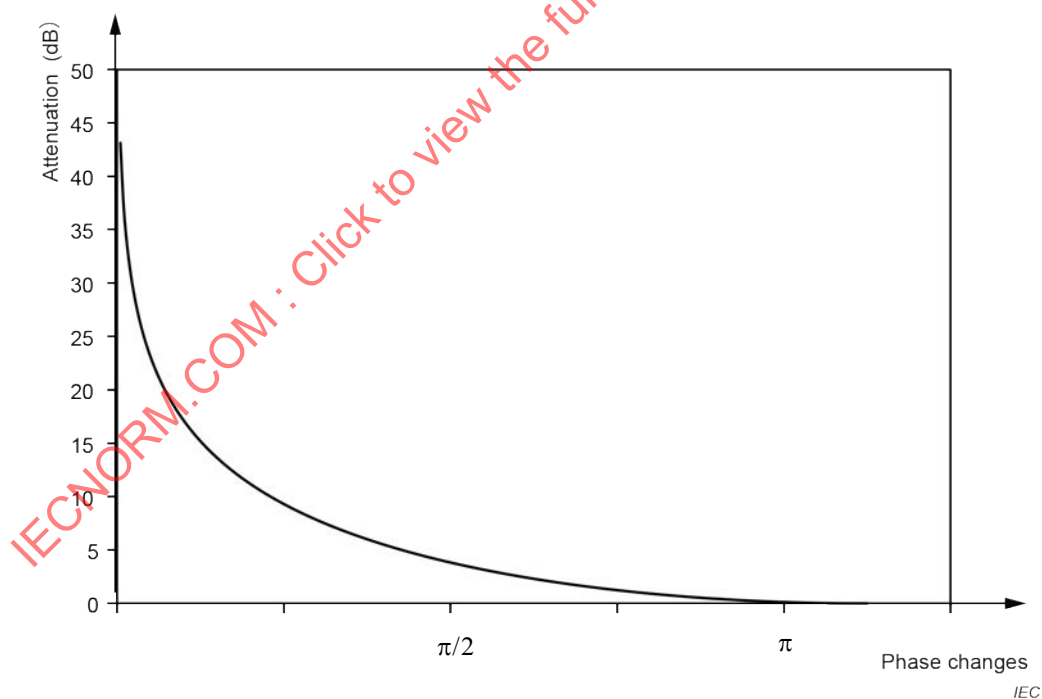
a) Top view



IEC

b) Cross-section view

Figure G.2 – Example technology of PLC-TO based VOA



IEC

Figure G.3 – The relation of phase changes and attenuation

G.3 Example technology of magnet-optic (MO) based VOA

Figure G.4 shows the example technology of MO based VOA. The basic configuration is similar to that of a fibre optic isolator which has two polarisers made by birefringent crystals and a Faraday rotator in the middle. The direction of the magnetic field applying Faraday

rotator is different. By applying the magnetic field, the beam after the second polariser (analyser) splits and tilts.

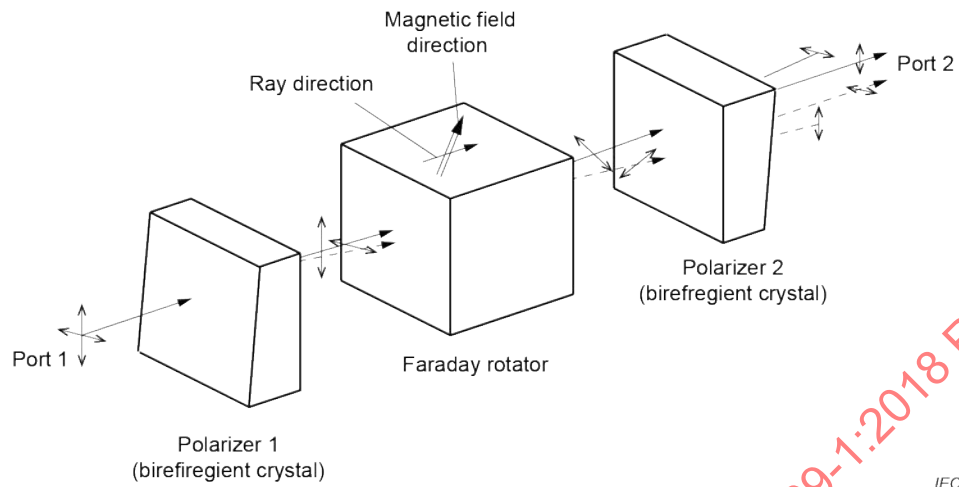


Figure G.4 – Example technology of MO based VOA

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IEC 61753-056-2, *Fibre optic interconnecting devices and passive components – Performance standard – Part 056-2: Single mode fibre pigtailed style optical fuse for category C – Controlled environment*

IEC 61753-057-2, *Fibre optic interconnecting devices and passive components – Performance standard – Part 057-2: Single mode fibre plug-receptacle style optical fuse for category C – Controlled environment*

IEC 61753-058-2, *Fibre optic interconnecting devices and passive components – Performance standard – Part 058-2: Single mode fibre pigtailed style optical power limiter for category C – Controlled environment*

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INTERNATIONAL STANDARD

NORME INTERNATIONALE



**Fibre optic interconnecting devices and passive components – Fibre optic passive power control devices –
Part 1: Generic specification**

**Dispositifs d'interconnexion et composants passifs fibroniques – Dispositifs fibroniques passifs de contrôle de la puissance –
Partie 1: Spécification générique**

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

**FIBRE OPTIC INTERCONNECTING DEVICES AND PASSIVE
COMPONENTS – FIBRE OPTIC PASSIVE POWER CONTROL DEVICES –****Part 1: Generic specification****FOREWORD**

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International Standard IEC 60869-1 has been prepared by subcommittee 86B: Fibre optic interconnecting devices and passive components, of IEC TC 86: Fibre optics.

This fifth edition cancels and replaces the fourth edition published in 2012 and constitutes a technical revision.

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

- a) the terms and definitions have been reviewed;
- b) the requirement concerning the IEC Quality Assessment System has been reviewed;
- c) the clause concerning quality assessment procedures has been deleted;
- d) Annex G, relating to technical information on variable optical attenuators, has been added.

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

FDIS	Report on voting
86B/4139/FDIS	86B/4144/RVD

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

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

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.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

FIBRE OPTIC INTERCONNECTING DEVICES AND PASSIVE COMPONENTS – FIBRE OPTIC PASSIVE POWER CONTROL DEVICES –

Part 1: Generic specification

1 Scope

This part of IEC 60869 applies to fibre optic passive power control devices. These have all of the following general features:

- they are passive in that they contain no optoelectronic or other transducing elements;
- they have two ports for the transmission of optical power and control of the transmitted power in a fixed or variable fashion;
- the ports are non-connectorized optical fibre pigtails, connectorized optical fibres or receptacles.

This document establishes generic requirements for the following passive optical devices:

- optical attenuator;
- optical fuse;
- optical power limiter.

This document also provides generic information including terminology for the IEC 61753-05x series. Published IEC 61753-05x series documents are listed in Bibliography.

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 60027 (all parts), *Letter symbols to be used in electrical technology*

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

IEC 60617, *Graphical symbols for diagrams* (available at <http://std.iec.ch/iec60617>)

IEC 60695-11-5, *Fire hazard testing – Part 11-5: Test flames – Needle-flame test method – Apparatus, confirmatory test arrangement and guidance*

IEC 60825 (all parts), *Safety of laser products*

IEC 61300 (all parts), *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures*

IEC TS 62627-09, *Fibre optic interconnecting devices and passive components – Vocabulary for passive optical devices*

ISO 129-1, *Technical product documentation (TPD) – Presentation of dimensions and tolerances*

ISO 286-1, *Geometrical product specifications (GPS) – ISO code system for tolerances on linear sizes – Part 1: Basis of tolerances, deviations and fits*

ISO 1101, *Geometrical product specifications (GPS) – Geometrical tolerancing – Tolerances of form, orientation, location and run-out*

ISO 8601, *Data elements and interchange formats – Information interchange – Representation of dates and times*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60050-731, IEC TS 62627-09 and the following 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>

3.1 Component terms

3.1.1

fibre optic passive power control device

passive optical device (component) which controls a transmittance with a designed wavelength-independent transfer coefficient

Note 1 to entry: The transfer coefficient may be controlled for all intensity of input power or for input power over a threshold power.

3.1.2

optical attenuator

passive optical device (component), which produces a wavelength-independent controlled signal attenuation in an optical fibre transmission line

Note 1 to entry: An attenuator is intended to be wavelength independent.

3.1.3

fixed optical attenuator

optical attenuator in which attenuation is constant

3.1.4

variable optical attenuator

VOA

optical attenuator in which attenuation is controllable

Note 1 to entry: Attenuation values of variable optical attenuators are generally controlled by manual or electric means.

Note 2 to entry: This note applies to the French language only.

3.1.5

optical fuse

fibre optic passive power control device, which produces controlled, permanent, signal blocking for higher optical power than a predetermined power threshold in an optical fibre transmission line

3.1.6

optical power limiter

fibre optic passive power control device that regulates the optical power in fibres, producing a controlled, constant optical output power of optical limit power, as a result of varying optical input power higher than the input optical limit power

3.1.7

plug-receptacle style device

fibre optic device having a combination of two interfacing features, a plug at one end and a receptacle at the other

3.2 Performance terms

3.2.1

optical fuse power threshold

P_{th}

optical input power, into an optical fuse, in which the optical output power is blocked

Note 1 to entry: The optical fuse power threshold P_{th} is expressed in watt or dBm.

3.2.2

optical fuse response time

time between the start of the input power and the end time when the output optical power has decreased to be less than the predetermined optical power

Note 1 to entry: The predetermined power shall be either of the power threshold, P_{th} minus insertion loss, IL , ($P_{th} - IL$) in dB, or the input power, P_{in} minus the required blocking attenuation at threshold, A_{block} .

Note 2 to entry: The optical fuse response time depends on the optical input power level and the input pulse time.

Note 3 to entry: An example of the input power, P_{in} , is recommended to be 3 dB over of the power threshold, P_{th} , and the rectangle shape pulse of 1 ms ($P_{in} = P_{th} + 3$ dB). An example of the required blocking attenuation at threshold, A_{block} of 30 dB is recommended.

3.2.3

optical fuse blocking attenuation at threshold

A_{block}

drop in optical power through the optical fuse when exposed to more than the optical fuse power threshold P_{th} , with response by blocking the power, expressed in dB

3.2.4

optical power limiter response time

length of time between the start of the input power and the end time in decreasing the output power to be less than or equal to the predetermined power

Note 1 to entry: The optical power limiter response time depends on the optical input power level and the input pulse time.

Note 2 to entry: An example of the input power, P_{in} is recommended to be 3 dB over of the optical limit power and the rectangular pulse of 1 ms ($P_{in} = P_{limit} + 3$ dB). An example of the pre-determined optical power of $P_{limit} + 1$ dB is recommended.

3.2.5

input optical limit power

$P_{in-limit}$

optical input power, into an optical power limiter, at which the optical output power is latched and cannot exceed that value, $P_{in-limit}$, which is expressed in watt or dBm

3.2.6

output optical limit power

$P_{out-limit}$

optical output power from an optical power limiter, at which the optical output power is latched and cannot exceed that value, $P_{out-limit}$, which is expressed in watt or dBm

3.2.7**minimum insertion loss**

lowest insertion loss to which a VOA is adjusted

3.2.8**variable attenuation range**

range of attenuation to which the device may be adjusted

Note 1 to entry: This term is applicable only to VOAs.

3.2.9**nominal attenuation**

supplier specified attenuation value for fixed attenuators and user-set attenuation value for variable attenuators

3.2.10**maximum attenuation**

<for variable optical attenuator> attenuation of the maximum value which is set

3.2.11**minimum attenuation**

<for variable optical attenuator> attenuation of the minimum value which is set

3.2.12**attenuation setting resolution**

minimal adjustable step size or difference of the attenuation of a VOA

Note 1 to entry: This term is applicable only to VOAs.

3.2.13**error of setting value of attenuation**

difference between the insertion loss of the device at a given setting and nominal attenuation

Note 1 to entry: This term is applicable only to VOAs.

3.2.14**repeatability of setting attenuation value**

maximum deviation of the insertion loss of the device at a given setting in multiple times of repeated settings

Note 1 to entry: This term is applicable only to VOAs.

3.2.15**maximum allowed power input**

maximum input power that the device can handle without causing malfunction or permanent damage, expressed in watt or dBm

Note 1 to entry: This term is applicable to all fibre optic passive power control devices.

Note 2 to entry: This term is equal to optical fuse power threshold to optical fuse.

Note 3 to entry: The maximum input power defined in IEC TS 62627-09 has a different meaning of the maximum input optical power for which a passive optical device keeps the required optical performances.

4 Description of devices**4.1 Optical attenuator**

The optical attenuator is a passive optical device used for optical power reduction into or out of an optical device. The optical attenuator is normally used for a broad range of wavelengths, attenuating the power by a predetermined attenuation rate.

There are two types of optical attenuator: a fixed optical attenuator and a variable optical attenuator.

The power reduction rate of a fixed optical attenuator is constant. The performance curve of a fixed optical attenuator is shown in Figure 1, where the attenuated power is always lower than the non-attenuated power and proportional to it.

Annex E describes the fixed optical attenuator application note as a users' guide.

