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INTERNATIONAL STANDARD

Fibre optic communication subsystem test procedures – Part 2-1: Digital systems – Receiver sensitivity and overload measurement

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

FIBRE OPTIC COMMUNICATION SUBSYSTEM TEST PROCEDURES –

Part 2-1: Digital systems – Receiver sensitivity and overload measurement

FOREWORD

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International Standard IEC 61280-2-1 has been prepared by subcommittee 86C: Fibre optic systems and active devices, of IEC technical committee 86: Fibre optics.

This second edition cancels and replaces the first edition, published in 1998, and constitutes a technical revision.

The main changes with respect to the previous edition are listed below:

– revised to include the requirements associated with data communication equipment, regenerators and amplifiers;
– the term "jumper lead" has been replaced by "test cord":
– a section for definitions has been added;
– a section on measurement uncertainties has been added.

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

CDV	Report on voting
86C/881/CDV	86C/945/RVC

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

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

A list of all parts of the IEC 61280 series, published under the general title *Fibre optic communication subsystem test procedures,* 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- withdrawn,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.

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FIBRE OPTIC COMMUNICATION SUBSYSTEM TEST PROCEDURES –

Part 2-1: Digital systems – Receiver sensitivity and overload measurement

1 Scope and object

This part of IEC 61280 describes the test procedures applicable to digital fibre optic communication and data systems.

The object of this test procedure is to measure the minimum and maximum optical powers required and allowed at the optical input port of a fibre optic system to ensure its operation within specified limits. Another objective is to verify that the guaranteed error performance is obtained at the minimum and the maximum optical input powers specified by the terminal equipment manufacturer.

Figure 1 shows the typical elements associated with optical fibre systems. Optical amplifiers or regenerators may be used in long haul telecom systems, but are not usually associated with data transport systems such as Ethernet, etc. In bi-directional systems the transmitter and corresponding receiver are usually co-located, as indicated by the dotted lines. This specification is concerned with the characteristics of the optical input interface of the receiver, amplifier or regenerator shown.

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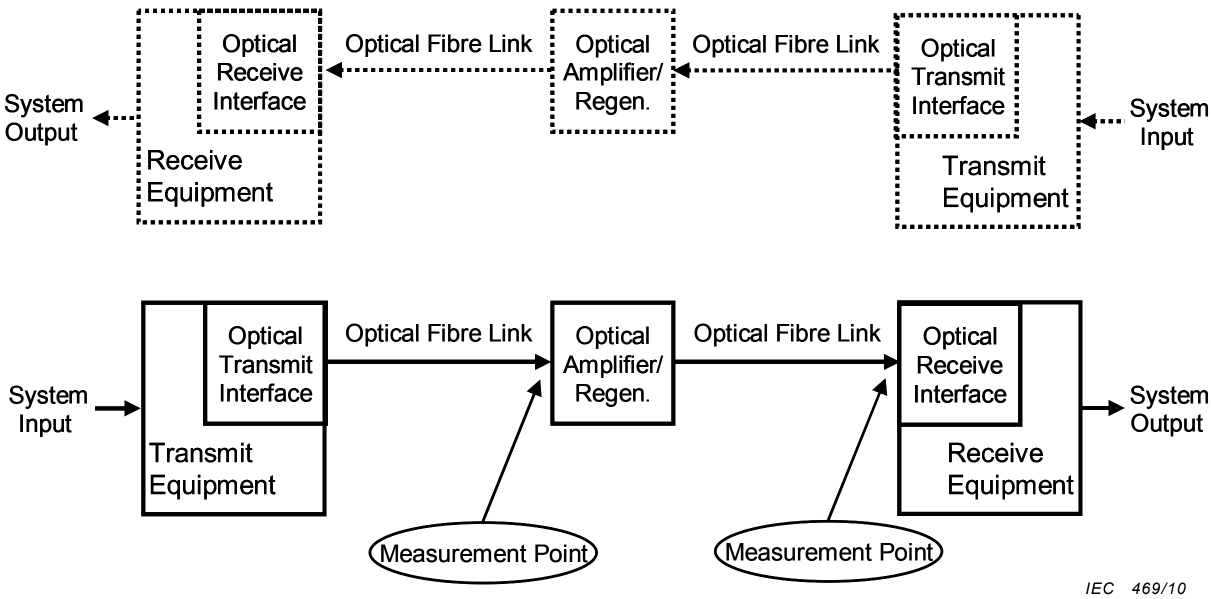

