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Edition 1.0 2012-12

INTERNATIONAL STANDARD

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

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FOREWORD

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International Standard IEC 61753-056-2 has been prepared by subcommittee SC86B: Fibre optic interconnecting devices and passive components, of IEC technical committee TC86: Fibre optics.

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

FDIS	Report on voting
86B/3500/FDIS	86B/3544/RVD

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

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

A list of all parts in the IEC 61753 series, published under the general title *Fibre optic interconnecting devices and passive components – Performance standard*, can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

A bilingual version of this publication may be issued at a later date.

INTRODUCTION

1) The International Electrotechnical Commission (IEC) draws attention to the fact that it is claimed that compliance with this document may involve the use of a patent concerning optical fuse.

   IEC takes no position concerning the evidence, validity and scope of this patent right.

   The holder of this patent right has assured the IEC that he/she is willing to negotiate licences either free of charge or under reasonable and non-discriminatory terms and conditions with applicants throughout the world. In this respect, the statement of the holder of this patent right is registered with IEC. Information may be obtained from:

   KiloLambda technologies, Ltd.
   22a Wallenberg street,
   Tel-Aviv 69719,
   Israel

   Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights other than those identified above. IEC shall not be held responsible for identifying any or all such patent rights.

   ISO (www.iso.org/patents) and IEC (http://patents.iec.ch) maintain on-line data bases of patents relevant to their standards. Users are encouraged to consult these data bases for the most up-to-date information concerning patents.

   US patent US-7162,114 B2, Optical Energy switching device and method", granted January 9, 2007.

   Japan patent 4376632, Optical Energy switching device and method", granted September 18, 2009.

2) The optical fuse is a passive device, designed to protect equipment and fibre cables from damage due to optical overpower, spikes and surges. The optical fuse produces a controlled, permanent, signal blocking at a predetermined power threshold in an optical fibre transmission line. The optical fuse is wavelength independent over its entire specified spectral range. IEC 60869-1 contains generic information on optical fuses. The optical fuse has a maximum allowed power input $P_{\text{in max}}$. Beyond this power it is dysfunctional and can let light through. Numerical values for $P_{\text{in max}}$ are given in Annex B.

FIBRE OPTIC INTERCONNECTING DEVICES AND PASSIVE COMPONENTS – PERFORMANCE STANDARD –

Part 056-2: Single mode fibre pigtailed style optical fuse for category C – Controlled environment

1 Scope

This part of IEC 61753 contains the minimum initial test and measurement requirements and severities which a fibre optical fuse satisfies in order for it to be categorised as meeting the requirements of single mode fibre pigtailed style optical fuse used in controlled environments. Optical performance specified in this document relates to in-line type configurations fuses only.

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

IEC 60869-1, *Fibre optic interconnecting devices and passive components – Fibre optic passive power control devices – Part 1: Generic specification*[1]

IEC 61300-1, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 1: General and guidance*

IEC 61300-2-1, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 2-1: Tests – Vibration (sinusoidal)*

IEC 613000-2-4, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 2-4: Fibre/cable retention*

IEC 61300-2-9, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 2-9: Tests – Shock*

IEC 61300-2-14, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 2-14: Tests – High optical power*[1]

IEC 61300-2-17, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 2-17: Tests – Cold*

IEC 61300-2-18, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 2-18: Tests – Dry heat – High temperature endurance*

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1 To be published.

IEC 61300-2-19, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 2-19: Tests – Damp heat (steady state)*

IEC 61300-2-22, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 2-22: Tests – Change of temperature*

IEC 61300-2-42, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 2-42: Tests – Static side load for connectors*

IEC 61300-2-44, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 2-44: Tests – Flexing of the strain relief of fibre optic devices*

IEC 61300-3-2, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 3-2: Examinations and measurements –Polarization dependent loss in a single-mode fibre optic device*

IEC 61300-3-3, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 3-3: Examinations and measurements – Active monitoring of changes in attenuation and return loss*

IEC 61300-3-7, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 3-7: Examinations and measurements – Wavelength dependence of attenuation and return loss of single mode components*

IEC 61300-3-32, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 3-32: Examinations and measurements – Polarization mode dispersion measurement for passive optical components*

3 Tests

All test methods are in accordance with the IEC 61300 series.

