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BASIC EMC PUBLICATION

PUBLICATION FONDAMENTALE EN CEM

Electromagnetic compatibility (EMC) – Part 4-11: Testing and measurement techniques – Voltage dips, short interruptions and voltage variations immunity tests

Compatibilité électromagnétique (CEM) – Partie 4-11: Techniques d'essai et de mesure – Essais d'immunité aux creux de tension, coupures brèves et variations de tension

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IEC Central Office
3, rue de Varembé
CH-1211 Geneva 20
Switzerland
Email: inmail@iec.ch
Web: www.iec.ch

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ELECTROMAGNETIC COMPATIBILITY (EMC) –

Part 4-11: Testing and measurement techniques –
Voltage dips, short interruptions and voltage variations immunity tests

INTERPRETATION SHEET 1

This interpretation sheet has been prepared by subcommittee 77A: Low frequency phenomena, of IEC technical committee 77: Electromagnetic compatibility.

The text of this interpretation sheet is based on the following documents:

ISH	Report on voting
77A/726/ISH	77A/731/RVD

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

Interpretation of the rise-time and fall-time requirements during EUT testing in IEC 61000-4-11:2004: Electromagnetic compatibility (EMC) – Part 4-11: Testing and measurement techniques – Voltage dips, short interruptions and voltage variations immunity tests.

1) In IEC 61000-4-11:2004, Table 4 does not apply to EUT (equipment under test) testing. Table 4 is for generator calibration and design only.
2) With reference to Table 1 and Table 2, there is no requirement in 61000-4-11:2004 for rise-time and fall-time when testing EUT; therefore, it is not necessary to measure these parameters during tests.
3) With reference to Table 4, all of the requirements apply to design and calibration of the generator. The requirements of Table 4 only apply when the load is a non-inductive 100 Ω resistor. The requirements of Table 4 do not apply during EUT testing.

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ELECTROMAGNETIC COMPATIBILITY (EMC) –

Part 4-11: Testing and measurement techniques – Voltage dips, short interruptions and voltage variations immunity tests

FOREWORD

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International Standard IEC 61000-4-11 has been prepared by subcommittee 77A: Low frequency phenomena, of IEC technical committee 77: Electromagnetic compatibility.

This second edition cancels and replaces the first edition published in 1994 and its amendment 1 (2000). This second edition constitutes a technical revision in which

1) preferred test values and durations have been added for the different environment classes;

2) the tests for the three-phase systems have been specified.

It forms part 4-11 of IEC 61000. It has the status of a Basic EMC Publication in accordance with IEC Guide 107.

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The text of this standard is based on the following documents:

FDIS	Report on voting
77A/452/FDIS	77A/455/RVD

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

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 2008. At this date, the publication will be

- reconfirmed;
- withdrawn;
- replaced by a revised edition, or
- amended.

The contents of the interpretation sheet 1 of August 2010 have been included in this copy.

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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).

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ELECTROMAGNETIC COMPATIBILITY (EMC) –

Part 4-11: Testing and measurement techniques – Voltage dips, short interruptions and voltage variations immunity tests

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1 Scope

This part of IEC 61000 defines the immunity test methods and range of preferred test levels for electrical and electronic equipment connected to low-voltage power supply networks for voltage dips, short interruptions, and voltage variations.

This standard applies to electrical and electronic equipment having a rated input current not exceeding 16 A per phase, for connection to 50 Hz or 60 Hz a.c. networks.

It does not apply to electrical and electronic equipment for connection to 400 Hz a.c. networks. Tests for these networks will be covered by future IEC standards.

The object of this standard is to establish a common reference for evaluating the immunity of electrical and electronic equipment when subjected to voltage dips, short interruptions and voltage variations.

NOTE Voltage fluctuation immunity tests are covered by IEC 61000-4-14.

The test method documented in this part of IEC 61000 describes a consistent method to assess the immunity of equipment or a 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 defining the appropriate test levels. Technical committee 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.

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 61000-2-8, *Electromagnetic compatibility (EMC) – Part 2-8: Environment – Voltage dips and short interruptions on public electric power supply systems with statistical measurement results*

3 Terms and definitions

For the purpose of this document, the following terms and definitions apply:

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3.1
basic EMC standard
standard giving general and fundamental conditions or rules for the achievement of EMC, which are related or applicable to all products and systems and serve as reference documents for product committees

NOTE As determined by the Advisory Committee on Electromagnetic Compatibility (ACEC) – see IEC Guide 107.

