SLOVENSKI

PREDSTANDARD

SIST EN 61000-4-3:2006/oprA2:2007

februar 2007

Elektromagnetna združljivost (EMC) - 4-3. del: Preskusne in merilne tehnike – Preskušanje odpornosti proti sevanim radiofrekvenčnim elektromagnetnim poljem

Electromagnetic compatibility (EMC) - Part 4-3: Testing and measurement techniques - Radiated, radio-frequency, electromagnetic field immunity test

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ICS 33.100.20

Referenčna številka
SIST EN 61000-4-3:2006/oprA2:2007(en)

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77B/531/CDV

COMMITTEE DRAFT FOR VOTE (CDV)
PROJET DE COMITÉ POUR VOTE (CDV)

	Project number Numéro de projet	IEC 61000-4-3 Ed.3 A2
	IEC/TC or SC: **77B** CEI/CE ou SC:	Secretariat / Secrétariat **France**
☒ Submitted for parallel voting in CENELEC Soumis au vote parallèle au CENELEC	Date of circulation Date de diffusion **2006-11-10**	Closing date for voting (Voting mandatory for P-members) Date de clôture du vote (Vote obligatoire pour les membres (P)) **2007-04-13**

Also of interest to the following committees Intéresse également les comités suivants	Supersedes document Remplace le document 77B/488/CD & 77B/507/CC

Functions concerned
Fonctions concernées

☐ Safety / Sécurité ☒ EMC / CEM ☐ Environment / Environnement ☐ Quality assurance / Assurance qualité

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Titre :
Amendement 2 à la 61000-4-3 Ed.3: Incertitude de mesure de l'instrumentation d'essai

Title :
Amendment 2 to IEC 61000-4-3 edition 3: Measurement uncertainty of Test instrumentation

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Note d'introduction

ATTENTION
VOTE PARALLÈLE
CEI – CENELEC

L'attention des Comités nationaux de la CEI, membres du CENELEC, est attirée sur le fait que ce projet de comité pour vote (CDV) de Norme internationale est soumis au vote parallèle.
Un bulletin de vote séparé pour le vote CENELEC leur sera envoyé par le Secrétariat Central du CENELEC.

Introductory note

ATTENTION
IEC – CENELEC
PARALLEL VOTING

The attention of IEC National Committees, members of CENELEC, is drawn to the fact that this Committee Draft for Vote (CDV) for an International Standard is submitted for parallel voting.
A separate form for CENELEC voting will be sent to them by the CENELEC Central Secretariat.

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Annex M
(informative)
Measurement Uncertainty of Test Instrumentation

M.1 Introduction

The repeatability of EMC testing relies on many factors or influences that affect the test result. These influences give rise to errors in the realization of the disturbance quantity which may be ascribed to random or systematic effects. The conformance of the realized disturbance quantity with the disturbance quantity defined in this standard usually is confirmed by a series of measurements (e.g. measurement of the magnitude of the electric field strength with field probes, measurement of the modulation depth with an oscilloscope,…). The result of each measurement is only an approximation to the value of the measurand and the measured quantity may differ from the true value by some amount due to measurement uncertainty.

In order to achieve a high reliability of the test result, it is necessary to identify the sources of uncertainty involved in the test instrumentation and to make a statement of the uncertainty of the measurement.

Uncertainties for immunity tests cannot be handled in the same way as for emission measurements since immunity tests normally do not have a numerical result, but will give a simple “pass” or “fail” as test result. During the immunity test, the disturbance quantity characterised by several parameters is applied to the EUT. One or more observable signals of the EUT are monitored or observed and compared against agreed criteria, from which the test result (pass/fail) is derived.

A classical measurement uncertainty can, in principle, be applied to the measurement of the signals from the EUT. Since the process of measurement for the monitoring is EUT specific, a basic standard cannot and should not deal with measurement uncertainties for the monitoring system (the observer), however this may be performed.

Uncertainties can also be specified for the parameters of the disturbance quantity. As such they describe the degree of agreement of the specified instrumentation with the specifications of this basic standard.

These uncertainties derived for a particular test instrumentation do not describe the degree of agreement between the simulated electromagnetic phenomenon, as defined in the basic standard and the real electromagnetic phenomena in the world outside the laboratory. Therefore questions regarding the definitions of the disturbance quantity (e.g. the deletion of maximum 25 % of the points of the UFA) are not relevant for the test instrumentation uncertainties.

