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SERIES G: TRANSMISSION SYSTEMS AND MEDIA, DIGITAL SYSTEMS AND NETWORKS

Transmission media characteristics – Characteristics of optical components and sub-systems

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Transmission characteristics of passive optical components

ITU-T Recommendation G.671

(Previously CCITT Recommendation)

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ITU-T RECOMMENDATION G.671

TRANSMISSION CHARACTERISTICS OF PASSIVE OPTICAL COMPONENTS

Summary

This Recommendation covers the transmission-related aspects of passive optical components used in long haul networks and access networks. A broad range of types of passive fibre-optic components are included in this Recommendation. This Recommendation also includes transmission characteristics of passive optical components under the full range of operating conditions, but does not specify the operating service conditions, installation aspects, or other aspects of passive components not affecting the optical transmission path. This Recommendation also draws upon the relevant IEC definitions and test methods where applicable.

Source

ITU-T Recommendation G.671 was prepared by ITU-T Study Group 15 (1993-1996) and was approved under the WTSC Resolution No. 1 procedure on the 8th of November 1996.

FOREWORD

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

The approval of Recommendations by the Members of the ITU-T is covered by the procedure laid down in WTSC Resolution No. 1.

In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

NOTE

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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As of the date of approval of this Recommendation, the ITU had/had not received notice of intellectual property, protected by patents, which may be required to implement this Recommendation. However, implementors are cautioned that this may not represent the latest information and are therefore strongly urged to consult the TSB patent database.

CONTENTS

Recommendation G.671

TRANSMISSION CHARACTERISTICS OF PASSIVE OPTICAL COMPONENTS

(Geneva, 1996)

1 Scope

The object of this Recommendation is to identify the transmission-related parameters for each of the components listed below and define the values of such parameters specifiable for each of the most relevant system applications. Where applicable, IEC definitions will be used. Applicable systems are anticipated to be covered by the following ITU-T Recommendations:

- Long haul networks: Networks using equipment with interfaces according to Recommendation G.957, and Recommendations of optical interfaces for single channel and multichannel SDH systems with optical amplifiers (when published).
- Access networks: Network using equipment according to Recommendation G.982, and the Recommendation of optical access networks to support services greater than the ISDN primary bit rate (when published).

This Recommendation covers passive fibre-optic components[1] used in the optical networks described in the Recommendations above. Where possible, common parameter values will be defined across all applications, but where necessary, specific values to each of the application groups may be given.

This Recommendation will cover the transmission characteristics in the various operating conditions of the following passive optical components:

- (Fibre-optic) multiplexer and demultiplexer (including WDM device).
- (Fibre-optic) branching component (wavelength non-selective).
- (Fibre-optic) attenuator.
- (Fibre-optic) filter.
- (Fibre-optic) isolator.
- (Fibre-optic) termination.
- (Fibre-optic) switch.
- Passive dispersion compensator.
- (Fibre-optic) connector.
- (Fibre-optic) splice.
- Optical Multiplexer/Optical Demultiplexer (OM/OD) device applications in multichannel systems using optical amplifiers.

This Recommendation will not cover:

- Installation aspects, service conditions, and environmental and mechanical characteristics not affecting the optical transmission path of the various passive optical components.
- Specific details of test methods. According to an agreement with IEC TC86, the guidelines to be followed for the measurement of most of the parameters defined in clause 5 are given

1 The term fibre-optic device is intended to refer to all implementations of technologies for the devices specified, and not limited to just the ones implemented in optical fibre.

in the IEC 1300-3 series of Transmission and Geometrical Test Methods. The tables in clause 5 indicate the recommended test methods, collecting the test parameters into homogeneous groups and quoting for each group the relevant IEC Basic Specification number(s).

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; all users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published.

– ITU-T Recommendation G.650 (1997), *Definition and test methods for the relevant parameters of single-mode fibres.*

– ITU-T Recommendation G.652 (1997), *Characteristics of a single-mode optical fibre cable*.

– ITU-T Recommendation G.653 (1997), *Characteristics of a dispersion-shifted single-mode optical fibre cable*.

– ITU-T Recommendation G.654 (1997), *Characteristics of a cut-off shifted single-mode optical fibre cable*.

– ITU-T Recommendation G.661 (1996), *Definition and test methods for the relevant generic parameters of optical fibre amplifiers*.

– ITU-T Recommendation G.662 (1995), *Generic characteristics of optical fibre amplifier devices and sub-systems.*

– ITU-T Recommendation G.957 (1995), *Optical interfaces for equipments and systems relating to the synchronous digital hierarchy*.

– ITU-T Recommendation G.982 (1996), *Optical access networks to support services up to the ISDN primary rate or equivalent bit rates*.

3 Terms and definitions

Most of the definitions of functional parameters specified in this Recommendation, for each of the above mentioned passive components, are given in the corresponding IEC generic specification and are summarized below:

– IEC Publication 869-1 (1994), *Fibre optic attenuators – Part 1: Generic specification.*

– IEC Publication 874-1 (1993), *Connectors for optical fibres and cables – Part 1: Generic specification*.