3.2
immunity (to a disturbance)
the ability of a device, equipment or system to perform without degradation in the presence of an electromagnetic disturbance

[IEV 161-01-20]

3.3
voltage dip
a sudden reduction of the voltage at a particular point of an electricity supply system below a specified dip threshold followed by its recovery after a brief interval

NOTE 1 Typically, a dip is associated with the occurrence and termination of a short circuit or other extreme current increase on the system or installations connected to it.

NOTE 2 A voltage dip is a two-dimensional electromagnetic disturbance, the level of which is determined by both voltage and time (duration).

3.4
short interruption
a sudden reduction of the voltage on all phases at a particular point of an electric supply system below a specified interruption threshold followed by its restoration after a brief interval

NOTE Short interruptions are typically associated with switchgear operations related to the occurrence and termination of short circuits on the system or on installations connected to it.

3.5
residual voltage (of voltage dip)
the minimum value of r.m.s. voltage recorded during a voltage dip or short interruption

NOTE The residual voltage may be expressed as a value in volts or as a percentage or per unit value relative to the reference voltage.

3.6
malfunction
the termination of the ability of equipment to carry out intended functions or the execution of unintended functions by the equipment

3.7
calibration
method to prove that the measurement equipment is in compliance with its specifications

NOTE For the purposes of this standard, calibration is applied to the test generator.

3.8
verification
set of operations which is used to check the test equipment system (e.g. the test generator and the interconnecting cables) to demonstrate that the test system is functioning within the specifications given in Clause 6

NOTE 1 The methods used for verification may be different from those used for calibration.

NOTE 2 The verification procedure of 6.1.2 is meant as a guide to insure the correct operation of the test generator, and other items making up the test set-up that the intended waveform is delivered to the EUT.

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4 General

Electrical and electronic equipment may be affected by voltage dips, short interruptions or voltage variations of power supply.

Voltage dips and short interruptions are caused by faults in the network, primarily short circuits (see also IEC 61000-2-8), in installations or by sudden large changes of load. In certain cases, two or more consecutive dips or interruptions may occur. Voltage variations are caused by continuously varying loads connected to the network.

These phenomena are random in nature and can be minimally characterized for the purpose of laboratory simulation in terms of the deviation from the rated voltage and duration.

Consequently, different types of tests are specified in this standard to simulate the effects of abrupt voltage change. These tests are to be used only for particular and justified cases, under the responsibility of product specification or product committees.

It is the responsibility of the product committees to establish which phenomena among the ones considered in this standard are relevant and to decide on the applicability of the test.

5 Test levels

The voltages in this standard use the rated voltage for the equipment (U_T) as a basis for voltage test level specification.

Where the equipment has a rated voltage range the following shall apply:

– if the voltage range does not exceed 20 % of the lower voltage specified for the rated voltage range, a single voltage within that range may be specified as a basis for test level specification (U_T);
– in all other cases, the test procedure shall be applied for both the lowest and highest voltages declared in the voltage range;
– guidance for the selection of test levels and durations is given in IEC 61000-2-8.

5.1 Voltage dips and short interruptions

The change between U_T and the changed voltage is abrupt. The step can start and stop at any phase angle on the mains voltage. The following test voltage levels (in % U_T) are used: 0 %, 40 %, 70 % and 80 %, corresponding to dips with residual voltages of 0 %, 40 %, 70 % and 80 %.

For voltage dips, the preferred test levels and durations are given in Table 1, and an example is shown in Figure 1a) and Figure 1b).

For short interruptions, the preferred test levels and durations are given in Table 2, and an example is shown in Figure 2.

The preferred test levels and durations given in Tables 1 and 2 take into account the information given in IEC 61000-2-8.

The preferred test levels in Table 1 are reasonably severe, and are representative of many real world dips, but are not intended to guarantee immunity to all voltage dips. More severe dips, for example 0 % for 1 s and balanced three-phase dips, may be considered by product committees.

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The voltage rise time, t_r, and voltage fall time, t_f, during abrupt changes are indicated in Table 4.

The levels and durations shall be given in the product specification. A test level of 0 % corresponds to a total supply voltage interruption. In practice, a test voltage level from 0 % to 20 % of the rated voltage may be considered as a total interruption.

Shorter durations in the table, in particular the half-cycle, should be tested to be sure that the equipment under test (EUT) operates within the performance limits specified for it.

When setting performance criteria for disturbances of 0,5 period duration for products with a mains transformer, product committees should pay particular attention to effects which may result from inrush currents. For such products, these may reach 10 to 40 times the rated current because of magnetic flux saturation of the transformer core after the voltage dip.