Since the influence of the parameters of the disturbance quantity (e.g. level setting, frequency, modulation index etc.) on the EUT is a priori unknown and in most cases the EUT shows non linear system behaviour, a single uncertainty number cannot be defined for the disturbance quantity as “overall uncertainty”. Each of the parameters of the disturbance quantity should be accompanied with a specific uncertainty, which may yield to more than one uncertainty budget for the test.

This document focuses on the uncertainties for level setting. Other parameters of the disturbance quantity may be of equal importance and should also be considered by the test laboratory. The methodology shown in this annex is considered to be applicable to all parameters of the disturbance quantity. However Clause M.8 should be applied with the test level uncertainty only.

The National Committees are requested to note that for this publication the maintenance result date is 2009

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The treatment of uncertainty involves the use of statistics to estimate the probability of an outcome and to assign an associated confidence interval to each characteristic of the realized disturbance quantity.

M.2 Definitions

M.2.1
accuracy of measurement
closeness of the agreement between the result of a measurement and the conventional true value of the measurand. [VIM 3.5 MOD]

NOTE 1 – "Accuracy" is a qualitative concept.
NOTE 2 – The term "precision" should not be used for "accuracy".

[394-20-39]

M.2.2
accuracy (of a measuring instrument)
quality which characterizes the ability of a measuring instrument to provide an indicated value close to a true value of the measurand [H VIM 5.18]

NOTE 1 . This term is used in the "true value" approach.
NOTE 2 . Accuracy is all the better when the indicated value is closer to the corresponding true value.

[311-06-08]

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M.2.3
confidence level
probability, generally expressed as a percentage, that the true value of a statistically estimated quantity falls within a pre-established interval about the estimated value

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[393-18-31]

M.2.4
error
The difference between the result of a measurement and the conventional true value of the measurand. [VIM 3.10 MOD]

[394-20-38]

M.2.5
influence quantity
quantity which is not the subject of the measurement but which influences the value of the quantity to be measured or the indications of the measuring instrument

[311-06-01 MOD]

M.2.6
limits of error of a measuring instrument (tolerance)
extreme values of an error permitted by specifications, regulations, etc., for a given measuring instrument

M.2.7
measurand
particular quantity subject to measurement [VIM 2.6]

[311-01-03]

M.2.8
measuring system
complete set of measuring instruments and other equipment assembled to carry out specified measurements [VIM 4.5]

[311-03-06]

M.2.9
random error
The difference between a measurement and the mean that would result from a sufficiently large number of measurements of the same measurand carried out under repeatability conditions. [VIM 3.13 MOD]

[394-20-36]

M.2.10
range of uncertainty (confidence interval) of measurement
value expressed by the formula 2kσ for a single measurement and by 2kσr for the arithmetic mean of a series of measurements. This corresponds to the statistical term "confidence interval".

M.2.11
repeatability (of results of measurements)
closeness of agreement between the results of successive measurements of the same measurand, carried out under the same conditions of measurement, i.e.:

. by the same measurement procedure,
. by the same observer,
. with the same measuring instruments, used under the same conditions,
. in the same laboratory,
. at relatively short intervals of time.
[H VIM 3.6]

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NOTE . The concept of "measurement procedure" is defined in VIM 2.5.

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[311-06-06]

M.2.12
reproducibility of measurements
closeness of agreement between the results of measurements of the same value of a quantity, when the individual measurements are made under different conditions of measurement:

. principle of measurement,
. method of measurement,
. observer,
. measuring instruments,
. reference standards,
. laboratory,
. under conditions of use of the instruments, different from those customarily used,
. after intervals of time relatively long compared with the duration of a single measurement. [H VIM 3.7]

NOTE 1 . The concepts of "principle of measurement" and "method of measurement" are respectively defined in VIM 2.3 and 2.4.

NOTE 2 . The term "reproducibility" also applies to the instance where only certain of the above conditions are taken into account, provided that these are stated.