– IEC Publication 875-1 (1992), *Fibre optic branching devices – Part 1: Generic specification*.

– IEC Publication 876-1 (1994), *Fibre optic switches – Part 1: Generic specification.*

– IEC Publication 1073-1 (1994), *Splices for optical fibres and cables – Part 1: Generic specification – Hardware and accessories.*

– IEC Publication 1202-1 (1994), *Fibre optic isolators – Part 1: Generic specification.*

– IEC Publication 1931-1, *Fibre-optic terminology*.

Where IEC definitions are used, they are noted as such. Additional parameters under study or not defined in IEC Publications are also given in this clause:

3.1 Component definitions

3.1.1 (fibre-optic) wavelength multiplexer and demultiplexer (including WDM device): Multiplexing device (WDM device): A wavelength selective branching device (used in WDM transmission systems) in which optical signals can be transferred between two predetermined ports, depending on the wavelength of the signal. (6.51 of IEC 1931-1.)

- Wavelength multiplexer: A branching device with two or more input ports and one output port where the light in each Input port is restricted to a preselected wavelength range and the output is the combination of the light from the input ports. (6.52 of IEC 1931-1.)
- Wavelength demultiplexer: A device which performs the inverse operation of a wavelength multiplexer, where the input is an optical signal comprising two or more wavelength ranges and the output of each port is a different preselected wavelength range. (6.53 of IEC 1931-1.)

3.1.2 (fibre-optic) branching component (wavelength non-selective): A passive component (wavelength non-selective) possessing three or more ports which shares optical power among its ports in a predetermined fashion, without any amplification, switching, or other active modulation. (1.31 of IEC 875-1.)

3.1.3 coupler (splitter-combiner): A term which is used as a synonym for a branching device. The term is also used to define a structure for transferring optical power between two fibres or between an active device and a fibre. (1.3.2 of IEC 875-1.)

3.1.4 symmetric branching component: A device whose transfer matrix is diagonally symmetric, i.e. where for all i and j, t_{ij} and t_{ji} are nominally equal. (1.3.15 of IEC 875-1.)

3.1.5 asymmetric branching component: A device whose transfer matrix is diagonally asymmetric, i.e. where for all i and j, t_{ij} and t_{ji} are nominally unequal. (1.3.16 of IEC 875-1.)

3.1.6 (fibre-optic) attenuator: A passive component which produces a controlled signal attenuation in an optical fibre transmission line. (1.3.1 of IEC 869-1.)

3.1.7 (fibre-optic) filter: A passive component used to modify the optical radiation passing through it, generally by altering the spectral distribution. (6.35 of IEC 1931-1.) Alternative: In particular, (Fibre-optic) filters are usually employed to reject or absorb optical radiation in particular ranges of wavelength, while transmitting optical radiation in other ranges of wavelength.

NOTE – A tuneable optical filter has the ability to track the signal wavelength variation over its operating wavelength range. A non-tuneable optical filter has a fixed value over the operating wavelength range.

3.1.8 (fibre-optic) isolator: A non-reciprocal optical device intended to suppress backward reflections along an optical fibre transmission line while having minimum insertion loss in the forward direction. (1.3.1 of IEC 1202-1)

3.1.9 (fibre-optic) termination: A component used to terminate a fibre (connectorized or not) in order to suppress reflections.

3.1.10 (fibre-optic) switch: A passive component possessing one or more ports which selectively transmits, redirects, or blocks optical power in an optical fibre transmission line. (1.3.1 of IEC 876-1.)

3.1.11 passive (chromatic) dispersion compensator: A passive component used to compensate the chromatic dispersion of an optical path.

3.1.12 (fibre-optic) connector: A component normally attached to an optical cable or piece of apparatus for the purpose of providing frequent optical interconnection/disconnection of optical fibres or cables. (6.01 of IEC 1931-1.)

3.1.13 (fibre-optic) splice: A permanent or semi-permanent joint whose purpose is to couple optical power between two optical fibres. (6.08 of IEC 1931-1.)

- Fusion splice: a splice in which the fibre ends are joined in a permanent manner by means of fusion. (6.09 of IEC 1931-1.)
- Mechanical splice: a splice in which the fibre ends are joined in a permanent or separable manner by means other than fusion. (6.10 of IEC 1931-1.)

3.1.14 optical multiplexer/optical demultiplexer (OM/OD) device: A device fulfilling the OM/OD function as described in Recommendation G.692.

3.2 Functional parameter definitions

NOTE – Not all of the definitions cited in this subclause apply to all devices. The relevance of a particular definition to a specific type of device will be found in clauses 5 and 6.