All tests are to be carried out to validate performance over the required operating wavelength and power range. As a result, single or multiple spectral bands may be chosen for the qualification in addition to threshold power.

4 Test reports

Fully documented test reports and supporting evidence shall be prepared and shall be available for inspection as evidence that the tests have been carried out and complied with.

5 Performance requirements

5.1 Sample size, sequencing and grouping

Sample sizes for the tests are defined in Annex A.

5.2 Dimensions

Dimensions shall comply with either an appropriate IEC interface standard or with those given in appropriate manufacturers' drawings, where the IEC interface standard does not exist or cannot be used.

5.3 Test details and requirements

Table 1 specifies the optical environmental and mechanical performance requirements and test methods for optical fuses pertaining to this standard.

Compliance to this standard requires demonstration of the ability to meet the performance requirement in Table 1.

Table 1 – Performance requirements for optical fuses *(1 of 6)*

No.	Tests	Requirements	Details	
1	Insertion loss	Operating wavelength range: 1 520 nm to1 625 nm Insertion loss ≤ 1,5 dB Insertion loss is measured with input power ≤ –5 dBm	Method: Launch patchcord length: Launch conditions: Source power stability: Wavelength range: Total uncertainty	IEC 61300-3-7, test sample configuration according to Method B2.1 ≥ 2 m. Only the fundamental mode shall propagate at the fuse interface and at the detector. The wavelength of the source shall be longer than cut-off wavelength of the fibre. Less than or equal or equal ± 0,05 dB over the measuring period or at least 1 h 1 520 nm to 1 625 nm ≤ ± 0,05 dB
2	Return loss below power threshold	≥ 35 dB Grade T ≥ 40 dB Grade R ≥ 50 dB Grade U ≥ 60 dB Grade V Return loss is measured with input power ≤ –5 dBm	Method: Source: Total uncertainty	IEC 61300-3-7 measurement, Method 1 OCWR for grades T,R, U IEC 61300-3-7, measurement method 1 OFDR for grade V LD 1 520 nm and 1 625 nm Test every sample with the two wavelengths. ≤± 2 dB
3	Return loss above power threshold, after fuse response	≥ 30 dB Return loss is measured with input power ≤ –5 dBm	Method: Source: Total uncertainty	IEC 61300-3-7, measurement method 1 OCWR LD 1 520 nm and 1 625 nm Test every sample with the two wavelengths. ≤ ± 2 dB
4	Polarization dependent loss	≤0,2 dB Over the specified operating wavelength range The samples shall be terminated onto single-mode fibres as per IEC 60793-2-50, Type B 1.1, in either coated fibres (primary and secondary) or reinforced cable format	Method: Optical source Wavelength: Total uncertainty:	IEC 61300-3-2, all polarization methods 1 550 nm ± 10 nm ≤ ± 0,05 dB over the dynamic range to be measured
5	Polarization mode dispersion	≤ 0,2 ps Over the specified operating wavelength range	Method: Optical source Wavelength: Total uncertainty:	IEC 61300-3-32, MPS method 1 550 nm ± 10 nm ≤ ± 0,05 dB over the dynamic range to be measured

Table 1 (*2 of 6*)