Figure 1 – Optical fibre system

It should be noted that the performance of fibre optic receivers may differ for different signal formats. It is therefore necessary to use the signal format that represents actual operating conditions.

2 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

2.1
bit error ratio (*BER*)
the number of errored bits divided by the total number of bits, over some stipulated period of time

[IEC 61931, definition 2.9.33]

2.2
bit sequence
a defined sequence of ones (1) and zeros (0) in a digital signal

2.3
bit pattern
a predetermined sequence of 1's and 0's in a digital signal which is repeated at regular intervals

2.4
errored block ratio (*EBR*)
the number of errored blocks, containing a defined number of digits, divided by the total number of blocks received in a specified period of time. An errored block may contain more than one errored bit

2.5
overload level
the maximum input power above which a specified quality of performance is no longer achieved

2.6
pseudo random binary sequence (PRBS)
a repeated bit sequence which simulates a random pattern of 1's and 0's. It is generated by the addition of the r^{th} preceding digit of a sequence of n bits and eliminating the sequence of n 0's (or n 1's). The pattern repeats after 2^n-1 bits

2.7
receiver sensitivity
the minimum power required to achieve a specified quality of performance

[IEC 61931, definition 2.7.58, modified]

2.8
system input and output signals
for the purpose of this specification, the system input and output are defined as signals which interface with external equipment. These signals have specified formats specific to the application and may be electrical or optical. The signals are accessed via physical interfaces that are specific to the equipment

3 Apparatus

3.1 General

The test setup is shown in Figure 2. It is important that test cords 3 and 4 are of a similar type and make and are of equal length.

3.2 BER test set

The BER test set is made up of the elements described here.

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3.2.1 Data generator

The data generator of the BER test set shall be capable of providing a data input to the system which may be a pseudo-random sequence or otherwise specified bit pattern with the signal format (pulse shape, amplitude, etc.) that is consistent with the requirements at the system input interface of the EUT.

As a minimum requirement the data generator shall be capable of providing the following output date formats; other data formats may be used in compliance with the system requirements.

- a 2^{23}-1 pseudo-random data stream;
- an all 1 data stream;
- a 1 + 15 zeros data stream.

The format (pulse shape, amplitude, etc.) of the test signal shall be compliant with that required at the transmit input interface. The receiver portion of the test equipment shall be able to interface with the system output for the measurement of digital errors.

3.2.2 Error counter

The error counter of the BER test set shall be able to interface with the output of the EUT. It shall be capable counting single errors or errored blocks at the data rate of system output interface of the EUT. If the error counter has the facility for computing the BER or EBR value it must be capable of calculating a value as low as 10^{-12}.

3.3 Optical power meter

The optical power meter used shall have a resolution of at least 0,1 dB, shall be data format and bit rate independent and shall have been calibrated for the wavelength and power range of operation for the equipment to be tested. All measurements shall be recorded on the dB scale.

3.4 Variable optical attenuator

The optical attenuator shall be capable of attenuation in steps less than or equal to 0,25 dB and should be able to provide a total attenuation that is at least 5 dB greater than the specified input range of the receiver under test. Care should be taken to avoid back reflection into the transmitter.

3.5 Optical splitter

The optical splitter (coupler) shall have one input port and two output ports equipped with appropriate connectors. The splitting ratio for the output ports should be 50 % ± 0,1 dB (unless otherwise specified).

