INTERNATIONAL TELECOMMUNICATION UNION

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TRANSMISSION MEDIA CHARACTERISTICS

DEFINITION AND TEST METHODS FOR THE RELEVANT GENERIC PARAMETERS OF OPTICAL FIBRE AMPLIFIERS

ITU-T Recommendation G.661

(Previously "CCITT Recommendation")

FOREWORD

The ITU Telecommunication Standardization Sector (ITU-T) is a permanent organ of the International Telecommunication Union. The ITU-T is responsible for studying technical, operating and tariff questions and issuing Recommendations on them with a view to standardizing telecommunications on a worldwide basis.

The World Telecommunication Standardization Conference (WTSC), which meets every four years, established the topics for study by the ITU-T Study Groups which, in their turn, produce Recommendations on these topics.

ITU-T Recommendation G.661 was revisedd by the ITU-T Study Group XV (1988-1993) and was approved by the WTSC (Helsinki, March 1-12, 1993).

NOTES

1 As a consequence of a reform process within the International Telecommunication Union (ITU), the CCITT ceased to exist as of 28 February 1993. In its place, the ITU Telecommunication Standardization Sector (ITU-T) was created as of 1 March 1993. Similarly, in this reform process, the CCIR and the IFRB have been replaced by the Radiocommunication Sector.

In order not to delay publication of this Recommendation, no change has been made in the text to references containing the acronyms "CCITT, CCIR or IFRB" or their associated entities such as Plenary Assembly, Secretariat, etc. Future editions of this Recommendation will contain the proper terminology related to the new ITU structure.

2 In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

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Recommendation G.661

DEFINITION AND TEST METHODS FOR THE RELEVANT GENERIC PARAMETERS OF OPTICAL FIBRE AMPLIFIERS

(Helsinki, 1993)

The CCITT,

considering

(a) that optical fibre amplifiers (OFAs) of different design for different application are going to be widely used in telecommunication networks;

(b) that different Recommendations are being prepared concerning the generic characteristics and the system aspects of OFAs;

(c) that the definition of the relevant parameters of these Recommendations, characterizing the transmission, operation, reliability and environmental properties of the OFA device seen as a "black box", are preliminarily needed;

(d) that the test methods to verify said characteristics are preliminarily needed;

(e) that further Recommendations concerning OFAs of different design and application could be prepared in the future, when practical use studies have sufficiently progressed, but referring substantially to the same definitions and test methods,

recommends

the definitions of the relevant parameters, common to the different types of OFAs, listed in 1, and the test methods of said parameters described in 2, to be followed, as far as applicable, for OFAs covered by CCITT Recommendations.

1 Definitions

The OFA is to be considered as a black box, as shown in Figure 1, with at least two optical ports and electrical connections for power supply. The optical ports are usually distinguished as input and output port and may consist of unterminated fibres or optical connectors.

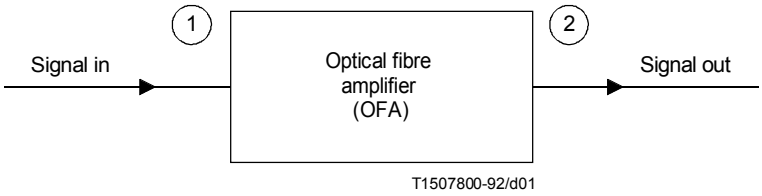

FIGURE 1/G.661

The optical fibre amplifier

Hereafter, two different operating conditions will be usually referred to: nominal operating conditions, for a normal use of the OFA, and limit operating conditions, in which all the adjustable parameters (e.g. temperature, gain, pump laser injection current, etc.) are at their maximum values, according to the stated absolute maximum ratings.

NOTES

1 If one of these parameters is specified for a particular device, it will be generally necessary to provide certain appropriate operating conditions such as temperature, bias current, pump power, etc.

2 The device amplifies signals in a nominal operating wavelength region. In addition, other signals out of the band of operating wavelength could in some applications also cross the device. The purpose of these out-of-band signals and their wavelength or wavelength region can be specified explicitly case by case. For OFAs described in this Recommendation, the operating wavelength will be in the 1550 nm region.

3 All gains are measured as the dB ratio of the output signal over the input signal in a fibre pigtail. If connectors are used, then the signals are measured in fibre pigtails joined to connectors which are connected to the OFA ports. The measured input and output optical power levels refer to the signal only and discriminate against pump or spontaneous emission radiation.

4 There is a correspondence in the numbering of the parameters given in this clause and the corresponding test methods given in clause 2.

5 Except where noted, the optical powers mentioned in the following are intended as average powers.

6 Some additional definitions concerning specific types of OFAs (power, pre- and line amplifiers) will be given in successive Recommendations.