[311-06-07]

M.2.13
standard deviation of a single measurand in a series of measurements
parameter characterising the dispersion of the result obtained in a series of n measurements of the same measurand

M.2.14
standard deviation of the arithmetic mean of a series of measurements
parameter $s(q_j)$ characterising the dispersion of the arithmetic mean of a series of n independent measurements q_j of the same value of a measured quantity, given by the formula:

$$s(q_j) = \sqrt{\frac{1}{(n-1)} \sum_{j=1}^{n} (q_j - \bar{q})^2} \qquad \text{(M.1)}$$

where $\bar{q}$ is the mean value of the n measurements

[394-20-44 MOD]

M.2.15
systematic error
The difference between the arithmetic mean that would result from an infinite number of measurements of the same measurand carried out under repeatability conditions and the conventional true value of the measurand. [VIM 3.14 MOD]

[394-20-35]

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M.2.16
systematic uncertainty
where it is not possible to identify and correct for a systematic error, then an uncertainty may be estimated and ascribed to the measure value

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M.2.17
true Value
actual value of the quantity being measured. This can never be known absolutely but can be approximated (within the bounds of uncertainty) by traceability to national standards.

M.2.18
uncertainty of measurement
estimate characterising the range of values within which the true value of a measurand lies, generally with a given confidence. (Uncertainty takes the form of a range within which the true value is believed to lie with a stated level of confidence)

M.3 Abbreviations

dB: Decibel

RF: Radio frequency

RSS: Root Sum of the Squares.

UFA: Uniform Field Area (a 16 point grid as described in this standard)

M.4 Uncertainty Analysis

M.4.1 Type A and Type B uncertainties

Errors of measurement generally have two components; a random component and a systematic component. Random uncertainty is associated with unpredictable effects. Systematic uncertainty is generally connected with the instrumentation used for the measurement. Systematic components can sometimes be corrected or reduced but random components by definition cannot. Within a given measurement system, there may be many effects which can influence either of these components.

It can happen that a random uncertainty of one test method can become a systematic uncertainty in another where the results of the first are applied. To avoid this possible confusion, instead of "systematic" and "random" uncertainty the types of uncertainty contribution are grouped into two categories:

- Type A: Those uncertainty contributions which are evaluated by the statistical analysis of a series of observations.

- Type B: Those uncertainty contributions which are evaluated by other means. They are usually associated with effects such as mismatch, cable losses, and instrumentation non-linearities. In an analysis the magnitude and distribution of Type B uncertainties can be estimated based upon calibration data, instrument manufacturer’s specifications or simply knowledge and experience.

The classification into Type A and Type B does not mean that there is any difference in the nature of the components, it is a division based on their means of evaluation. Both types will have probability distributions (although possibly falling under different rules), and the uncertainty components resulting from either type may be quantified by standard deviations.

M.4.2 Limitations

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The following limitations and conditions apply to the considerations in this text:

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- The uncertainty budget is limited to the uncertainty due to the test instrumentation (mainly Type B uncertainty).

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Note: This does not imply that a laboratory should ignore the influence of type A uncertainties but that these should be separately assessed by individual test laboratories to obtain a more complete picture of their uncertainty.

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- All contributions are assumed to be uncorrelated.
- A level of confidence of 95 % is regarded as acceptable.

M.5 Calculation of the Type B Uncertainty

The standard uncertainty is calculated from the determined value (e.g. value taken from the calibration certificate) by applying the divisor assigned to its probability distribution.

The divisors for the individual probability distributions considered in this document are given in Table M.1:

Table M.1: Divisors for individual probability distributions

Distribution	Divisor	Comments
Normal	Coverage factor, *k*	*k* = 2 for 95 % confidence. Typically sourced from calibration certificates
Rectangular	√3	Typically sourced from manufacturer's data for the instrument
U-Shaped	√2	Mismatch Uncertainty Uncertainty contribution most likely to be at the limits
Triangular	√6	Most likely contribution at centre of distribution

In all cases where the distribution of the uncertainty is unknown, the rectangular distribution is taken as the default model.

Calculating the combined standard uncertainty for any test involves combining the individual standard uncertainties by the RSS method. This is valid provided that all quantities are in the same units, are uncorrelated and combine by addition in a logarithmic scale (usually dB). In this case the sensitivity coefficient c_i equals to 1.

This condition is fulfilled in test with radiated disturbance quantities as well as most tests with conducted disturbance quantities where the amplitude (level) is of importance, since the contributors combine by addition (in dB).

