INTERNATIONAL TELECOMMUNICATION UNION

ITU-T

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STANDARDIZATION SECTOR
OF ITU

G.650.1

Amendment 1
(03/2003)

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Transmission media characteristics – Optical fibre cables

Definitions and test methods for linear, deterministic attributes of single-mode fibre and cable

Amendment 1

ITU-T Recommendation G.650.1 (2002) – Amendment 1

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ITU-T Recommendation G.650.1

Definitions and test methods for linear, deterministic attributes of single-mode fibre and cable

Amendment 1

Summary

This Amendment 1 to ITU-T Rec. G.650.1 is related to spectral attenuation modelling as a third alternative test method for the measurement of attenuation.

Source

Amendment 1 to ITU-T Recommendation G.650.1 (2002) was prepared by ITU-T Study Group 15 (2001-2004) and approved under the WTSA Resolution 1 procedure on 16 March 2003.

FOREWORD

The International Telecommunication Union (ITU) is the United Nations specialized agency in the field of telecommunications. The ITU Telecommunication Standardization Sector (ITU-T) is a permanent organ of ITU. 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 Assembly (WTSA), which meets every four years, establishes the topics for study by the ITU-T study groups which, in turn, produce Recommendations on these topics.

The approval of ITU-T Recommendations is covered by the procedure laid down in WTSA Resolution 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, ITU 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.

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ITU-T Recommendation G.650.1

Definitions and test methods for linear, deterministic attributes of single-mode fibre and cable

Amendment 1

1) New clause 5.4.4

Add the following clause 5.4.4:

5.4.4 Third alternative test method: Spectral attenuation modelling

5.4.4.1 General

The attenuation coefficient of a fibre across a spectrum of wavelengths may be calculated by means of a characterizing matrix, *M*, and a vector, *v*. The vector contains the measured attenuation coefficients of a small number (three to five) of wavelengths (e.g., 1310 nm, 1360 nm, 1380 nm, 1410 nm, 1550 nm, and/or 1625 nm).

In one approach, the fibre or cable supplier shall provide a matrix characteristic of its product, and the modelled spectral attenuation is a vector, *w*, calculated from the product of *M* and *v:*

$$w = M \cdot v$$

Alternatively, if using a generic matrix, the supplier shall provide a correction-factor vector such that the prediction equation becomes:

$$W = w + e$$

where:

- W is the modified vector;
- w comes from $w = M \cdot v$;
- e is the correction-factor vector.

A generic matrix is a characterizing matrix which can be applied to a variety of fibres, designs, and suppliers (presumably within a single fibre type), and which is determined and/or invoked by a standards body, single customer/end-user, or other industry source to which individual suppliers can compare their products, the difference being resolved by the vector, *e*.

5.4.4.2 Test apparatus

Since this technique involves a calculation using previously determined values, there is no specific apparatus required. Any of the recommended test methods (5.4.1 the cut-back technique; 5.4.2 the backscattering technique; 5.4.3 the insertion loss technique) may be used to generate the measured values upon which the calculations are made.

Direct measurements of attenuation take precedent over this method in the case of a conflict.

5.4.4.3 Calculation procedure

The attenuation coefficient of a fibre across a spectrum of wavelengths may be calculated from $w = M \cdot v$. The vector, *v*, contains the measured attenuation coefficients of a small number (three to five) of predictor wavelengths (e.g., 1310 nm, 1360 nm, 1380 nm, 1410 nm, 1550 nm, and/or 1625 nm) which were measured using one of the previous attenuation test methods. Multiplying the matrix, *M*, times the vector, *v*, yields another vector, *w*, which contains the predicted attenuation coefficients at many wavelengths (such as at 10 nm wavelength intervals from 1240 nm to 1600 nm).

The matrix, *M*, is given by:

A_{11}	A_{12}	A_{1n}
A_{21}	A_{22}	A_{2n}
"	"	
"	"	
"	"	
A_{m1}	A_{m2}	A_{mn}

where m is the number of wavelengths where the attenuation coefficients have to be estimated, and n is the number of predictor wavelengths. An example of such a matrix is given for illustrative purposes in Appendix III to this Recommendation.

