BS EN 60869-1:2013

BSI Standards Publication

Fibre optic interconnecting devices and passive components - Fibre optic passive power control

Part 1: Generic specification

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National foreword

This British Standard is the UK implementation of EN 60869-1:2013. It is identical to IEC 60869-1:2012. It supersedes BS EN 60869-1:2000 which is withdrawn.

The UK participation in its preparation was entrusted by Technical Committee GEL/86, Fibre optics, to Subcommittee GEL/86/2, Fibre optic interconnecting devices and passive components.

A list of organizations represented on this committee can be obtained on request to its secretary.

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English version

Fibre optic interconnecting devices and passive components - Fibre optic passive power control devices - Part 1: Generic specification
(IEC 60869-1:2012)

Dispositifs d'interconnexion et composants passifs à fibres optiques - Dispositifs à fibres optiques passifs de contrôle de la puissance - Partie 1: Spécification générique
(CEI 60869-1:2012)

Lichtwellenleiter - Verbindungselemente und passive Bauteile - Passive Geräte zur Leistungsbegrenzung - Teil 1: Fachgrundspezifikation
(IEC 60869-1:2012)

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European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

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Foreword

The text of document 86B/3505/FDIS, future edition 4 of IEC 60869-1, prepared by SC 86B, "Fibre optic interconnecting devices and passive components", of IEC TC 86, "Fibre optics" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN 60869-1:2013.

The following dates are fixed:

• latest date by which the document has to be implemented at national level by publication of an identical national standard or by endorsement	(dop)	2013-12-28
• latest date by which the national standards conflicting with the document have to be withdrawn	(dow)	2014-01-16

This document supersedes EN 60869-1:2000.

EN 60869-1:2013 includes the following significant technical changes with respect to EN 60869-1:2000:

– the terms and definitions were reconsidered;

– the requirement concerning the IEC Quality Assessment System was reconsidered;

– the clause concerning quality assessment procedures was deleted.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CENELEC [and/or CEN] shall not be held responsible for identifying any or all such patent rights.

Endorsement notice

The text of the International Standard IEC 60869-1:2012 was approved by CENELEC as a European Standard without any modification.

In the official version, for Bibliography, the following notes have to be added for the standards indicated:

IEC 61300-1	NOTE	Harmonised as EN 61300-1.
IEC 61754-4	NOTE	Harmonised as EN 61754-4.
IEC 61754-2	NOTE	Harmonised as EN 61754-2.
IEC 61754-13	NOTE	Harmonised as EN 61754-13.
IEC 61300-2 series	NOTE	Harmonised in EN 61300-2 series.
IEC 61300-3 series	NOTE	Harmonised in EN 61300-3 series.
IEC 61753-051-3	NOTE	Harmonised as EN 61753-051-3.
IEC 61753-056-2	NOTE	Harmonised as EN 61753-056-2.
IEC 61753-057-2	NOTE	Harmonised as EN 61753-057-2.
IEC 61753-058-2	NOTE	Harmonised as EN 61753-058-2.
IEC 61753-059-2	NOTE	Harmonised as EN 61753-059-2.
IEC 60874 series	NOTE	Harmonised in EN 60874 series.
IEC 61073-1	NOTE	Harmonised as EN 61073-1.
IEC 61300 series	NOTE	Harmonised in EN 61300 series.

IEC 61753 series	NOTE Harmonised in EN 61753 series.
IEC 61754 series	NOTE Harmonised in EN 61754 series.
IEC 61755 series	NOTE Harmonised in EN 61755 series.
IEC 62005 series	NOTE Harmonised in EN 62005 series.

Annex ZA
(normative)

Normative references to international publications with their corresponding European publications

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

NOTE When an international publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

Publication	Year	Title	EN/HD	Year
IEC 60027	Series	Letter symbols to be used in electrical technology	EN 60027	Series
IEC 60050-731	-	International Electrotechnical Vocabulary (IEV) - Chapter 731: Optical fibre communication	-	-
IEC 60617	Data-base	Graphical symbols for diagrams	-	-
IEC 60695-11-5	-	Fire hazard testing - Part 11-5: Test flames - Needle-flame test method - Apparatus, confirmatory test arrangement and guidance	EN 60695-11-5	-
IEC 60825	Series	Safety of laser products	EN 60825	Series
ISO 129	-	Technical drawings - Dimensioning - General principles, definitions, methods of execution and special indications	-	-
ISO 286-1	-	ISO system of limits and fits - Part 1: Bases of tolerances, deviations and fits	EN ISO 286-1	-
ISO 1101	-	Geometrical Product Specifications (GPS) - Geometrical tolerancing - Tolerances of form, orientation, location and run-out	EN ISO 1101	-
ISO 8601	-	Data elements and interchange formats - Information interchange - Representation of dates and times	-	-

CONTENTS

FIBRE OPTIC INTERCONECTING 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 power control devices. These have all of the following general features:

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

This standard 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].

