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TECHNICAL REPORT

colour inside

Fibre optic communication system design guides – Part 14: Determination of the uncertainties of attenuation measurements in fibre plants

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CONTENTS

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FIBRE OPTIC COMMUNICATION SYSTEM DESIGN GUIDES –

Part 14: Determination of the uncertainties of attenuation measurements in fibre plants

FOREWORD

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IEC 61282-14, which is a technical report, has been prepared by subcommittee 86C: Fibre optic systems and active devices, of IEC technical committee 86: Fibre optics.

This publication contains an attached file titled, "Supplemental Data for Section 8", in the form of an Excel spread sheet. This file is intended to be used as a complement and does not form an integral part of the standard.

The text of this technical report is based on the following documents:

Enquiry draft	Report on voting
86C/1339/DTR	86C/1351/RVC

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

A list of all parts in the IEC 61282 series, published under the general title *Fibre-optic communication system design guides*, can be found on the IEC website.

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

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC website 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- withdrawn,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.

The contents of the corrigendum of April 2016 have been included in this copy.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INTRODUCTION

The determination of the uncertainty of every measurement is a key activity, which should be performed by applying dedicated methods as extensively presented in reference documents such as ISO/IEC Guide 98-3:2008, Guide to the uncertainty of measurement (GUM).

This Technical Report shows a practical application of these methods for the determination of the measurement uncertainty of the attenuation of fibre optic cabling using optical light sources and power meters as defined in IEC 61280-4-1 and IEC 61280-4-2.

It includes the review of all contributing factors to uncertainty (such as launch conditions, spectral width, stability of source, power meter polarization, resolution, linearity, quality of test cord reference connectors, etc.) to determine the overall measurement uncertainty. The Technical Report applies to the measurement of single mode or multimode fibres without restrictions to the fibre parameters, including mode field diameter, core diameter and numerical aperture. However, numerical values given in Clause C.2 and typical values given in Annex D are not valid for multimode fibres types A2, A3 and A4.

The list of uncertainties presented in this Technical Report is related to this particular application and should be reconsidered if measurement conditions are not compliant to measurement requirements defined by IEC 61280-4-1 and 61280-4-2.

The reference document for general uncertainty calculations is ISO/IEC Guide 98-3:2008, and this report does not intend to replace it; it only represents an example and should be used in conjunction with ISO/IEC Guide 98-3:2008. A brief introduction to the determination of measurement uncertainty according to ISO/IEC Guide 98-3:2008 is given in Annex A.

This Technical Report is associated with a calculation spreadsheet (Excel) containing practical calculations.

FIBRE OPTIC COMMUNICATION SYSTEM DESIGN GUIDES –

Part 14: Determination of the uncertainties of attenuation measurements in fibre plants

1 Scope

This part of IEC 61282, which is a Technical Report, establishes the detailed analysis and calculation of the uncertainties related to the measurement of the attenuation of both multimode and single mode optical fibre cabling using optical light sources and power meters.

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 61280-4-1:2009, *Fibre-optic communication subsystem test procedures – Part 4-1: Installed cable plant – Multimode attenuation measurement*

IEC 61280-4-2:2014, *Fibre-optic communication subsystem test procedures – Part 4-2: Installed cable plant – Single-mode attenuation and optical return loss measurement*

ISO/IEC Guide 98-3:2008, *Uncertainty of measurement – Part 3 Guide to the expression of uncertainty in measurement (GUM:1995)*

3 Terms, definitions and abbreviations

3.1 Terms and definitions

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

3.1.1
attenuation
L
reduction of optical power induced by transmission through a medium such as cabling, given as L (dB)

$$L_{dB} = 10 \log_{10}(P_{in}/P_{out})$$

where P_{in} and P_{out} are the power, typically measured in mW, into and out of the cabling

3.1.2
calibration
set of operations that establish, under specified conditions, the relationship between the values of quantities indicated by a measuring instrument and the corresponding values realized by standards

3.1.3
encircled flux
EF
fraction of the radial-weighted cumulative near field power to the total radial-weighted output power as a function of radial distance from the optical centre of the core

3.1.4
measurement repeatability
measurement precision under a set of repeatability conditions of measurement

3.1.5
measurement reproducibility
reproducibility
measurement precision under reproducibility conditions of measurement

3.1.6
polarization dependent loss
PDL
maximum variation of insertion loss due to a variation of the state of polarization (SOP) over all the SOPs

3.1.7
nonlinearity
NL
for a power meter, the relative difference between the *response* at a given power P and the response at a reference power P_0:

$$nl_{P/P_0} = \frac{r(P)}{r(P_0)} - 1$$

Note 1 to entry: The nonlinearity is equal to zero at the reference power.

3.1.8
uncertainty of measurement
quantified doubt about the result of a measurement

3.1.9
stability
ability of a measuring instrument to keep its performance characteristics within a specified range during a specified time interval, all other conditions being the same

3.1.10
repeatability condition
condition of measurement that includes the same measurement procedure, same operators, same measuring system, same operating conditions and same location, and replicates measurements on the same or similar objects over a short period of time

3.1.11
reproducibility condition
condition of measurement that includes different locations, operators, measuring systems, and replicate measurements on the same or similar objects

3.1.12
standard uncertainty
u
uncertainty of a measurement result expressed as a standard deviation

Note 1 to entry: For further information, see ISO/IEC Guide 98-3.

3.1.13
uncertainty type A
type of uncertainty obtained by a statistical analysis of a series of observations, such as when evaluating certain random effects of measurement

Note 1 to entry: See Annex A and ISO/IEC Guide 98-3.

3.1.14
uncertainty type B
type of uncertainty obtained by means other than a statistical analysis of observations, for example an estimation of probable sources of uncertainty, such as when evaluating systematic effects of measurement

Note 1 to entry: See Annex A and ISO/IEC Guide 98-3.

3.2 Abbreviations

For the purposes of this document, the following acronyms apply.

APC	angled physical contact (description of connector style)
CW	continuous wave
LSPM	light source power meter
OPM	optical power meter
PC	physical contact (description of connector style that is not angled)

4 Overview of uncertainty

4.1 What is uncertainty?

According to ISO/IEC Guide 98-3:2008 (GUM), the uncertainty of a measurement is the quantified doubt that exists about the result of any measurement. For every measurement, even the most careful, there is always a margin of doubt.

For example, when measuring the attenuation of fibre optic cabling, the operator may observe a variation of the displayed power level on the power meter and be unable to know which value should be recorded. This variation of the displayed value is an element of doubt regarding the result of the measurement.

4.2 Origin of uncertainties

Uncertainties come from: measurement devices, the item to be measured, the measurement process, operator skills, references used, and the environment.

4.3 What may not be considered as uncertainty?

Unknown parameters that contribute directly or indirectly to the quantity to be measured cannot be considered as uncertainties. For example, when measuring a cabling, mode field diameter or numerical aperture of different fibres of cabling are unknown; however, mismatch of these parameters cause the measured attenuation.

Also, poor knowledge of measurement conditions generates uncertainties but is not directly an uncertainty. A common example is the wavelength of the optical source: If the wavelength of the source is known with an uncertainty smaller than 1 nm, the measurement condition can be specified precisely. Conversely, if the wavelength of the source is known to be within a range of 40 nm, the possible variation of the attenuation of the device under test should be estimated based on the typical variation of attenuation over the wavelength range for a given length of fibre.