No.	Tests	Requirements	Details	
6	High optical power Below power threshold	The fuse will not change its insertion and return loss up to power threshold Before and after the test the Insertion loss shall meet the requirements of test 1 Before and after the test the return loss shall meet the requirements of test 2 The insertion loss change during the test shall be within ± 0,5 dB of the initial value	Method: Optical source Wavelength: Test power: Test temperature: Test duration:	IEC 61300-2-14 1 550 nm ± 10 nm 3 dB below power threshold 25 °C ± 2 °C Long-term test: 96 h at test power
7	High optical power Above power threshold (destructive test)	The fuse will block the power from power threshold to ≥ 30 dBm input power or higher value specified in Annex B Before the test the Insertion loss shall meet the requirements of test 1 After and during the test the Insertion loss shall meet the requirements of test 9 Before and after the test the return loss shall meet the requirements of test 2	Method: Optical source Wavelength: Test power: Test temperature: Test duration:	IEC 61300-2-14 1 550 nm ± 10 nm 3 dB above power threshold 25 °C ± 2 °C Long-term test: 96 h at test power
8	Power threshold (destructive test)	The tolerance is ± 1 dB from the specified optical fuse power threshold The fuse will meet the power threshold requirements as specified when operated at the 3 specified temperatures	Method: Optical source Wavelength: Test temperature:	See Annex D for detailed test description. The test power input is 1 dB to 3 dB above power threshold and the blocking attenuation is measured accordingly. Samples from every batch will be destructively tested, all will comply. 1 550 nm 10 °C ± 2 °C 25 °C ± 2 °C 60 °C ± 2 °C
9	Blocking attenuation at threshold (destructive test)	>30 dB The fuse will meet the requirement as specified, when operated at the 3 specified temperatures for the specified duration	Method: Optical source Wavelength: Test duration: Test temperature:	See Annex D for detailed test description. The test power input is 1 to 3 dB above power threshold and the blocking attenuation is measured accordingly. Samples from every batch will be destructively tested, all will comply. 1 550 nm 96 h at test power 10 °C ± 2 °C 25 °C ± 2 °C 60 °C ± 2 °C

Table 1 (*3 of 6*)

No.	Tests	Requirements	Details	
10	Response time	<100 µs The fuse will meet the requirement as specified, when operated at the 3 specified temperatures	Method: Optical source Wavelength: Test temperature:	See Annex D for detailed test description. The test power input is 1 dB to 3 dB above power threshold and the blocking attenuation is measured accordingly. Samples from every batch will be destructively tested, all will comply. 1 550 nm 10 °C ± 2 °C 25 °C ± 2 °C 60 °C ± 2 °C
11	Damp heat (steady state)	By the end of the test the Insertion loss shall meet the requirements of test 1 By the end of the test the return loss shall meet the requirements of test 2 The insertion loss change during the test shall be within ± 0,5 dB of the initial value. Insertion loss is measured with input power ≤ –5 dBm After the test the power threshold shall meet the requirements of test 8	Method: Pre conditioning procedure: Temperature: Relative humidity: Duration of exposure: Specimen optically functioning: Optical source Wavelength: Optical power: Recovery procedure:	IEC 61300-2-19 During the test the change in Insertion loss shall be measured by test method IEC 61300-3-3. Standard atmospheric conditions as defined in IEC 61300-1 for 2 h + 40 ± 2 °C 93 % $^{+2}_{-3}$ RH 96 h Yes 1 550 nm 3 dB lower than power threshold, as defined in Annex B Allow specimens to return to standard atmospheric conditions defined in IEC 61300-1 in 2 h.

Table 1 (*4 of 6*)

No.	Tests	Requirements	Details	
12	Change of temperature	By the end of the test the insertion loss shall meet the requirements of test 1 By the end of the test the return loss shall meet the requirements of test 2 The insertion loss change during the test shall be within ± 0,5 dB of the initial value. Insertion loss is measured with input power ≤ –5 dBm After the test the power threshold shall meet the requirements of test 8	Method: Pre conditioning procedure: High temperature: Low temperature: Duration at extreme temperature: Temperature rate of change: Number of cycles: Specimen optically functioning: Maximum sampling interval during the test: Optical source Wavelength: Optical power: Recovery procedure:	IEC 61300-2-22 During the test the change in Insertion loss shall be measured by test method IEC 61300-3-3. Standard atmospheric conditions as defined in IEC 61300-1 for 2 h + 60 ± 2 °C –10 ± 2 °C 1 h 1 °C/min 5 Yes 15 min 1 550 nm 3 dB lower than power threshold, as defined in Annex B Allow specimens to return to standard atmospheric conditions defined in IEC 61300-1 in 2 h.
13	Dry heat-high temperature endurance	By the end of the test the insertion loss shall meet the requirements of test 1 By the end of the test the return loss shall meet the requirements of test 2 The insertion loss change during the test shall be within ± 0,5 dB of the initial value. Insertion loss is measured with input power ≤ –5 dBm After the test the power threshold shall meet the requirements of test 8	Method: Pre conditioning procedure: High temperature: Duration at extreme temperature: Specimen optically functioning: Optical source Wavelength: Optical power: Recovery procedure:	IEC 61300-2-18 During the test the change in insertion loss shall be measured by test method IEC 61300-3-3. Standard atmospheric conditions as defined in IEC 61300-1 for 2 h + 60 ± 2 °C 96 h Yes 1 550 nm 3 dB lower than power threshold, as defined in Annex B Allow specimens to return to standard atmospheric conditions defined in IEC 61300-1 in 2 h.