3.2.1 insertion loss: It is the reduction in optical power between an input and output port of a passive component in decibels. It is defined as:

$$IL = -10 \log\left(P_1 / P_0\right)$$

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

NOTE 1 – For a (Fibre-optic) branching component, it is an element a_{ij} (where $i \neq j$), of the logarithmic transfer matrix. (1.3.7 of IEC 875-1.)

NOTE 2 – For a WDM device, it is an element a_{ij} (where $i \neq j$), of the logarithmic transfer matrix and it shall be specified at each operating wavelength range.

NOTE 3 – For a (Fibre-optic) switch, it is an element a_{ij} (where $i \neq j$), of the logarithmic transfer matrix. It depends on the state of the switch. (1.3.9 of IEC 876-1.)

NOTE 4 – For a (Fibre-optic) filter, it shall be specified in each operating wavelength range.

3.2.2 return loss: It is the fraction of input power that is returned from the input port of a passive component. It is defined as:

$$RL = -10 \log\left(P_r / P_i\right)$$

where P_i is optical power launched into the input port and P_r the optical power received back from the same input port.

NOTE 1 – For a (Fibre-optic) branching component, it is an element a_{ij} (where $i = j$), of the logarithmic transfer matrix. (1.3.8 of IEC 875-1.)

NOTE 2 – For a WDM device, it is an element a_{ij} (where $i = j$), of the logarithmic transfer matrix and it shall be specified at each operating wavelength range.

NOTE 3 – For a (Fibre-optic) switch, it is an element a_{ij} (where $i = j$), of the logarithmic transfer matrix. It depends on the state of the switch (1.3.10 of IEC 876-1.)

NOTE 4 –For a (Fibre-optic) filter, it shall be specified in each operating wavelength range.

NOTE 5 – For clarity, return loss values for fibre-optic devices do not include the return loss contributions of connectors. Return loss contributions from connectors will be considered separately.

3.2.3 reflectance: The ratio of reflected power P_r to incident power, P_i at a given port of a passive component, for given conditions of spectral composition, polarization, and geometrical distribution. Generally expressed in dB as:

$$R = -10 \log\left(P_r / P_i\right) \qquad \text{(1.34 of IEC 1931-1.)}$$

NOTE – When referring to reflected power from an individual component, reflectance is the term preferred to return loss (6.49 of IEC 1931-1). For clarity, reflectance values for fibre-optic devices do not include the reflectance contributions of connectors. Reflectance contributions from connectors will be considered separately.

3.2.4 operating wavelength range: The specified range of wavelengths from λ_{imin} to λ_{imax} about a nominal operating wavelength λ_I, within which a passive component is designed to operate with a specified performance. (1.3.18 of IEC 875-1.)

NOTE 1 – For a (Fibre-optic) branching component with more than one operating wavelength, the corresponding wavelength ranges are not necessarily equal. (1.3.18 of IEC 875-1.)

NOTE 2 – The components including attenuators, terminations, connectors and splices may operate with a specified performance or acceptable performance even outside the specified range of applications.

3.2.5 polarization dependent loss (PDL): Maximum variation of insertion loss due to a variation of the state of polarization over all states of polarization.

3.2.6 polarization dependent reflectance: Maximum variation of reflectance due to a variation of the state of polarization over all states of polarization.

3.2.7 polarization mode dispersion (PMD): Under study.

3.2.8 wavelength dependent attenuation: Under study.

3.2.9 backward loss (Isolation) (for a Fibre-optic isolator): A measure of the decrease in optical power (decibels) resulting from the insertion of an isolator in its backward direction. The launching port is the output port and the receiving port is the input port of the isolator. It is given by the following formula:

$$BL = -10 \log\left(P_{ob} / P_{ib}\right) \qquad \text{(dB)},$$

where P_{ob} is the optical power measured at the input port of the isolator when P_{ib} is launched into the operating port. In operating conditions, P_{ib} is the optical power reflected at the far end optical circuit devices in the backward direction into the output port of the isolator being measured. (1.3.10 of IEC 1202-1.)

3.2.10 far-end cross-talk (for a WDM device): In a WDM device able to separate n wavelengths (λ_1, λ_2, ...λ_n) radiation coming from one input port into n output ports, each one nominally passing radiation at a specific λ_j for j = 1 to n. The measure of the part of optical power at each wavelength, λ_i (i = 1 to n) exiting from the port j at wavelengths different from the nominal wavelength (j = 1 to n, for $j \neq i$). It is given by the following formula:

$$FC_j\left(\lambda_i\right) = -10 \log\left[P_j\left(\lambda_i\right) / P_i\left(\lambda_i\right)\right] \text{ for i, j = 1 to n; and for } j \neq i \quad \left(\text{in dB}\right)$$

where $P_j(\lambda_i)$ is the optical power at wavelength λ_i exiting from the j^{th} port.

3.2.11 near-end cross-talk (for a WDM device): Under study.