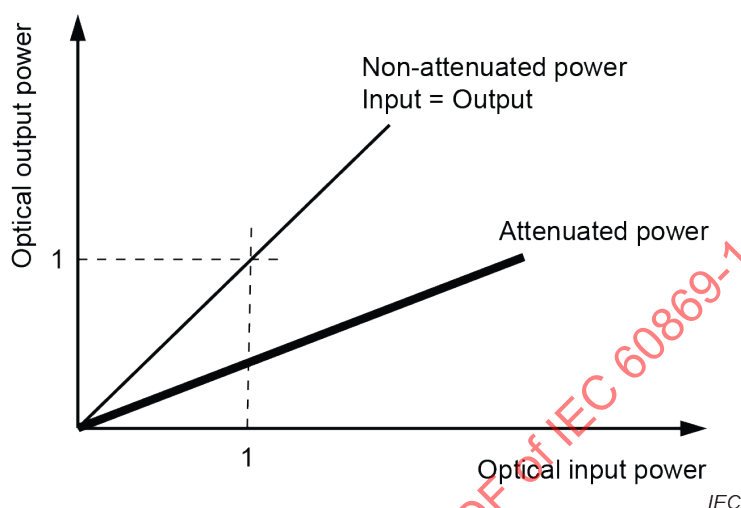


Figure 1 – Fixed optical attenuator operation curve

The performance curve of a variable optical attenuator (VOA) is shown in Figure 2. In a manner similar to that of the fixed optical attenuator, the attenuated power is always lower than the non-attenuated power and proportional to it. The VOA produces a controlled, optical output power, as a result of manual or electrical control input.

Annex F describes the variable optical attenuator application note as a users' guide.

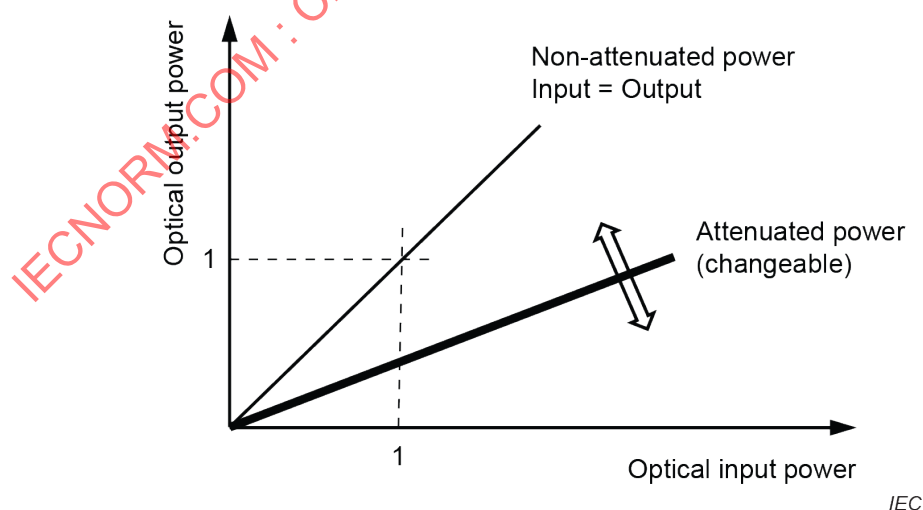
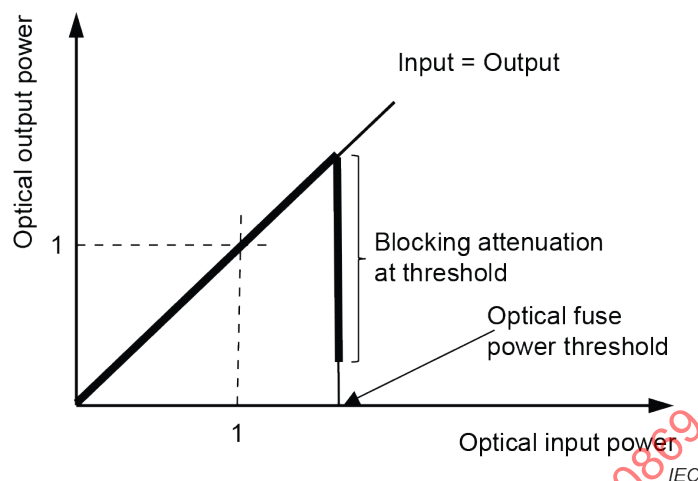


Figure 2 – VOA operation curve

4.2 Optical fuse

The optical fuse (see Figure 3) is a passive device, designed to protect equipment and fibre cables from damage due to optical overpower, spikes and surges. When the input power is

lower than a predetermined threshold power, the optical fuse remains transparent, ideally. However, the optical fuse becomes permanently opaque when the optical power exceeds the specified predetermined threshold level. The optical fuse is wavelength independent in the region of its transparency. The optical fuse is bidirectional.



NOTE Figure 3 schematically explains how the optical fuse operates, with the representation of the ideal optical fuse, which has no insertion loss (IL).

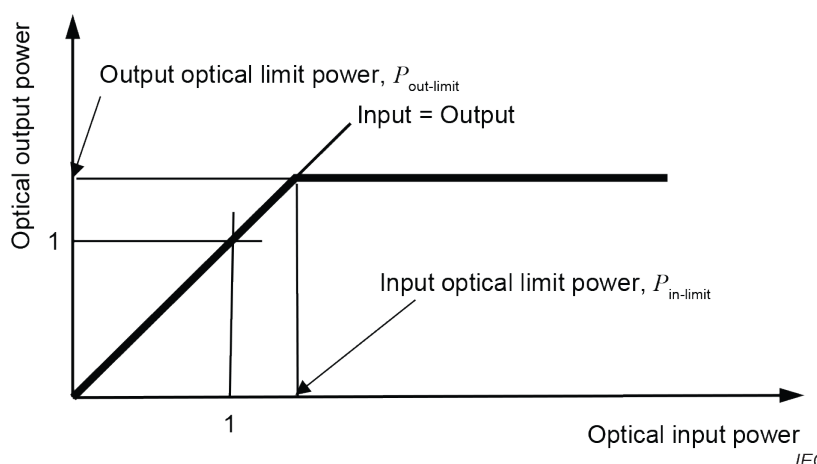
Figure 3 – Optical fuse operation curve

The optical fuse protects against power spikes and surges. The optical fuse is placed either at the input port of an optical device, such as in the case of a detector, or at the output port of a high power device, such as in the case of a laser or optical amplifier. An activated (burnt) fuse permanently blocks the forward optical power without increasing the reflected power, thus preventing damage. The optical fuse can be used as an eye safety device.

Annexes A and B describe optical fuse configuration and performance examples, and optical fuse application notes.

4.3 Optical power limiter

The optical power limiter (see Figure 4) is a passive device that regulates the optical power in fibres, producing a controlled, constant output power $P_{\text{out-limit}}$, as a result of varying input power higher than $P_{\text{in-limit}}$, and has no influence at powers below $P_{\text{in-limit}}$. Under normal operation, when the input power is low, the optical power limiter has no effect on the system. However, when the input power is high, the optical output power is limited to a predetermined level ($P_{\text{out-limit}}$). The optical power limiter can typically operate under continuous wave (CW) input up to 5 dB above $P_{\text{in-limit}}$, and can sustain short duration pulses and spikes (1 s/min) up to 8 dB above $P_{\text{in-limit}}$.



NOTE Figure 4 schematically explains how the optical power limiter operates, with the representation of the ideal optical power limiter, which has no insertion loss (IL).

Figure 4 – Optical power limiter operation curve

The optical power limiter is used at the input of power-sensitive equipment and at the output of high power devices, such as amplifiers, or wherever power regulation is required. The optical power limiter can serve as an eye safety device. The optical power limiter is wavelength independent in the region of its transparency. The optical power limiter is bidirectional. The optical power limiter is, in some cases, combined in line with an optical fuse, ensuring that at high powers, when the optical power limiter fails, the following device is not exposed to damaging power.

Annexes C and D describe optical power limiter configuration and performance examples, and optical power limiter application notes.

5 Requirements

5.1 Classification

5.1.1 General

Power control devices are classified by the following categories:

- type;
- wavelength band;
- style;
- variant;
- environmental category;
- assessment level;
- normative reference extensions.

An example of a typical power control device classification is as follows:

Type:	– continuously variable
Wavelength band:	– L band
Style:	– configuration C
	– LC-LC connectors
Variant:	– means of mounting
Assessment level:	– A

5.1.2 Type

Power control device types are defined by their intended function.

There are three types of optical attenuators:

- fixed;
- continuously variable;
- discrete step variable.

There is one type of optical fuse having discrete predetermined threshold power.

There is one type of optical power limiter having discrete predetermined limit power.

There are various combinations of the above-mentioned devices, for example a fixed optical attenuator and an optical power limiter in one device, or an optical power limiter and an optical fuse in one device.

There are several technology types for VOAs, such as manual, micro-electromechanical system (MEMS), magnet optics effect, planar lightwave circuit and thermal optic effect, LiNbO_3 crystal based electro-optic effect. Annex G shows the example of technical information on variable optical attenuators.

5.1.3 Wavelength band

Power control device types are defined by their wavelength band, O, C or L, and sometimes by a combination of these bands (such as C and L).

5.1.4 Style

Power control devices may be classified into styles based upon fibre type, connector type, cable type, housing shape and dimensions and configuration.

The configuration of the power control device ports is classified as follows.

- Configuration A – A device as shown in Figure 5 containing integral optical pigtails without connectors.

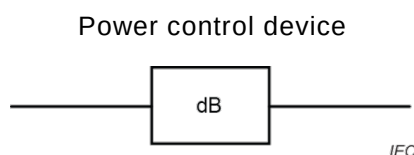


Figure 5 – Configuration A

- Configuration B – A device as shown in Figure 6 containing integral optical pigtails, with a connector on each pigtail.

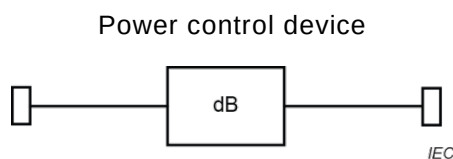


Figure 6 – Configuration B

- Configuration C – A device as shown in Figure 7 containing fibre optic connectors as an integral part of the device housing.

Power control device



Figure 7 – Configuration C

- Configuration D – A device containing some combination of the interfacing features of the preceding configurations.

5.1.5 Variant

The power control device variant identifies those features which encompass structurally similar components.

Examples of features which define a variant include, but are not limited to, the following:

- orientation of ports on housing;
- means for mounting.

5.1.6 Assessment level

The detail specification shall include all required tests for quality assessment.

Each test shall be assigned to one of four groups labelled A, B, C and D.

The detail specification shall specify one or more assessment levels, each of which shall be designated by a capital letter. The assessment level defines the relationship between the inspection levels/acceptable quality levels (AQLs) of groups A and B and the inspection periods of groups C and D.

The following are preferred levels:

- Assessment level A
 - group A inspection: inspection level II, AQL = 4 %
 - group B inspection: inspection level II, AQL = 4 %
 - group C inspection: 24-month periods
 - group D inspection: 48-month periods
- Assessment level B
 - group A inspection: inspection level II, AQL = 1 %
 - group B inspection: inspection level II, AQL = 1 %
 - group C inspection: 18-month periods
 - group D inspection: 36-month periods
- Assessment level C
 - group A inspection: inspection level II, AQL = 0,4 %
 - group B inspection: inspection level II, AQL = 0,4 %
 - group C inspection: 12-month periods
 - group D inspection: 24-month periods

Groups A and B are subject to lot-by-lot inspection and groups C and D are subject to periodic inspection. One additional assessment level (other than those specified above) may be added in the detail specification. In this case, it shall be designated by the capital letter X.

5.1.7 Normative reference extensions

Normative reference extensions are used to introduce integrated independent standard specifications or other reference documents into blank detail specifications.

Additional requirements imposed by normative reference extensions are mandatory, unless otherwise specified. Usage is primarily intended to merge associated components to form hybrid devices, or integrated functional application requirements that are dependent on technical expertise other than fibre optics.

Published reference documents produced by ITU, consistent with the scope statements of the relevant IEC specification series, may be used as extensions. Published documents produced by regional standardization bodies, such as TIA, CENELEC, JIS, may be referenced in an informative annex attached to the generic specification.

Some optical fibre splice configurations require special qualification provisions which shall not be imposed universally. These cases encompass individual component design configurations, specialised field tooling, or specific application processes. In these cases, requirements are necessary to ensure repeatable performance or adequate safety, and provide additional guidance for complete product specification. These extensions are mandatory whenever used to prepare, assemble or install an optical fibre splice either for field application usage or preparation of qualification test specimens. The relevant specification shall clarify all stipulations. However, design- and style-dependent extensions shall not be imposed universally.

In the event of conflicting requirements, precedence, in descending order, shall be for "generic" to prevail over "mandatory extension", which latter prevails over "blank detail", which latter prevails over "detail", which latter prevails over "application specific extension".

Examples of optical connector extensions are given as follows:

- using IEC 61754-4 and IEC 61754-2 to partially define a future IEC 60874 series specification for a duplex type "SC/BFOC/2,5" hybrid connector adapter;
- using IEC 61754-13 and IEC 60869-1-1 to partially define a future IEC 60874 series specification for an integrated type "FC" present attenuated optical connector;
- using IEC 61754-2 and IEC 61073-4 to partially define a future IEC 60874 series specification for a duplex "BFOC/2,5" receptacle incorporating integral mechanical splices.

Other examples of requirements to normative extensions are the following: some commercial or residential building applications may require direct reference to specific safety codes and regulations or incorporate other specific material flammability or toxicity requirements for specialised locations.

Specialised field tooling may require an extension to implement specific ocular safety, electric shock, burn hazard avoidance requirements, or require isolation procedures to prevent potential ignition of combustible gases.

5.2 Documentation

5.2.1 Symbols

Graphical and letter symbols shall, whenever possible, be taken from IEC 60027 (all parts) and IEC 60617 unless superseded by this document.

5.2.2 Specification system

5.2.2.1 General

This document forms part of a three-level IEC specification system. Subsidiary specifications shall consist of blank detail specifications and detail specifications. This system is shown in Table 1. There are no sectional specifications for power control devices.