3.6 Test cords

Single-mode or multimode fibre reference test cords and fitted with the appropriate connectors as required by the application shall be used, unless otherwise agreed. The optical loss of the test cords including connectors shall not exceed 1,0 dB.

3.7 Optical transmit interface

The optical transmit interface shall have electrical and optical characteristics similar to those of transmitters that are used in the specified fibre optic terminal devices, except that the output power shall exceed the maximum specified input power of the receiver by at least 2 dB.

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4 Equipment under test (EUT)

The EUT shall be a fibre optic receiver, optical amplifier or optical regenerator, including all associated signal conditioning, processing and multiplexing equipment used in the system under normal operating conditions. The system input and output terminations shall be those normally seen by the user of the system.

5 Test procedure

The test procedure consists of the following steps.

5.1 Operating conditions and test environment

Unless otherwise specified, normal operating conditions apply. The ambient or reference point temperature and humidity shall be specified.

Switch on the EUT and all test equipment (apply any special operating conditions to the EUT if required) and allow 30 min. (unless otherwise specified) for the equipment to reach a steady-state temperature and performance condition.

5.2 Connector end-face cleaning

Whenever optical connections are changed, the end faces of the connectors shall be cleaned. Cleaning equipment (including apparatus, materials, and substances) and the methods to be used shall be suitable for the connectors to be cleaned. Connector suppliers' instructions shall be consulted where doubt exists as to the suitability of particular equipment and cleaning methods.

5.3 Measurement of input sensitivity

Connect the equipment as shown in Figure 2, if terminal equipment is tested, or Figure 3, if an amplifier or regenerator is tested, and set the data generator and error counter to operate with a pseudo random sequence with word length of 2^{23}-1 (unless otherwise specified).

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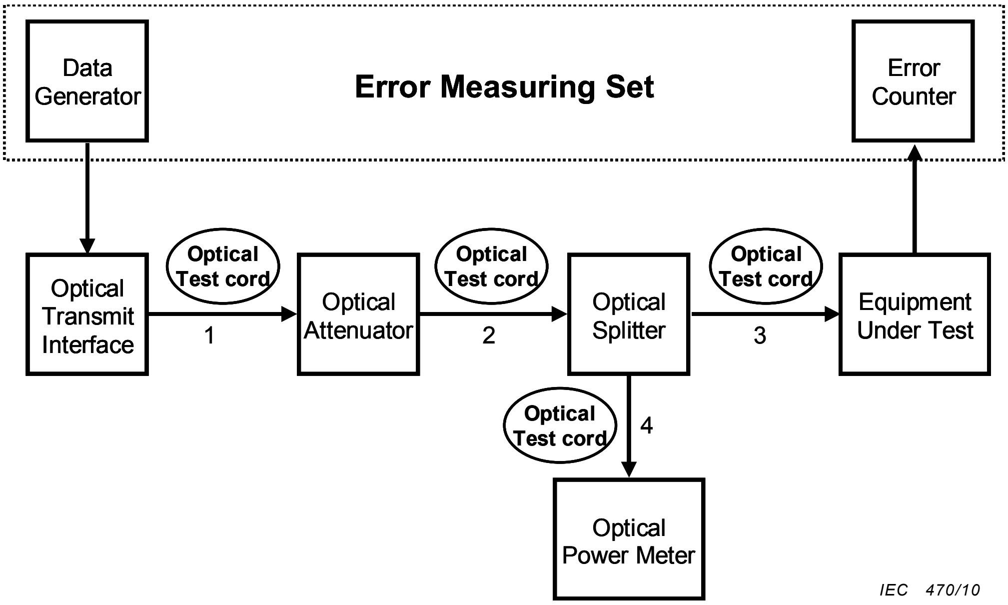