Table 1 (*5 of 6*)

No.	Tests	Requirements	Details	
14	Cold	By the end of the test the insertion loss shall meet the requirements of test 1 By the end of the test the return loss shall meet the requirements of test 2 The insertion loss change during the test shall be within ± 0,5 dB of the initial value. Insertion loss is measured with input power ≤ –5 dBm After the test the power threshold shall meet the requirements of test 8	Method: Pre conditioning procedure: Low temperature: Duration at extreme temperature: Specimen optically functioning: Optical source Wavelength: Optical power: Maximum sampling interval during the test: Recovery procedure:	IEC 61300-2-17. During the test the change in insertion loss shall be measured by test method IEC 61300-3-3. Standard atmospheric conditions as defined in IEC 61300-1 for 2 h -10 ± 2 °C 96 h Yes 1 550 nm 3 dB lower than power threshold, as defined in Annex B 1 h Allow specimens to return to standard atmospheric conditions defined in IEC 61300-1 in 2 h.
15	Vibration (Sinusoidal)	After the test the insertion loss shall meet the requirements of test 1 After the test the return loss shall meet the requirements of test 2 The insertion loss change during the test shall be within ± 0,5 dB of the initial value. Insertion loss is measured with input power ≤ –5 dBm After the test the power threshold shall meet the requirements of test 8	Method: Frequency range: Vibration amplitude: Number of cycles: Rate of change: Number of axes: Specimen optically functioning: Optical power: Optical source Wavelength	IEC 61300-2-1 During the test the change in insertion loss shall be measured by test method IEC 61300-3-3. 10 – 55 Hz 0,75 mm 15 1 octave/min 3 orthogonal axes No 3 dB lower than power threshold, as defined in Annex B 1 550 nm
16	Shock	After the test the insertion loss shall meet the requirements of test 1 After the test the return loss shall meet the requirements of test 2 After the test the power threshold shall meet the requirements of test 8	Method: Acceleration force: Number of axes: Number of cycles: Duration per axis: Measurements required: Specimen optically functioning: Optical source Wavelength Optical power:	IEC 61300-2-9 500 g 3 axes, 2 directions 2 shocks per direction, 12 shocks total Nominal 1 ms duration, half sine pulse Before, after each axis, and after the test No 1 550 nm 3 dB lower than power threshold, as defined in Annex B

Table 1 (*6 of 6*)

No.	Tests	Requirements	Details	
17	Static side load[1]	After the test the insertion loss shall meet the requirements of test 1 After the test the return loss shall meet the requirements of test 2 Above measurements carried out in power ≤ –5 dBm	Method: Magnitude of the load: Rate of load application: Load application point: Specimen optically functioning: Optical source Wavelength:	IEC 61300-2-42 1 N for 1 h for reinforced cable 0,2 N for 5 min for secondary coated fibres 0,5 N/s 0,3 m from the end of the device and two mutually perpendicular directions as permitted by the product design No 1 550 nm
18	Fibre/cable retention	By the end of the test the insertion loss shall meet the requirements of test 1 By the end of the test the return loss shall meet the requirements of test 2 The insertion loss change during the test shall be within ± 0,5 dB of the initial value. Insertion loss is measured with input power ≤ –5 dBm	Method: Magnitude of the load: Load application point: Duration of the load: Method of mounting: Specimen optically functioning: Optical source Wavelength: Optical power:	IEC 61300-2-4. 10 N ± 1 N at 5 N/s for reinforced cables 5,0 N ± 0,5 N at 0,5 N/s for secondary coated fibres 2,0 N ± 0,2 N at 0,5 N/s for primary coated fibres 0,3 m from point where the fibre/cable exits from the specimen 120 s duration at 10 N 60 s duration at 2 N or 5 N The sample shall be rigidly mounted such that the load is only applied to the fibre/cable retention mechanism. Yes 1 550 nm 3 dB lower than power threshold, as defined in Annex B
19	Optical fibre cable flexing	After the test the insertion loss shall meet the requirements of test 1 After the test the return loss shall meet the requirements of test 2	Method: Magnitude of the load: Angle of deflection per cycle: Number of cycles: Specimen optically functioning: Method of mounting:	IEC 61300-2-44 2 N for reinforced cable ± 90° 30 No The sample shall be rigidly mounted such that the load is only applied to the fibre/cable.