Table 1 – Three-level IEC specification structure

Specification level	Examples of information to be included	Applicable to
Basic	– Assessment system rules – Inspection rules – Optical measurement methods – Sampling plans – Identification rule – Marking standards – Dimensional standards – Terminology – Symbols – Preferred number series – SI units	Two or more component families or subfamilies
Generic	– Specific terminology – Specific symbols – Specific units – Preferred values – Marking – Quality assessment procedures – Selection of tests – Qualification approval and/or capability approval procedures	Component family
Blank detail	– Quality conformance test schedule – Inspection requirements – Information common to a number of types	Groups of types having a common test schedule
Detail	– Individual values – Specific information – Completed quality conformance test schedules	Individual type

5.2.2.2 Blank detail specification

The blank detail specification lists all the parameters and features applicable to power control devices including the type, operating characteristics, housing configurations, test methods and performance requirements. The blank detail specification is applicable to any power control device design and quality assessment requirement. The blank detail specification contains the preferred format for stating the required information in the detail specification.

5.2.2.3 Detail specification

A specific power control device is described by a corresponding detail specification, which is prepared by filling in the blanks of the blank detail specification. Within the constraints imposed by this generic specification, the blank detail specification may be filled in by any national committee of the IEC, thereby defining as an official IEC standard a particular power control device design.

Detail specifications shall specify the following, as applicable:

- type (see 5.1.2);
- wavelength band (see 5.1.3);
- style (see 5.1.4);
- variant(s) (see 5.1.5);

- variant identification number(s) (see 5.7.2);
- all tests required;
- assessment level (see 5.1.6);
- performance requirements (see 5.6).

5.2.3 Drawings

5.2.3.1 General

The drawings and dimensions given in detail specifications shall not restrict details of construction, nor shall they be used as manufacturing drawings.

5.2.3.2 Projection system

Either first-angle or third-angle projection shall be used for the drawings in documents covered by this document. All drawings within a document shall use the same projection system, and the drawings shall state which system is used.

5.2.3.3 Dimensional system

All dimensions shall be given in accordance with ISO 129-1, ISO 286-1 and ISO 1101.

The metric system shall be used in all specifications.

Dimensions shall not contain more than five significant digits.

When units are converted, a note shall be added in each relevant specification, and the conversion between systems of units shall use a factor of 25,4 mm to 1 inch.

5.2.4 Tests and measurements

5.2.4.1 Measurement method

The size measurement method to be used for dimensions shall be specified in the detail specification for any dimensions which are specified within a total tolerance zone of 0,01 mm or less.

5.2.4.2 Reference components

Reference components for measurement purposes, if required, shall be specified in the detail specification.

5.2.4.3 Gauges

Gauges, if required, shall be specified in the relevant specification.

5.2.5 Test data sheets

Test data sheets shall be prepared for each test conducted as required by a detail specification. The data sheets shall be included in the qualification report and in the periodic inspection report.

Data sheets shall contain the following information as a minimum:

- title of test and date;
- specimen description including the variant identification number (see 5.7.2);
- test equipment used;

- all applicable test details;
- all measurement values and observations;
- sufficient detailed documentation to provide traceable information for failure analysis.

5.2.6 Instructions for use

Instructions for use, when required, shall be given by the manufacturer and shall consist of the following:

- assembly and connection instructions;
- cleaning method;
- safety aspects;
- additional information as necessary.

5.3 Standardization system

5.3.1 Interface standards

The interface standards provide both manufacturer and user with all the information they require to make or use the product in conformity with the physical features of that standard interface. Interface standards fully define and dimension the features essential for the mating and unmating of optical fibre connectors and other components. They also serve to position the optical datum target, where defined, relative to other reference data.

Interface standards ensure that connectors and adapters that comply with the standard will fit together. The standards may also contain tolerance grades for ferrules and alignment devices. Tolerance grades are used to provide different levels of alignment precision.

The interface dimensions may also be used to design other components that will mate with the connectors. For example, an active device mount can be designed using the adapter interface dimensions. The use of these dimensions combined with those of a standard plug provides the designer with assurance that the standard plugs will fit into the optical device mount. They also provide the optical datum target location of the plugs.

Standard interface dimensions do not, by themselves, guarantee optical performance. They guarantee connector mating at a specified fit. Optical performance is currently guaranteed via the manufacturing specification. Products from the same or different manufacturing specifications using the same standard interface will always fit together. Guaranteed performance can be given by any single manufacturer only for products delivered to the same manufacturing specification. However, it can be reasonably expected that some level of performance will be obtained by mating products from different manufacturing specifications, although the level of performance cannot be expected to be any better than that of the lowest specified performance.

5.3.2 Performance standards

Performance standards contain a series of test sets and measurements (which may or may not be grouped into a specified schedule, depending on the requirements of those standards) with clearly defined conditions, severities and pass/fail criteria. The tests are intended to be run on a one-off basis to prove any product's ability to satisfy the performance standards' requirements. Each performance standard has a different set of tests and/or severities (and/or groupings), and represents the requirements of a market sector, user group or system location.

A product that has been shown to meet all the requirements of a performance standard can be declared as complying with a performance standard but should then be controlled by a quality assurance/quality conformance programme.

A key point for the application of the test and measurement standards (particularly with regard to insertion loss and return loss) in conjunction with interface standards of inter-product compatibility, may be defined. The conformity of each individual product with this document will be ensured.

5.3.3 Reliability standards

Reliability standards are intended to ensure that a component can meet performance specifications under stated conditions for a stated time period.

For each type of component, the following elements need to be identified (and appear in the standard):

- failure modes (observable general mechanical or optical effects of failure);
- failure mechanisms (general causes of failure, common to several components);
- failure effects (detailed causes of failure, specific to the component).

These are all related to environmental and material aspects.

Initially, just after component manufacture, there is an "infant mortality phase" during which many components would fail if they were deployed in the field. To avoid early field failure, all components may be subjected to a screening process in the factory, involving environmental stresses that may be mechanical, thermal, and humidity-related. This is to induce known failure mechanisms in a controlled environmental situation to occur earlier than would normally be seen in the unscreened population. For those components that survive (and are then sold), there is a reduced failure rate since these mechanisms have been eliminated.

Screening is an optional part of the manufacturing process, rather than a test method. It will not affect the "useful life" of a component, defined as the period during which it performs according to specifications. Eventually, other failure mechanisms appear, and the failure rate increases beyond some defined threshold. At this point, the useful life ends, the "wear-out region" begins, and the component shall be replaced.

At the beginning of the useful life, performance testing on a sample population of components may be applied by the supplier, by the manufacturer, or by a third party. This is to ensure that the component meets performance specifications over the range of intended environments at this initial time. Reliability testing, on the other hand, is applied to ensure that the component meets performance specifications for at least a specified minimum useful lifetime or with a specified maximum failure rate. These tests are usually done by utilising the same performance testing, with increased duration and severity to accelerate the failure mechanisms.

A reliability theory relates component reliability testing to component parameters and to lifetime or failure rate under testing. The theory then extrapolates these to lifetime or failure rate under less stressful service conditions. The reliability specifications include values of the component parameters needed to ensure the specified minimum lifetime or maximum failure rate in service.

5.3.4 Interlinking

The standards relevant to fibre optic passive power control devices are given in Figure 8. A large number of test and measurement standards are already in place. The quality assurance / qualification approval standards produced under the banner of the IECQ have already been in place for many years.

With regard to standards relating to interface, performance, optical interface, reliability, and tests and measurements, the matrix given in Table 2 demonstrates some of the options available for product standardization once all of these standards are in place.

Product A is fully IEC standardized, having a standard interface and meeting defined optical interface performance and reliability requirements.

Product B is a product with a proprietary interface, but which meets defined IEC optical interface, performance and reliability requirements.

Product C is a product with a proprietary interface, which meets defined IEC optical interface and performance standards but does not comply with reliability requirements.

Product D is a product which complies with an IEC standard interface which complies with the IEC optical interface standard but which does not meet the requirements of either an IEC performance standard or those of reliability documentation.

Product E is a product which complies with both an IEC standard interface and a performance standard, but does not meet the optical interface or reliability requirements.

Obviously, the matrix is more complex than that shown in Table 2, since a number of interface, performance and reliability documents will be able to be cross-related. In addition, the products may all be subject to a quality assurance programme that could be conducted under IEC approval, or even under a national or company quality assurance system.

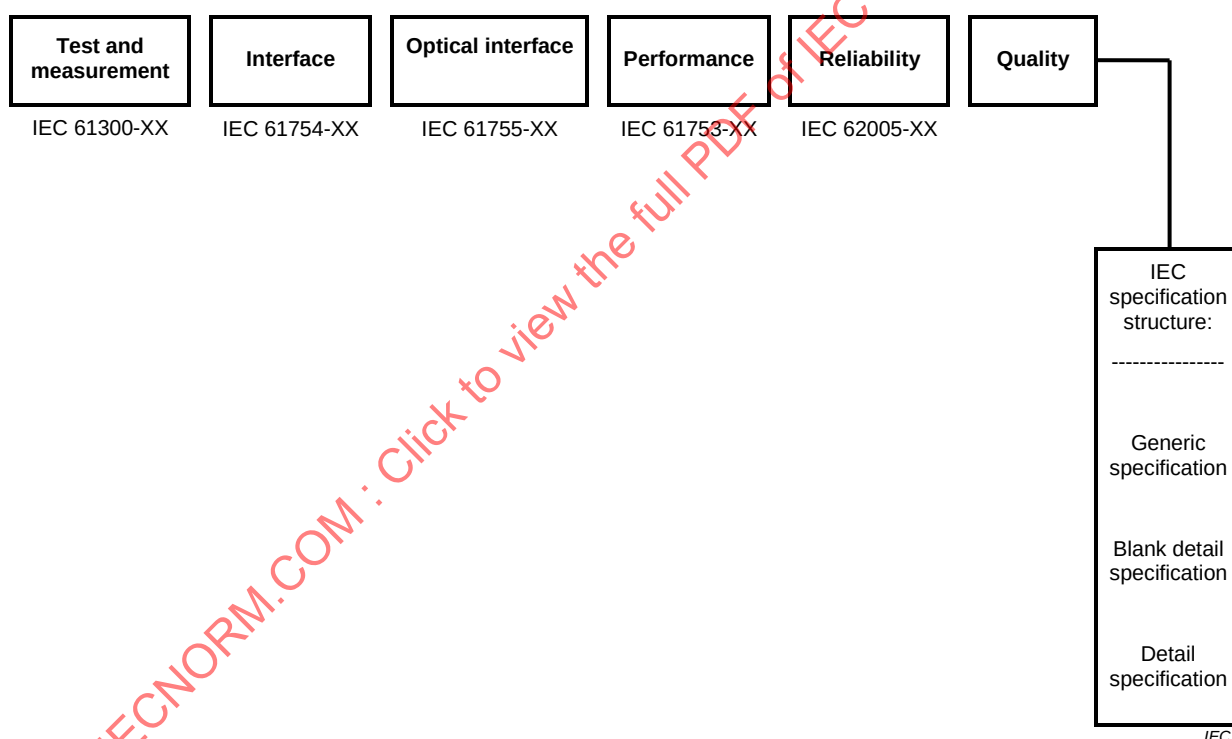


Figure 8 – Standardization structure

Table 2 – Standards' interlink matrix

	Interface standard	Optical interface standard	Performance standard	Reliability documentation
Product A	YES	YES	YES	YES
Product B	NO	YES	YES	YES
Product C	NO	YES	YES	NO
Product D	YES	YES	NO	NO
Product E	YES	NO	YES	NO

5.4 Design and construction

5.4.1 Materials

The devices shall be manufactured from materials which meet the requirements of the relevant specification.

When non-flammable materials are required, the requirement shall be specified in the relevant specification, and the needle-flame test (see IEC 60695-11-5) shall be referenced.

5.4.2 Workmanship

Devices and associated hardware shall be manufactured to a uniform quality and shall be free of sharp edges, burrs or other defects that would affect life, serviceability or appearance. Particular attention shall be given to neatness and thoroughness of marking, plating, soldering, bonding, etc.

5.5 Quality

Power control devices shall be controlled by the quality assessment procedures.

5.6 Performance

Power control devices shall meet the performance requirements specified in the relevant specification standards.

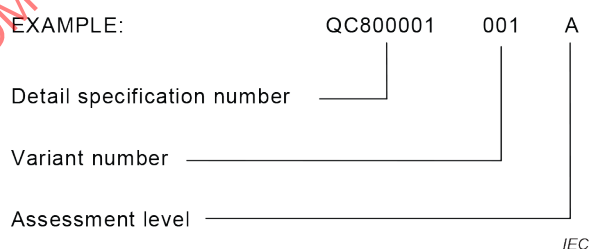
5.7 Identification and marking

5.7.1 General

Devices, associated hardware and shipping packages shall be permanently and legibly identified and marked when required by the relevant specification.

5.7.2 Variant identification number

Each variant in a detail specification shall be assigned a variant identification number; this number shall be set out as follows.



5.7.3 Component marking

Component marking, if required, shall be specified in the detail specification. The preferred order of marking is the following:

- a) port identification;
- b) manufacturer's part number (including serial number, if applicable);
- c) manufacturer's identification mark or logo;
- d) manufacturing date;
- e) variant identification number;
- f) any additional marking required by the detail specification.

If space does not allow for all the required marking on the component, each unit shall be individually packaged with a data sheet containing all of the required information which is not marked.

5.7.4 Package marking

Several power control devices may be packaged together for shipment.

Package marking, if required, shall be specified in the detail specification. The preferred order of marking is the following:

- a) manufacturer's identification mark or logo;
- b) manufacturer's part numbers;
- c) manufacturing date codes (year/week, see ISO 8601);
- d) variant identification number(s);
- e) type designations;
- f) assessment levels;
- g) any additional marking required by the detail specification.

When applicable, individual unit packages (within the sealed package) shall be marked with the reference number of the certified record of released lots, the manufacturer's factory identity code and the component identification.

5.8 Packaging

Packages shall include instructions for use when required by the specification.

