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BASIC EMC PUBLICATION
PUBLICATION FONDAMENTALE EN CEM

Electromagnetic compatibility (EMC) –
Part 4-27: Testing and measurement techniques – Unbalance, immunity test for equipment with input current not exceeding 16 A per phase

Compatibilité électromagnétique (CEM) –
Partie 4-27: Techniques d'essai et de mesure – Essai d'immunité aux déséquilibres pour des matériels avec un courant appelé n'excédant pas 16 A par phase

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CONTENTS

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ELECTROMAGNETIC COMPATIBILITY (EMC) –

Part 4-27: Testing and measurement techniques – Unbalance, immunity test for equipment with input current not exceeding 16 A per phase

FOREWORD

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IEC 61000-4-27 edition 1.1 contains first edition (2000) [documents 77A/308/FDIS and 77A/314/RVD] and its amendment 1 (2009) [documents 77A/672/FDIS and 77A/675/RVD].

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

International Standard IEC 61000-4-27 has been prepared by subcommittee 77A: Low-frequency phenomena, of IEC technical committee 77: Electromagnetic compatibility.

It forms part 4-27 of IEC 61000. It has the status of basic EMC publication in accordance with IEC Guide 107.

Annexes A, B, C and D 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- withdrawn,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.

INTRODUCTION

This standard is part of IEC 61000 series, 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 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 completed by a second number identifying the subdivision (example: 61000-6-1).

ELECTROMAGNETIC COMPATIBILITY (EMC) –

Part 4-27: Testing and measurement techniques – Unbalance, immunity test for equipment with input current not exceeding 16 A per phase

1 Scope and object

This part of IEC 61000 is a basic EMC (electromagnetic compatibility) publication. It considers immunity tests for electric and/or electronic equipment (apparatus and system) in its electromagnetic environment. Only conducted phenomena are considered, including immunity tests for equipment connected to public and industrial networks.

The object of this standard is to establish a reference for evaluating the immunity of electrical and electronic equipment when subjected to unbalanced power supply voltage.

This standard applies to 50 Hz/60 Hz three-phase powered electrical and/or electronic equipment with rated line current up to 16 A per phase.

This standard does not apply to equipment with three-phase plus neutral connection if that equipment operates as a group of single-phase loads connected between phase and neutral.

This standard does not apply to electrical and/or electronic equipment connected to a.c. 400 Hz distribution networks.

This standard does not include tests for the zero-sequence unbalance factor.

The immunity test levels required for a specific electromagnetic environment together with performance criteria are indicated in the product, product family or generic standards as applicable. This immunity test should be included in product, product family or generic standards when equipment is likely to show reduced performance or function when exposed to a supply voltage with voltage unbalance.

The verification of the reliability of electrical components (capacitors, motors, etc.) and long-term effects (greater than a few minutes) is not considered in this standard.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of IEC 61000. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of IEC 61000 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 60050(161), *International Electrotechnical Vocabulary (IEV) – Chapter 161: Electromagnetic compatibility*

IEC 61000-2-4, *Electromagnetic compatibility (EMC) – Part 2: Environment – Section 4: Compatibility levels in industrial plants for low-frequency conducted disturbances*

3 Definitions

For the purposes of this part of IEC 61000, the following definitions apply.

3.1
immunity (to a disturbance**)**
ability of a device, equipment or system to perform without degradation in the presence of an electromagnetic disturbance
[IEV 161-01-20]

3.2
voltage unbalance
in a polyphase system, condition in which the r.m.s. values of the phase voltages or the phase angles between consecutive phases are not all equal
[IEV 161-08-09]

3.3
unbalance factor k_{u2} (%)
ratio of the negative sequence component to the positive sequence component measured at mains frequency (50 Hz or 60 Hz) as defined by the method of symmetrical components

$$k_{u2} = 100\ \%\ (U_2\ /\ U_1)\quad \text{(negative-sequence voltage/positive-sequence voltage)}$$

NOTE The negative-sequence voltages in a network mainly result from the negative currents of unbalanced loads flowing in the network.

3.4
malfunction
termination of the ability of an equipment to carry out intended functions or the execution of unintended functions by the equipment

4 General

Three-phase electrical and electronic equipment may be affected by voltage unbalance. Annex A describes the sources, effects and measurement of this disturbance.