The standard deviation of the difference between the actual and predicted attenuation coefficients at each wavelength is to be less than 0,xx dB/km within a stated wavelength range. A different tolerance – 0,yy dB/km – may be necessary if an additional wavelength range is specified. The values of xx (and (yy), and the wavelength range(s) should be agreed upon between the user and the manufacturer.

If the estimate is obtained by using the supplier's specific matrix, *M*, then no correction vector, *e*, is necessary.

Since the elements of both *M* and *e* are achieved on a statistical basis, the *w* vector elements shall be determined as statistical. To indicate the accuracy of the predicted attenuation coefficients, the fibre suppliers shall give a vector containing the standard deviation of the differences between the actual and predicted attenuation coefficients, together with *M* and/or *e* (see 5.4.4.4).

NOTE 1 – In order to facilitate use of this matrix, the fibre should be routinely measured at the predictor wavelengths. The predictor wavelengths should number from 3 to 5, with a strong preference given to the lower number if sufficient accuracy can be achieved.

NOTE 2 – This model considers only uncabled fibre attenuation. An additional vector must be added to *w* to take account of cabling effects and environmental effects.

5.4.4.4 Presentation of the results

In addition to the items to be reported for the test method used in measuring the attenuation coefficients, report the following items:

a) The predicted attenuation and corresponding wavelength.

b) The method used to obtain the measured attenuation coefficient values (if requested).

c) The matrix used to predict the spectral attenuation, or the correction vector if a standard matrix was used (if requested).

d) The vector containing the standard deviation of the differences between the actual and predicted attenuation coefficients obtained during the development of the matrix (if requested).

2) New Appendix III

Add the following Appendix III:

Appendix III

Example of a Matrix Model

The following is an example of an m × n = 38 × 3 matrix, as described in 5.4.4.3, for G.652 fibres. Please note it is given for illustrative purposes only. If the spectral attenuation is to be estimated over the range of 1240 nm to 1600 nm (in steps of 10 nm) using 1310 nm, 1380 nm, and 1550 nm as predictor wavelengths, an example of matrix elements which has been shown to be applicable[1] for some ITU-T G.652 fibres follows:

Output wavelength (µm)	Predictive coefficients		
	1310 nm	1380 nm	1550 nm
1.23	1.46027	–0.04235	–0.20771
1.24	1.35288	–0.01493	–0.13289
1.25	1.31704	–0.00412	–0.14768
1.26	1.26613	–0.00997	–0.13715
1.27	1.20167	–0.00843	–0.10635
1.28	1.14970	–0.01281	–0.06363
1.29	1.11290	–0.01059	–0.06245
1.30	1.03600	–0.00711	0.00711
1.31	0.96276	0.00342	0.05412
1.32	0.90437	0.01435	0.08572
1.33	0.86168	0.02098	0.11776
1.34	0.83194	0.05500	0.05849
1.35	0.73415	0.08336	0.14196
1.36	0.83266	0.11032	–0.10694
1.37	0.69137	0.22596	–0.05961
1.38	0.01006	0.99798	–0.01126
1.39	–0.25502	0.94764	0.48887
1.40	0.00227	0.58463	0.51813
1.41	0.25780	0.33834	0.40811
1.42	0.29085	0.20419	0.49620
1.43	0.29329	0.13569	0.54995
1.44	0.33133	0.09266	0.51936
1.45	0.31608	0.06343	0.55905
1.46	0.24183	0.04483	0.68361

[1] HANSON (T.A.): Spectral Attenuation Modelling with Matrix Models, *Conference Digest NPL Optical Fibre Measurement Conference (OFMC'91)*, pp. 8-11, York, United Kingdom, 1991.

Output wavelength (µm)	Predictive coefficients		
	1310 nm	**1380 nm**	**1550 nm**
1.47	0.29207	0.03019	0.59222
1.48	0.19214	0.02196	0.75669
1.49	0.18650	0.01132	0.76122
1.50	0.21242	0.00541	0.70722
1.51	0.16884	0.00648	0.75347
1.52	0.11484	–0.00091	0.84972
1.53	0.09334	0.00419	0.85304
1.54	0.07231	–0.00021	0.88512
1.55	0.03111	–0.00115	0.94957
1.56	0.07054	–0.00321	0.87414
1.57	–0.03723	–0.01127	1.08140
1.58	–0.02543	0.00556	1.01041
1.59	–0.01370	0.00457	0.99389
1.60	–0.06916	–0.00107	1.11623

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