5.9 Storage conditions

Where short-term degradable materials, such as adhesives, are supplied with the package of connector parts, the manufacturer shall mark these with the expiry date (year and week numbers according to ISO 8601) together with any requirements or precautions concerning safety hazards or environmental conditions for storage.

5.10 Safety

Optical power control devices, when used on an optical fibre transmission system and/or equipment, may emit potentially hazardous radiation from an uncapped or unterminated output port or fibre end. Safety instructions shall be according to IEC 60825 (all parts) relating to laser safety.

The manufacturers of optical power control devices shall make available sufficient information to alert system designers and users about the potential hazard and shall indicate the required precautions and working practices.

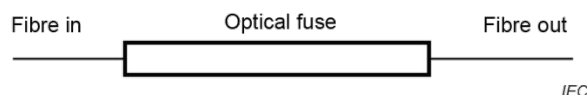
In addition, each relevant specification shall include the following text:

WARNING – Care should be taken when handling small diameter fibres to prevent puncturing the skin, especially in the eye area. Direct viewing of the end of an optical fibre or an optical fibre connector when it is propagating energy is not recommended unless prior assurance has been obtained as to the safety of the energy output level.

Annex A (informative)

Optical fuse configuration and performance examples

Examples of optical fuse configurations are given in Figures A.1 and A.2.



NOTE Typical dimensions are 4 mm to 6 mm diameter and 40 mm length.

Figure A.1 – Optical fuse, non-connectorized style

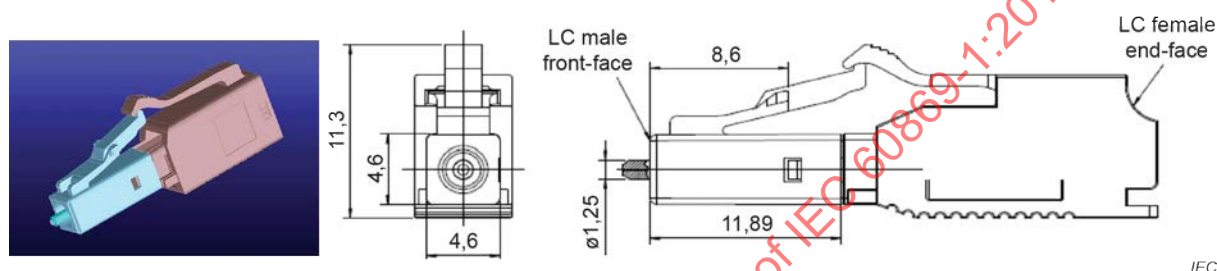


Figure A.2 – Optical fuse, plug-receptacle style (LC)

Optical fuses are manufactured in various optical power threshold values, and it is recommended that continuous optical power applied to a fuse be no more than 3 dB below the threshold values.

The response time of the optical fuse is the total length of time between the start of the input power (for example $P_{in} = P_{th} + 3$ dB, 1 ms rectangle pulse) and the end time when the output optical power has decreased to be less than $P_{th} - IL$ dB or $P_{in} - A_{block}$ (for example 30 dB). An example of optical fuse response time is given in Figure A.3. Here the input pulse duration is 1 ms with rise time of 10 μ s and a steady-state of $(P_{th} + 3)$ dB. Figure A.3 illustrates the parameters.

Figure A.4 shows an input power vs output power of an optical fuse, having power threshold approximately 30 dBm (1 W), showing output power drop at threshold of approximately 25 dB.

In this case, the rise time is the elapsed time for input power to reach 90 % of its steady-state value from the time it starts.

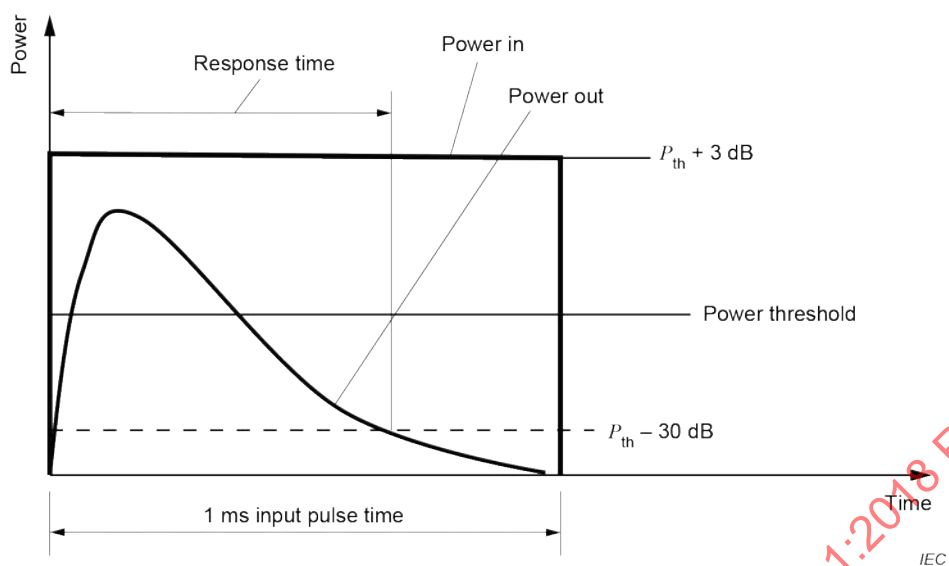


Figure A.3 – Response time curve of an optical fuse

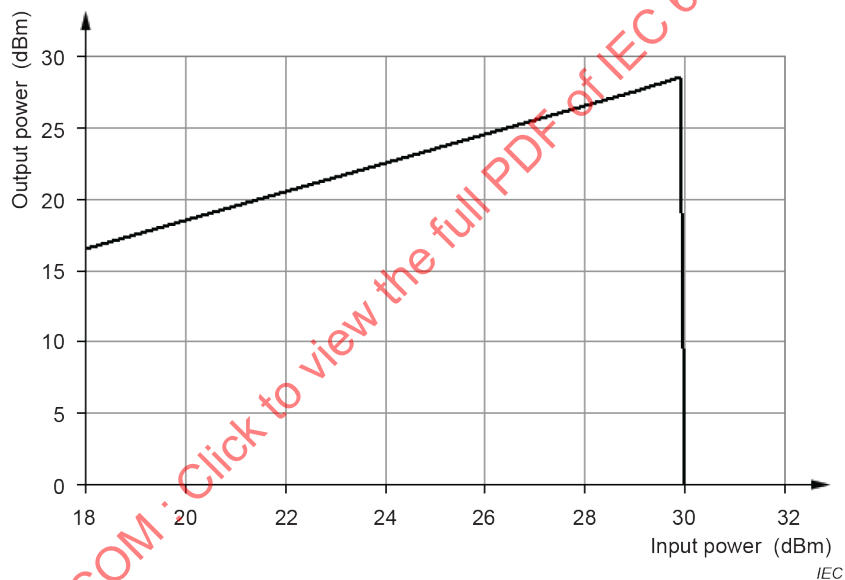


Figure A.4 – Optical fuse, power threshold approx. 30 dBm (1 W), output power drop at threshold approx. 25 dB

Annex B (informative)

Optical fuse application notes

The passive optical fuse is a device, which can be used for optical over-power safety. The optical fuse is activated at a broad range of wavelengths, shutting off the optical power propagation from input to output at a predetermined optical power level.

The main characteristics of the optical fuse are the following:

- the transmitted optical communication data is unaffected by the optical fuse as long as the optical power is below the predetermined threshold power;
- the optical fuse is wavelength independent for the optical communication ranges;
- the response time is $< 100 \mu\text{s}$, offering fast response;
- used in SMF, MM, and PM fibres;
- can be used as a stand-alone unit or an integrated unit into an optical sub-system as an internal part.

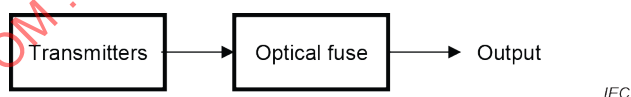
The optical fuse can be used as an add-on at the output port of:

- transmitters and
- amplifiers.

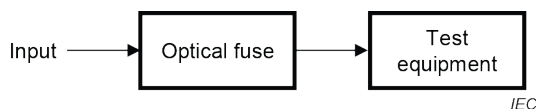
The optical fuse can be used as an add-on at the input port of:

- optical switches,
- test equipment (e.g. optical power meters, wavelength meters, optical spectrum analysers), and
- receivers.

The next device is therefore protected from damage by the light source, as shown in Figure B.1.



a) Placement at output



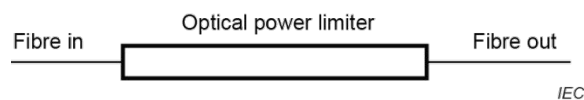
b) Placement at input

Figure B.1 – Placement of an optical fuse

Annex C (informative)

Optical power limiter configuration and performance examples

The optical power limiter configurations are shown in Figures C.1 and C.2.



NOTE Typical dimensions are 6 mm diameter and 50 mm length.

Figure C.1 – Optical power limiter, non-connectorized style

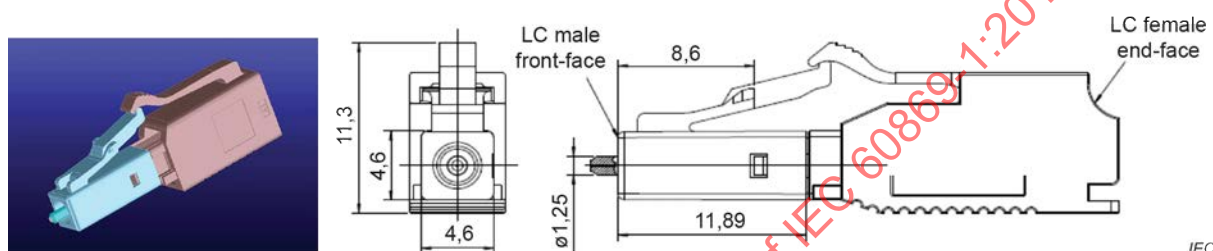


Figure C.2 – Optical power limiter, plug-receptacle style (LC)

Optical power limiters are manufactured with various limit power values.

An experimental example of optical power limiter behaviour appears in Figure C.3; here, the input power was varied up from 0 to +18 dBm and back a few tens of cycles, showing curves that are identical within 0,2 dBm (black lines).

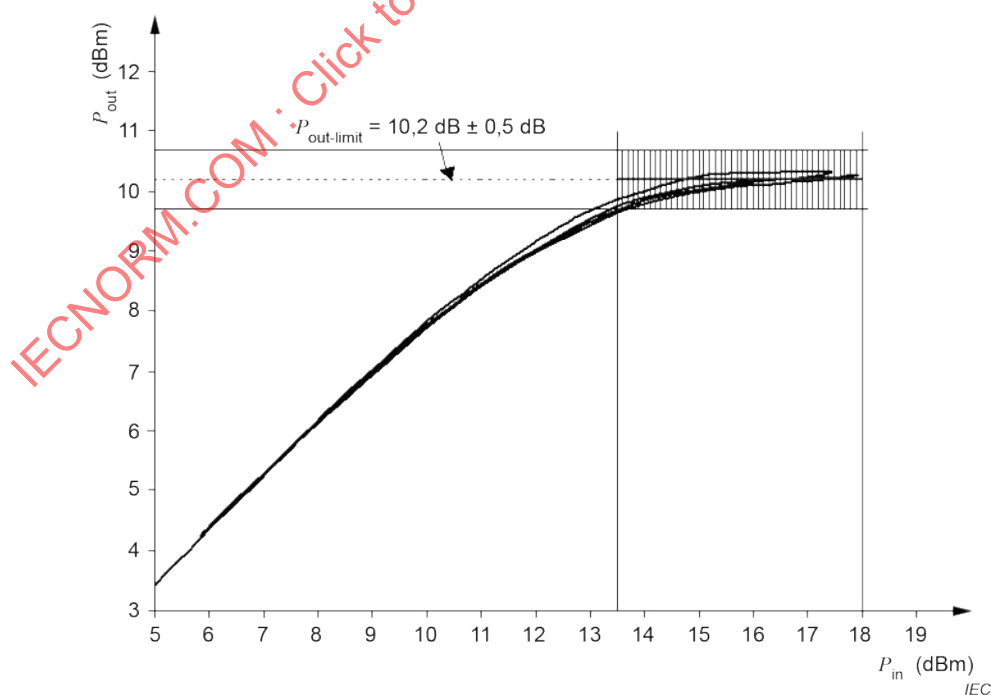


Figure C.3 – Optical power limiter – Experimental

The response time of the optical limiter is the total time elapsing between the start of the input power (for example $P_{in} = P_{limit} + 3 \text{ dB}$, 1 ms rectangle pulse) and the end time when the output power has decreased to be less than or equal to the predetermined power (for example the output power is less than $P_{limit} + 1 \text{ dB}$). Figure C.4 illustrates the parameters.

In this case, the rise time is the elapsed time for input power to reach 90 % of its steady-state value from the time it starts.