Unbalance is caused by either voltage amplitude or phase-shift variations. A formula for the calculation of the unbalance factor, based upon these parameters, is given in annex B.

The purpose of the test is to investigate the influence of unbalance in a three-phase voltage system on equipment which may be sensitive to this disturbance, which could cause:

– overcurrents in a.c. rotating machines;
– generation of non-characteristic harmonics in electronic power converters;
– synchronization problems or control errors in the control part of electrical equipment (see annex A).

5 Test levels

The equipment under test (EUT) is set up at a steady mains voltage and is then subjected to unbalance sequences according to figure 2.

Table 1 specifies the test levels which are derived as explained in annex C.

The duration of the unbalance test, specified between 0,1 s to 60 s, can be taken as a general guide to study short-term effects.

Table 1 – Test levels

Test number	Test level Class 1	Test level for Class 2					Test level for Class 3					Test level for Class X
		Phase	Amplitude % U_N	Angle °	k_{u2} %	Time s	Phase	Amplitude % U_N	Angle	k_{u2} %	Time s	
Test 1	No test required	U_a	100	0°	6	30	U_a	100	0°	8	60	
		U_b	95,2	125°			U_b	93,5	127°			
		U_c	90	240°			U_c	87	240°			
Test 2		U_a	100	0°	13	15	U_a	100	0°	17	15	
		U_b	90	131°			U_b	87	134°			
		U_c	80	239°			U_c	74	238°			
Test 3		U_a	110	0°	25	0,1	U_a	110	0°	25	2	
		U_b	66	139°			U_b	66	139°			
		U_c	71	235°			U_c	71	235°			

NOTE 1 U_N is the nominal voltage
NOTE 2 U_b is lagging against U_a, and U_c is leading against U_a.

Tests are respectively specified for equipment in relation to levels 2 and 3 in IEC 61000-2-4.

The product committee may specify any test level; however, for equipment connected to public supply systems, it is recommended that the levels should not be lower than those defined for class 2.

6 Test equipment

6.1 Test generators

The generator shall have provisions to prevent the emission of disturbances which, if injected in the power supply network, may influence the test results.

The output voltage shall be adjusted to ±1% of U_N and the phase to ±0,3°.

Table 2 – Characteristics of the generator

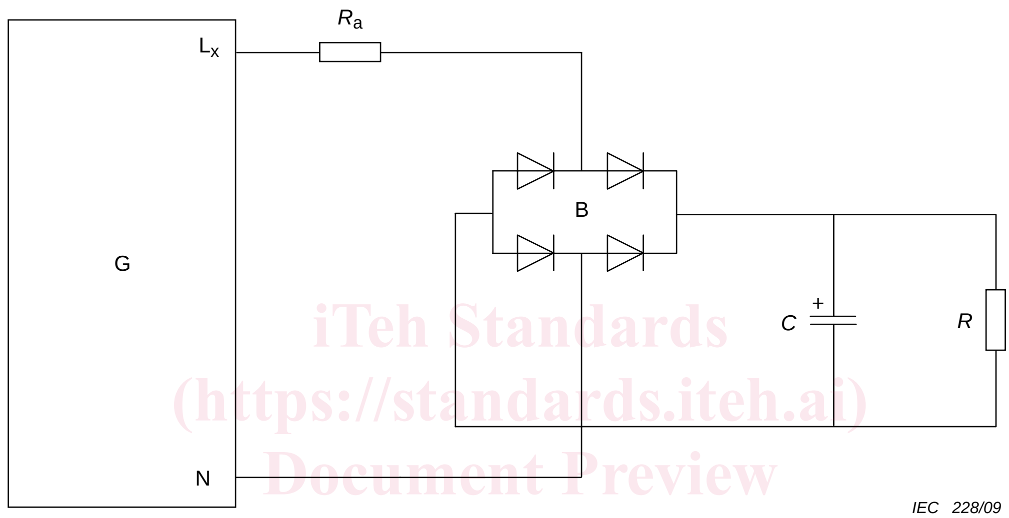
Characteristic	Performance specification
Output voltage capability	U_N +15, −40 %
Output voltage accuracy	±2 % of U_N.
Output current capability	Sufficient to supply the EUT under all test conditions
Overshoot/undershoot of the actual voltage, generator loaded with 100 Ω resistive load	Less than 5 % of the change in voltage
Voltage rise (and fall time) during voltage changes, generator loaded with 100 Ω resistive load	1 µs to 5 µs
Total harmonic distortion of the output voltage	Less than 3 %
Phase shifting Phase accuracy	0°, 120° and 240° ± 30° 1° between any two phases
Frequency accuracy	0,5 % of f_1 (50 Hz or 60 Hz)