Table 1 – Preferred test level and durations for voltage dips

Class[a]	Test level and durations for voltage dips (t_s) (50 Hz/60 Hz)				
Class 1	Case-by-case according to the equipment requirements				
Class 2	0 % during ½ cycle	0 % during 1 cycle	70 % during 25/30[c] cycles		
Class 3	0 % during ½ cycle	0 % during 1 cycle	40 % during 10/12[c] cycles	70 % during 25/30[c] cycles	80 % during 250/300[c] cycles
Class X[b]	X	X	X	X	X

[a] Classes as per IEC 61000-2-4; see Annex B.

[b] To be defined by product committee. For equipment connected directly or indirectly to the public network, the levels must not be less severe than Class 2.

[c] "25/30 cycles" means "25 cycles for 50 Hz test" and "30 cycles for 60 Hz test".

Table 2 – Preferred test level and durations for short interruptions

Class[a]	Test level and durations for short interruptions (t_s) (50 Hz/60 Hz)
Class 1	Case-by-case according to the equipment requirements
Class 2	0 % during 250/300[c] cycles
Class 3	0 % during 250/300[c] cycles
Class X[b]	X

[a] Classes as per IEC 61000-2-4; see Annex B.

[b] To be defined by product committee. For equipment connected directly or indirectly to the public network, the levels must not be less severe than Class 2.

[c] "250/300 cycles" means "250 cycles for 50 Hz test" and "300 cycles for 60 Hz test".

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5.2 Voltage variations (optional)

This test considers a defined transition between rated voltage U_T and the changed voltage.

NOTE The voltage change takes place over a short period, and may occur due to change of load.

The preferred duration of the voltage changes and the time for which the reduced voltages are to be maintained are given in Table 3. The rate of change should be constant; however, the voltage may be stepped. The steps should be positioned at zero crossings, and should be no larger than 10 % of U_T. Steps under 1 % of U_T are considered as constant rates of change of voltage.

Table 3 – Timing of short-term supply voltage variations

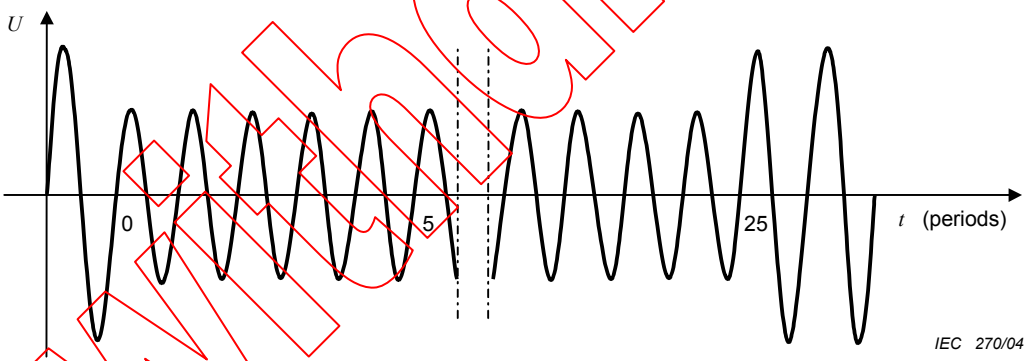
Voltage test level	Time for decreasing voltage (t_d)	Time at reduced voltage(t_s)	Time for increasing voltage (t_r) (50 Hz/60 Hz)
70 %	Abrupt	1 cycle	25/30[b] cycles
X[a]	X[a]	X[a]	X[a]

[a] To be defined by product committee.

[b] "25/30 cycles" means "25 cycles for 50 Hz test" and "30 cycles for 60 Hz test".

This shape is the typical shape of a motor starting.

Figure 3 shows the r.m.s. voltage as a function of time. Other values may be taken in justified cases and shall be specified by the product committee.



NOTE The voltage decreases to 70 % for 25 periods. Step at zero crossing.