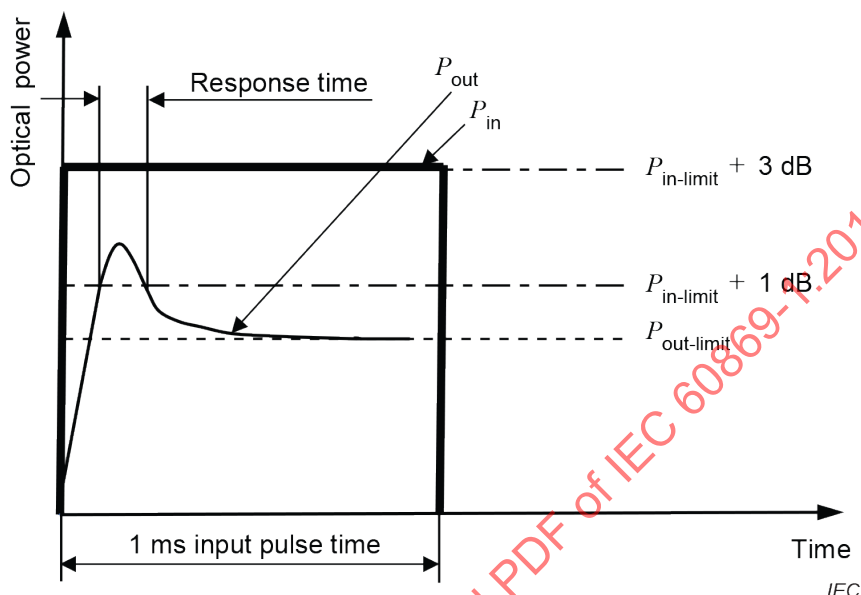


Figure C.4 – Schematic optical power limiter response time; 1 ms input pulse time

Optical limit power, P_{limit} is measured experimentally as the average between $P_{out \text{ max.}}$ and $P_{out \text{ min.}}$ within a 3 dB input power range during a cycle of P_{out} as a function of P_{in} , as depicted in Figure C.5.

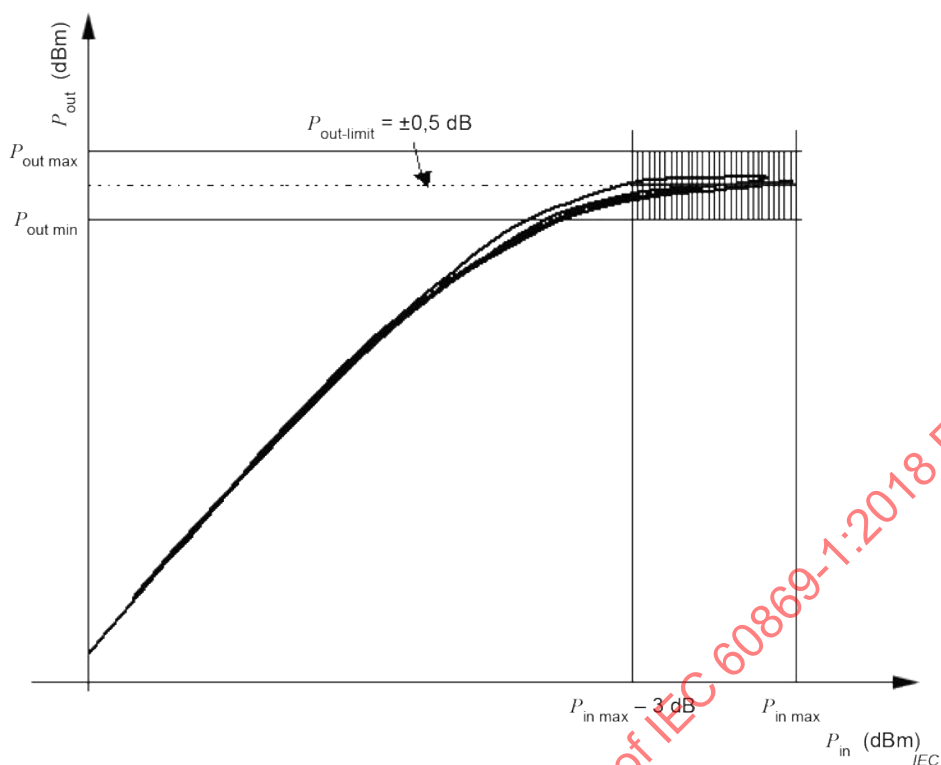


Figure C.5 – Schematic power definitions

The optical power limiter can typically operate under CW input up to 5 dB above P_{limit} , and can accommodate short duration pulses and spikes (1 s/min) up to 8 dB above P_{limit} as shown in Figure C.6.

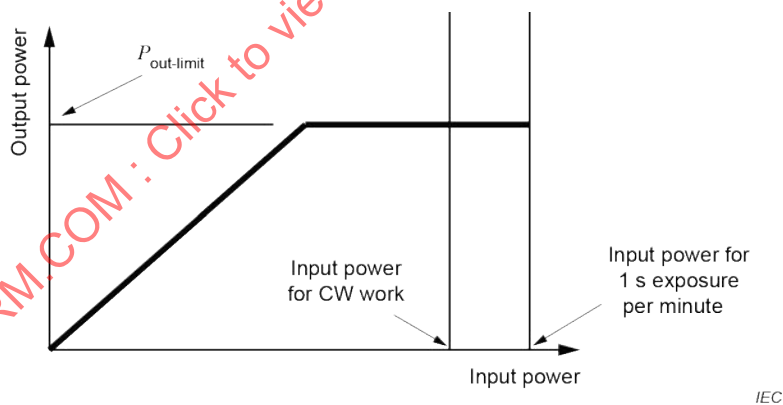


Figure C.6 – Optical power limiter, input power definitions

Annex D (informative)

Optical power limiter application notes

The optical power limiter regulates the optical power. It is used at the input to power-sensitive equipment, and at the output of high power components, such as amplifiers or lasers, where power regulation is required. The optical power limiter can serve as a protection device and as an eye safety power regulator. Under normal operation, when the input power is low, the limiter has no effect on the system. However, when the input power is high, the output power is limited to a certain level (P_{limit}). The limiter is wavelength-independent in the region of its transparency.

The main characteristics of the optical power limiter are the following:

- the transmitted optical communication data is unaffected by the optical power limiter;
- the optical power limiter is wavelength independent for the optical communication regions;
- the response time is $< 500 \mu\text{s}$, offering fast response (at $P_{\text{in}} = P_{\text{in max.}}$);
- used in SMF, MM, and PM fibres;
- can be used as a stand-alone unit or an integrated unit into an optical sub-system as an internal part.

The optical power limiter can be used as an add-on at the output port of:

- transmitters and
- amplifiers.

The optical power limiter can be used as an add-on at the input port of:

- optical switches,
- test equipment (e.g. optical power meters, wavelength meters, optical spectrum analysers) and
- receivers.

The optical power limiter can be used to protect the next device from damage by the light source.

The optical power limiter is, in some cases, combined in line with an optical fuse, ensuring that at high powers, if the limiter fails, the following device is not exposed to damaging power, as shown in Figure D.1.

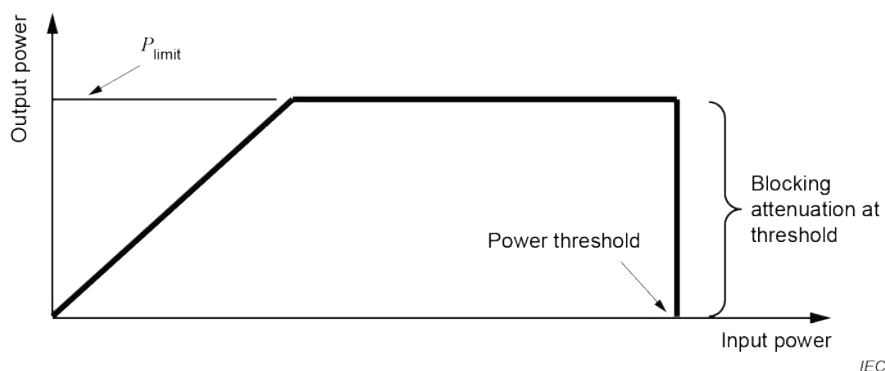


Figure D.1 – Optical power limiter and optical fuse, combined, operation curve

Annex E (informative)

Fixed optical attenuator application note

The fixed optical attenuator is a passive device that has fixed attenuation, which can be used for optical power control and optical over-power safety. The fixed optical attenuator handles a broad range of wavelengths, reducing the optical power propagation from input to output at a predetermined amount. Fixed attenuators can be of plug-style attenuators or pigtailed style attenuators.

The main characteristics of the fixed optical attenuator are the following:

- the transmitted optical communication data is unaffected by the fixed optical attenuator;
- the fixed optical attenuator is wavelength independent for the optical communication regions;
- the response time is immediate;
- used in SMF, MM, and PM fibres;
- can be used as a stand-alone unit or an integrated unit into an optical sub-system as an internal part.

The fixed optical attenuator can be used as an add-on at the output port of:

- transmitters and
- amplifiers.

The fixed optical attenuator can be used as an add-on at the input port of:

- optical switches,
- test equipment (e.g. optical power meters, wavelength meters, optical spectrum analysers), and
- receivers.

The next device is therefore protected from damage by the light source, as shown in Figure E.1.

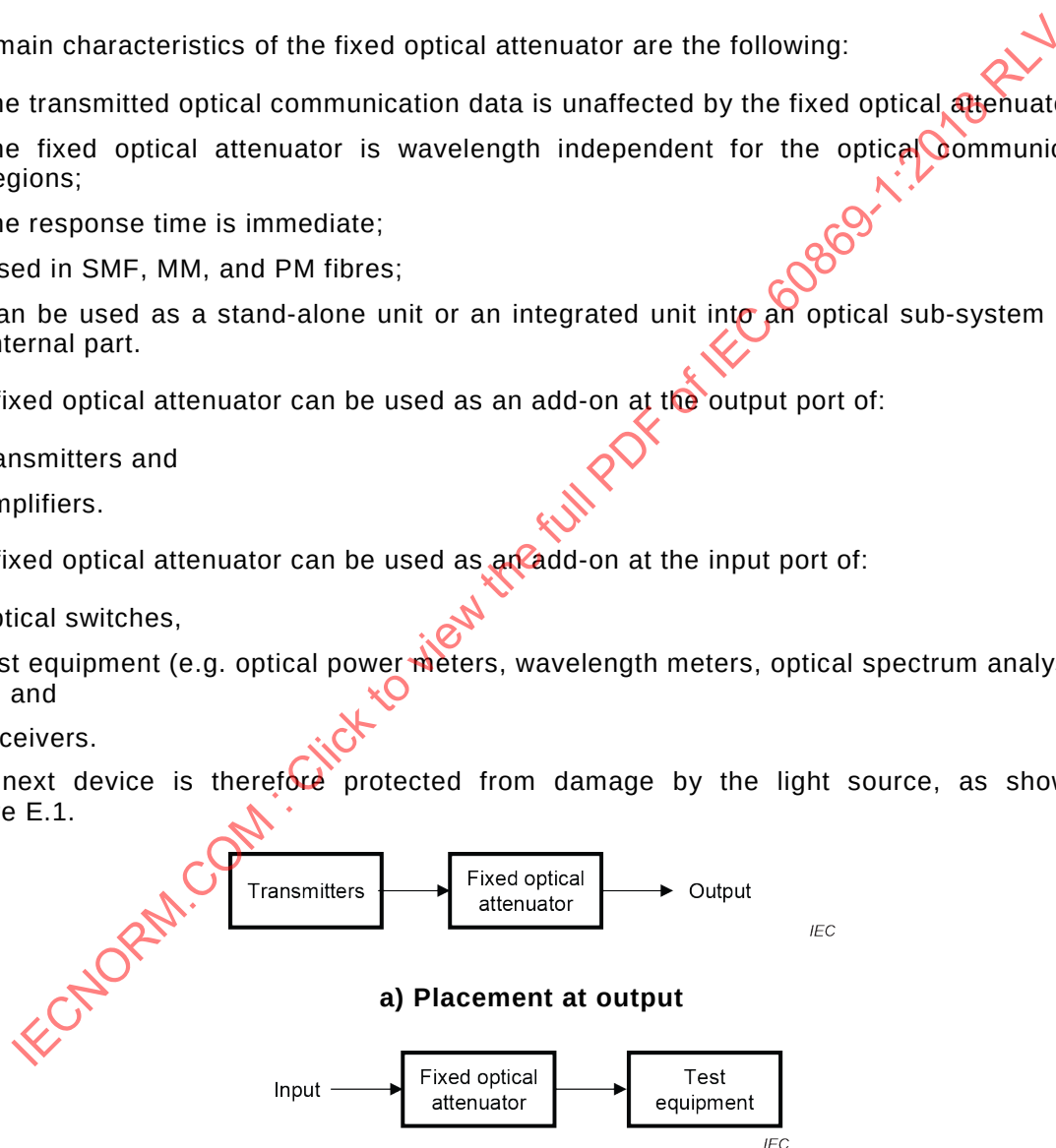


Figure E.1 – Placement of a fixed optical attenuator

Annex F

(informative)

Variable (manually or electrically) optical attenuator application note

The variable (manually or electrically) optical attenuator is a passive device, which produces controlled signal attenuation in an optical fibre transmission line. It can be used for optical power control or over-power safety. The variable (manually or electrically) optical attenuator handles a broad range of wavelengths, reducing the optical power propagation from input to output at a controlled, variable amount. The variable (manually or electrically) optical attenuator can be of plug-style or pigtailed style.

The main characteristics of the variable (manually or electrically) optical attenuator are:

- attenuation according to a manual or electrical setting;
- the transmitted optical communication data is unaffected by the variable, manual or electrical, optical attenuator;
- the variable, manual or electrical, optical attenuator is wavelength independent for the optical communication regions;
- used in SMF, MM, and PM fibres;
- can be used as a stand-alone unit or an integrated unit into an optical sub-system as an internal part.

The variable (manually or electrically) optical attenuator can be used as an add-on at the output port of:

- transmitters and
- amplifiers.

Here, the variable (manually or electrically) optical attenuator controls the output power and sets it to a desired level.

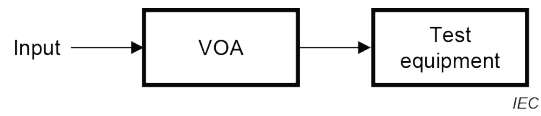
The variable optical attenuator can be used as an add-on at the input port of:

- optical switches,
- test equipment (e.g. optical power meters, wavelength meters, optical spectrum analysers) and
- receivers.