3.2.12 directivity: For a (Fibre-optic) branching component, the value a_{ij}, of the logarithmic transfer matrix for between two isolated ports. (1.3.11 of IEC 875-1.)

3.2.13 uniformity: The logarithmic transfer matrix of a branching component may contain a specified set of coefficients which are nominally finite and equal. In this case the range of these

coefficients a_{ij}, expressed in decibels, is termed the uniformity of the branching component. (1.3.13 of IEC 875-1.)

3.2.14 attenuation range (variable attenuators only): Under study.

3.2.15 incremental attenuation (variable attenuators only): A term applicable only to variable attenuators. It refers to the difference between the attenuation of the component at a given setting and the minimum attenuation (1.3.6 of IEC 869-1.)

3.2.16 switching time: The elapsed time it takes the switch to turn path ij on or off from a particular initial state, measured from the time the actuation energy is applied or removed. (1.3.19 of IEC 876-1.)

3.2.17 insertion loss tolerance [for (Fibre-optic) attenuators only]: The difference between nominal and actual insertion loss of the attenuator.

3.2.18 directivity of a (fibre-optic) switch: Under study.

3.2.19 (far-end) crosstalk of a (fibre-optic) switch: Under study.

3.2.20 repeatability of a (fibre-optic) switch: Under study.

3.3 Definitions of component characteristics

NOTE – Not all of the definitions cited in this subclause apply to all devices. The relevance of a particular definition to a specific type of device will be found in clauses 5 and 6.

3.3.1 port: An optical fibre or an optical fibre connector attached to a (Fibre-optic) component for the entry and/or exit of the optical power. (1.3.3 of IEC 875-1.)

3.3.2 conducting port: Two ports i and j between which t_{ij} is nominally greater than zero. (1.3.9 of IEC 875-1)

3.3.3 isolated port: Two ports i and j between which t_{ij} is nominally zero, and a_{ij} is nominally infinite (1.3.10 of IEC 875-1.).

3.4 Definitions of functional parameter characteristics

NOTE – Not all of the definitions cited in this subclause apply to all devices. The relevance of a particular definition to a specific type of device will be found in clauses 5 and 6.

3.4.1 transfer matrix [for (Fibre-optic) branching device and WDM device]: The optical properties of a fibre-optic branching device can be defined in terms of an n x n matrix of coefficients. n is the number of ports, and the coefficients represent the fractional optical power transferred between designated ports. In general, the transfer matrix T is:

$$T = \begin{bmatrix} t_{11} & t_{12} & \cdot & t_{1n} \\ \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & t_{ij} & \cdot \\ t_{n1} & \cdot & \cdot & t_{nn} \end{bmatrix}$$

where t_{ij} is the ratio of optical power P_{ij} transferred out of port j with respect to input power P_i into port i, i.e.:

$$t_{ij} = P_{ij} / P_i \qquad \text{(1.3.4 of IEC 875-1.)}$$

NOTE – Generally, t_{ij} could be wavelength dependent.

3.4.2 transfer coefficient [for (Fibre-optic) branching device and WDM device]: An element t_{ij} of the transfer matrix. (1.3.5 of IEC 875-1.)

3.4.3 logarithmic transfer matrix coefficient [for (Fibre-optic) branching and WDM device]: In general, the logarithmic transfer matrix is:

$$A = \begin{bmatrix} a_{11} & a_{12} & \cdot & a_{1n} \\ \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & a_{ij} & \cdot \\ a_{n1} & \cdot & \cdot & a_{nn} \end{bmatrix}$$

where a_{ij} is the optical power reduction in decibels out of port j with unit power into port i, i.e.:

$$a_{ij} = -10 \log t_{ij}$$

where t_{ij} is the transfer matrix coefficient. (1.3.6 of IEC 875-1.)

3.4.4 transfer matrix [for (Fibre-optic) switch]: The optical properties of a fibre-optic switch can be defined in a m x n matrix of coefficient (n is the number of ports). The T matrix represents the on-state paths (worst-case transmission), and the T^o matrix represents the off-state paths (worst-case isolation). (1.3.6 of IEC 876-1.)

$$T = \begin{bmatrix} t_{11} & t_{12} & \cdot & t_{1n} \\ t_{21} & & & t_{2n} \\ \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & t_{ij} & \cdot \\ t_{n1} & \cdot & \cdot & t_{nn} \end{bmatrix}$$

$$T^o = \begin{bmatrix} t^o_{11} & t^o_{12} & \cdot & t^o_{1n} \\ t^o_{21} & & & t^o_{2n} \\ \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & t^o_{ij} & \cdot \\ t^o_{n1} & \cdot & \cdot & t^o_{nn} \end{bmatrix}$$

3.4.5 transfer coefficient [for (Fibre-optic) switch]: An element t_{ij} or t^o_{ij} of the transfer matrix. Each coefficient t_{ij} is the worst case (minimum) fraction of power transferred from port i to port j for any state with path ij switched on. Each coefficient t^o_{ij} is the worst case (maximum) fraction of power transferred from port i to port j for any state with path ij switched off. (1.3.7 of IEC 876-1.).