Figure 2 – Setup for the measurement of input sensitivity of a receive terminal

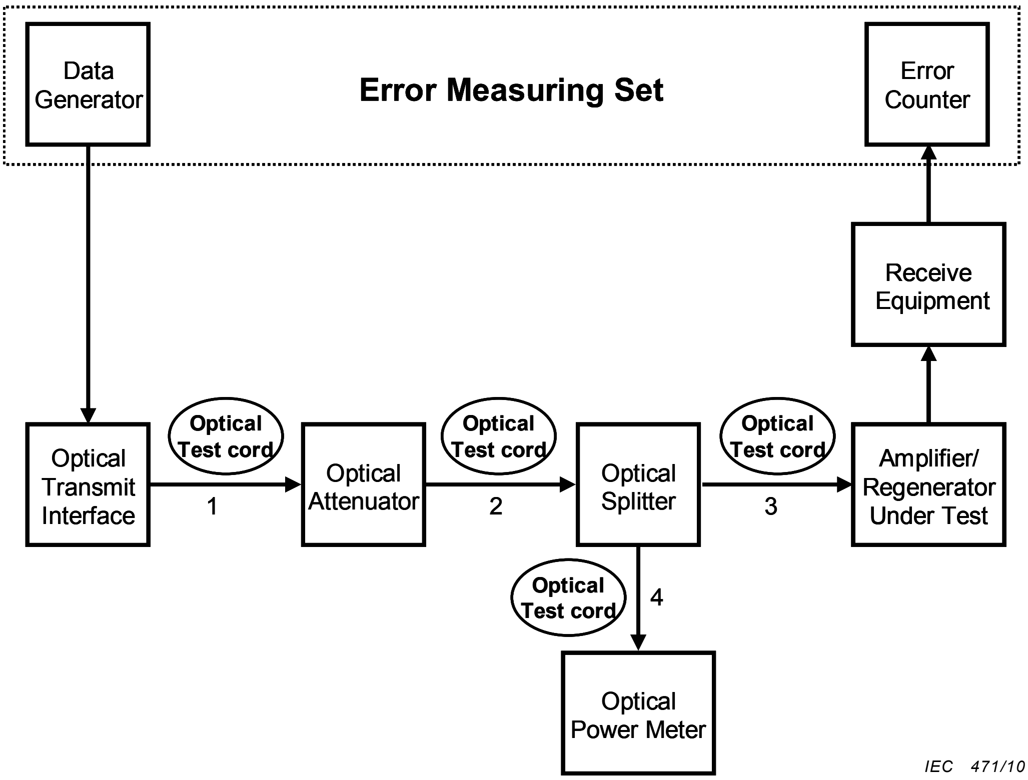

Figure 3 – Setup for the measurement of input sensitivity of an amplifier or regenerator

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5.3.1 Optical input power calibration

This procedure shall be carried out as follows:

a) Disconnect the optical power meter from the output of optical test cord 4 and disconnect the output of optical test cord 3 from the EUT.

b) Connect the optical power meter to the output of optical test cord 3.

c) Set the attenuator to 0 dB and measure the optical power.

d) Connect the optical power meter to the output of test cord 4 and re-connect the output of optical test cord 3 to the EUT.

e) Measure the optical power.

f) Record any difference between the two measurements.

5.3.2 *BER* or *EBR* determination

The procedure consists of the following steps:

a) Adjust the optical attenuator to provide an optical power level which is 3 dB higher than the minimum specified input power.

b) Adjust the optical attenuator to increase the attenuation until the first errors are observed. If the error counter has the facility to compute the *BER* or *EBR* directly, record the result and power level.

c) If such a facility is not provided, count the number of errors occurring in a defined monitoring time that exceeds or is equal to the minimum monitoring time given in Table 1. Calculate the error ratio using the following formula:

$$BER = \frac{N}{DT} \quad \text{or} \quad EBR = \frac{BN}{DT}$$

where

N is the number of errors observed in monitoring time;

D is the data rate;

T is the monitoring time;

B is the number of data in a block.