The variable (manually or electrically) optical attenuator controls the output power or protects the next device from damage by the light source, as shown in Figure F.1.



a) Placement at output



b) Placement at input

Figure F.1 – Placement of a variable, manual or electrical, optical attenuator

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Annex G (informative)

Example of technology of variable optical attenuators

G.1 Example technology of micro-electromechanical system (MEMS) based VOA

Figure G.1 shows the example technology of MEMS based VOA. An optical beam from the input port fibre focuses on the MEMS mirror by the lens; it is then reflected and reaches the output port fibre through the lens. When the MEMS mirror tilts due to electrostatic force by applying a voltage, the beam focuses on the side of the output port fibre. This makes for increasing attenuation. By controlling the applied voltage, the tilt angle of the mirror is changed and thus the attenuation is changed.

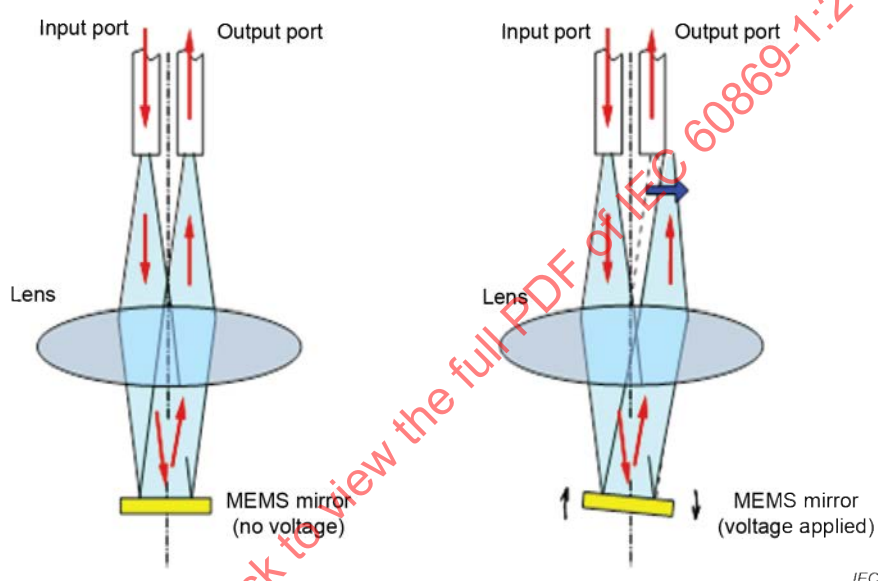
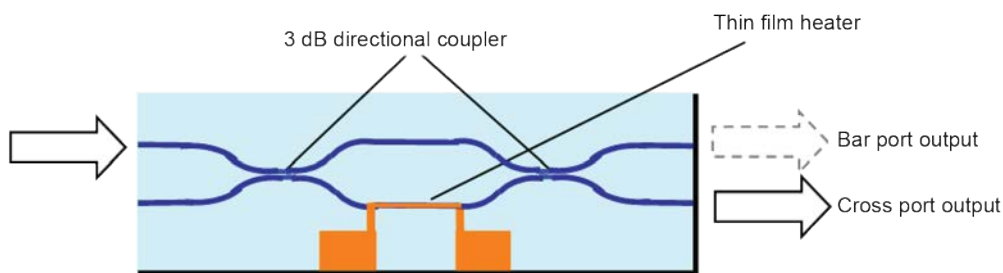


Figure G.1 – Example technology of MEMS based VOA

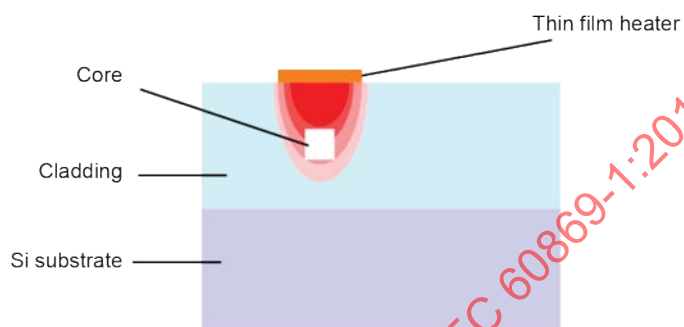
G.2 Example technology of planar lightwave circuit (PLC) based and thermo-optic (TO) based VOA

Figure G.2 shows the example technology of PLC and TO based VOA. Connecting two 3-dB directional couplers in silica waveguide, the Mach-Zehnder interferometer is fabricated. The electrode on the bottom arm is attached. When the electrode is heated by applying electrical current, the refractive index changes, causing the optical phase difference in the two arms, resulting in output optical power change. Figure G.3 shows the relationship of the phase and attenuation.



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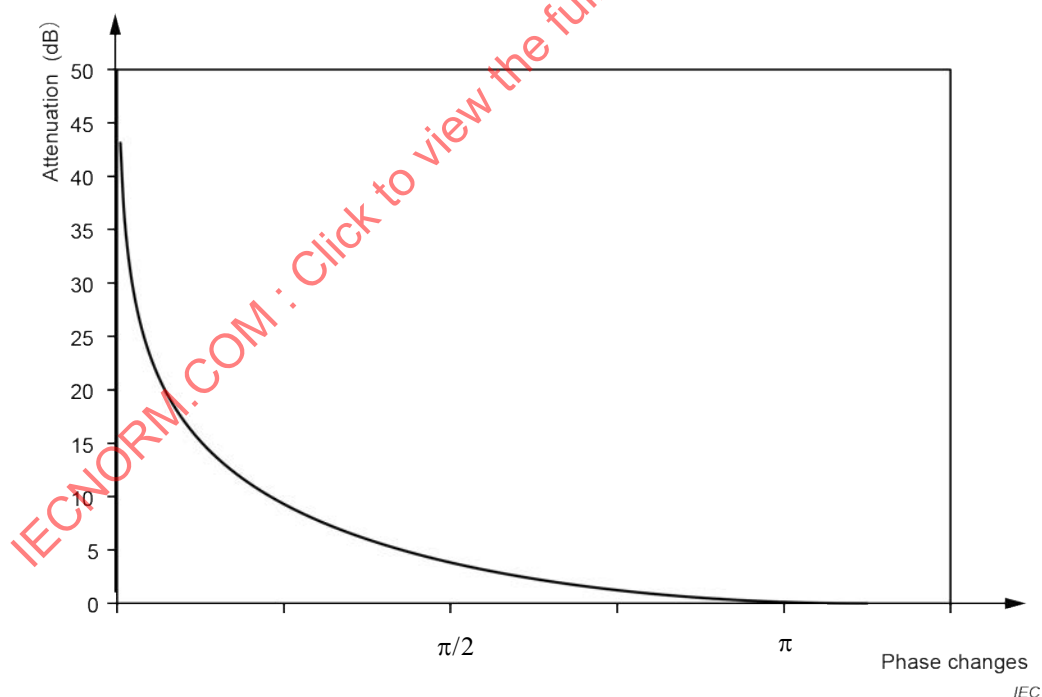
a) Top view



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b) Cross-section view

Figure G.2 – Example technology of PLC-TO based VOA



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Figure G.3 – The relation of phase changes and attenuation

G.3 Example technology of magnet-optic (MO) based VOA

Figure G.4 shows the example technology of MO based VOA. The basic configuration is similar to that of a fibre optic isolator which has two polarisers made by birefringent crystals and a Faraday rotator in the middle. The direction of the magnetic field applying Faraday

rotator is different. By applying the magnetic field, the beam after the second polariser (analyser) splits and tilts.

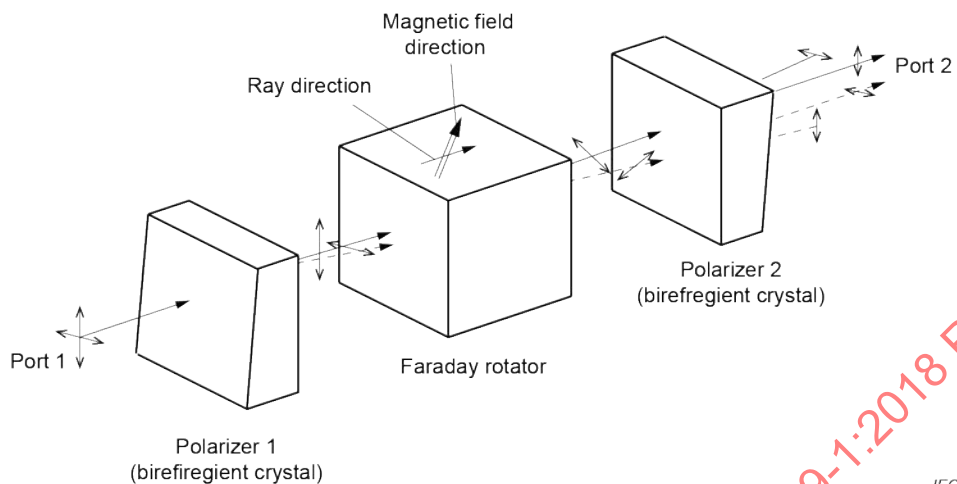


Figure G.4 – Example technology of MO based VOA

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IEC 61753-052-3, *Fibre optic interconnecting devices and passive components – Performance standard – Part 052-3: Single-mode fibre non-connectorized fixed attenuator – Category U in uncontrolled environment*

IEC 61753-052-6, *Fibre optic interconnecting devices and passive components – Performance standard – Part 052-6: Single-mode fibre non-connectorized fixed attenuator – Category O in outside plant environment*

IEC 61753-053-2, *Fibre optic interconnecting devices and passive components – Performance standard – Part 053-2: Non-connectorized single-mode fibre, electrically controlled, variable optical attenuator for category C – Controlled environments*

IEC 61753-056-2, *Fibre optic interconnecting devices and passive components – Performance standard – Part 056-2: Single mode fibre pigtailed style optical fuse for category C – Controlled environment*

IEC 61753-057-2, *Fibre optic interconnecting devices and passive components – Performance standard – Part 057-2: Single mode fibre plug-receptacle style optical fuse for category C – Controlled environment*

IEC 61753-058-2, *Fibre optic interconnecting devices and passive components – Performance standard – Part 058-2: Single mode fibre pigtailed style optical power limiter for category C – Controlled environment*

IEC 61753-059-2, *Fibre optic interconnecting devices and passive components – Performance standard – Part 059-2: Single-mode fibre plug-receptacle style optical limiter for category C – Controlled environment*

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IEC 61754-4, *Fibre optic interconnecting devices and passive components – Fibre optic connector interfaces – Part 4: Type SC connector family*

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COMMISSION ELECTROTECHNIQUE INTERNATIONALE

**DISPOSITIFS D'INTERCONNEXION ET COMPOSANTS PASSIFS
FIBRONIQUES – DISPOSITIFS FIBRONIQUES PASSIFS
DE CONTRÔLE DE LA PUISSANCE –****Partie 1: Spécification générique****AVANT-PROPOS**

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La Norme internationale IEC 60869-1 a été établie par le sous-comité 86B: Dispositifs d'interconnexion et composants passifs à fibres optiques, du comité d'études 86 de l'IEC: Fibres optiques.

Cette cinquième édition annule et remplace la quatrième édition parue en 2012 et constitue une révision technique.

Cette édition inclut les modifications techniques majeures suivantes par rapport à l'édition précédente:

- a) les termes et définitions ont été revus;
- b) l'exigence concernant le système IEC 'd'évaluation de la qualité a été revue;
- c) l'article concernant les procédures d'assurance de la qualité a été supprimé;

- d) l'Annexe G, concernant les informations techniques des affaiblisseurs optiques variables, a été ajoutée.

Le texte de cette Norme internationale est issu des documents suivants:

FDIS	Rapport de vote
86B/4139/FDIS	86B/4144/RVD

Le rapport de vote indiqué dans le tableau ci-dessus donne toute information sur le vote ayant abouti à l'approbation de cette Norme internationale.

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DISPOSITIFS D'INTERCONNEXION ET COMPOSANTS PASSIFS FIBRONIQUES – DISPOSITIFS FIBRONIQUES PASSIFS DE CONTRÔLE DE LA PUISSANCE –

Partie 1: Spécification générique

1 Domaine d'application

La présente partie de l'IEC 60869 s'applique aux dispositifs fibroniques passifs de contrôle de la puissance. Ceux-ci présentent toutes les caractéristiques générales suivantes:

- ils sont passifs dans le sens où ils ne contiennent aucun élément optoélectronique ou autre élément transducteur;
- ils disposent de deux ports pour la transmission de la puissance optique et ils contrôlent l'énergie transmise de manière fixe ou variable;
- les ports sont des fibres amorce optiques dépourvues de connecteurs, des fibres optiques munies de connecteurs ou des embases.

Le présent document établit les exigences génériques pour les dispositifs optiques passifs suivants:

- affaiblisseur optique,
- fusible optique,
- limiteur de puissance optique.

Le présent document prévoit également l'information générique y compris la terminologie pour la série IEC 61753-05x. Les publications de la série IEC 61753-05x sont indiquées dans la Bibliographie.

2 Références normatives

Les documents suivants cités dans le texte constituent, pour tout ou partie de leur contenu, des exigences du présent document. Pour les références datées, seule l'édition citée s'applique. Pour les références non datées, la dernière édition du document de référence s'applique (y compris les éventuels amendements).