3.4.6 logarithmic transfer matrix [for (Fibre-optic) switch]: In general a logarithmic transfer matrix is:

$$A = \begin{bmatrix} a_{11} & a_{12} & \cdot & a_{1n} \\ \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & a_{ij} & \cdot \\ a_{n1} & \cdot & \cdot & a_{nn} \end{bmatrix}$$

where a_{ij} is the optical power reduction in decibels out of port j with unit power into port i, i.e.

$$a_{ij} = -10 \log \left(t_{ij} \right)$$

where t_{ij} is the transfer matrix coefficient.

Similarly, for the off state, $a_{ij}^{o} = -10 \log \left(t_{ij}^{o} \right)$ (1.3.8 of IEC 876-1.)

3.4.7 excess loss [for (Fibre-optic) branching device]: The total power lost in a branching device when optical signal is launched into port i. It is defined as:

$$EL_i = -10 \log \sum_j t_{ij}$$

where the summation is performed only over those values of j for which i and j are conducting ports. For a branching device with N input ports, there will be an array of N values of excess loss, one for each input port i. (1.3.12 of IEC 875-1.)

3.4.8 coupling ratio: For a given input port i, this is the ratio of light at a given output port k to the total light from all output ports. It is defined as:

$$CR_{ik} = t_{ik} / \sum_j t_{ij}$$

where j are the operational output ports. (1.3.14 of IEC 875-1.)

3.4.9 operating wavelength: A nominal wavelength λ, at which a passive component is designed to operate with the specified performance. (1.3.17 of IEC 875-1.)

3.4.10 switching time matrix [for (Fibre-optic) switch]:

$$S = \begin{bmatrix} s_{11} & s_{12} & \cdot & s_{1n} \\ \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & s_{ij} & \cdot \\ s_{n1} & \cdot & \cdot & s_{nn} \end{bmatrix}$$

A matrix of coefficients in which each coefficient S_{ij} is the longest switching time to turn path ij on or off from any initial state. (1.3.21 of IEC 876-1.)

3.4.11 in-band ripple: Under study.

3.4.12 adjacent channel isolation: Under study.

3.4.13 non-adjacent channel isolation: Under study.

3.4.14 filter bandwidth: Under study.

4 Abbreviations

This Recommendation uses the following abbreviations.

OM/OD Optical Multiplexer/Optical Demultiplexer

PDL Polarization Dependent Loss

PMD Polarization Mode Dispersion

WDM Wavelength Division Multiplexing

5 Test methods

Generally, in this Recommendation, the test methods for relevant parameters will not be developed. However, full reference to existing IEC basic specifications are made according to the lists provided in the following tables. The measurement and environmental test procedures that are reported in the IEC Generic Specifications cited in clause 3 and in the IEC 1300 Basic Standard on tests and

measurement procedures for interconnecting devices and passive components are referenced to the functional parameters.

The following minimum list of functional parameters for the specification of the optical passive components cited in clause 1 are applicable over the optical passbands of 1260 nm to 1360 nm and 1480 nm to 1580 nm unless differently specified.

5.1 Parameters common to all components

These parameters are applicable to all component types cited in clause 1, with the exception noted below.

Subclause	Parameter	Test method
5.1.1	Insertion Loss (Note)	IEC 1300-3-4, IEC 1300-3-7
5.1.2	Optical Reflectance	IEC 1300-3-6
5.1.3	Operating Wavelength Range	IEC 1300-3-7
5.1.4	Polarization Dependent Loss	IEC 1300-3-2, IEC 1300-3-12
5.1.5	Polarization Dependent Reflectance	IEC 1300-3-19
NOTE – Not applicable for (Fibre-optic) optical terminations.		

5.2 Parameters unique to specific components

The parameters cited in this subclause are unique to the specific type of components listed below.

5.2.1 (Fibre-optic) wavelength multiplexer and demultiplexer (wavelength selective)

Subclause	Parameter	Test method
5.2.1.1	Wavelength dependent attenuation	Under study
5.2.1.2	Far-end Cross-talk	Under study
5.2.1.3	Near-end Cross-talk	Under study

5.2.2 (Fibre-optic) branching component (wavelength non-selective)

Subclause	Parameter	Test method
5.2.2.1	Directivity	Under study
5.2.2.2	Uniformity	Under study

5.2.3 (Fibre-optic) attenuator

Subclause	Parameter	Parameter
5.2.3.1	Insertion loss tolerance	Under study
5.2.3.2	Attenuation range (Variable atten.)	Under study
5.2.3.3	Incremental attenuation(Variable atten.)	Under study

5.2.4 (Fibre-optic) filter

No additional parameters specified. Note that insertion loss should be provided for each operating wavelength range.