2 Normative references

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

IEC 60027, *Letter symbols to be used in electrical technology*

IEC 60050-731, *International Electrotechnical Vocabulary – Chapter 731: Optical fibre communication*

IEC 60617, *Graphical symbols for diagrams*. Available from <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*

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

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

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1 References in square brackets refer to the Bibliography.

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 definitions given in IEC 60050-731 as well as the following apply.

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 $\lambda_{i\ min}$ to $\lambda_{i\ max}$ about a nominal operating wavelength λ_i, 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.

3.2 Component terms

3.2.1
optical attenuator
passive device, which produces a controlled signal attenuation in an optical fibre transmission line. An attenuator is intended to be wavelength independent

3.2.2
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

3.2.3
optical fuse
passive device, which produces a controlled, permanent, signal blocking at a predetermined power threshold in an optical fibre transmission line

3.2.4
optical power limiter
passive device that regulates the optical power in fibres, producing a controlled, constant optical output power P_{limit}, as a result of varying optical input power higher than P_{limit}, and has no influence at optical powers below P_{limit}

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

3.3 Performance terms

3.3.1
optical fuse power threshold
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.

3.3.2
optical fuse response time
total time when the optical fuse output power level is higher than the optical fuse power threshold by 1 dB, staring 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

3.3.3
optical fuse blocking attenuation at threshold
drop of optical power through the optical fuse when exposed to more than the optical fuse power threshold P_{th}, and responds by blocking the power, expressed in dB

3.3.4
optical power limiter response time
total time where the optical power limiter output power level is higher than limit power + 1 dB, staring 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

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

3.3.6
minimum insertion loss
term applicable only to variable optical attenuators, (VOAs); it is the lowest insertion loss to which the device may be adjusted

3.3.7
variable attenuation range
range of insertion loss to which the device may be adjusted

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

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.

3.3.10
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

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

3.3.11
maximum allowed power input
maximum input power that the device can handle without causing dysfunction or permanent damage, expressed in Watt or dBm

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

4 Description of devices

4.1 Optical attenuator

The optical attenuator 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 predetermined level.

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

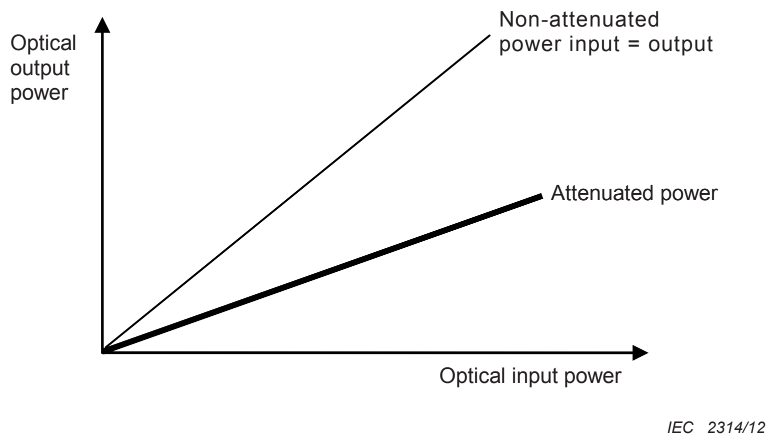


Figure 1 – Optical attenuator operation curve

4.2 Variable optical attenuator (VOA)

The performance curve of a VOA is similar to Figure 1 of an attenuator, where 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.

4.3 Optical fuse

The optical fuse (see Figure 2) 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. 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 bi-directional.

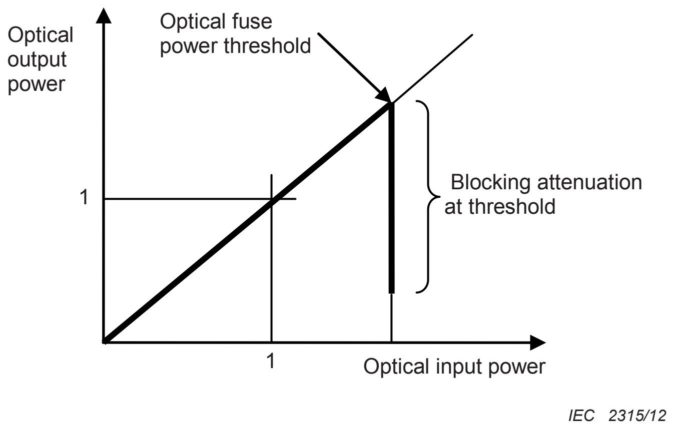


Figure 2 – Optical fuse operation curve

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 a detector, or at the output port of a high power device, such as a laser or optical amplifier. An activated (burnt) fuse permanently blocks the forward optical power without enlarging the reflected power, thus preventing damage. The optical fuse can be used as an eye safety device.

