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INTERNATIONAL STANDARD

NORME INTERNATIONALE

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BASIC EMC PUBLICATION

PUBLICATION FONDAMENTALE EN CEM

Electromagnetic compatibility (EMC) – Part 4-13: Testing and measurement techniques – Harmonics and interharmonics including mains signalling at a.c. power port, low frequency immunity tests

Compatibilité électromagnétique (CEM) – Partie 4-13: Techniques d'essai et de mesure – Essais d'immunité basse fréquence aux harmoniques et inter-harmoniques incluant les signaux transmis sur le réseau électrique alternatif

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FOREWORD

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International Standard IEC 61000-4-13 has been prepared by subcommittee 77A: Low frequency phenomena, of IEC technical committee 77: Electromagnetic compatibility.

This consolidated version of IEC 61000-4-13 consists of the first edition (2002) [documents 77A/368/FDIS and 77A/377/RVD] and its amendment 1 (2009) [documents 77A/668/CDV and 77A/684/RVC].

The technical content is therefore identical to the base edition and its amendment and has been prepared for user convenience.

It bears the edition number 1.1.

A vertical line in the margin shows where the base publication has been modified by amendment 1.

This standard has the status of a basic EMC publication in accordance with IEC Guide 107.

Annexes A, B, and C, are for information only.

The committee has decided that the contents of the base publication and its amendments will remain unchanged until the maintenance result date indicated on the IEC web site 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- withdrawn,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.

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 publication using a colour printer.

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 of the environment

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: 61000-6-1).

This part is an EMC basic standard which gives immunity requirements and test procedures related to harmonics and interharmonics including mains signalling at a.c. power port.

ELECTROMAGNETIC COMPATIBILITY (EMC) –

Part 4-13: Testing and measurement techniques – Harmonics and interharmonics including mains signalling at a.c. power port, low frequency immunity tests

1 Scope and object

This part of IEC 61000 defines the immunity test methods and range of recommended basic test levels for electrical and electronic equipment with rated current up to 16 A per phase at disturbance frequencies up to and including 2 kHz (for 50 Hz mains) and 2,4 kHz (for 60 Hz mains) for harmonics and interharmonics on low voltage power networks.

It does not apply to electrical and electronic equipment connected to 16 2/3 Hz , or to 400 Hz a.c. networks. Tests for these networks will be covered by future standards.

The object of this standard is to establish a common reference for evaluating the functional immunity of electrical and electronic equipment when subjected to harmonics and inter-harmonics and mains signalling frequencies. The test method documented in this part of IEC 61000 describes a consistent method to assess the immunity of an equipment or system against a defined phenomenon. As described in IEC Guide 107, this is a basic EMC publication for use by product committees of the IEC. As also stated in Guide 107, the IEC product committees are responsible for determining whether this immunity test standard should be applied or not, and if applied, they are responsible for determining the appropriate test levels and performance criteria. TC 77 and its sub-committees are prepared to co-operate with product committees in the evaluation of the value of particular immunity tests for their products.

The verification of the reliability of electrical components (for example capacitors, filters, etc.) is not in the scope of the present standard. Long term thermal effects (greater than 15 min) are not considered in this standard.

The levels proposed are more adapted for residential, commercial and light industry environments. For heavy industrial environments the product committees are responsible for the definition of a class X with the necessary levels. They have also the possibility of defining more complex waveforms for their own need. Nevertheless, the simple waveforms proposed have been mainly observed on several networks (flat curve more often for single phase system) and also on industrial networks (overswing curve more for three phase systems).

2 Normative references

The following referenced documents are indispensable for the application 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 60050(161), *International Electrotechnical Vocabulary (IEV) – Chapter 161: Electromagnetic compatibility*

IEC 61000-2-2, *Electromagnetic compatibility (EMC) – Part 2-2: Environment – Compatibility levels for low-frequency conducted disturbances and signalling in public low-voltage power supply systems*

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

IEC 61000-4-7, *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*

3 Definitions

For the purposes of this part of IEC 61000, the following definitions and terms apply as well as the definitions of IEC 60050(161):

3.1
immunity
ability of a device, equipment or system to perform without degradation in the presence of an electromagnetic disturbance

[IEV 161-01-20]

3.2
harmonic (component)
component of order greater than 1 of the Fourier series of a periodic quantity

[IEV 161-02-18]

3.3
fundamental (component)
component of order 1 of the Fourier series of a periodic quantity

[IEV 161-02-17]

3.4
flat curve waveshape
waveform that follows a time related function in which each half-wave consists of three parts:

Part 1: starts from zero and follows a pure sine function up to the specified value;

Part 2: is a constant value;

Part 3: follows a pure sine function down to zero

3.5
overswing waveshape
waveform which consists of discrete values of the fundamental harmonic, the 3rd and the 5th harmonics with the specified phase shift

3.6
***f*$_1$**
fundamental frequency

3.7
mains signalling frequencies
signal frequencies between harmonics for control and communication

3.8
EUT

equipment under test

4 General

4.1 Description of the phenomenon

4.1.1 Harmonics

Harmonics are sinusoidal voltages and currents with frequencies that are integer multiples of the frequency at which the supply system operates.

Harmonic disturbances are generally caused by equipment with non-linear voltage – current characteristics or by periodic and line-synchronised switching of loads. Such equipment may be regarded as sources of harmonic currents.

The harmonic currents from the different sources produce harmonic voltage drops across the impedance of the network.

As a result of cable capacitance, line inductance and the connection of power factor correction capacitors, parallel or series resonance may occur in the network and cause a harmonic voltage amplification even at a remote point from the distorting load. The waveforms proposed are the result of the summation of different harmonic orders of one or several harmonic sources.

4.1.2 Interharmonics

Between the harmonics of the power frequency voltage and current, further frequencies can be observed which are not an integer multiple of the fundamental. They can appear as discrete frequencies or as a wide-band spectrum. Summation of different interharmonic sources is not likely and is not taken into account in this standard.

4.1.3 Mains signalling (ripple control)

Signal frequencies ranging from 110 Hz to 3 kHz used in networks or parts of them in order to transfer information from a sending point to one or more receiving points.

For the scope of this standard, the frequency range is limited to 2 kHz/50 Hz (2,4 kHz/60 Hz).

4.2 Sources

4.2.1 Harmonics

Harmonic currents are generated to a small extent by generation, transmission and distribution equipment and to a greater extent by industrial and residential loads. Sometimes, there are only a few sources generating significant harmonic currents in a network; the individual harmonic level of the majority of the other devices is low, nevertheless these may make a relatively high contribution to the harmonic voltage distortion, at least for low order harmonics due to their summation.

Significant harmonic currents in a network can be generated by non-linear loads, for example:

– controlled and uncontrolled rectifiers, especially with capacitive smoothing (for example used in television, indirect and direct static frequency converters, and self-ballasted lamps), because these harmonics are in approximately the same phase from different sources and there is only poor compensation in the network;

– phase controlled equipment, some types of computers and UPS equipment.

Sources may produce harmonics at a constant or varying level, depending on the method of operation.

4.2.2 Interharmonics

Sources of interharmonics can be found in low-voltage networks as well as in medium-voltage and high voltage networks. The interharmonics produced in the medium-voltage/high voltage networks flow in the low-voltage networks they supply and vice versa.

The main sources are indirect and direct static frequency converters, welding machines and arc furnaces.

4.2.3 Mains signalling (ripple control)

Sources of mains signalling frequencies covered by this standard are transmitters operating mostly in the 110 Hz to 2 kHz (2,4 kHz) frequency range in order for the public supplier to control equipment in the supply network (public lighting, tariffs for meters, etc.). The transmitter energy is coupled into the system on HV, MV, or LV level. The transmitters operate with interrupted signals, and normally for a short time only. The frequencies used lie normally in between the harmonics.

5 Test levels

The test level is the harmonic voltage specified as a percentage of the fundamental voltage. The voltages given in this standard have the nominal power supply network voltage (U_1 fundamental) as a basis.

It is essential that the r.m.s. voltage of the resultant waveforms remain at the nominal value during the application of these tests by adjusting the voltage values of fundamental and harmonics according to the percentages indicated in the corresponding tables (for example 230 V r.m.s., 120 V r.m.s.).

5.1 Harmonics test levels

The preferential range of test levels for individual harmonics are given in tables 1 to 3.

Harmonic voltages at a test level of 3 % and higher, up to the 9th harmonic, shall be applied using a phase shift of both 0° and 180° with respect to the positive zero-crossing of the fundamental. Harmonic voltages at a test level of less than 3 % shall be applied using no phase-shift with respect to the positive zero-crossing of the fundamental.

For compatibility levels see IEC 61000-2-2 using factor *k*. Immunity levels have to be higher (for example times 1,5 additionally).

The application of the test to a multiphase EUT is given in 8.2.5.