[1] Static side load shall be applied in two mutually perpendicular directions as permitted by the product design. For example, a product with a base plate extending beyond the fibre exit may prohibit loading in that direction.

Annex A
(normative)

Sample size and product sourcing requirements

Table A.1 gives sample size and product sourcing requirements.

Table A.1 – Sample size and product sourcing requirements

No.	Test	Sample size	Source
N/A	Dimensional	10	New
1	Insertion loss	80	New
2	Return loss below power threshold (against two fusion splices)	80	Test 1
3	Return loss above power threshold (against two fusion splices)	12	Test 8 or 9
4	Polarization dependent loss	4	Test 2
5	Polarization mode dispersion	4	Test 4
6	High optical power. Below power threshold	4	Test 5
7	High optical power. Above power threshold	4	Test 2
8	Power threshold, (destructive test) 4 samples at each temperature	12	Test 2
9	Blocking attenuation at threshold, (destructive test)	12	Test 2
10	Response time, (destructive test)	12	Test 2
11	Damp heat (steady state)	4	Test 2
12	Change of temperature	4	Test 2
13	High temperature endurance	4	Test 2
14	Cold	4	Test 2
15	Vibration (sinusoidal)	4	Test 2
16	Shock	4	Test 2
17	Static side load	4	Test 2
18	Fibre/cable retention	4	Test 2
19	Optical fibre cable flexing	4	Test 2
NOTE Tests 5 to 19 may be performed at any order. Samples for tests 5 to 18 should be randomly selected from the samples of tests 2 and 4. Some tests are destructive and the samples cannot be used for any further testing. Tests 8 and 9 are performed on the same samples or on different samples.			

Annex B
(normative)

Power thresholds for optical fuses

Table B.1 gives powers for optical fuses, single-mode.

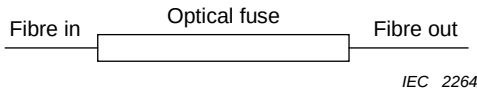
Table B.1 – Powers for optical fuses, single-mode

Power threshold dBm	**Recommended power for normal CW work** dBm	**Maximum allowed power input, $P_{in\ max}$** dBm
18	Up to 15	Up to 36
19	Up to 16	Up to 36
20	Up to 17	Up to 36
21	Up to 18	Up to 36
22	Up to 19	Up to 36
23	Up to 20	Up to 36
24	Up to 21	Up to 36
25	Up to 22	Up to 36
26	Up to 23	Up to 36
27	Up to 24	Up to 36
28	Up to 25	Up to 36
29	Up to 26	Up to 36
30	Up to 27	Up to 36
NOTE $P_{in\ max}$ of 36 dBm is the maximum allowed power input into an optical fuses having power threshold up to 30 dBm. Beyond this power it is dysfunctional and can let light through.		

Annex C
(informative)

Example of dimensions for optical fuses

The optical fuse configurations are shown in Figure C.1.



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

Figure C.1 – Optical fuse, in-line configuration, regularly without connectors

Annex D
(normative)

Testing of optical fuses[2]

D.1 Introductory remark

Testing of the optical fuse functionality and measuring its parameters are described in this Annex. Testing of the following parameters, which do not appear in regular IEC standards, is described:

- power threshold;
- blocking attenuation at threshold;
- response time.