4.4 Optical power limiter

The optical power limiter (see Figure 3) is a passive device that regulates the optical power in fibres, producing a controlled, constant output power P_{limit}, as a result of varying input power higher than P_{limit}, and has no influence at powers below P_{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_{limit}). The optical power limiter can typically operate under CW input up to 5 dB above P_{limit}, and can sustain short duration pulses and spikes (a second in every minute) up to 8 dB above P_{limit}.

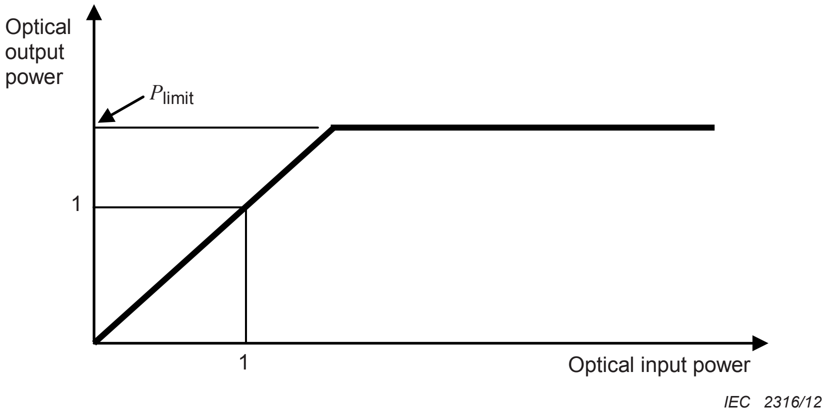


Figure 3 – Optical power limiter operation curve

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 bi-directional. 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.

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, e.g. a fixed optical attenuator and an optical power limiter in one device, or an optical power limiter and an optical fuse in one device.

5.1.3 Wavelength band

Power control devices types are defined by their wavelength band, O, C or L, and sometimes two or more bands.

5.1.4 Style

Power control devices may be classified into styles based upon fibre type, connector type, and 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 4 containing integral optical pigtails without connectors.

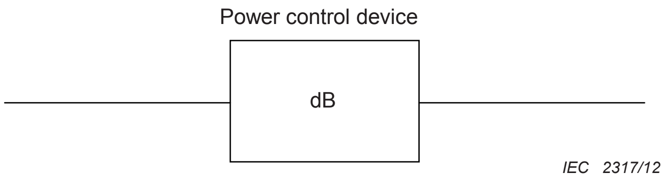


Figure 4 – Configuration A

– Configuration B – A device as shown in Figure 5 containing integral optical pigtails, with a connector on each pigtail.

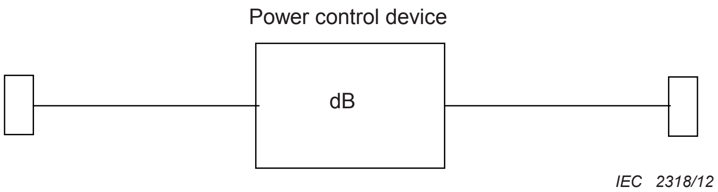


Figure 5 – Configuration B

– Configuration C – A device as shown in Figure 6 containing fibre optic connectors as an integral part of the device housing.

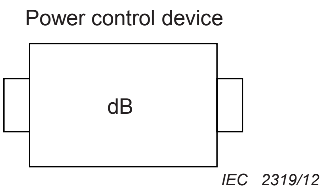


Figure 6 – Configuration C

– 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/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 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. 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 assure 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 "generic" over "mandatory extension", over "blank detail", over "detail", 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 adaptor;
– using IEC 61754-13 and IEC 60869-1 to partially define a future IEC 60874 series specification for an integrated type "FC" preset 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.

Specialized field tooling may require an extension to implement specific ocular safety, electrical 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 the IEC 60027 and the IEC 60617 series unless superseded by this part of IEC 60859.

5.2.2 Specification system

5.2.2.1 General

This specification 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 specification. 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, 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

- 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 adaptors 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 adaptor 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 that standard) 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 requirement of the performance standards. 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 of the test and measurements standards, for their application (particularly with regard to insertion loss and return loss) in conjunction with interface standards of inter product compatibility, may be defined. The conformity with this standard of each individual product 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 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 are given in Figure 7. 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 interface, performance optical interface and reliability standards, the matrix given in Table 2 demonstrates some of the options available for product standardization once all 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 does not meet the requirements of either an IEC performance standard or 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.