Figure 1a) – Voltage dip – 70 % voltage dip sine wave graph

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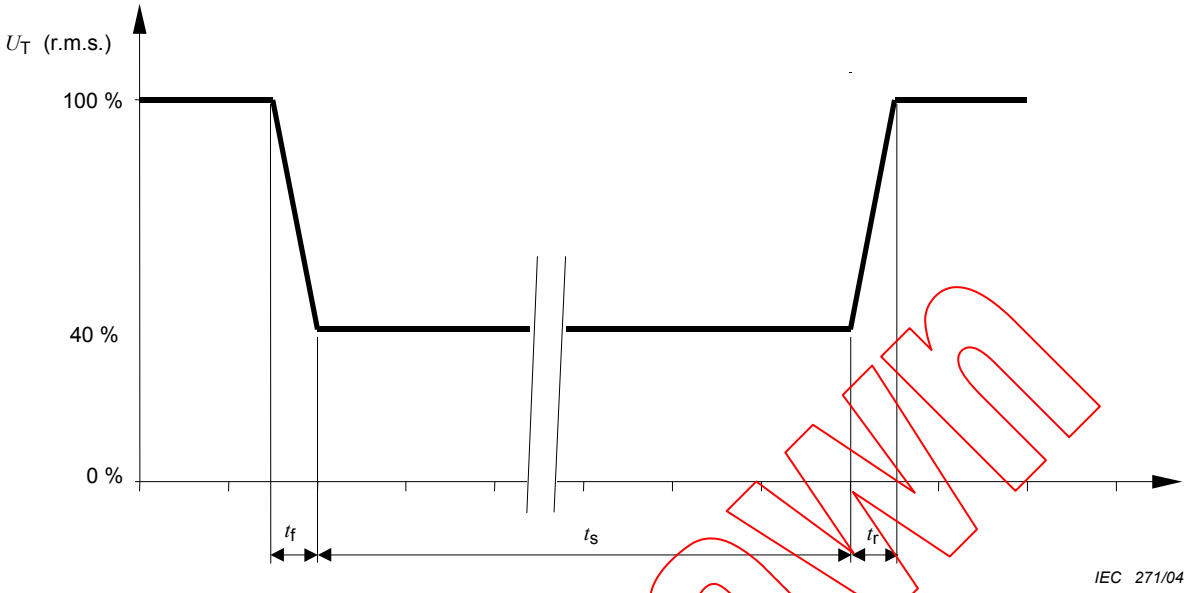
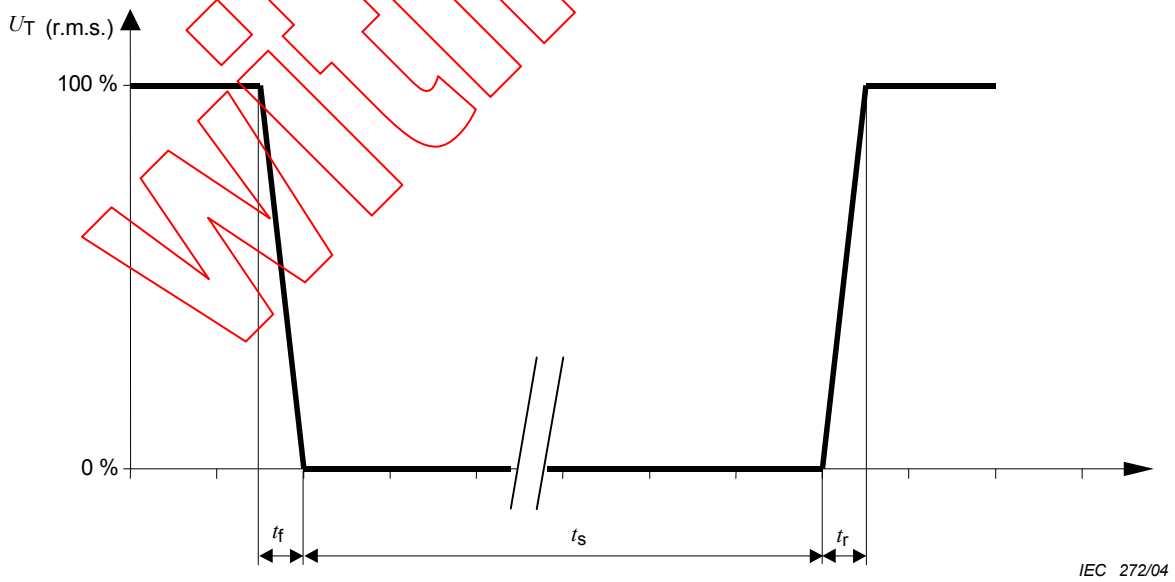