1.1 small-signal gain: The gain of the amplifier, when operated in linear regime, where it is quite independent of the input signal optical power, at given signal wavelength and pump optical power level.

NOTE – This property can be described at a discrete wavelength or as a function of wavelength.

1.2 reverse small-signal gain: The small-signal gain measured using the input port as output port and vice versa.

1.3 maximum small-signal gain: The highest small-signal gain that can be achieved under nominal operating conditions.

1.4 maximum small-signal gain wavelength: The wavelength at which the maximum small-signal gain occurs.

1.5 maximum small-signal gain variation with temperature: The change in small-signal gain for temperature variation within a specified range.

1.6 wavelength bandwidth: The wavelength interval within which the small-signal gain is less than N dB below the maximum small-signal gain.

NOTE – A value of $N = 3$ has been proposed.

1.7 small-signal gain wavelength variation: The peak-to-peak variation of the small-signal gain over a given wavelength range.

1.8 small-signal gain stability: The degree of small-signal gain fluctuation expressed by the ratio (in dB) of the maximum and minimum small-signal gain, for a certain specified test period, under nominal operating conditions.

1.9 large-signal output stability: The degree of output optical power fluctuation expressed by the ratio (in dB) of the maximum and minimum output signal optical powers, for a certain specified test period, under nominal operating conditions and a specified large input signal optical power.

1.10 polarization-dependent gain variation: The maximum variation of the small-signal gain due to a variation of the state of polarization of the input signal.

1.11 saturation output power (gain compression power): The optical output signal optical power above which the gain is reduced by 3 dB with respect to the small-signal gain at the signal wavelength.

NOTE – The wavelength at which the parameter is specified must be stated.

1.12 nominal output signal power: The minimum output signal optical power for a specified input signal optical power under nominal operating conditions.

1.13 noise figure: The decrease of the signal-to-noise ratio (SNR) due to the propagation of a quantum limited signal through the OFA, expressed in dB.

NOTES

1 The operating conditions at which the noise figure is specified must be stated.

2 This property can be described at a discrete wavelength or as a function of wavelength.

1.14 forward ASE (amplified spontaneous emission) power level: The optical power in a specified bandwidth associated to the ASE exiting from the output port under nominal operating conditions.

NOTES

1 This parameter is particularly important for OFAs used as pre-amplifiers or in-line amplifiers and it depends mainly on the filter used.

2 The operating conditions (e.g. the gain and input signal optical power) at which the ASE level is specified must be stated).

1.15 reverse ASE power level: The optical power in a specified bandwidth associated to the ASE exiting from the input port under nominal operating conditions.

1.16 input optical return Loss (ORL): The fraction of incident optical power at operating wavelength reflected by the input port of the OFA, under nominal operating conditions, expressed in dB.

1.17 output optical return loss: The fraction of incident optical power at operating wavelength reflected by the output port of the OFA, under nominal operating conditions, expressed in dB.

1.18 maximum optical return loss tolerable at input: The maximum reflection seen from the input port for which the device still meets its specifications.

NOTE – The measurement is performed with a given input signal optical power.

1.19 maximum optical return loss tolerable at output: The maximum reflection seen from the output port for which the device still meets its specifications.

NOTE – The measurement is performed with a given input signal optical power.

1.20 pump leakage to output: The pump optical power which is emitted from the OFA output port.

NOTE – The measurement is performed with a given input signal optical power.

1.21 pump leakage to input: The pump optical power which is emitted from the OFA input port.

NOTE – The measurement is performed with a given input signal optical power.

1.22 out-of-band insertion loss: OFA insertion loss for a signal at the specified out-of-band wavelength(s).

1.23 out-of-band reverse insertion loss: OFA insertion loss for a signal at the specified out-of-band wavelength(s), measured using the input port of the OFA as output port and vice versa.

1.24 maximum power consumption: Electrical power needed and absorbed by the OFA operating within the absolute maximum ratings.

1.25 maximum total output power: The highest optical power level at the output port of the OFA operating within the absolute maximum ratings.

1.26 operating temperature: The temperature range within which the OFA can be operated and still meets all its specified parameters values.

1.27 optical connections: The connector and/or the fibre type used as input and output ports of the OFA.

NOTE – Optical connections do not necessarily need to be specified.

2 Test methods

According to an agreement with IEC/TC 86/WG 6, the measurement procedures for the parameters previously defined can be found in the IEC Generic Specification on Optical Fibre Amplifiers.

NOTE – Such a Generic Specification is currently under development. When it will be available, the chosen reference test methods and possible alternative test methods for each relevant parameter defined in this Recommendation will be indicated.

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