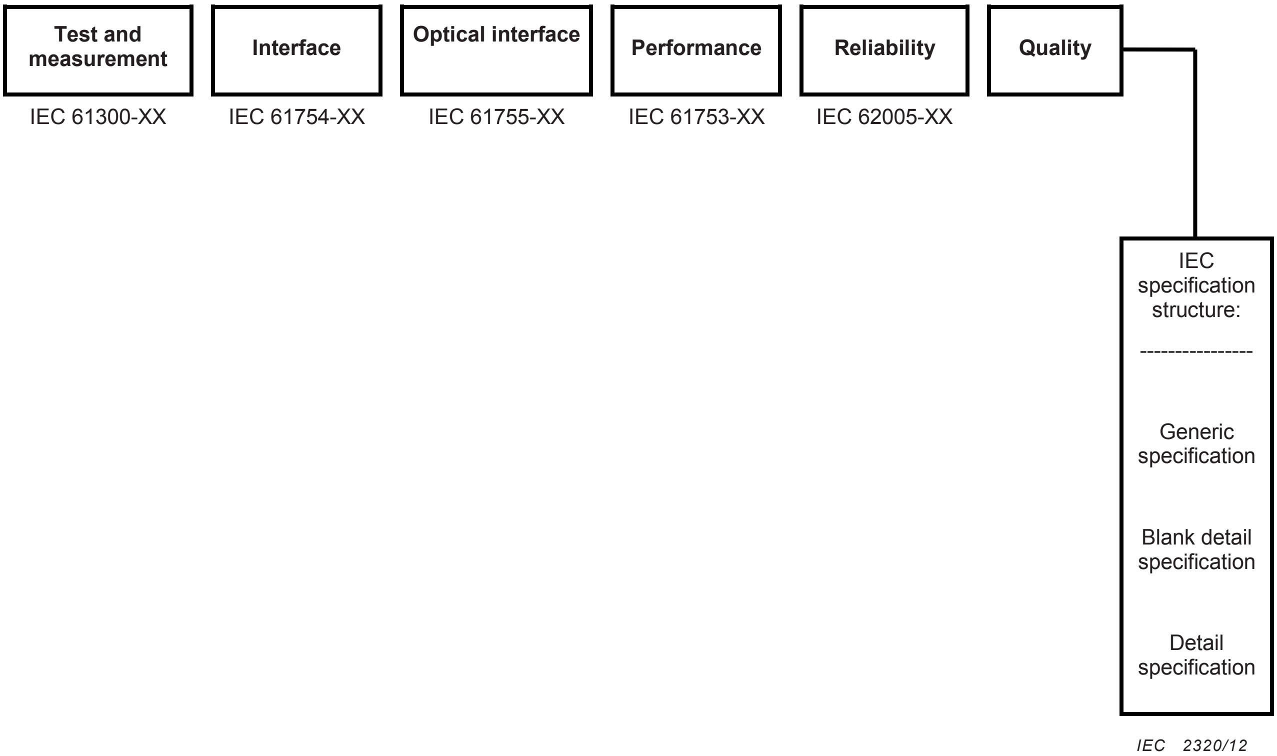


Figure 7 – Standardization structure

Table 2 – Standards interlink matrix

Product	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.

EXAMPLE: QC800001 001 A

Detail specification number (QC800001)

Variant number (001)

Assessment level (A)

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 expirate 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 the IEC 60825 series (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:

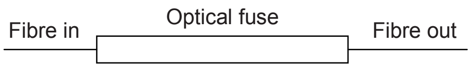
WARNING NOTE

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

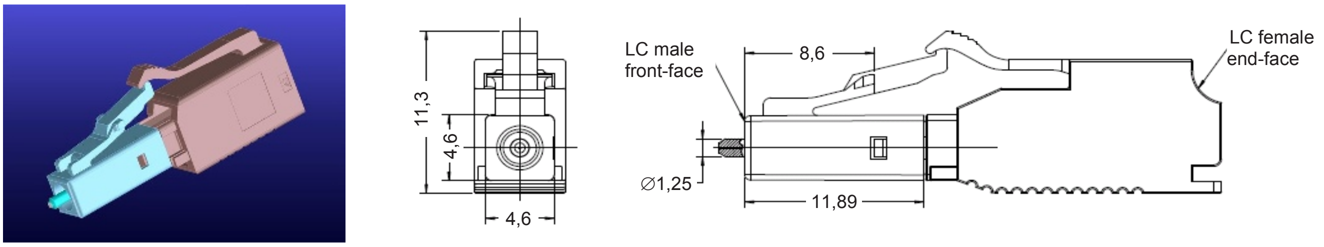
Examples of optical fuse configurations are given in Figures A.1 and A.2:



IEC 2264/12

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

Figure A.1 – Optical fuse, pigtail style



IEC 2321/12

Figure A.2 – Optical fuse, plug 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 is 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.