5.2.5 (Fibre-optic) isolator

Subclause	Parameter	Test method
5.2.5.1	Backward Loss	Under study
5.2.5.2	Polarization mode dispersion	Under study

5.2.6 (Fibre-optic) termination

No additional parameters specified.

5.2.7 (Fibre-optic) switch

Subclause	Parameter	Test method
5.2.7.1	Switching time matrix	Under study
5.2.7.2	Repeatability	Under study
5.2.7.3	Uniformity	Under study
5.2.7.4	Crosstalk	Under study
5.2.7.5	Directivity	Under study
5.2.7.6	Transfer Matrix	Under study

5.2.8 Passive dispersion compensator

Subclause	Parameter	Test method
5.2.8.1	Dispersion over operating wavelength range	Under study
5.2.8.2	Polarization Mode dispersion	Under study

5.2.9 (Fibre-optic) connector

No additional parameters specified.

5.2.10 (Fibre-optic) splice

No additional parameters specified.

5.2.11 OM/OD device (For multichannel systems applications)

Under study.

6 Values of functional transmission parameters

This clause cites the recommended values of functional transmission parameters by (Fibre-optic) component type.

NOTE 1 – Values for statistical approach are for further study and will eventually be considered in an appendix.

NOTE 2 – All table values represent worst case end of life values over all temperature, humidity, and perturbations.

NOTE 3 – Insertion loss and reflectance values for (Fibre-optic) connectors shall include the effects of mating durability.

NOTE 4 – For particular applications, tighter reflectance values than those indicated in these tables could be required.

NOTE 5 – Polarization dependent reflectance is under study.

6.1 (Fibre-optic) multiplexer and demultiplexer (wavelength selective) ($1 \times n$ ports where $2 \leq n \leq 32$)

Subclause	Parameter	All networks	
		Max	**Min**
6.1.1	Insertion Loss (dB)	$1.5 \log_2 n$	Not applicable
6.1.2	Optical Reflectance (dB)	–40	Not applicable
6.1.3	Operating Wavelength Range (nm) (Note)	$\frac{1580}{1360}$	$\frac{1480}{1260}$
6.1.4	Polarization Dependent Loss (ΔdB)	$0.1 (1 + \log_2 n)$	Not applicable
6.1.5	Wavelength dependent attenuation	Under study	Not applicable
6.1.6	Far-end Cross-talk (dB)	Not applicable	Under study
6.1.7	Near-end Cross-talk (dB)	Not applicable	Under study
NOTE – Assumes operation at either or both passbands, but if a restricted wavelength exists over a passband, then parameter values like loss apply only over that restricted band as well.			

6.2 (Fibre-optic) branching component (Wavelength non-selective) ($1 \times n$ ports where $2 \leq n \leq 32$) (Note 1)

Subclause	Parameter	All networks	
		Max	**Min**
6.2.1	Insertion Loss (dB)	$4.0 \log_2 n$	Not applicable
6.2.2	Optical Reflectance (dB)	–40	Not applicable
6.2.3	Operating Wavelength Range (nm) (Note 2)	$\frac{1580}{1360}$	$\frac{1480}{1260}$
6.2.4	Polarization Dependent Loss (ΔdB)	$0.1 (1 + \log_2 n)$	Not applicable
6.2.5	Directivity (dB)	Not applicable	50
6.2.6	Uniformity (dB)	$1.0 \log_2 n$	Not applicable
NOTE 1 – $2 \times n$ devices for $2 \leq n \leq 32$ are under study. NOTE 2 – Assumes operation at either or both passbands, but if a restricted wavelength exists over a passband, then parameter values like loss apply only over that restricted band as well.			

6.3 (Fibre-optic) attenuator

Subclause	Parameter	All networks		All networks
		Max	Min	Nominal
6.3.1	Insertion Loss Tolerance	±15%	±15%	Not applicable
6.3.2	Insertion Loss (dB) (Fixed Attenuators)	Not applicable	Not applicable	3, 5, 10, 15, 20, 25, 30
6.3.2	Optical Reflectance (dB)	–40	Not applicable	Not applicable
6.3.3	Operating Wavelength Range (nm) (Note)	1580 1360	1480 1260	1310 1550
6.3.4	Polarization Dependent Loss (ΔdB)	0.3	Not applicable	Not applicable
6.3.5	Attenuation range (Variable atten.) (ΔdB)	Under study	Under study	Not applicable
6.3.6	Incremental attenuation(Variable atten.) (dB)	Under study	Under study	Not applicable
NOTE – Assumes operation at either or both passbands, but if a restricted wavelength exists over a passband, then parameter values like loss apply only over that restricted band as well.				