Table 1 – Minimum monitoring time

Data rate	Minimum monitoring time, s
1 Mb/s < data rate < 30 Mb/s	(1/data rate) $\times 10^{8}$
Data rate > 30 Mb/s	(1/data rate) $\times 10^{10}$

NOTE When the *EBR* is measured, the minimum monitoring time should be multiplied by the number of data bits in the block.

d) Record the calculated error ratio together with the optical power.

e) Increase the attenuation in steps of 1 dB and record the power level and the measured or calculated error ratio for each step until the maximum error ratio specified for the equipment is reached. As the specified maximum error ratio is approached, it may be necessary increase the attenuation in smaller increments.

f) The input power level observed represents the receiver sensitivity or minimum required input power level for the equipment to meet the error performance specified for that equipment. Any difference between the actual and observed optical power determined by the calibration procedure shall be taken into account.

g) It should be noted that some equipment has internal error monitoring and may output a special signal at the system output to indicate loss of input when a specified error ratio is reached. In such case, the input sensitivity shall be taken as the input level measured at the onset of the special signal.

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5.4 Measurement of overload level

5.4.1 General

Connect the equipment as shown in Figure 4 or Figure 5 and set the data generator and error counter to operate with pseudo random sequence with word length of 2^{23}-1 (unless otherwise specified). For this test, the optical transmitter shall be capable of providing optical signal power at the receive interface of the EUT to exceeds its maximum specified input power by at least 0,5 dB.

5.4.2 Power level calibration

The procedure consists of the following steps:

a) Disconnect the output of optical test cord 2 from the EUT and connect it to the optical power meter.

b) Adjust the optical attenuator to give an output power level which is 3 dB below the maximum input power level specified by the manufacturer or supplier of the equipment. If no such specification is available, set the input power level to a value equal to the sensitivity power level. Any difference between the actual and observed optical power determined by the calibration procedure shall be taken into account.

c) Note and record the output level and attenuator setting.

d) Disconnect the output of optical test cord 2 from the optical power meter and re-connect it to the EUT.