IEC 60027 (toutes les parties), *Symboles littéraux à utiliser en électrotechnique*

IEC 60050-731, *Vocabulaire Electrotechnique International – Chapitre 731: Télécommunications par fibres optiques* (disponible sur le site web www.electropedia.org)

IEC 60617, *Symboles graphiques pour schémas* (disponible sur le site web <http://std.iec.ch/iec60617>)

IEC 60695-11-5, *Essais relatifs aux risques du feu – Partie 11-5: Flammes d'essai – Méthode d'essai au brûleur-aiguille – Appareillage, dispositif d'essai de vérification et lignes directrices*

IEC 60825 (toutes les parties), *Sécurité des appareils à laser*

IEC 61300 (toutes les parties), *Dispositifs d'interconnexion et composants passifs fibroniques – Procédures fondamentales d'essais et de mesures*

IEC TS 62627-09, *Fibre optic interconnecting devices and passive components – Vocabulary for passive optical devices* (disponible en anglais seulement)

ISO 129-1, *Documentation technique de produits – Représentation des dimensions et tolérances*

ISO 286-1, *Spécification géométrique des produits (GPS) – Système de codification ISO pour les tolérances sur les tailles linéaires – Partie 1: Base des tolérances, écarts et ajustements*

ISO 1101, *Spécification géométrique des produits (GPS) – Tolérancement géométrique – Tolérancement de forme, orientation, position et battement*

ISO 8601, *Éléments de données et formats d'échange – Échange d'information – Représentation de la date et de l'heure*

3 Termes et définitions

Pour les besoins du présent document, les termes et définitions donnés dans l'IEC 60050-731, l'IEC TS 62627-09 ainsi que les suivants s'appliquent.

L'ISO et l'IEC tiennent à jour des bases de données terminologiques destinées à être utilisées en normalisation, consultables aux adresses suivantes:

- IEC Electropedia: disponible à l'adresse <http://www.electropedia.org/>;
- ISO Online browsing platform: disponible à l'adresse <http://www.iso.org/obp>.

3.1 Termes concernant les composants

3.1.1

dispositif fibronique passif de contrôle de la puissance

dispositif (composant) optique passif qui contrôle une transmittance ayant un coefficient de transfert prédéfini, indépendant de la longueur d'onde

Note 1 à l'article: Le coefficient de transfert peut être contrôlé pour toute intensité de la puissance d'entrée ou pour une puissance d'entrée supérieure à un seuil de puissance.

3.1.2

affaiblisseur optique

dispositif (composant) optique passif qui produit un affaiblissement contrôlé du signal, indépendant de la longueur d'onde, dans une ligne de transmission à fibres optiques

Note 1 à l'article: Un affaiblisseur est conçu pour être indépendant de la longueur d'onde.

3.1.3

affaiblisseur optique fixe

affaiblisseur optique dans lequel l'atténuation est constante

3.1.4

affaiblisseur optique variable

VOA

affaiblisseur optique dans lequel l'atténuation peut être contrôlée

Note 1 à l'article: La valeur de l'affaiblissement des affaiblisseurs optiques variables est généralement contrôlée par un moyen manuel ou électrique.

Note 2 à l'article: L'abréviation "VOA" est dérivée du terme anglais développé correspondant "variable optical attenuator".

3.1.5

fusible optique

dispositif fibronique passif de contrôle de la puissance, qui produit un blocage contrôlé et permanent des signaux pour une puissance optique supérieure à un seuil de puissance prédéterminé dans une ligne de transmission à fibres optiques

3.1.6

limiteur de puissance optique

dispositif fibronique passif de contrôle de la puissance, chargé de réguler la puissance optique dans les fibres en produisant une puissance de sortie optique contrôlée et constante correspondant à une puissance limite de sortie lorsque la puissance d'entrée optique variable est supérieure à la puissance limite optique d'entrée

3.1.7

dispositif de type fiche-embase

dispositif fibronique ayant une combinaison de deux caractéristiques d'interfaçage, une fiche à une extrémité et une embase à l'autre

3.2 Termes concernant les performances

3.2.1

seuil de puissance d'un fusible optique

P_{th}
puissance optique d'entrée, entrant dans un fusible optique, pour laquelle la puissance optique de sortie est bloquée

Note 1 à l'article: Le seuil de puissance du fusible optique P_{th} est exprimé en watt ou en dBm.

3.2.2

temps de réponse du fusible optique

temps écoulé entre le début de la puissance d'entrée et l'instant final auquel la puissance optique de sortie a diminué jusqu'à être inférieure à la puissance optique prédéterminée

seuil de puissance, P_{th} moins la perte d'insertion, IL , ($P_{th} - IL$) en dB, ou à la puissance d'entrée, P_{in} moins l'affaiblissement de blocage exigé au niveau du seuil, A_{block}

Note 1 à l'article: La puissance optique prédéterminée doit être soit le seuil de puissance, P_{th} moins la perte d'insertion, IL , ($P_{th} - IL$) en dB, soit la puissance d'entrée, P_{in} moins l'affaiblissement de blocage exigé au niveau du seuil, A_{block} .

Note 2 à l'article: La réponse du fusible optique dépend du niveau de puissance d'entrée optique et de la durée d'impulsion d'entrée.

Note 3 à l'article: Dans un exemple, il est recommandé que la puissance d'entrée, P_{in} , soit de 3 dB supérieure au seuil de puissance, P_{th} , et que l'impulsion de forme rectangulaire soit de 1 ms ($P_{in} = P_{th} + 3$ dB). Dans un exemple, il est recommandé que la valeur exigée de l'affaiblissement de blocage au niveau du seuil, A_{block} soit de 30 dB.

3.2.3

affaiblissement de blocage du fusible optique au niveau du seuil

A_{block}
chute de la puissance optique à travers le fusible optique en présence d'une valeur supérieure au seuil de puissance du fusible optique P_{th} , et avec comme réponse le blocage de la puissance, exprimée en dB

3.2.4

temps de réponse du limiteur de puissance optique

temps écoulé entre le début de la puissance d'entrée et l'instant final auquel la puissance optique de sortie a diminué jusqu'à être inférieure ou égale à la puissance prédéterminée

Note 1 à l'article: Le temps de réponse du limiteur de puissance optique dépend du niveau de puissance d'entrée optique et de la durée d'impulsion d'entrée.

Note 2 à l'article: Dans un exemple, il est recommandé que la puissance d'entrée, P_{in} , soit de 3 dB supérieure à la puissance limite optique et que l'impulsion de forme rectangulaire soit de 1 ms ($P_{in} = P_{limite} + 3$ dB). Dans un exemple, une puissance optique prédéterminée égale à $P_{limite} + 1$ dB est recommandée.

3.2.5

puissance limite optique d'entrée

$P_{in-limite}$

puissance optique d'entrée, entrant dans un limiteur de puissance optique, pour laquelle la puissance optique de sortie est verrouillée et ne peut pas dépasser cette valeur, $P_{in-limite}$, qui est exprimée en watts ou dBm

3.2.6

puissance limite optique de sortie

$P_{out-limite}$

puissance optique de sortie, sortant d'un limiteur de puissance optique, pour laquelle la puissance optique de sortie est verrouillée et ne peut pas dépasser cette valeur, $P_{out-limite}$, qui est exprimée en watts ou dBm

3.2.7

perte d'insertion minimale

perte d'insertion la plus basse sur laquelle un VOA est réglé

3.2.8

plage d'affaiblissement variable

plage d'affaiblissement sur laquelle le dispositif peut être réglé

Note 1 à l'article: Ce terme est uniquement applicable aux VOA.

3.2.9

affaiblissement nominal

valeur d'affaiblissement spécifiée par le fournisseur pour les affaiblisseurs fixes et valeur d'affaiblissement définie par l'utilisateur pour les affaiblisseurs variables

3.2.10

affaiblissement maximal

<pour un affaiblisseur optique variable> affaiblissement correspondant à la valeur maximale qui a été réglée

3.2.11

affaiblissement minimal

<pour un affaiblisseur optique variable> affaiblissement correspondant à la valeur minimale qui a été réglée

3.2.12

résolution de réglage d'affaiblissement

réglage minimal du pas ou de la différence de l'affaiblissement d'un VOA

Note 1 à l'article: Ce terme est uniquement applicable aux VOA.

3.2.13

erreur de la valeur de réglage de l'affaiblissement

différence entre la perte d'insertion du dispositif à un réglage donné et l'affaiblissement nominal

Note 1 à l'article: Ce terme est uniquement applicable aux VOA.

3.2.14

répétabilité de la valeur d'affaiblissement de réglage

déviations maximales de la perte d'insertion du dispositif à un réglage donné pour de multiples réglages répétés

Note 1 à l'article: Ce terme est uniquement applicable aux VOA.

3.2.15

valeur d'entrée de puissance maximale autorisée

puissance maximale d'entrée que le dispositif peut traiter sans causer de dysfonctionnement ou de dommage permanent; elle est exprimée en watts ou en dBm

Note 1 à l'article: Ce terme est applicable à tous les dispositifs fibroniques passifs de contrôle de la puissance.

Note 2 à l'article: Ce terme correspond au seuil de puissance pour un fusible optique.

Note 3 à l'article: La puissance d'entrée maximale définie dans l'IEC TS 62627-09 a une signification différente de la puissance optique d'entrée maximale pour laquelle un dispositif optique passif garde les performances optiques exigées.

4 Description des dispositifs

4.1 Affaiblisseur optique

L'affaiblisseur optique est un dispositif optique passif utilisé pour réduire la puissance optique qui entre ou sort d'un dispositif optique. L'affaiblisseur optique est normalement utilisé pour une large plage de longueurs d'onde; il affaiblit la puissance par un taux d'affaiblissement prédéterminé.

Il existe deux types d'affaiblisseurs optiques: l'affaiblisseur optique fixe et l'affaiblisseur optique variable.

Le taux de réduction de puissance d'un affaiblisseur optique fixe est constant. La courbe de performance d'un affaiblisseur optique fixe est représentée à la Figure 1, la puissance affaiblie étant toujours inférieure à la puissance non affaiblie et proportionnelle à celle-ci.

L'Annexe E décrit la note d'application des affaiblisseurs optiques fixes sous forme de guide de l'utilisateur.

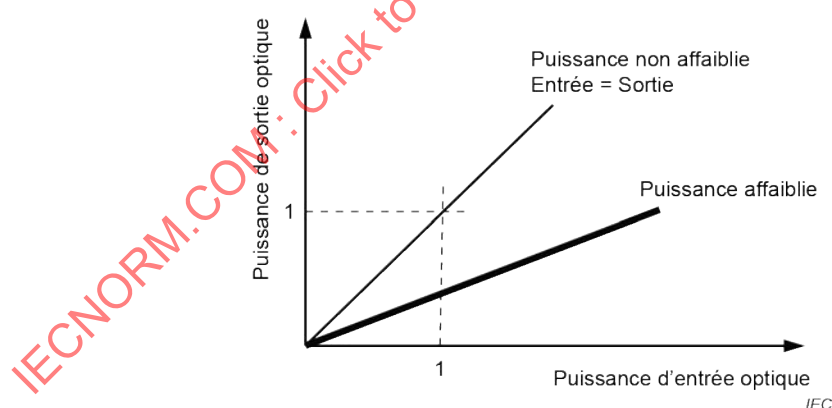


Figure 1 – Courbe de fonctionnement de l'affaiblisseur optique fixe

La courbe de performance d'un affaiblisseur optique variable (VOA) est représentée à la Figure 2. De même que pour un affaiblisseur optique fixe, la puissance affaiblie est toujours inférieure à la puissance non affaiblie et proportionnelle à celle-ci. Le VOA produit une puissance de sortie optique contrôlée, qui résulte d'une entrée de contrôle manuelle ou électrique.

L'Annexe F décrit la note d'application des affaiblisseurs optiques variables sous forme de guide de l'utilisateur.

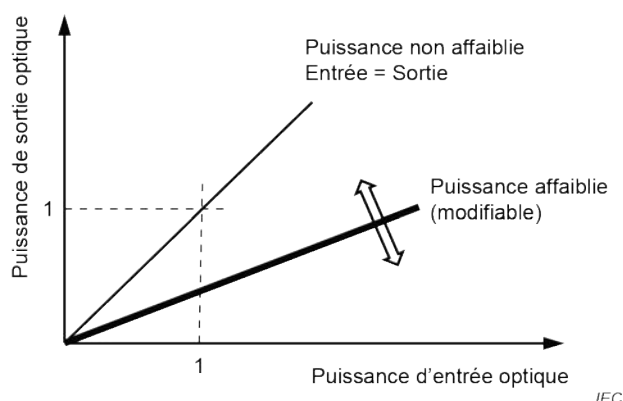
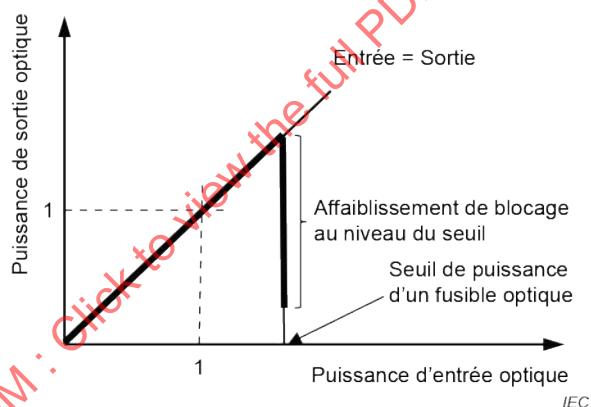


Figure 2 – Courbe de fonctionnement du VOA

4.2 Fusible optique

Le fusible optique (voir Figure 3) est un dispositif passif conçu pour protéger les équipements et les câbles à fibres optiques contre les dommages résultant de surpuissances, de pics et de sautes optiques. Dans l'idéal, lorsque la puissance d'entrée est inférieure à une puissance de seuil prédéterminée, le fusible optique reste transparent. Toutefois, le fusible optique devient opaque de manière permanente lorsque la puissance optique dépasse le niveau de seuil prédéterminé spécifié. Le fusible optique ne dépend pas de la longueur d'onde dans sa région de transparence. Le fusible optique est bidirectionnel.



NOTE La Figure 3 explique schématiquement comment le fusible optique fonctionne, avec la représentation du fusible optique idéal, qui n'a aucune perte d'insertion (IL).