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

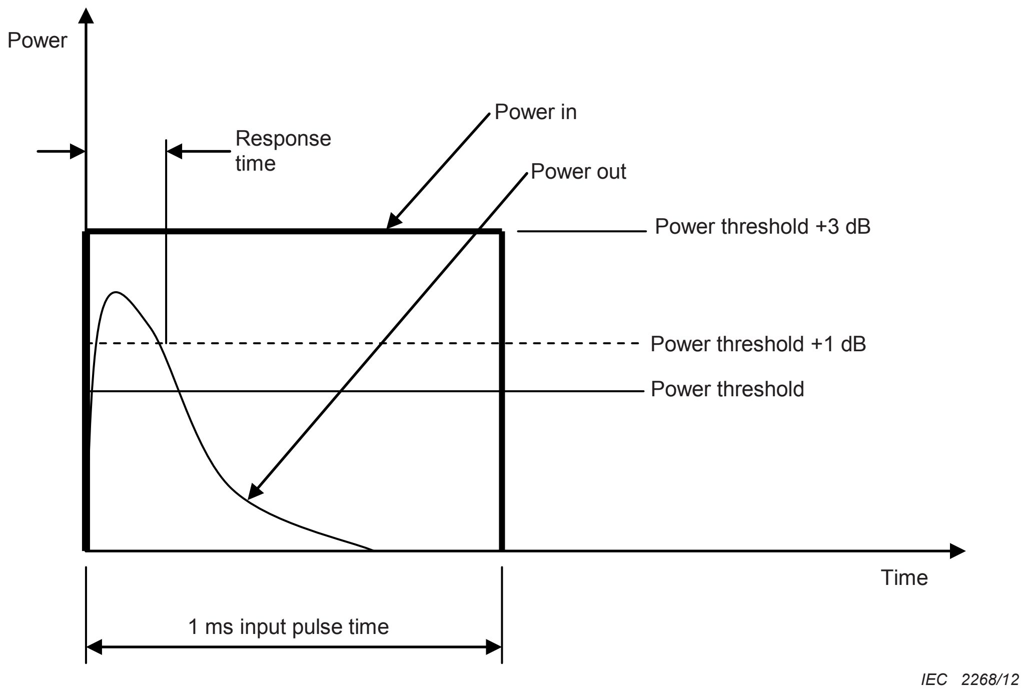


Figure A.3 – Response time curve of an optical fuse

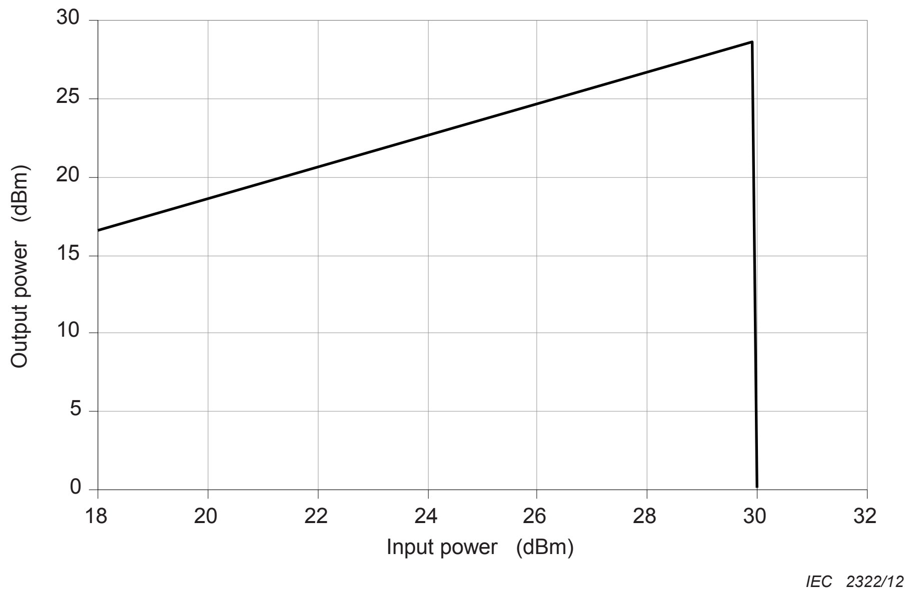


Figure A.4 – Optical fuse, power threshold ~30 dBm (1W), output power drop at threshold ~25 dB

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 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 as follows:

- 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.
- 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 input port of

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

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

- lasers,
- amplifiers,
- modulators.