Key
t_r Voltage rising time
t_f Voltage fall time
t_s Time at reduced voltage

Figure 1b) – Voltage dip – 40 % voltage dip r.m.s. graph

Figure 1 – Voltage dip - Examples



Key
t_r Voltage rising time
t_f Voltage fall time
t_s Time at reduced voltage

Figure 2 – Short interruption

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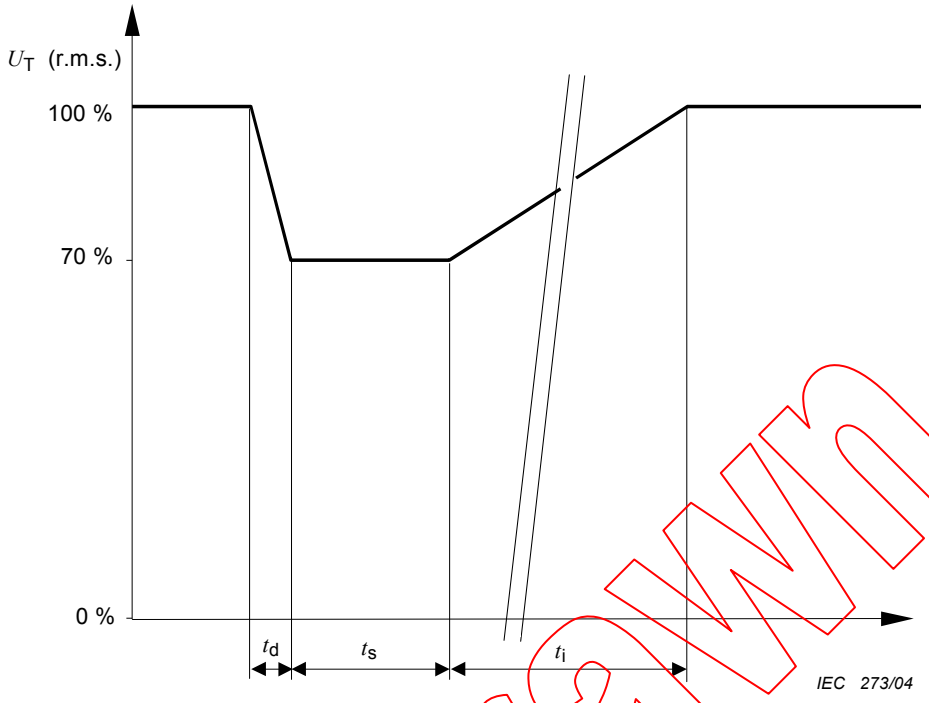

Key
t_d Time for decreasing voltage
t_i Time for increasing voltage
t_s Time at reduced voltage

Figure 3 – Voltage variation

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6 Test instrumentation

6.1 Test generator

The following features are common to the generator for voltage dips, short interruptions and voltage variations, except as indicated.

Examples of generators are given in Annex C.

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

Any generator creating a voltage dip of equal or more severe characteristics (amplitude and duration) than that prescribed by the present standard is permitted.

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6.1.1 Characteristics and performance of the generator

Table 4 – Generator specifications

Output voltage at no load	As required in Table 1, ± 5 % of residual voltage value
Voltage change with load at the output of the generator 100 % output, 0 A to 16 A 80 % output 0 A to 20 A 70 % output, 0 A to 23 A 40 % output, 0 A to 40 A	 less than 5 % of U_T less than 5 % of U_T less than 5 % of U_T less than 5 % of U_T
Output current capability	16 A r.m.s. per phase at rated voltage. The generator shall be capable of carrying 20 A at 80 % of rated value for a duration of 5 s. It shall be capable of carrying 23 A at 70 % of rated voltage and 40 A at 40 % of rated voltage for a duration of 3 s. (This requirement may be reduced according to the EUT rated steady-state supply current, see Clause A.3).
Peak inrush current capability (no requirement for voltage variation tests)	Not to be limited by the generator. However, the maximum peak capability of the generator need not exceed 1 000 A for 250 V to 600 V mains, 500 A for 200 V to 240 V mains, or 250 A for 100 V to 120 V mains.
Instantaneous peak overshoot/undershoot of the actual voltage, generator loaded with 100 Ω resistive load	Less than 5 % of U_T
Voltage rise (and fall) time t_r (and t_f), see Figures 1b) and 2, during abrupt change, generator loaded with 100 Ω resistive load	Between 1 µs and 5 µs
Phase shifting (if necessary)	0° to 360°
Phase relationship of voltage dips and interruptions with the power frequency	Less than ±10 °
Zero crossing control of the generators	±10°

Output impedance shall be predominantly resistive.

The output impedance of the test voltage generator shall be low even during transitions (for example, less than 0,4 + j0,25 Ω).

NOTE 1 The 100 Ω resistive load used to test the generator should not have additional inductivity.