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The result of this calculation is a combined standard uncertainty, $u_c(y)$, where

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$$u_c(y) = \sqrt{\sum_{i=1}^{m} u_i^2(y)} \tag{M.2}$$

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The Student's t-distribution gives coverage factors (i.e. multipliers) for the uncertainty, assuming that the output variable y follows a Normal distribution.

When the combined standard uncertainty, $u_c(y)$, has been calculated then, given that the resulting distribution is assumed to be normal, the uncertainty limits relate to a confidence level of σ = 68,3 % (due to the properties of the Gaussian curve).

By multiplying $u_c(y)$ by a coverage factor (*k*) an expanded uncertainty, U_c, giving a greater confidence level can be achieved.

M.6 Compilation of an uncertainty budget

An uncertainty budget is a list of the probable sources of error in a measurement with an estimation of their uncertainty limits and probability distribution.

The calculation of an uncertainty budget requires the following steps:

1. Specification of the characteristic of the disturbance quantity (i.e. what is being generated by the test instrumentation).
2. Identification of the contributions to uncertainty and their value.
3. Definition of the probability distribution of each contribution.
4. Calculation of the standard uncertainty $u(x_i)$ for each contribution.
5. Calculation of the combined uncertainty $u_c(y)$ and the expanded uncertainty, $U_c = u_c(y) * k$.
6. Application of the expanded uncertainty.

7. Publication of the expanded uncertainty in quality documentation as necessary (it is not required for the test laboratory to publish these figures in test reports unless requested to do so).

Example uncertainty budgets with identified contributors and associated values are given in the next section. It should be noted that these are intended for guidance and a test laboratory should identify the actual contributors and values for their particular test setup. (e.g. The final budget may identify a minimum list of contributors that should be taken into account. A lab will then need to identify additional contributors. This will provide better comparison of uncertainty between test labs).

The coverage factor, *k* = 1,64, has been assigned to the level of the disturbance quantity on the basis that the compliance involves a limit value (3 V/m, 10 V/m, etc.). This is indicated below.

Coverage factor *k* for 95% confidence

Coverage factor *k* for 95% confidence to a limit

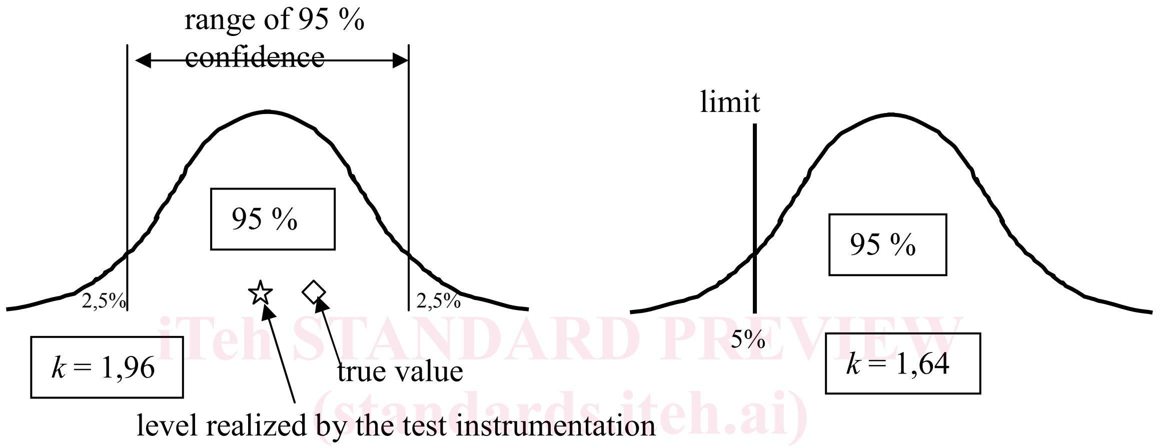

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Figure M.1: Coverage factor *k* for 95% confidence,
and coverage factor *k* for 95% confidence to a limit

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It can be seen that 95 % of the distribution is above the limit when a value of *k* = 1,64 (factor for 90 % from tables) is assigned. It is recommended that this value be used in determining the combined expanded uncertainty for the test level.

M.7 Uncertainty budgets for test methods

M.7.1 Identification of the contributions to uncertainty and their values

M.7.1.1 Contributions

The following fishbone diagram (Figure M.2) gives examples of influences upon the test method. It should be understood that the diagram is not exhaustive.