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

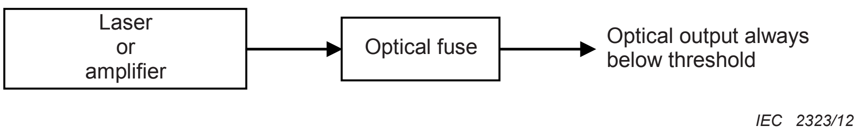


Figure B.1a – Placement at output of active devices

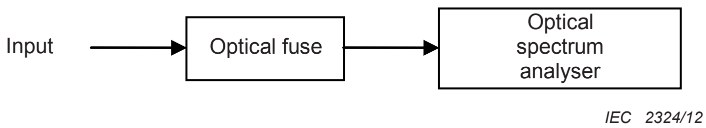


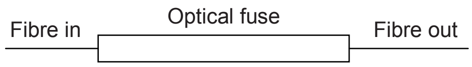
Figure B.1b – Placement at input of active devices

Figure B.1 – Optical fuse

Annex C
(informative)

Optical power limiter configuration and performance examples

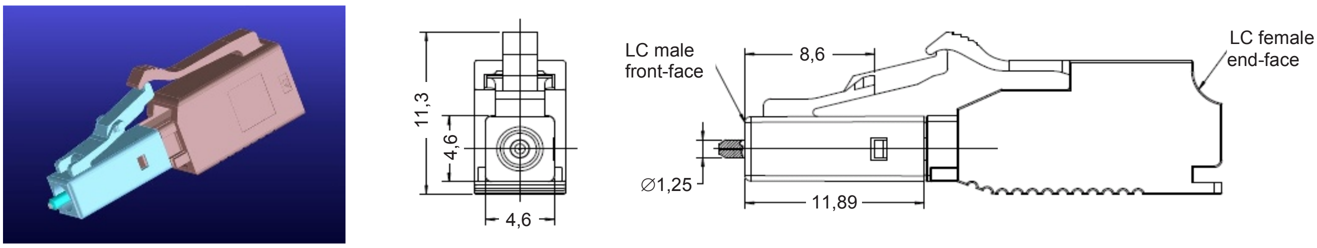
The optical power limiter configurations are shown in Figures C.1 and C.2.



IEC 2264/12

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

Figure C.1 – Optical power limiter, pigtail style



IEC 2321/12

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

Optical power limiters are manufactured in 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 dBm to 18 dBm and back a few tens of cycles, showing curves that are identical within 0,2 dBm (black lines).

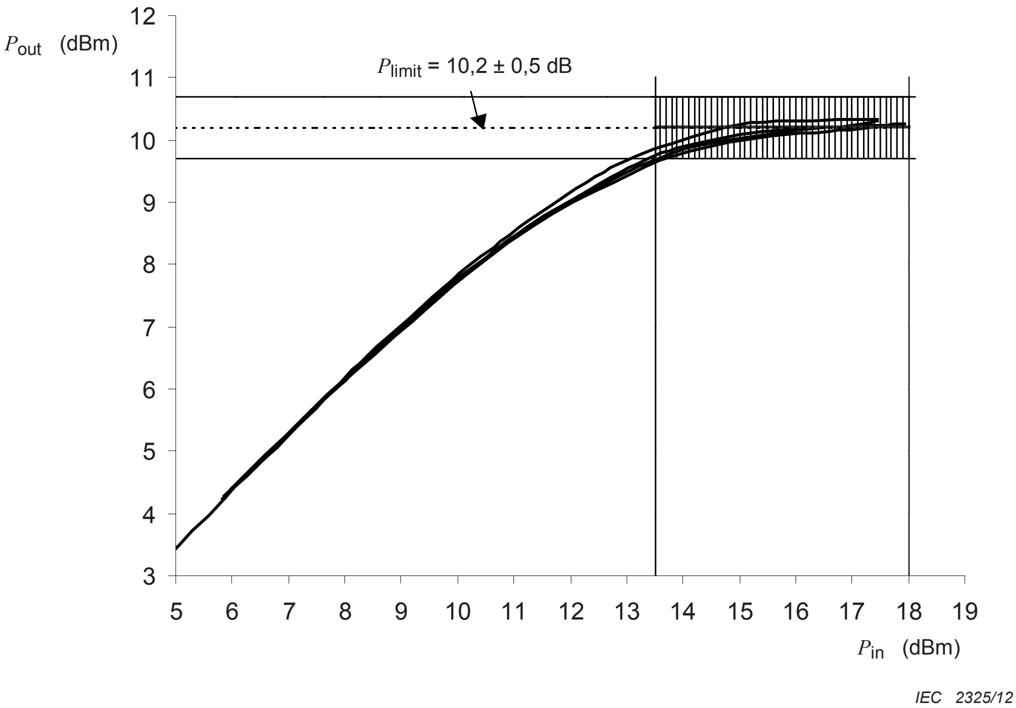
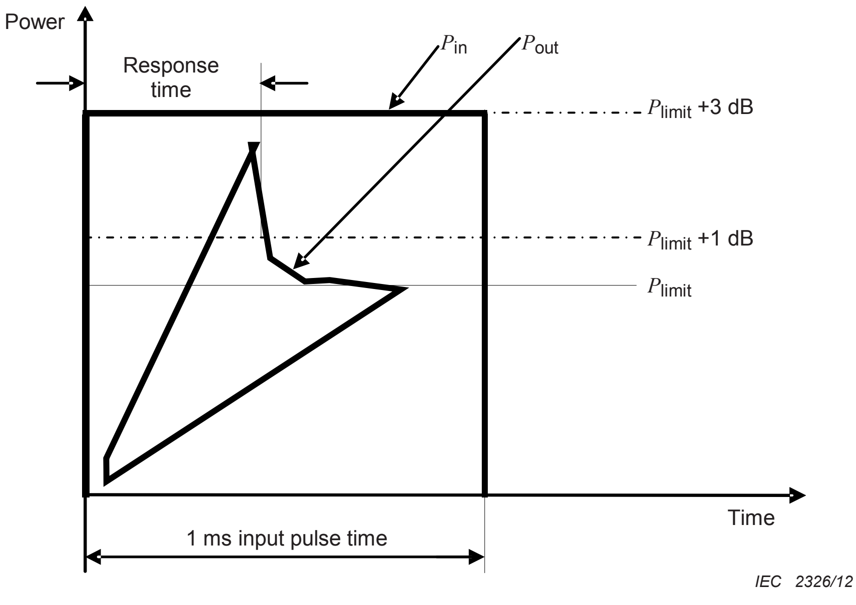