6.4 (Fibre-optic) filter (Note 1)

Subclause	Parameter	All networks	
		Max	Min
6.4.1a	Insertion Loss (Pass Band) (dB)	1.5	Not applicable
6.4.1b	Insertion Loss (Stop Band) (dB)	Not applicable	40
6.4.2	Optical Reflectance (dB)	–40	Not applicable
6.4.3	Operating Wavelength Range (nm)	Note 2	
6.4.4	Polarization Dependent Loss (ΔdB)	Under study	Not applicable
NOTE 1 – The filters described in this section are intended to be used in the optical path. The device described in section 6.11 is intended to be used for G.692 applications. NOTE 2 – Operating wavelength passband and stopband as defined in relevant specifications.			

6.5 (Fibre-optic) isolator

Subclause	Parameter	All networks	
		Max	**Min**
6.5.1a	(Isolation) Backward Insertion Loss (dB)	Not applicable	Under study
6.5.1b	Forward Insertion Loss (dB)	Under study	Not applicable
6.5.2	Optical Reflectance (dB)	–40	Not applicable
6.5.3	Operating Wavelength Range (nm) (Note)	1580 1360	1480 1260
6.5.4	Polarization Dependent Loss (ΔdB)	Under study	Not applicable
6.5.5	Polarization Mode Dispersion (ps)	Under study	Under study
NOTE – Assumes operation at either or both passbands, but if a restricted wavelength exists over a passband, then parameter values like loss apply only over that restricted band as well.			

6.6 (Fibre-optic) termination

Subclause	Parameter	All networks	
		Max	**Min**
6.6.1	Optical Reflectance (dB)	–50	Not applicable
6.6.2	Operating Wavelength Range (nm) (Note)	1580 1360	1480 1260
NOTE – Assumes operation at either or both passbands, but if a restricted wavelength exists over a passband, then parameter values like loss apply only over that restricted band as well.			

6.7 (Fibre-optic) switch

NOTE – 2 × n switches for future study.

Subclause	Parameter	1 × n Switches (Note 1)		2 × 2 Switches	
		Max	**Min**	**Mean**	**Std**
6.7.1	Insertion Loss (dB)	2.5 | $\log_2 n$	Not applicable	Under study	Not applicable
6.7.2	Optical Reflectance (dB)	–40	Not applicable	–40	Not applicable
6.7.3	Operating Wavelength Range (nm)	Under study	Under study	Under study	Under study
6.7.4	Polarization Dependent Loss (ΔdB)	Under study | $0.1(1 + \log_2 n)$	Not applicable	Under study	Not applicable
6.7.5	Switching time	10s | 20ms	Not applicable	Under study	Not applicable
6.7.6	Repeatability (dB)	0.25	Not applicable	Under study	Not applicable
6.7.7	Uniformity (dB)	Under study | $0.4\log_2 n$	Not applicable	Under study	Not applicable
6.7.8	Crosstalk (dB)	Not applicable	Under study (Note 2)	Under study	Not applicable
6.7.9	Directivity (dB)	Not applicable	50	Under study	Not applicable
NOTE 1 – Dual values (a | b) indicate values for "slow" and "fast" switches respectively. NOTE 2 – A value of 25 dB is under consideration, pending an agreed definition of crosstalk.					

6.8 Passive dispersion compensator

Subclause	Parameter	All networks	
		Max	Min
6.8.1	Insertion Loss (dB)		
	• 20 km of G.652 Equivalent Compensation	4.0	Not applicable
	• 40 km of G.652 Equivalent Compensation	7.0	Not applicable
	• 60 km of G.652 Equivalent Compensation	10.0	Not applicable
	• 80 km of G.652 Equivalent Compensation	13.6	Not applicable
	• 120 km of G.652 Equivalent Compensation	20.0	Not applicable
6.8.2	Optical Reflectance (dB)	Under study	Not applicable
6.8.3	Operating Wavelength Range (nm) (Note 1)	1565	1530
6.8.4	Polarization Dependent Loss (ΔdB)	Under study	Under study
6.8.5	Polarization Mode Dispersion (ps)	Under study	Under study
6.8.6	Dispersion over operating wavelength range (ps/nm) (Note 2)		
	• 20 km of G.652 Equivalent Compensation	–320	–380
	• 40 km of G.652 Equivalent Compensation	–640	–760
	• 60 km of G.652 Equivalent Compensation	–960	–1140
	• 80 km of G.652 Equivalent Compensation	–1280	–1530
	• 120 km of G.652 Equivalent Compensation	–1920	–2290

NOTE 1 – For some passive dispersion compensators, the operating wavelength range can be narrower, but covering the wavelength range of the used optical source.

NOTE 2 – Values derived from assumptions of compensating a specific length of G.652 type fibre, using the equation found in 2.2/G.652, although other lengths and assumptions are under study.

6.9 (Fibre-optic) connector

NOTE – Insertion loss and reflectance values also include effects of mating durability.