6.2 Verification of the characteristics of the test generators

It is recognized that there is a wide range of EUTs and that consequently test generators with different output power capabilities may be used, as required.

The test generator shall be verified that it complies with the characteristics and specifications listed in Table 2. Performance of the test generator shall be verified with resistive loads drawing an rms current of no more than the output capability of the generator.

In addition, the generator's output current capability shall be verified as being able to provide a crest factor of at least 3 when U_N is applied to a single phase load drawing an rms current of no more than the output capability of the generator. Each output phase of the generator shall be verified in turn. An example of a suitable 230V/16A verification load is given in Figure 4.



Components

G Test generator

B Bridge rectifier

C 11 000 µF ± 20 % electrolytic capacitor

R 35 Ω ± 1 % resistor

R_a Additional resistor

NOTE R_a shall be selected so that the total series resistance (sum of the additional resistor R_a, the wiring resistance R_{wire}, the internal resistance of two conducting diodes R_{diodes}, and the internal resistance of the capacitor R_c) is 92 mΩ (±10 %).

Figure 4 – Example of test generator verification load

7 Test set-up

The test shall be performed with the EUT connected to the test generator with a supply cable as specified by the manufacturer. If no cable length is specified, it shall be the shortest possible length adapted to the EUT. The length shall be reported in the test report.

Figure 3 shows a schematic drawing for the generation of voltage unbalance (amplitude or phase change) using a generator with power amplifier.

Generators with transformers and switches need to have variable transformers on at least two phases.

The ports of the EUT shall be connected to appropriate peripherals as defined by the manufacturer. If appropriate peripherals are not available, they may be simulated.

8 Test procedures

8.1 Laboratory reference conditions

In order to minimize the impact of environmental parameters on test results, the tests shall be carried out in climatic and electromagnetic reference conditions as specified in 8.1.1 and 8.1.2.

8.1.1 Climatic conditions

Unless otherwise specified by the committee responsible for the generic or product standard, the climatic conditions in the laboratory shall be within any limits specified for the operation of the EUT and the test equipment by their respective manufacturers.

Tests shall not be performed if the relative humidity is so high as to cause condensation on the EUT or the test equipment.

NOTE Where it is considered that there is sufficient evidence to demonstrate that the effects of the phenomenon covered by this standard are influenced by climatic conditions, this should be brought to the attention of the committee responsible for this standard.

8.1.2 Electromagnetic conditions

The electromagnetic conditions of the laboratory shall not influence the test results.

8.2 Execution of the test

The EUT shall be configured for its normal operating conditions.

The tests shall be performed according to a test plan that shall specify

– test number (see table 1);
– test level;
– test duration;
– ports to which the test shall be applied;
– representative operating conditions of the EUT;
– auxiliary equipment.

The power supply, signals and other functional electrical quantities shall be applied within their rated range. If the actual operating signal sources are not available, they may be simulated.

For each test level, a succession of at least three unbalance sequences shall be applied, with an interval of a least 3 min between each (see figure 2).

The applied test levels shall be rotated as follows:

First sequence: U_a to L_1, U_b to L_2, U_c to L_3;
Second sequence: U_a to L_2, U_b to L_3, U_c to L_1;
Third sequence: U_a to L_3, U_b to L_1, U_c to L_2.

where

U_a, U_b and U_c (see table 1) are the voltages of the generator and

L_1, L_2 and L_3 are the inputs of the EUT.

Changes in supply voltage shall occur at zero crossings of U_a. The output impedance of the test generator shall be low in steady state and during transition periods.