NOTE 2 To test equipment which regenerates energy, an external resistor connected in parallel to the load can be added. The test result must not be influenced by this load.

6.1.2 Verification of the characteristics of the voltage dips, short interruptions generators

In order to compare the test results obtained from different test generators, the generator characteristics shall be verified according to the following:

– the 100 %, 80 %, 70 % and 40 % r.m.s. output voltages of the generator shall conform to those percentages of the selected operating voltage: 230 V, 120 V, etc.;

– the 100 %, 80 %, 70 % and 40 % r.m.s. output voltages of the generator shall be measured at no load, and shall be maintained within a specified percentage of the U_T;

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– load regulation shall be verified at nominal load current at each of the output voltages and the variation shall not exceed 5 % of the nominal power supply voltage at 100 %, 80 %, 70 % and 40 % of the nominal power supply voltage.

For output voltage of 80 % of the nominal value, the above requirements need only be verified for a maximum of 5 s duration.

For output voltages of 70 % and 40 % of the nominal value, the above requirements need only be verified for a maximum of 3 s duration.

If it is necessary to verify the peak inrush drive current capability, the generator shall be switched from 0 % to 100 % of full output, when driving a load consisting of a suitable rectifier with an uncharged capacitor whose value is 1 700 µF on the d.c. side. The test shall be carried out at phase angles of both 90° and 270°. The circuit required to measure generator inrush current drive capability is given in Figure A.1.

When it is believed that a generator with less than the specified standard generator peak inrush current may be used because the EUT may draw less than the specified standard generator peak inrush current (e.g., 500 A for 220 V-240 V mains), this shall first be confirmed by measuring the EUT peak inrush current. When power is applied from the test generator, measured EUT peak inrush current shall be less than 70 % of the peak current drive capability of the generator, as already verified according to Annex A. The actual EUT inrush current shall be measured both from a cold start and after a 5 s turn-off, using the procedure of Clause A.3.

Generator switching characteristics shall be measured with a 100 Ω load of suitable power-dissipation rating.

NOTE The 100 Ω resistive load used to test the generator should not have additional inductivity.

Rise and fall time, as well as overshoot and undershoot, shall be verified for switching at both 90° and 270°, from 0 % to 100 %, 100 % to 80 %, 100 % to 70 %, 100 % to 40 %, and 100 % to 0 %.

Phase angle accuracy shall be verified for switching from 0 % to 100 % and 100 % to 0 %, at nine phase angles from 0° to 360° in 45° increments. It shall also be verified for switching from 100 % to 80 % and 80 % to 100 %, 100 % to 70 % and 70 % to 100 %, as well as from 100 % to 40 % and 40 % to 100 %, at 90° and 180°.

The voltage generators shall, preferably, be recalibrated at defined time periods in accordance with a recognized quality assurance system.

6.2 Power source

The frequency of the test voltage shall be within ± 2% of rated frequency.

7 Test set-up

The test shall be performed with the EUT connected to the test generator with the shortest power supply cable as specified by the EUT manufacturer. If no cable length is specified, it shall be the shortest possible length suitable to the application of the EUT.

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The test set-ups for the three types of phenomena described in this standard are:

– voltage dips;
– short interruptions;
– voltage variations with gradual transition between the rated voltage and the changed voltage (option).

Examples of test set-ups are given in Annex C.

Figure C.1a) shows a schematic for the generation of voltage dips, short interruptions and voltage variations with gradual transition between rated and changed voltage using a generator with internal switching, and Figure C.1b) using a generator and a power amplifier.

Figure C.2 shows a schematic for the generation of voltage dips, short interruptions and voltage variations using a generator and a power amplifier for three-phase equipment.

8 Test procedures

Before starting the test of a given EUT, a test plan shall be prepared.

The test plan should be representative of the way the system is actually used.

Systems may require a precise pre-analysis to define which system configurations must be tested to reproduce field situations.

Test cases must be explained and indicated in the Test report.

It is recommended that the test plan include the following items:

– the type designation of the EUT;
– information on possible connections (plugs, terminals, etc.) and corresponding cables, and peripherals;
– input power port of equipment to be tested;
– representative operational modes of the EUT for the test;
– performance criteria used and defined in the technical specifications;
– operational mode(s) of equipment;
– description of the test set-up.

If the actual operating signal sources are not available to the EUT, they may be simulated.

For each test, any degradation of performance shall be recorded. The monitoring equipment should be capable of displaying the status of the operational mode of the EUT during and after the tests. After each group of tests, a full functional check shall be performed.

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