Figure 3 – Courbe de fonctionnement du fusible optique

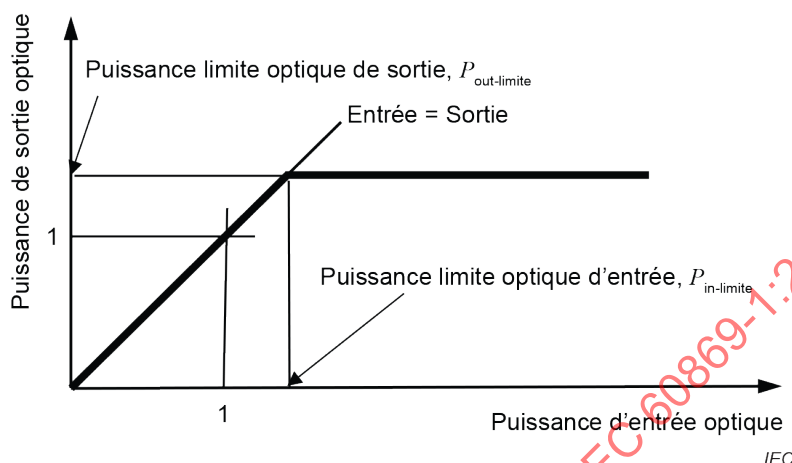
Le fusible optique protège contre les pics et les sautes de puissance. Il est placé soit au niveau du port d'entrée d'un détecteur optique, comme dans le cas d'un détecteur, soit au niveau du port de sortie d'un dispositif à puissance élevée, comme dans le cas d'un laser ou d'un amplificateur optique. Un fusible activé (opacifié) bloque de manière permanente la puissance optique transmise sans augmenter la puissance réfléchie, évitant ainsi des dommages. Le fusible optique peut être utilisé comme dispositif de sécurité oculaire.

Les Annexes A et B décrivent des exemples de configuration et de performance des fusibles optiques, et donnent des notes d'application concernant les fusibles optiques.

4.3 Limiteur de puissance optique

Le limiteur de puissance optique (voir Figure 4) est un dispositif passif qui régule la puissance optique dans les fibres, en produisant une puissance de sortie constante contrôlée $P_{\text{out-limite}}$, obtenue en faisant varier la puissance d'entrée à des valeurs supérieures à $P_{\text{in-limite}}$, et qui

n'a pas d'influence aux niveaux de puissance inférieurs à $P_{in-limite}$. En fonctionnement normal, lorsque la puissance optique d'entrée est faible, le limiteur de puissance optique n'a pas d'effet sur le système. Toutefois, lorsque la puissance optique d'entrée est élevée, la puissance optique de sortie est limitée à un niveau prédéterminé ($P_{out-limite}$). Le limiteur de puissance optique peut généralement fonctionner sous une entrée d'onde entretenue (CW) jusqu'à 5 dB au-dessus de $P_{in-limite}$, et il peut supporter des impulsions et des pics de courte durée (une seconde par minute) jusqu'à 8 dB au-dessus de $P_{in-limite}$.



NOTE La Figure 4 explique schématiquement comment le limiteur de puissance optique fonctionne, avec la représentation du limiteur de puissance optique idéal, qui n'a aucune perte d'insertion (IL).

Figure 4 – Courbe de fonctionnement du limiteur de puissance optique

Le limiteur de puissance optique est utilisé à l'entrée des équipements sensibles à la puissance et à la sortie des dispositifs à puissance élevée, comme dans le cas des amplificateurs ou lorsque la régulation de puissance est exigée. Le limiteur de puissance optique peut servir de dispositif de sécurité oculaire. Le limiteur de puissance optique ne dépend pas de la longueur d'onde dans sa région de transparence. Le limiteur de puissance optique est bidirectionnel. Le limiteur de puissance optique est, dans certains cas, combiné en ligne avec un fusible optique, ce qui garantit qu'à des puissances élevées, lorsque le limiteur de puissance optique connaît une défaillance, le dispositif qui suit ne soit pas exposé à une puissance qui lui soit nuisible.

Les Annexes C et D décrivent des exemples de configuration et de performance des limiteurs de puissance optique, et donnent des notes d'application concernant les limiteurs de puissance optique.

5 Exigences

5.1 Classification

5.1.1 Généralités

Les dispositifs de contrôle de la puissance sont classés selon les catégories suivantes:

- type,
- bande de longueur d'onde,
- modèle,
- variante,
- catégorie environnementale,
- niveau d'évaluation de la qualité,
- extensions des références normatives.

Un exemple de classification type d'un dispositif de contrôle de la puissance est donné ci-après:

Type:	– variable en continu
Bande de longueur d'onde:	– bande L
Modèle:	– configuration C – connecteurs LC-LC
Variante:	– moyens de montage
Niveau d'évaluation de la qualité:	– A

5.1.2 Type

Les types de dispositifs de contrôle de la puissance sont définis selon leur utilisation prévue.

Il existe trois types d'affaiblisseurs optiques:

- fixe,
- variable en continu,
- variable par pas discret.

Il existe un type de fusible optique avec une puissance de seuil prédéterminée discrète.

Il existe un type de limiteur de puissance optique avec une puissance limite prédéterminée discrète.

Il existe plusieurs combinaisons des dispositifs mentionnés ci-dessus, par exemple un affaiblisseur optique fixe et un limiteur de puissance optique dans un même dispositif, ou un limiteur de puissance optique et un fusible optique dans un même dispositif.

Il existe différents types de technologies pour les VOA, tels que les dispositifs manuels, les systèmes micro-électromécaniques (MEMS), les dispositifs à effet magnéto-optique, les circuits optiques planaires, les dispositifs à effet thermo-optique et les dispositifs à effet électro-optique à base de cristaux LiNbO_3 . L'Annexe G représente l'exemple des informations techniques concernant les affaiblisseurs optiques variables.

5.1.3 Bande de longueur d'onde

Les types de dispositifs de contrôle de la puissance sont définis par leur bande de longueur d'onde, O, C ou L, et parfois par une combinaison de ces bandes (par exemple C et L).

5.1.4 Modèle

Les dispositifs de contrôle de la puissance peuvent être classés en modèles selon le type de fibres, de connecteur et de câble, ou selon la forme et les dimensions du boîtier et sa configuration.

La configuration des ports du dispositif de contrôle de puissance est classée de la façon suivante.

- Configuration A – Dispositif tel que représenté à la Figure 5, comportant des fibres amorces optiques intégrées sans connecteurs.

Dispositif de contrôle de la puissance

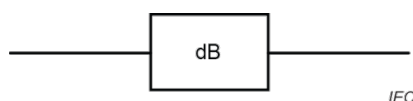


Figure 5 – Configuration A

- Configuration B – Dispositif tel que représenté à la Figure 6, comportant des fibres amorcees optiques intégrées, avec un connecteur sur chaque fibre amorcee.

Dispositif de contrôle de la puissance



Figure 6 – Configuration B

- Configuration C – Dispositif tel que représenté à la Figure 7, comportant des connecteurs fibroniques faisant partie intégrante du boîtier du dispositif.

Dispositif de contrôle de la puissance



Figure 7 – Configuration C

- Configuration D – Dispositif comportant une combinaison donnée d'interfaces des configurations précédentes.

5.1.5 Variante

La variante d'un dispositif de contrôle de la puissance optique identifie les caractéristiques qui incluent des composants de structure similaire.

Exemples de caractéristiques qui définissent une variante, entre autres:

- l'orientation des ports sur le boîtier,
- les moyens de montage.

5.1.6 Niveau d'évaluation de la qualité

La spécification particulière doit contenir tous les essais nécessaires à l'évaluation de la qualité.

Chaque essai doit être attribué à l'un des quatre groupes désignés par A, B, C et D.

La spécification particulière doit préciser un ou plusieurs niveaux d'évaluation de la qualité, chacun de ces niveaux devant être désigné par une lettre capitale. Le niveau d'évaluation de la qualité définit le rapport entre les niveaux de contrôle/niveaux de qualité acceptable (NQA) pour les groupes A et B et la périodicité de contrôle des groupes C et D.

Les niveaux suivants sont les niveaux préférentiels:

- Niveau A d'évaluation de la qualité
 - contrôle du groupe A: niveau de contrôle II, NQA = 4 %
 - contrôle du groupe B: niveau de contrôle II, NQA = 4 %

- contrôle du groupe C: périodicité de 24 mois
- contrôle du groupe D: périodicité de 48 mois
- Niveau B d'évaluation de la qualité
 - contrôle du groupe A: niveau de contrôle II, NQA = 1 %
 - contrôle du groupe B: niveau de contrôle II, NQA = 1 %
 - contrôle du groupe C: périodicité de 18 mois
 - contrôle du groupe D: périodicité de 36 mois
- Niveau C d'évaluation de la qualité
 - contrôle du groupe A: niveau de contrôle II, NQA = 0,4 %
 - contrôle du groupe B: niveau de contrôle II, NQA = 0,4 %
 - contrôle du groupe C: périodicité de 12 mois
 - contrôle du groupe D: périodicité de 24 mois

Les groupes A et B font l'objet d'un contrôle lot par lot et les groupes C et D font l'objet d'un contrôle périodique. Il est admis d'intégrer dans la spécification particulière un niveau d'évaluation de la qualité supplémentaire (autre que ceux définis ci-dessus). Dans ce cas, la lettre capitale X doit être utilisée.

5.1.7 Extensions des références normatives

Les extensions de références normatives sont utilisées pour identifier des spécifications de normes indépendantes ou d'autres documents de référence intégrés dans les spécifications particulières cadre.

Sauf exceptions spécifiées, des exigences complémentaires imposées par une extension sont obligatoires. Le but est principalement de combiner des composants associés pour constituer des dispositifs hybrides, ou de combiner des exigences d'application de fonctionnement intégrées dépendant d'une expertise technique autre que celle de la fibronique.

Les documents de référence publiés par l'UIT, qui sont compatibles avec le domaine d'application de séries de spécifications IEC particulières, peuvent être utilisés comme extensions. Les documents publiés par d'autres organismes régionaux de normalisation tels que TIA, CENELEC, JIS, peuvent être cités en référence dans une annexe informative jointe à la spécification générique.

Certaines configurations d'épissures optiques exigent des dispositions d'homologation particulières qui ne doivent pas être imposées de manière universelle. Ces cas comprennent les configurations de conception de composant individuelles, l'outillage spécialisé ou les procédés d'application spécifique. Dans ces cas, des exigences sont nécessaires pour assurer des caractéristiques de fonctionnement pouvant se répéter ou une sécurité adéquate, et pour fournir un guide supplémentaire complétant les spécifications de produit. Ces extensions sont obligatoires dès lors qu'elles sont utilisées pour préparer, assembler ou installer une épissure optique, soit pour l'utilisation sur le terrain, soit pour la préparation des spécimens d'essai pour l'homologation. Les spécifications applicables doivent clarifier toutes les stipulations. Toutefois, les extensions qui dépendent de la conception et du modèle ne doivent pas être imposées de manière universelle.

En cas d'exigences divergentes, la priorité suit l'ordre décroissant, qui doit être le suivant: "générique" doit primer sur "extension obligatoire" qui prime sur "particulière cadre" qui prime sur "particulière" qui prime sur "extension spécifique à l'application".

Des exemples d'extensions pour des connecteurs optiques sont énumérés ci-après:

- utilisation de l'IEC 61754-4 et de l'IEC 61754-2 pour définir partiellement une future série IEC 60874 pour un type de raccord pour connecteur hybride duplex "SC/BFOC/2,5";

- utilisation de l'IEC 61754-13 et de l'IEC 60869-1-1 pour définir partiellement une future série IEC 60874 pour un connecteur optique intégré présent à affaiblissement de type "FC";
- utilisation de l'IEC 61754-2 et de l'IEC 61073-4 pour définir partiellement une future série IEC 60874 pour une embase "BFOC/2,5" duplex incorporant des épissures mécaniques intégrales.

Il existe d'autres exemples d'exigences d'extensions normatives: certaines applications dans les bâtiments commerciaux ou d'habitation peuvent nécessiter une référence directe à des codes et règlements de sécurité spécifiques ou incorporent d'autres exigences spécifiques relatives à l'inflammabilité des matériaux ou à la toxicité pour des emplacements spéciaux.

L'outillage de terrain spécialisé peut nécessiter une extension pour la mise en œuvre d'exigences spécifiques pour la sécurité oculaire, les chocs électriques, la prévention des risques de brûlure, ou peut nécessiter des procédures d'isolation pour prévenir l'allumage éventuel de gaz combustibles.

5.2 Documentation

5.2.1 Symboles

Les symboles graphiques et littéraux doivent, dans la mesure du possible, être ceux utilisés dans l'IEC 60027 (toutes les parties) et l'IEC 60617, sauf indication contraire dans le présent document.

5.2.2 Système de spécifications

5.2.2.1 Généralités

Le présent document entre dans le système de spécification IEC à trois niveaux. Les spécifications auxiliaires doivent être constituées de spécifications particulières cadre et de spécifications particulières. Ce système est représenté dans le Tableau 1. Il n'existe pas de spécifications intermédiaires pour les dispositifs de contrôle de la puissance.

Tableau 1 – Structure de spécification de l'IEC à trois niveaux

Niveau de spécification	Exemples d'informations à inclure	Applicable à
De base	– Règles du système d'évaluation de la qualité – Règles des contrôles – Méthodes de mesure optique – Plans d'échantillonnage – Règle d'identification – Normes de marquage – Normes dimensionnelles – Terminologie – Symboles – Séries numériques préférentielles – Unités SI	Deux ou plusieurs familles ou sous-familles de composants
Générique	– Terminologie spécifique – Symboles spécifiques – Unités spécifiques – Valeurs préférentielles – Marquage – Procédures d'évaluation de la qualité – Sélection des essais – Procédures d'homologation et/ou d'agrément	Famille de composants
Particulière cadre	– Programmes d'essai de conformité de la qualité – Exigences pour les contrôles – Informations communes à un certain nombre de types	Groupes de types ayant un programme d'essais commun
Particulière	– Valeurs individuelles – Informations spécifiques – Programmes d'essai de conformité de la qualité complets	Type individuel