Table 1 – Odd harmonics non-multiple of 3 harmonics

h	Class 1	Class 2	Class 3	Class X
	Test levels % U_1	Test levels % U_1	Test levels % U_1	Test levels % U_1
5	4,5	9	12	Open
7	4,5	7,5	10	Open
11	4,5	5	7	Open
13	4	4,5	7	Open
17	3	3	6	Open
19	2	2	6	Open
23	2	2	6	Open
25	2	2	6	Open
29	1,5	1,5	5	Open
31	1,5	1,5	3	Open
35	1,5	1,5	3	Open
37	1,5	1,5	3	Open

NOTE 1 Classes 1, 2, and 3 are defined in annex C.

NOTE 2 The levels given for class X are open. These levels shall be defined by the product committees. However, for equipment supplied by low voltage public supply systems, the values shall not be lower than those of class 2.

Table 2 – Odd harmonics multiple of 3 harmonics

h	Class 1	Class 2	Class 3	Class X
	Test levels % U_1	Test levels % U_1	Test levels % U_1	Test levels % U_1
3	4,5	8	9	Open
9	2	2,5	4	Open
15	No test	No test	3	Open
21	No test	No test	2	Open
27	No test	No test	2	Open
33	No test	No test	2	Open
39	No test	No test	2	Open

NOTE 1 Classes 1, 2, and 3 are defined in annex C.

NOTE 2 The levels given for class X are open. These levels shall be defined by the product committees. However, for equipment supplied by low voltage public supply systems the values shall not be lower than those of class 2.

Table 3 – Even harmonics

h	Class 1	Class 2	Class 3	Class X
	Test levels % U_1	Test levels % U_1	Test levels % U_1	Test levels % U_1
2	3	3	5	Open
4	1,5	1,5	2	Open
6	No test	No test	1,5	Open
8	No test	No test	1,5	Open
10	No test	No test	1,5	Open
12-40	No test	No test	1,5	Open

NOTE 1 Classes 1, 2, and 3 are defined in annex C.

NOTE 2 The levels given for class X are open. These levels shall be defined by the product committees. However, for equipment supplied by low voltage public supply systems the values shall not be lower than those of class 2.

5.2 Test levels for interharmonics and mains signalling

The preferential ranges of test levels are given in tables 4a and 4b.

Table 4 – Frequencies between harmonic frequencies

Table 4a – Frequencies between harmonic frequencies (for 50 Hz mains)

Frequency range	Class 1	Class 2	Class 3	Class X
Hz	Test levels % U_1	Test levels % U_1	Test levels % U_1	Test levels % U_1
16 – 100	no test	2,5	4	Open
100 – 500	no test	5	9	Open
500 – 750	no test	3,5	5	Open
750 – 1 000	no test	2	3	Open
1 000 – 2 000	no test	1,5	2	Open

NOTE 1 Classes 1, 2, and 3 are defined in annex C.

NOTE 2 The levels for class X are open. These levels shall be defined by the product committees.

Table 4b – Frequencies between harmonic frequencies (for 60 Hz mains)

Frequency range	Class 1	Class 2	Class 3	Class X
Hz	Test levels % U_1	Test levels % U_1	Test levels % U_1	Test levels % U_1
20 – 120	no test	2,5	4	Open
120 – 600	no test	5	7,5	Open
600 – 900	no test	3,5	5	Open
900 – 1200	no test	2	3	Open
1200 – 2400	no test	1,5	2	Open

NOTE 1 Classes1, 2, and 3 are defined in annex C.

NOTE 2 The levels given for class X are open. These levels shall be defined by the product committees.

Immunity test levels for interharmonics above 100 Hz are based on the mains signalling levels or by the Meister curve levels defined in 8.2.4 depending on the class of equipment being tested. Mains signalling levels are in the range of 2 % to 6 % of U_1. Discrete interharmonic frequencies have a level of about 0,5 % of the fundamental frequency voltage U_1 (in absence of resonance). In class 3 for industrial networks, these levels can be considerably higher.

6 Test instrumentation

6.1 Test generator

The test generator shall have the ability to generate a signal with a 50 Hz or 60 Hz fundamental frequency and to superimpose the required frequencies (harmonics and frequencies between the harmonics).

The test generator shall have sufficient filtering such that the harmonic and interharmonic disturbances do not influence any auxiliary equipment which may be used to perform the test.

The test levels according to tables 1 to 4 shall be applied at the terminals of the EUT connected as in normal conditions (single or three phase) and operating as specified in the relevant product standard.

The test generator shall have the following specifications: