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TECHNICAL REPORT

Electromagnetic compatibility (EMC) –
Part 1-9: General – Evaluation of uncertainty for the measurement of harmonic current emissions

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IEC Secretariat
3, rue de Varembé
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
info@iec.ch
www.iec.ch

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CONTENTS

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ELECTROMAGNETIC COMPATIBILITY (EMC) –

Part 1-9: General – Evaluation of uncertainty for the measurement of harmonic current emissions

FOREWORD

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IEC TR 61000-1-9 has been prepared by subcommittee 77A: EMC - Low frequency phenomena, of IEC technical committee 77: Electromagnetic compatibility. It is a Technical Report.

The text of this Technical Report is based on the following documents:

Draft	Report on voting
77A/1194/DTR	77A/1204/RVDTR

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

The language used for the development of this Technical Report is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

A list of all parts in the IEC 61000 series, published under the general title *Electromagnetic compatibility (EMC),* can be found on the IEC website.

This document contains attached files in the form of a spreadsheet. These files are intended to be used as a complement and do not form an integral part of the document.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn, or
- revised.

INTRODUCTION

IEC 61000 is published in separate parts, according to the following structure:

Part 1: General

General considerations (introduction, fundamental principles)

Definitions, terminology

Part 2: Environment

Description levels

Classification of the environment

Compatibility levels

Part 3: Limits

Emission limits

Immunity limits (in so far as they do not fall under the responsibility of the product committees)

Part 4: Testing and measurement techniques

Measurement techniques

Testing techniques

Part 5: Installation and mitigation guidelines

Installation guidelines

Mitigation methods and devices

Part 6: Generic standards

Part 9: Miscellaneous

Each part is further subdivided into several parts, published either as international standards or as technical specifications or technical reports, some of which have already been published as sections. Others will be published with the part number followed by a dash and a second number identifying the subdivision (example: IEC 61000-6-1).

The purpose of this document is to help testing laboratories that operate in accordance with ISO/IEC 17025 to evaluate measurement uncertainty of harmonic current emission tests for IEC 61000-3-2 and IEC 61000-3-12.

The document contains practical formulae that enable uncertainty calculations in accordance with ISO/IEC Guide 98-3 (GUM).

The tables in this document provide examples relating to a worst-case scenario when the measurement equipment introduces maximum permissible errors, as specified in IEC 61000-4-7 and IEC 61000-3-2 and the combination of fundamental and harmonic currents drawn by the equipment under test (EUT) is least favourable.

Furthermore the detailed formulae, linking the uncertainty contribution with the corresponding source of uncertainty, allow the user of the document to calculate measurement uncertainties based on their own measurement data. Typically, these uncertainties would be significantly lower than the worst-case uncertainties.

ELECTROMAGNETIC COMPATIBILITY (EMC) –

Part 1-9: General – Evaluation of uncertainty for the measurement of harmonic current emissions

1 Scope

This document provides examples for the evaluation of measurement uncertainty of harmonic emission tests performed using IEC 61000-3-2 and IEC 61000-3-12, and their application to the relevant conformity decisions. It also contains practical formulae to enable calculations in accordance with ISO/IEC Guide 98-3 (GUM).

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 61000-3-2:2018, *Electromagnetic compatibility (EMC) – Part 3-2: Limits – Limits for harmonic current emissions (equipment input current ≤16 A per phase)*
IEC 61000-3-2:2018/AMD1:*2020*

IEC 61000-3-12, *Electromagnetic Compatibility (EMC) – Part 3-12: Limits – Limits for harmonic currents produced by equipment connected to public low-voltage systems with input current >16 A and ≤75 A per phase*

IEC 61000-4-7:2002, *Electromagnetic compatibility (EMC) – Part 4-7: Testing and measurement techniques – General guide on harmonics and interharmonics measurements and instrumentation, for power supply systems and equipment connected thereto*
IEC 61000-4-7:2002/AMD1:2008

IEC GUIDE 115, *Application of uncertainty of measurement to conformity assessment activities in the electrotechnical sector*

ISO/IEC 17025:2017, *General requirements for the competence of testing and calibration laboratories*

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

ISO/IEC GUIDE 99, *International vocabulary of metrology – Basic and general concepts and associated terms (VIM)*

JCGM 106:2012, *Evaluation of measurement data – The role of measurement uncertainty in conformity assessment*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 61000-3-2, IEC 61000-3-12, IEC 61000-4-7, IEC GUIDE 115, ISO/IEC 17025, ISO/IEC GUIDE 98-3, ISO/IEC GUIDE 99 and JCGM 106, apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- IEC Electropedia: available at https://www.electropedia.org/
- ISO Online browsing platform: available at https://www.iso.org/obp

4 Uncertainty evaluation for harmonic emissions tests in IEC 61000-3-2 and IEC 61000-3-12

4.1 Methodology

Testing laboratories that operate in accordance with ISO/IEC 17025 are required to evaluate measurement uncertainty (ISO/IEC 17025:2017, 7.6.3). Other laboratories could, likewise, do so.