Subclause	Parameter	All networks	
		Max	**Min**
6.9.1	Insertion Loss (dB)	0.5 for single fibre (Note 1) 1.0 for multifibre (Note 1)	Not applicable
6.9.2	Optical Reflectance (dB)	–35 (Notes 1 and 2)	Not applicable
6.9.3	Operating Wavelength Range (nm) (Note 3)	1580 1360	1480 1260
6.9.4	Polarization Dependent Loss (ΔdB)	0.1	Not applicable
NOTE 1 – When used over an extended operating temperature range, these values may be exceeded and are under study. NOTE 2 – For networks other than those covered by Recommendation G.982, including other access networks, a value of –27 dB is allowed however, care should be taken to insure system functionality in systems implemented with several optical components with reflectance values at, or near, this limit. In consideration of future network evolutions, a value of –40 dB is under study. NOTE 3 – Assumes operation at either or both passbands, but if a restricted wavelength exists over a passband, then parameter values like loss apply only over that restricted band as well.			

6.10 (Fibre-optic) splice

Subclause	Parameter	All networks	
		Max	**Min**
6.10.1	Insertion Loss (dB) (Notes 1 and 2)		
	Mechanical splice	0.50	Not applicable
	Fusion Splice (Active Alignment)	0.30	Not applicable
	Fusion Splice (Passive Alignment)	0.50	Not applicable
6.10.2	Optical Reflectance (dB)		
	Mechanical splice	–40	Not applicable
	Fusion splice	–70	Not applicable
6.10.3	Operating Wavelength Range (nm) (Note 3)	1580 1360	1480 1260
6.10.4	Polarization Dependent Loss (ΔdB)	Under study	Not applicable
6.10.5	Polarization Dependent Reflectance (ΔdB)	Under study	Not applicable
NOTE 1 – These values assume the joining of fibre types covered by the same Recommendation. NOTE 2 – These values are worst case over all environments and for a large sample size. Typical values of insertion loss for mechanical splices are 0.15 dB, actively aligned fusion splices 0.08 dB and passively aligned fusion splices 0.15 dB. NOTE 3 – Assumes operation at either or both passbands, but if a restricted wavelength exists over a passband, then parameter values like loss apply only over that restricted band as well.			

6.11 OM/OD devices

6.11.a Generic OM/OD device parameters

Subclause	Parameter	Applications in multichannel systems using optical amplifiers	
		Max	**Min**
6.11.1	Insertion Loss (dB)	Under study	Under study
6.11.2	Reflectance (dB)	Under study	Under study
6.11.3	In-band Ripple (dB)	Under study	Under study
6.11.4	Adjacent Channel Isolation (dB)	Under study	Under study
6.11.5	Non-adjacent Channel Isolation (dB)	Under study	Under study
6.11.6	Polarization Dependent Loss (dB)	Under study	Under study
6.11.7	Polarization Mode Dispersion (ps)	Under study	Under study

6.11.b OM/OD device parameters for each channel spacing

Channel spacing (GHz)	Applications in multichannel systems using optical amplifiers		
	2 dB Bandwidth (nm)	**Passband (nm)**	**Guardband (nm)**
100	Under study	Under study	Under study
200	Under study	Under study	Under study
300	Under study	Under study	Under study
400	Under study	Under study	Under study
500	Under study	Under study	Under study
600	Under study	Under study	Under study
700	Under study	Under study	Under study
800	Under study	Under study	Under study
900	Under study	Under study	Under study
1 000	Under study	Under study	Under study

APPENDIX I

Reference list of IEC test methods

IEC 1300-3 Series Transmission and Geometrical Parameters

IEC 1300-3-1 Visual Examination.

IEC 1300-3-2 Polarization Dependence.

IEC 1300-3-3 Monitoring Attenuation and Return Loss (Multiple Path).

IEC 1300-3-4 Attenuation.

IEC 1300-3-5 Monitoring Attenuation.

IEC 1300-3-6 Return Loss.

IEC 1300-3-7 Spectral Loss.

IEC 1300-3-8 Ambient Light Coupling.

IEC 1300-3-9 Crosstalk.

IEC 1300-3-10 Gage Retention.

IEC 1300-3-11 Engagement and Separation.

IEC 1300-3-12 Polarization Dependence of Attenuation of a Single-Mode Fibre-optic Component: Matrix Calculation.

IEC 1300-3-13 Control Stability of a Fibre-optic Switch.

IEC 1300-3-14 Accuracy and Repeatability of the Attenuation Settings of a Variable Attenuator.

IEC 1300-3-15 Eccentricity of a Convex Polished Ferrule Endface.

IEC 1300-3-16 Endface Radius of Convex Polished Ferrules.

IEC 1300-3-17 Endface Angle of Angle-Polished Connectors.

IEC 1300-3-18 Keying Accuracy of an Angled Endface Connector.

IEC 1300-3-19 Polarization Dependence of Return Loss of a Single-Mode Component.

IEC 1300-3-20 Monitoring of Attenuation and Return Loss (Single Path).

IEC 1300-3-21 Switch and Bounce Time.

IEC 1300-3-22 Ferrule Compression Force.

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