Figure C.3 – Optical power limiter – Experimental

Response time is the total time where the optical power limiter output power level is above (P_{limit} + 1 dB) power line, when exposed to a square wave input power, 1 ms long, having a rise time of 10 µs and a steady-state power of P_{limit} + 3 dB. Figure C.4 illustrates the parameters.

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



NOTE Input pulse is 1 ms long.

Figure C.4 – Schematic optical power limiter response time

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

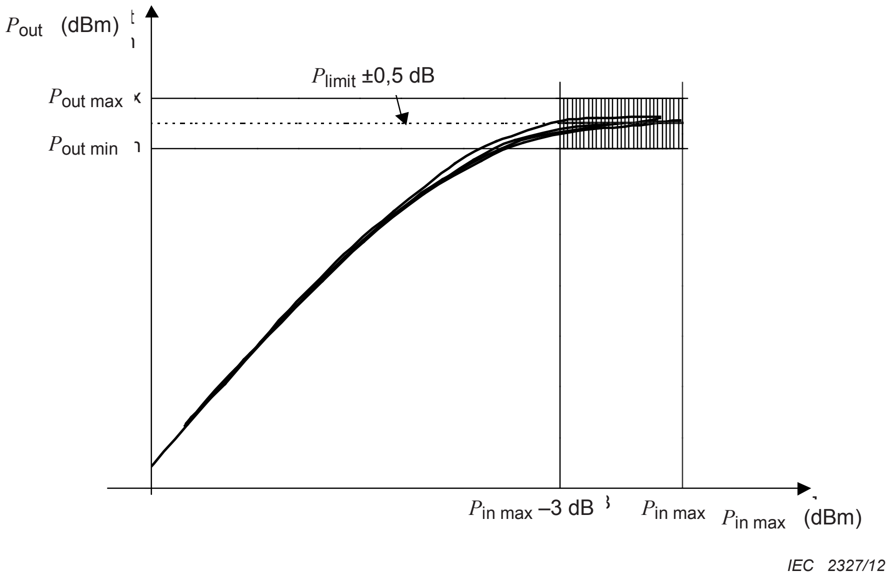


Figure C.5 – Schematic power definitions

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.

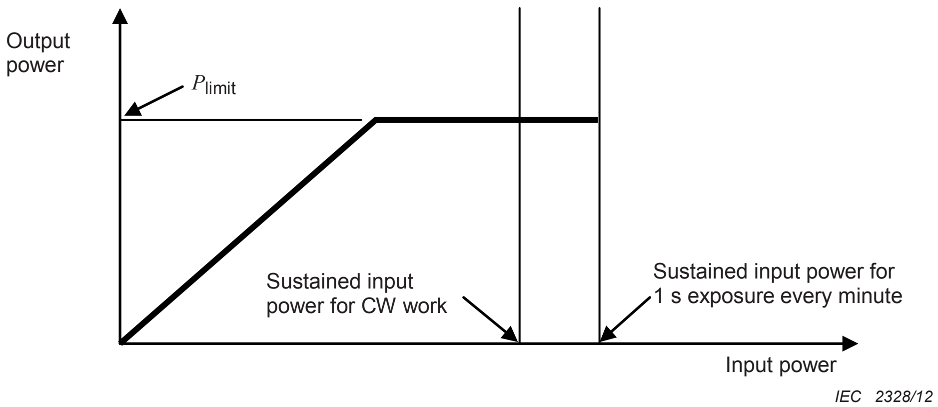


Figure C.6 – Optical power limiter, input power definitions

Annex D
(informative)

Optical power limiter application notes

The optical power limiter regulates the optical power. Its use is 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 as follows:

- 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 μS, 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 limiter can be used as an add-on at the input port of

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

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

- lasers,
- amplifiers,
- modulators.