This document applies ISO/IEC Guide 98-3 (GUM) to calculate the measurement uncertainty for the tests performed as specified in IEC 61000-3-2 and IEC 61000-3-12.

In 4.3, the uncertainty calculation is made for the worst-case scenario, when the following conditions are met:

– measurement equipment introduces maximum permissible errors, as specified in IEC 61000-4-7 and IEC 61000-3-2;

– the combination of fundamental and harmonic currents drawn by the equipment under test (EUT) is the least favourable. It is based on an EUT that reacts linearly to every external influence quantity. While not every EUT item exhibits such behaviour, the use of a linear model provides a meaningful uncertainty estimate for the purpose of conformity assessment. When the EUT is known to be non-linear, for example, when its harmonic emission currents depend on the harmonic composition of the test voltage, further evaluation can be required if accurate uncertainty assessment is sought.

Examples for typical uncertainties are given in Clause 5.

The calculated worst-case uncertainty values are expressed as a percentage of permissible harmonic current limit for a particular class of the EUT and harmonic number.

The detailed formulae, linking the uncertainty contribution with the corresponding source of uncertainty, allow the user of the document to calculate measurement uncertainties for the relevant tests. Typically, these uncertainties would be significantly lower than the worst-case uncertainties.

To calculate measurement uncertainty in accordance with ISO/IEC Guide 98-3, the following steps are performed:

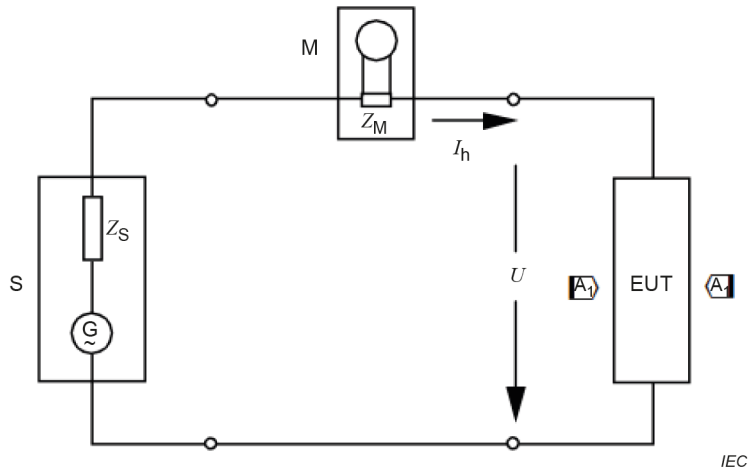
a) a measurement model is established, where the measurement is expressed in terms of formulae linking the measurand with each input quantity (see 4.2);

b) all uncertainty components are listed, their values characterized, and their effect on the measurement calculated numerically (see 4.3);

c) the combined standard uncertainty and the expanded uncertainty values are calculated and tabulated in the uncertainty budget (see 4.4).

4.2 Measurement model

An equipment setup shown in IEC 61000-3-2:2018, Figure A.1, is considered. The setup is used to measure current harmonics of a Class A appliance, see IEC 61000-3-2:2018 and IEC 61000-3-2:2018/AMD1:2020, 5.1.



Key

S	power supply source	Z_M	input impedance of measurement equipment
M	measurement equipment	Z_S	internal impedance of the supply source
EUT	equipment under test	I_h	harmonic component of order h of the line current
U	test voltage	G	open-loop voltage of the supply source

[SOURCE: IEC 61000-3-2:2018, Figure A.1]

Figure 1 – Measurement circuit for single-phase equipment

The measured harmonic current can be expressed as:

$$Y = I_h\left(1+\delta_M\right)\left(1-\delta_{Z_M}\right)\left(1+\delta_{U_{RMS}}\right)\left(1+\delta_{U_{THD}}\right)\left(1-\delta_V\right). \quad (1)$$

where:

Y is the measured value of harmonic current of a particular harmonic frequency, corrected for all known systematic effects,

I_h is the true value of harmonic current,

δ_M is the error of the current measurement equipment such as a power analyser,

δ_{Z_M} is the error due to the input impedance of current measurement equipment,

$\delta_{U_{RMS}}$ is the error due to the RMS value of the test voltage,

$\delta_{U_{THD}}$ is the error due to the harmonic distortion in the test voltage, and

δ_V is the loading effect of the voltmeter (connected in parallel to the EUT but not shown in Figure 1).