The fuse is a safety device and only destructive testing can test its functionality; it is not functional any more after exposure to powers over the threshold. The actual test requires high power, and needs a dedicated test setup, designed for these measurements.

An example of a test carried out on an optical fuse will be given in this Annex, where the optical fuse parameters are

– power threshold: (each fuse in the batch) 20 dBm ± 1dB;
– blocking attenuation at threshold >30 dB;
– response time: <100 μs.

D.2 Power threshold and blocking attenuation at threshold measurement

Measuring the threshold power is the first and most important functional test of the optical fuse, calling to expose the rated e.g. 20 dBm optical fuse to slowly varying powers starting at 10 dBm and up to 36 dBm. The powers needed call for an oscillator (e.g. diode laser) followed by fibre amplifiers, as demonstrated in Figure D.1.

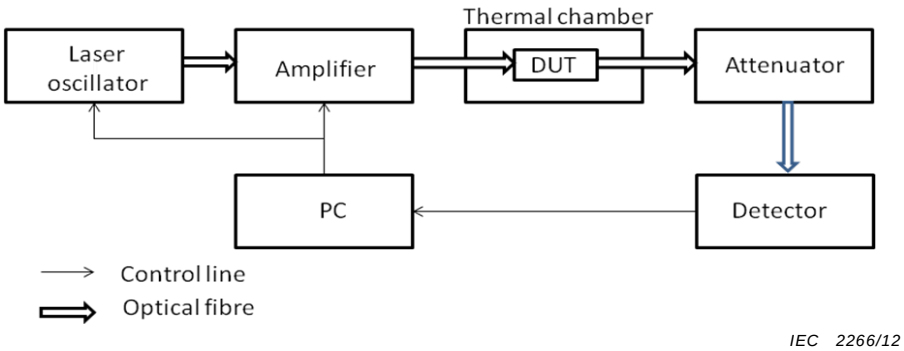


Figure D.1 – Test set-up schematics

The power measured by the detector, as a function of input power, is providing both, the threshold power as well as the blocking attenuation at threshold of the DUT. The insertion loss for low and high power is provided as well.

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2 This Annex will be deleted when an IEC standard for a test method for an optical fuse is published.

Figure D.2 shows a curve of the change of the IL against the P_{in}. The change of the IL that occurs at threshold can be seen, the IL change from ~0 dB to >50 dB, giving more than five orders of magnitude "protection", or blocking attenuation at threshold, being > 30 dB needed in this example. The values of the insertion loss before and after activation are part of the collected results.

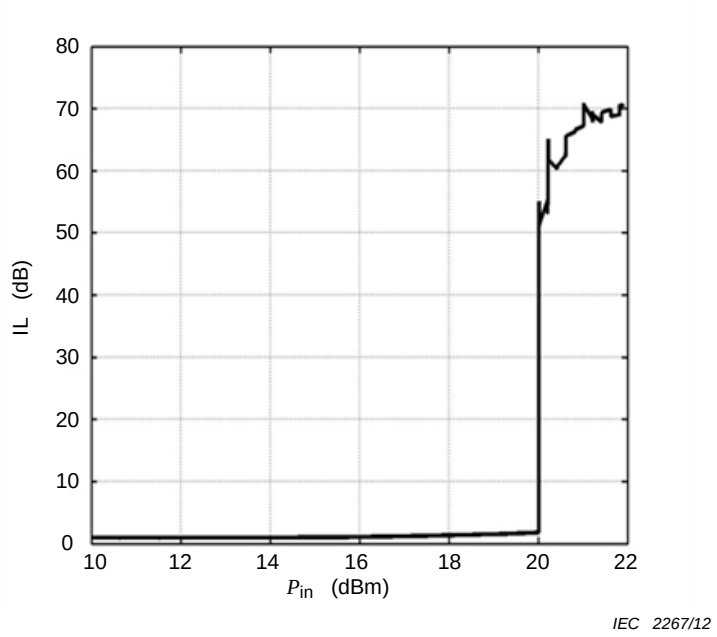

Figure D.2 – Example of power threshold and blocking attenuation at threshold measurements for sample 1280A of an optical fuse

D.3 Response time measurement

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 optical fuse power threshold by + 1 dB. Here the input pulse duration is 1 ms long, having a rise time of ~10 μs and a steady state power of fuse power threshold + 3 dB. Figure D.3 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.