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 the limiter fails, the following device is not exposed to damaging power, as shown in Figure D.1.

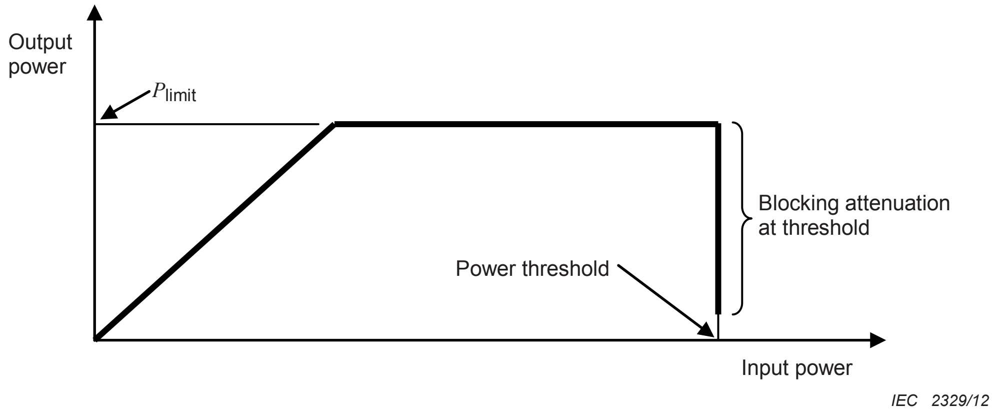


Figure D.1 – Optical power limiter and optical fuse, combined, operation curve

Annex E
(informative)

Fixed optical attenuator application note

The fixed optical attenuator is a passive device, having fixed attenuation, which can be used for 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 as follows:

- 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 input port of:

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

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

- lasers,
- AMPLIFIERS,
- modulators.

Thus the next device can be protected from damage by the light source, as shown in Figure E.1.

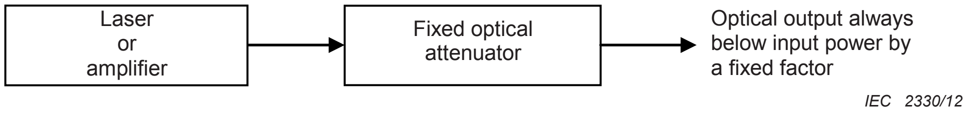


Figure E.1a – Placement at output of active devices

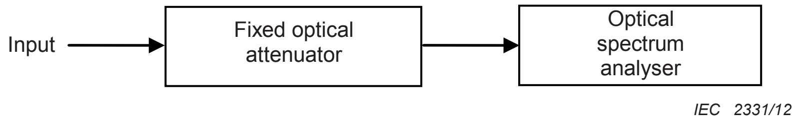


Figure E.1b – Placement at input of active devices

Figure E.1 – Fixed optical attenuator

Annex F
(informative)

Variable, manual or electrical optical attenuator application note

The variable, manual or electrical, 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, manual or electrical, optical attenuator handles a broad range of wavelengths, reducing the optical power propagation from input to output at a controlled, variable amount. The variable, manual or electrical, optical attenuator can be of plug-style or pigtailed style.

The main characteristics of the variable, manual or electrical, optical attenuator are as follows:

- 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, 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 spectrum analysers, detectors),
- receivers,
- MUX-DEMUX units.

Here the variable, manual or electrical, optical attenuator is controlling the input power and setting it to a desired level.

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

- lasers,
- amplifiers,
- modulators.

The variable, manual or electrical, optical attenuator is controlling the output power or protecting the next device from damage by the light source, as shown in Figure F.1.

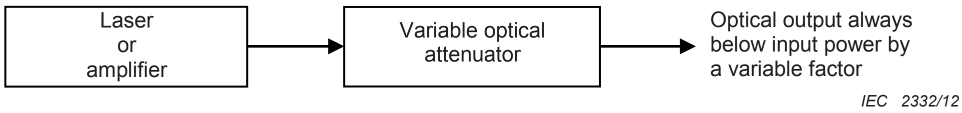


Figure F.1a – Placement at output of active devices

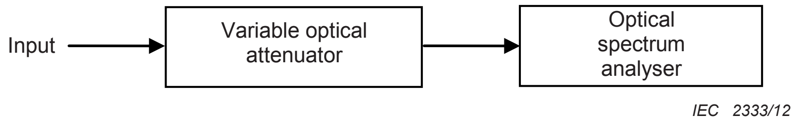


Figure F.1b – Placement at input of active devices

Figure F.1 – The variable, manual or electrical, optical attenuator

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2 To be published.

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