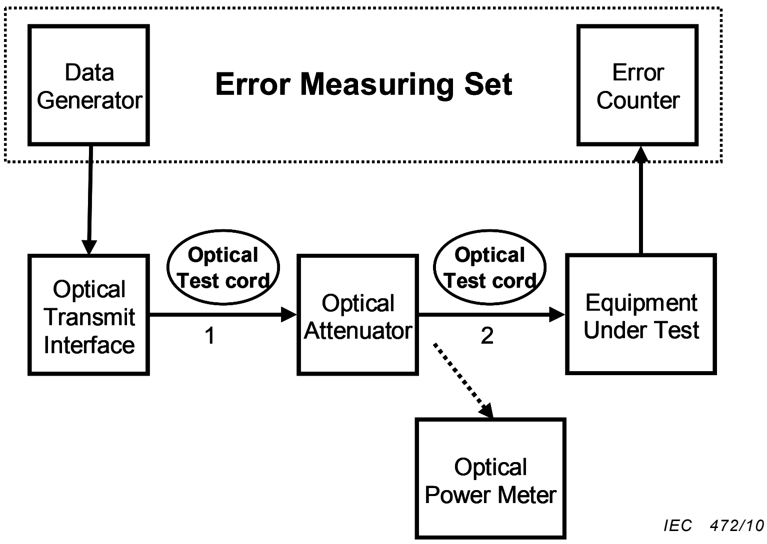

Figure 4 – Setup for the measurement of overload level for a receive terminal

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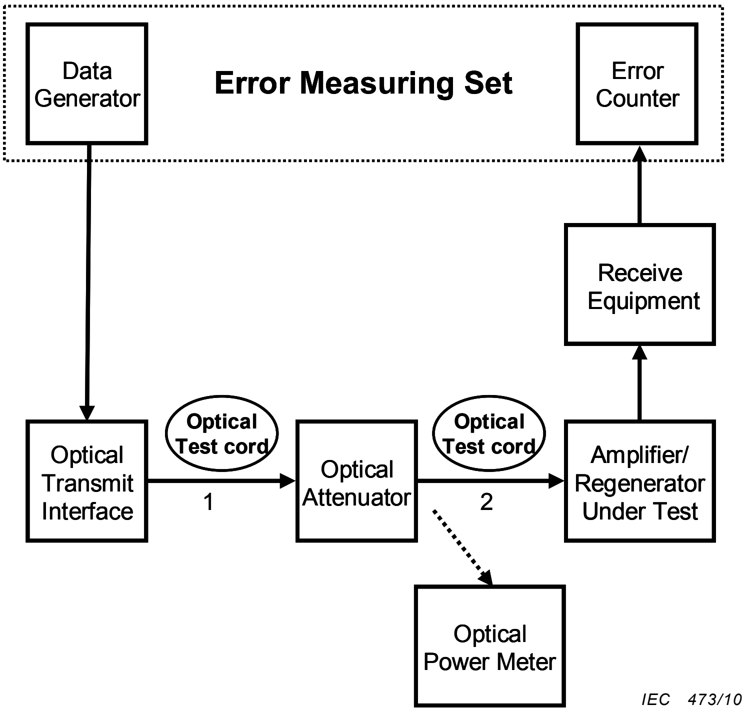

Figure 5 – Setup for the measurement of overload level for an amplifier or regenerator

5.4.3 Overload level determination

a) Adjust the optical attenuator to decrease the attenuation until the first few errors are observed. If the error counter has the facility to compute the error ratio directly, record the result and the value of the attenuator setting.

b) If such a facility is not provided, calculate the error ratio using the procedure described in 5.3.2.

c) Decrease further the value of the attenuator setting in small steps and measure or calculate the error ratio until the maximum error ratio specified for the EUT has been reached. Note and record the attenuator setting which indicates the overload point.

d) The transition from no errors or a very low error ratio to a very high error ratio may occur between a very small change in input power which may be less than minimum increment of the attenuator setting.

e) It should be noted that some equipments are equipped with internal error monitoring and may output a special signal at the system output when a specified error ratio is reached. In such a case, the overload level shall be taken as the input level measured at the onset of the special signal.

5.4.4 Calculation of overload level

The overload level is calculated by adding the numerical value of the total decrease in attenuation from the value set during the calibration procedure to the value of the optical power measured in that procedure.

$$P_{max} = A_0 - A_1 + P_0 \quad \text{(expressed in dB)}$$

where

P_{max} is the overload level, expressed in dB;

A_0 is the attenuator setting during calibration, expressed in dB;

$A_1$is the attenuator setting at calibration, expressed in dB;

P_0 is the power level at calibration, expressed in dB.

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6 Measurement uncertainties

The following uncertainties in the measurement of sensitivity and overload level, excluding operator error, have to be taken into account:

a) Calibration of the attenuator (for overload measurement only).

b) Calibration of the optical power meter.

c) Difference in the connector loss of the EUT and the optical power meter. This uncertainty can be minimized by the use of test cords fitted with reference grade connectors.

7 Test results

The test results contain required and available information.

7.1 Required information

The required information shall be as follows:

a) The EUT identification.

b) Date and title of the test.

c) Operating conditions.

d) Identification of test methods.

e) Environmental conditions.

f) Procedures used.

g) Test results.

7.2 Available information

The available information shall be as follows:

a) Identification of the test equipment used.

b) Identification of test cords and connector parameters.

c) The optical power measurement uncertainty.

d) Names of test personnel.

e) Supply voltage(s) and current(s).

f) Data rate and input signal characteristics.

g) Input/output measurement conditions: wavelength, specified receiver sensitivity, maximum receiver input.

h) Recommended warm-up time (time required for temperature stabilization).

i) Calibration details of optical power meter and optical attenuator.

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Bibliography

EIA/TIA-526-3:1989, *Fibre optic terminal equipment receiver sensitivity and maximum receiver input*

IEC 61931:1998, *Fibre optic – Terminology*

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