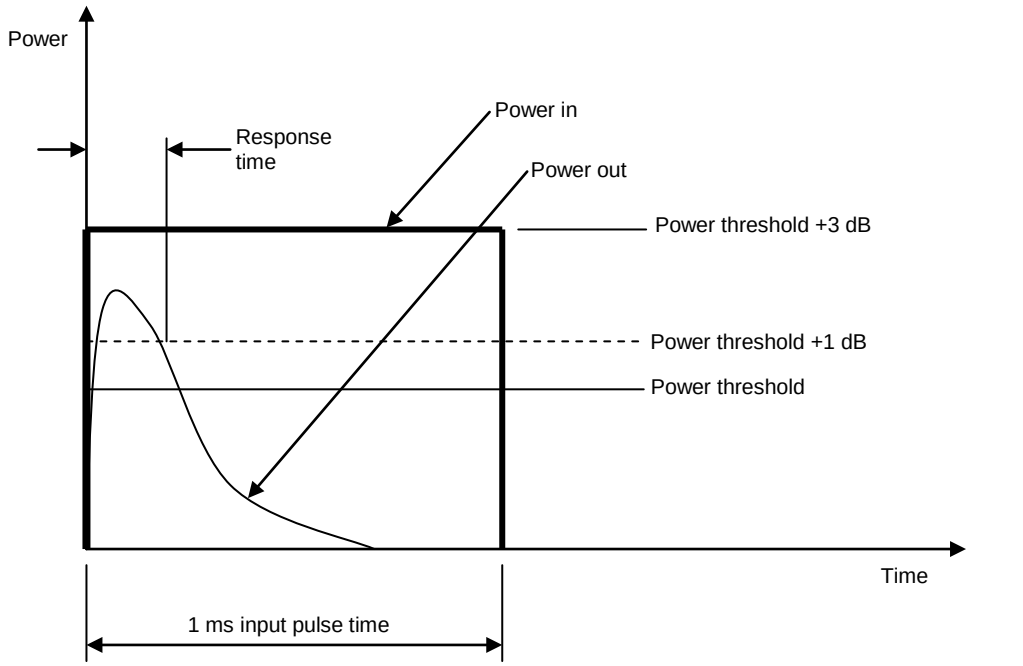

Figure D.3 – Response time curve of an optical fuse

Schematics of the test set-up and description are shown in Figure D.4:

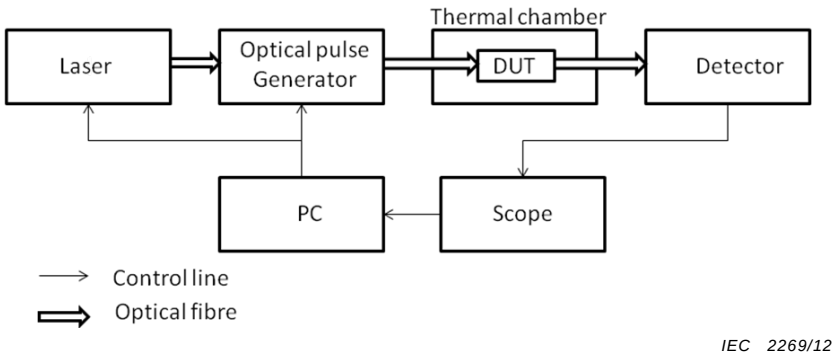

Figure D.4 – Response time testing set-up

A 1 550 nm wavelength laser provides the input signal, which is amplified and regenerated by the optical pulse generator unit, controlled by a designated software program. Output power is measured and presented graphically using an oscilloscope. Analysis of the data is carried out using standard mathematical software.

Since the test is carried out at three different temperatures, the minimal specified temperature, the maximal specified temperature and the average specified temperature of the optical fuse. The DUT is placed in a thermal chamber having a stable temperature as required.

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